بسم الله الرحمن الرحيم

ENERGY FOR SUSTAINABLE DEVELOPMENT
AND
SCIENCE FOR THE FUTURE OF THE ISLAMIC WORLD AND HUMANITY

ENERGY FOR SUSTAINABLE DEVELOPMENT
AND
SCIENCE FOR THE FUTURE OF THE ISLAMIC WORLD AND HUMANITY

Proceedings of the 13th IAS Science Conference on "Energy for Sustainable Development" and "Science for the Future of the Islamic World and Humanity," organised in Kuching/Sarawak, Malaysia,
29 September - 2 October 2003

Edited by

Mehmet Ergin
and
Moneef R. Zou'bi

Published by

Islamic World Academy of Sciences (IAS)
Amman, Jordan.

Publication sponsored by

Islamic Development Bank
Jeddah, Saudi Arabia.

OPEC Fund for
International Development
Vienna, Austria.

Copyright © Islamic World Academy of Sciences, Amman, Jordan; 2006.
All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, without the permission of the Islamic World Academy of Sciences.

First published in 2006 by
Islamic World Academy of Sciences (IAS)
PO Box 830036 Zahran
Amman 11183 – Jordan.

Telephones: + 9626 55 22 104
+ 9626 552 33 85
Fax: + 9626 55 11 803

Email: secretariat@ias-worldwide.org
ias@go.com.jo

Web Page: http://www.ias-worldwide.org

Type-setting at the Secretariat of the Islamic World Academy of Sciences, Amman, Jordan.

Printed in Jordan by the National Printing Press Company, Amman.

Jordan National Library Classification Deposit Number: 2569/12/2003
303.4830956
Zou'bi, Moneef\ Energy for Sustainable Development and Science for the Future of the Islamic World and Humanity\Edited by Moneef Zou'bi and Mehmet Ergin\Amman\ Islamic World Academy of Sciences\ 2003.
Descriptors\ Islamic Countries\ Sustainable Development\\Science Technology Planning

ISBN 9957-412-08-6

Price: US$ 30-00.

*** The views expressed in this book are those of the authors, and not necessarily of the editors, the Council or the General Assembly of the Islamic World Academy of Sciences. The Islamic World Academy of Sciences (IAS), providing a free forum for the exchange of scientific opinions and being a non-political institution of the whole of the Islamic Ummah, does not hold itself responsible for the statements made or ideas expressed by the contributors.*

Cover design by Jamal Dweik (Jordan).

Contents

Preface

Sustainable development provides the only practicable way forward if our World's peoples are to live in harmony with each other. Access to affordable and reliable energy, drawn from environmentally acceptable sources of supply, is an important feature of sustainable development. Renewable energy sources and technologies provide a virtually infinite supply and environmental compatibility with sustainable development.

OIC-member countries naturally vary in their energy and sustainability outlook. Some have developed a vision that interlinks their energy future to their sustainable development stance. Others, due to the abundance of their natural energy resources, have not given due priority to this issue.

The Islamic World Academy of Sciences (IAS), cognizant of its policy-making role in trying to bring such problems to the attention of OIC leaders and decision-makers, and realising the need to address such issues, tried through the convening of the conference, to bring back the issue of Energy for Development again to the forefront of the development landscape.

The IAS has moreover long realised that science is a major asset of humanity. An asset that in the 21st century faces new challenges as well as old ones. Challenges related to justice, tolerance, dialogue between civilisations, peace, and sustainable development.

At the 2003 IAS Conference, the IAS tried to freshly 'take-stock' of how science and scientific activities could and should be viewed in the light of the major international events that have swept through the world since the turn of the millennium in the hope that it could set the scene for the ensuing dialogue that would follow on the new roles and challenges of knowledge in the global society.

The conference, as with most IAS activities, was primarily an S&T platform. It assessed a number of facets of the OIC member countries' energy sector and attempted to define the energy priorities for OIC member countries and project energy success stories in the various parts of the world, and study some energy research activities currently undertaken in the various OIC countries.

The conference also attempted to entwine development in the energy sector to developments in the broader S&T sectors in the various countries.

The 13th IAS Conference was designed to be an open forum that brought together those working in energy policy development, academia, environmental policy, or involved in the political decision-making level, as well as to academics in the various pure science disciplines. It was also a platform designed to facilitate the free exchange of views among experts on Energy. Through encompassing lectures by eminent world scientists including Nobel Laureates, the conference evolved into lively intellectual exercise and provided a unique opportunity for much needed, genuine debate and lasting interaction among the scientists attending and between them and the world science community.

This book, which carries the same, rather elaborate title as the conference includes the majority of the papers that were actually presented at the 13th IAS Conference, which was held in Kuching, the capital state of Sarawak in Malaysia.

This book has been divided into ten parts.

Part One is made up of the statements of the two IAS Patrons, IAS President, and the host, that were delivered during the inaugural session of the conference. **Part Two** contains three keynote papers; by Nobel Prize Laureate Ferid Murad, the Foreign Secretary of the US National Academy of Sciences, and the President of the World Wind Energy Association (WWEA). **Part Three** includes three papers that describe the energy scenario in the Islamic world; Turkey, possibly the largest economy in the OIC; and Qatar, the OIC country with the highest per capita income. **Part Four** includes papers that address the specific issue of nuclear energy in Pakistan, Egypt, and Turkey. Pakistan is the only OIC country that has nuclear power while Turkey and Egypt are contemplating adopting this form of energy in the near future. **Part Five** looks at new forms of energy, namely Hydrogen energy in Iceland and

Biomass in Turkey, whereas **Part Six** includes one paper that describes the achievements of research institution in Tatarstan in the field of desulphurisation of oil products. **Part Seven** is made up of two papers on Sustainable Forest Management and Medicine and the Future of Mankind. These topics were addressed by the IAS in a conference it organised in Kuala Lumpur (Malaysia) in 1992; hence the session was called KL+10. **Part Eight** and **Part Nine** incorporate several interesting papers that address Innovation, Science Education, S&T activities, as well as the interaction between science and religion. The annual Lindau meeting of Nobel laureates as well as the inaugural lecture of M. Shamim Jairajpuri FIAS are also included.

Part Ten of the book is the appendix that includes the list of participants in the conference, the conference scientific and organising committees, the names of IAS Fellows and Council members, as well as various other details about the Islamic World Academy of Sciences.

Overall, the book represents an endeavour by the Academy to bring the issue of *Energy* back to the forefront in the hearts and minds of decision-makers in developing countries, especially at a time when international prices have been on the increase, adversely affecting the economies of many energy resource-poor countries.

Mehmet Ergin
Moneef R. Zou'bi

Acknowledgements

The Islamic World Academy of Sciences is grateful to Pehin Sri Dr Abdul Taib Mahmud Hon. FIAS; Chief Minister, State of Sarawak; Malaysia, for his patronage of the Thirteenth IAS Conference, and indeed for his support for the Academy. The support of His Excellency the President of Pakistan and His Royal Highness Prince Al-Hassan Ibn Talal of Jordan, Patrons of the IAS, is gratefully acknowledged.

The IAS extends its appreciation to all the organisations that sponsored the convening of the conference foremost among which are the Sarawak Islamic Council, Kuching, Sarawak; OIC Ministerial Committee on Scientific and Technological Co-operation (COMSTECH), Islamabad, Pakistan; Islamic Development Bank (IDB), Jeddah, Saudi Arabia; Sasakawa Peace Foundation, Tokyo, Japan; Arab Potash Company, Amman, Jordan; Higher Council of Science and Technology, Amman, Jordan; National Centre for Human Resources Development, Amman, Jordan; and Royal Jordanian Airlines, Amman, Jordan.

We also wish to thank all the Malaysian organisations, institutions, and banks that sponsored and supported the convening of the conference. The local advisory panel in Kuching, the numerous officials who have helped in organising the conference, and the local organising committee; Datu Putit Matzen, Dr James Dawos Mamit, Mr Misnu bin Haji Taha (Rapporteur), and Abg. Mohamad Shibli bin Abg. Nailie, all deserve our appreciation.

We are very grateful to all the eminent speakers who participated in the conference and to all the specialists and the various participants who made the effort to take part, in this international scientific activity.

The preliminary work done by the IAS Council and the efforts volunteered by Dr M. Ergin, IAS Secretary General; Dr M. B. E. Fayez FIAS; and Mr Moneef R. Zou'bi, IAS Director General, during the meetings of the scientific committee and the conference itself are gratefully acknowledged.

The IAS Council headed by Dr A. S. Majali has done a lot too to help realise this activity.

The dedicated staff at IAS Secretariat including Ms Lina Jalal, who was responsible for the painstaking effort of typesetting the manuscript, Ms Taghreed Saqer, Ms Hind Bilbeissi, Mr Habis Majali, Mr Saleh Asa'ad; as well as members of staff at the RSS printing unit; Mr George Anz and Ms A. Mizher, who undertook the elaborate effort of formatting the text; have all worked hard to produce this book, and deserve our thanks.

Mehmet Ergin
Moneef R. Zou'bi

IAS Kuching Conference
On

Energy for Sustainable Development and Science
for
the Future of the Islamic World and Humanity

Sponsor Organisations

1) Islamic World Academy of Sciences, Amman, Jordan;
2) Sarawak Islamic Council, Kuching, Sarawak;
3) OIC Ministerial Committee on Scientific and Technological Co-operation (COMSTECH), Islamabad, Pakistan;
4) Islamic Development Bank (IDB), Jeddah, Saudi Arabia;
5) Sasakawa Peace Foundation, Tokyo, Japan;
6) Arab Potash Company, Amman, Jordan;
7) Higher Council of Science and Technology, Amman, Jordan;
8) National Centre for Human Resources Development, Amman, Jordan; and
9) Royal Jordanian Airlines, Amman, Jordan.

IAS Kuching Declaration
on
Energy for Sustainable Development
and
Science for the Future of the Islamic World and Humanity

Adopted at Kuching/Sarawak (Malaysia), on
6 Sha'aban 1424
2 October 2003

PREAMBLE

WHEREAS *Allah* (God) *Subhanahu Wata'ala* has endowed Man with reason, and made the pursuit of knowledge an (absolute) obligation, and as the teachings of Islam emphasize the importance of prudently using all resources for Man's lasting well-being;

WHEREAS the doctrines of Islam explicitly emphasize that human-beings' relation to nature should be one of stewardship and not of unrestricted mastery, and as Islam promotes a balance between all living creatures and their life-sustaining environment;

WHEREAS concepts such as sustainability, and analytical tools such as human development indicators, provide conceptual frameworks for linking Research and Development (R&D) to societal outcomes, thus invariably leading towards the implementation of an R&D policy that addresses the complex interconnections among technological advance and societal responses and needs including sustainability;

WHEREAS sustainable development provides the only practicable way forward if our world's peoples are to live in harmony with each other, and as access to affordable and reliable energy, drawn from environmentally acceptable sources of supply, is an important feature of sustainable development;

WHEREAS renewable energy sources and technologies provide a virtually infinite supply and environmental compatibility with sustainable development;

WHEREAS Organisation of Islamic Conference (OIC) and developing countries vary in their energy and sustainability outlook, as some have developed a vision that interlinks their energy future to their sustainable development outlook, and others due, among other considerations, to the abundance of their natural energy resources, have not given due priority to this issue;

AND WHEREAS,

(a) The Islamic Academy of Sciences has long realised that science is a major asset of humanity, an asset that in the 21st century offers new opportunities and faces new challenges as well as old ones; challenges related to the prevalence of sustainable development, justice, tolerance, dialogue between civilisations and peace;

(b) The Islamic Academy of Sciences firmly believes that the international science/academic community must lead the way in bridging prevailing civilisational, social, economic, even political divides between the peoples of the world;

(c) Science education forms the starting point for genuine capacity building in Science and Technology (S&T) in developing countries;

MOREOVER,

(One) **BEING CONCERNED** about the prevailing and growing gaps – including knowledge gap – between the North and the South, which are marginalizing many developing countries and isolating the science communities therein;

(Two) **NOTING WITH CONCERN** that millions of people in rural areas of developing countries live without access to modern energy services, and that many in urban areas suffer the same deprivation and a third of our world's population has unreliable access to modern energy services;

(Three) **OBSERVING WITH CONCERN** the lack of a long-term energy policy at the national level in most member countries of the OIC;

(Four) **NOTING WITH CONCERN** the limited number of centres of excellence and the general deficiency of S&T institutions in many OIC member countries, especially those centres that are involved in renewable energy R&D;

(Five) **NOTING WITH CONCERN** the lack of specialized energy and sustainability-focused educational programmes at all levels of education in most OIC countries and the inadequacy of educational institutions;

AND,

(a) **RECOGNISING** the pressing need to encourage investment to support education in science and mathematics, fields where Muslim scientists have made highly significant contributions in earlier times, and noting that these efforts should take advantage of the enormous advances in Information and Communications Technologies (ICTs), but emphasising the great value of 'hands-on' approach to introduce young children to science, and further realizing that such initiatives should include school-based education as well as informal science education through science museums and centres, the media, organising and participating in science olympiads, to encourage greater public awareness of science;

(b) **OBSERVING WITH CONCERN** the difficulties faced by some OIC member countries in combating alphabetical adult illiteracy and in promoting computer awareness and utilization among the adult population;

(c) **NOTING WITH CONCERN** the absence of co-ordination between the various institutions involved in science and mathematics education within the educational process;

(d) **NOTING** the apparent slow adoption of advanced educational and ICT tools such as personal computers, access to the Internet, etc. and the general inadequacy of educational infrastructure;

NOW, THEREFORE, the Islamic Academy of Sciences:

(i) **REALIZING** that some OIC member countries face critical energy shortages and rely heavily on imported non-renewable resources;

(ii) **ACKNOWLEDGING** that renewable energy resources, appropriate to local conditions, usually offer an attractive energy resource to rural populations and can make an increasing contribution in urban areas, and that – for economic, strategic and environmental reasons – renewable energy resources are expected to become the supply of choice;

(iii) **ACKNOWLEDGING** that nuclear energy which does not release greenhouse gases at the generation stage as well as the clean renewable wind, hydro, biomass, geothermal, and solar energies, appear to be attractive for the generation of electricity and that their contribution in the global energy mix will significantly increase in future;

MOREOVER,

(a) **APPRECIATING** the activities being carried out by many UN, OIC, governments, academic institutions, and non-governmental organizations in the area of sustainable energy research and related technological applications;
(b) **REALISING** that no single nation-state can survive in the management of resources in total isolation from a regional and international context and that we all are interdependent;
(c) **UNDERSTANDING** that at the dawn of the 21st century, the world of science and higher education is marked by a complex struggle, between continuity and change, and the rise of new challenges, opportunities and new modes of 'learning to learn, ' and that the idea of reforms, innovations, transformations and *evolution* rather than *revolution* tells us that higher education and science are in ferment in creating and constructing knowledge;
(d) **NOTING** that in responding to the growing demands of the market-forces of the Knowledge-based or K-economy, a fresh-look is needed to re-examine the delivery of higher education in OIC and Developing countries in terms of quality and relevance, and also to re-examine the scientific development and acquisition capacity as well as technology application into the productive sectors of the economy;

THE ISLAMIC ACADEMY OF SCIENCES AND THE SCIENTISTS, TECHNOLOGISTS AND POLICY-MAKERS MEETING AT KUCHING, SARAWAK, MALAYSIA, DURING 29 SEPTEMBER- 02 OCTOBER 2003 CALL UPON the international community to:

(a) **EXTEND**, in the spirit of co-operation, all possible help to developing countries in the area of technology transfer, R&D human resource development, as well as debt relief, to enable them to channel more resources to mapping an environmentally sustainable future;
(b) **CONTINUE** to support research projects of importance in the developing countries, especially in the field of renewable energies, and related emerging technologies in general;
(c) **CONTINUE** to support research projects of importance in the developing countries in science and mathematics education;
(d) **INCREASE** institutional and national North-South and South-South academic and scientific collaboration to help developing countries build up their S&T capacity;
(e) **FACILITATE** the opportunities for scientists of the countries of the South in terms of under-graduate, post-graduate and post-doctorate studies in the North and other parts of the South as a means of building up the critical mass of scientists and technologists in poorer countries;

AND CALL UPON the leaders and decision-makers of Islamic countries to:

(i) **ESTABLISH** national academies of sciences in their countries, or where such independent entities exist strengthen them, so that they may act as independent advisory bodies to their respective governments;
(ii) **EVALUATE** their energy policies and where possible incorporate them into national S&T policies;
(iii) **STRENGTHEN** specialized R&D institutions, the output of which can eventually be smoothly transformed into marketable technological products;
(iv) **INTRODUCE** environmental awareness programmes at the various stages of the educational process;
(v) **STRENGTHEN** sustainable energy research centres, especially solar and hydrogen energy research centres, and provide them with all possible incentives to bolster their research and market their technological output;
(vi) **INTRODUCE** appropriate legislation and incentives, including tax relief and customs exemptions, to promote the use of sustainable energy resources;

(vii) **ALLOCATE/DIVERT** available resources to science education, with a view to building up a scientific and technological manpower base capable of adapting and developing new technologies;
(viii) **EMPHASIZE** the key role played by contemporary applied and basic sciences education for gaining mastery in the transformational technologies of information technology, biotechnology, and nanotechnology;
(ix) **ADOPT** a holistic approach to scientific research and development and technology utilisation and establish the necessary technology management processes for the purpose;

AND FURTHER CALL UPON the relevant OIC and other organisations to:

(a) **PROMOTE** a realization among educationists from all disciplines of the need to produce an appropriate base for socio-economic development in OIC countries through the use of a combination of ideological and utilitarian approaches;
(b) **ENCOURAGE** inter-agency collaboration in the area of sustainable energy adoption and assimilation;
(c) **COLLABORATE** with more advanced countries in building the scientific capacity required for the development of hydro and nuclear power, as well as wind, hydrogen, geothermal and solar energies;
(d) **ENCOURAGE** and support OIC-based sustainable-energy industrial ventures;
(e) **DEVELOP** databases of human resources involved in sustainable energy research and application in OIC countries to facilitate appraising national strengths and weaknesses;
(f) **PROMOTE** interest in science education at all levels, in a manner compatible with local culture and needs, but without excluding international experience gained in this domain including that of many European and American academies of sciences;
(g) **CONTINUE** to address developments in basic sciences and mathematics, and not to marginalize this backbone of S&T development;
(h) **UPGRADE** primary education through the introduction of illustrated and interactive educational resources and textbooks, and encourage scientists and educationists of repute to participate in the production of such materials and textbooks;
(i) **ENCOURAGE** and promote the publication of quality research material of OIC scientists on the Internet;
(j) **ENCOURAGE** the participation in the annual "Nobel Laureates Meeting in Lindau," which is a unique scientific event, at which Nobel Laureates give lectures to and interact with young researchers from a variety of countries;
(k) **IDENTIFY AND INTERACT WITH** champions of Science at the institutional, national, regional, OIC and international levels, to promote the cause of science for development;
(l) **STRENGTHEN** academic and scientific links with international science academies, and other scientific bodies worldwide;

MOREOVER, THE ISLAMIC ACADEMY OF SCIENCES:

(1) **SUPPORTS** the setting up of an OIC energy forum to critically examine future energy strategies of OIC member countries;
(2) **SUPPORTS** the setting up of the proposed International Renewable Energy Agency, as a new international body mandated to promote all aspects of renewable energies, at the international level;
(3) **URGES** all OIC member countries to contribute generously to the newly established OIC Science and Technology Fund, and commends highly the efforts of Pakistan and the OIC Standing Committee on Scientific and Technological Co-operation (COMSTECH) in launching this timely initiative.

Thirteenth IAS Conference

Energy for Sustainable Development
and
Science for the Future of the Islamic World and Humanity

29 September - 2 October 2003
Kuching/Sarawak, Malaysia

Conference Report

Under the patronage of the Chief Minister of Sarawak Hon. FIAS, Dr Abdul Taib Mahmud, the Islamic World Academy of Sciences convened its thirteenth international conference in Kuching, the capital of the Malaysian state of Sarawak, during 29 September-02 October 2003. The conference addressed the themes of *Energy for Sustainable Development* and *Science for the Future of the Islamic World and Humanity.*

The conference, which was held at the Kuching Hilton Hotel, was an open scientific activity in which over 250 participants representing over 25 countries participated. It was organised and sponsored by the following organisations:

- Islamic World Academy of Sciences, Amman, Jordan;
- Sarawak Islamic Council, Kuching, Sarawak;
- OIC Ministerial Committee on Scientific and Technological Co-operation (COMSTECH), Islamabad, Pakistan;
- Islamic Development Bank (IDB), Jeddah, Saudi Arabia;
- Sasakawa Peace Foundation, Tokyo, Japan;
- Arab Potash Company, Amman, Jordan;
- Higher Council of Science and Technology, Amman, Jordan; and
- National Centre for Human Resources Development, Amman, Jordan; and
- Royal Jordanian Airlines, Amman, Jordan.

The main objectives of the conference were:

(1) The conference, as with most IAS activities, was primarily an S&T platform. It appraised a number of facets of the OIC member countries' energy scene, attempted to define energy priorities for OIC member countries, projected energy success stories in the various parts of the world, and studied some energy research activities currently undertaken in the various OIC countries.

(2) The conference attempted to interlink development in the energy sector to developments in the broader S&T sectors in the various countries.

(3) The 13th IAS Conference was designed to be an open forum that brought together those working in energy policy development, academia, environmental policy, or involved in the political decision-making level, as well as academics in the various pure science disciplines. It was a platform designed to facilitate the free exchange of views among experts on energy.

(4) The conference, through encompassing lectures by eminent world scientists including Nobel Laureates, evolved into a lively intellectual exercise and provided a unique opportunity for much needed, genuine debate and lasting interaction among the scientists attending.

In addition to a memorable invited lecture by Prof. Ferid Murad Hon. FIAS, 1998 Nobel Laureate in Medicine, which was entitled *The Nitric Oxide/Cyclic GMP Pathway: Targets for Drug Development,* two other keynotes were presented; *Wind Energy for the Future*, by Prof. Preben Maegaard, President, World Wind Energy Association, Germany, *Science and the Future of Humanity,* which was presented by Dr Michael Clegg, Foreign Secretary, US National Academy of Sciences.

A conference session was dedicated to *Nuclear Energy for the Future* and included country papers on the subject from Pakistan, Egypt and Turkey. *Energy Policy* was discussed in a special session that included presentations from Turkey, Pakistan and Qatar.

Some *Energy R&D Aspects* were discussed in a lively session that included an outstanding paper on *Contemporary Problems and Achievements in Desulphurisation of Oil, Gas, Petroleum Products and Waste Waters,* which was presented by Prof. Akhmet Mazgarov FIAS, of the Russian Research Institute of Hydrocarbon Raw-Material (VNIIUS), Tatarstan, Russia. That was followed by a visio-conference presentation on Hydrogen energy entitled, *Towards New Energy for Sustainability: The Strategy in Iceland*, presented by Prof. Bragi Arnason and Prof. Thorstein I Sigfusson, of the University of Iceland and Icelandic New Energy, Iceland, which evoked a lively discussion.

Other specialised papers, including many that addressed the relationship between *Islam and Science* as well as *Science for the Future*, were presented in two specialised sessions. Two papers from Malaysia were also presented, the first by Omar Abdul Rahman, former science advisor the Malaysian Prime Minster, which was entitled *Harnessing Technology for Development;* the second by one of Sarawak's eminent scientists/politicians, Dr James D Mamit, on the *Science and Technology Scene in Sarawak, Malaysia.*

At the conclusion of the four-day conference in which 30 papers were presented, the Academy adopted the IAS Kuching Declaration on *Energy for Sustainable Development* and *Science for the Future of the Islamic World and Humanity.*

The declaration re-iterated the fact that the teachings of Islam emphasize the importance of prudently using all resources for Man's lasting well-being, and explicitly emphasize that human-beings' relation to nature should be one of stewardship and not of unrestricted mastery, and that Islam promotes a balance between all living creatures and their life-sustaining environment. It further called for the implementation of an R&D policy that addresses the complex interconnections among technological advance and societal responses and needs including sustainability.

Through the declaration, the IAS re-iterated that science is a major asset of humanity, an asset that in the 21st century offers new opportunities and faces new challenges as well as old ones, challenges related to the prevalence of sustainable development, justice, tolerance, dialogue between civilisations and peace. It promulgated that the international science/academic community must lead the way in bridging prevailing civilisational, social, economic, even political divides between the peoples of the world.

The declaration emphasised the need to promote the various renewable energy resources, in terms of both the related R&D effort as well as the downstream application. It supported the call to launch an OIC energy forum, as well an international renewable energy agency.

The declaration recognised the pressing need to encourage investment to support education in science and mathematics, and that these efforts should take advantage of the enormous advances in Information and Communications Technologies (ICTs), but emphasising the great value of 'hands-on' approach to introduce young children to science. It elaborated that such initiatives should include school-based education as well as informal science education through science museums and centres, the media, organising and participating in science olympiads, to encourage greater public awareness of science.

Moreover, the IAS, through the declaration, called on developed countries to extend all possible help to developing countries in the area of technology transfer, R&D human resource development, as well as debt relief, to enable them to channel more resources to mapping an environmentally sustainable future. It called on advanced countries to continue to support research projects of importance in the developing countries, especially in the field of renewable energies, and related emerging technologies in general.

The Academy called for an increase in institutional and national North-South and South-South academic and scientific collaboration to help developing countries build up their S&T capacity. It also urged advanced countries to facilitate the opportunities for scientists of the countries of the South in terms of under-graduate, post-graduate and post-doctorate studies in the North as a means of building up the critical mass of scientists and technologists in poorer countries.

As part of the follow-up action to the conference, the Academy will circulate the IAS Kuching Declaration to concerned individuals and relevant agencies throughout OIC and developing countries, so that measures are taken to implement the ideas proposed at the conference.

The Academy will also publish the complete proceedings of the conference in two quality volumes that will be distributed internationally. Such books, like all other published IAS proceedings, will become valuable references for experts that are involved in *Energy for Sustainable Development* or undertake research in the field of science education and science-society interaction.

Through IAS Fellows, personal contact and correspondence, the IAS will promote the concepts promulgated at the conference among the decision making circles of the Islamic world, and will provide whatever help it can to get the various recommendations implemented.

Message of*
His Excellency General Pervez Musharraf
President of the Islamic Republic of Pakistan
Patron of the Islamic Academy of Sciences

Since its creation, the Islamic Academy of Sciences had held regular deliberations on scientific issues of critical importance to the Ummah. These deliberations have played a vital role in identifying issues requiring the Ummah's utmost and urgent attention.

The two themes on the agenda of the Thirteenth Annual Conference, namely "Science and the Future of Mankind" and "Energy for Development" are timely and need deeper reflection form the eminent scientific scholars gathered here.

We are passing through a unique phase in human history – on the one hand, it is characterized by rapidly depleting resources, disappearing living species, shrinking glaciers, drying river systems and increasing pollution. On the other hand, we have unearthed the power to manipulate genomics, create designer plants and microbes and above all clone animals.

This rapid but paradoxical march of humanity, characterized by an increasingly globalized world and driven by advancement in science and technological breakthroughs is shaping the 21st century that we live in. Information and knowledge had become pivotal to human development and economic progress both at the national and international level.

However, as the developed countries become the dominant force in globalization, the Islamic Ummah has been marginalized and in the scientific field, left behind. This abysmal state is a direct outcome of decades of neglect and inattention in the Islamic world to the development of research, scientific infrastructure and indigenous technological capacity.

At the COMSTECH General Assembly meeting on 16-18 February 2002, we agreed on the need to reverse this sad state in which we find ourselves today. We also concluded that one of the reasons of the oppression of Muslims everywhere, in Palestine, Bosnia, India and Kashmir, to name a few, is partly due to the absence of skills in indigenous scientific research and technological development.

Can we ignore our own contribution to this despondent state of the Islamic World? Can we brush aside the fact that our advancement in science and technology largely rests on achievements and research done by those who lived when the Islamic World was the fountain head of knowledge, in particular in science, when Europe was in its dark ages?

In order to rectify and regain our lost glory, I suggested at the COMSTECH General Assembly last year that Muslim countries donate at least 0.1% of their GDP annually to establish a multibillion-dollar Pan Islamic Fund for the purpose of rapid development of science and technology in the OIC member states.

The idea was unanimously supported. Consequently, I appointed Prof. Atta-ur-Rahman, Coordinator General COMSTECH, as my personal emissary to deliver my message to the Head of Islamic states and to obtain their blessings for the Fund. Eighteen months have elapsed since I made the suggestion. Our progress has remained limited to the recognition of the problem.

Prof. Atta-ur-Rahman has presented my letters to Heads of States and discussed with them the urgent need to invest in science and technology in order to realistically address the issue of poverty alleviation and national self-reliance. The Fund can be used for research and development of basic sciences as well as for promotion of frontier technologies such as biotechnology, information technology, pharmaceuticals, optronics, robotics, material sciences, desertification and promotion of renewable sources of energy. COMSTECH can

* Delivered by Dr M A Mahesar, Assistant Co-ordinator General, COMSTECH.

play a pivotal role in operationlizing this research and in the development and implementation of such programs.

I consider it important and befitting for this distinguished body of scientists and scholars of the Islamic World to debate this all-important issue. I am confident that you will devote enough time to address this need and for identifying practical steps for the creation of this required joint multibillion dollar Pan Islamic Fund.

I earnestly hope that the Thirteenth Conference of Islamic Academy of Sciences will be a turning point in our quest for a better future. May allah give us all the courage to cope with these challenges and the wisdom to steer the Ummah through the troubled times. I wish you all success.

Message* of
His Royal Highness Prince El Hassan Ibn Talal of Jordan, Founding Patron of the Islamic Academy of Sciences

Datuk Patinggi Tan Sri Dr. Haji Abdul Taib Mahmud, Chief Minister of Sarawak;
Fellows of the Academy;
Distinguished Guests;
Ladies and Gentlemen:

Allow me first to congratulate you on launching yet another opportunity for Muslim scientists to exchange concerns, knowledge and ideas. Such meetings, between esteemed thinkers of your calibre, are of the utmost importance for the advancement of our *Ummah*.

Dramatic change has been taking place everywhere. One cannot overemphasise the volatility of our Islamic world, its diversity that is in desperate need of harmonisation, and some of the deepest concerns we have today regarding our history and our future as a culture and a community. This makes the mastery of the dynamics of the science-technology-development trilogy all the more crucial; it is simply a matter of survival.

Muslim countries face tremendous political, demographic, environmental, and regional development challenges. One such challenge is handling 'Energy for Development in the Islamic World'. In this regard, I say, despite the large income reaped by the Islamic world from the oil windfall of the seventies and eighties of the past century (almost 4 trillion dollars; probably twice as much by today's money), lasting benefits are limited. A lot of money has been wasted in local wars, in acquiring armament, and in sheer extravagance. In order to efficiently arrive at satisfactory levels of development compatible with income from oil, several lessons can be learned from the past. Above all, the economy in oil-exporting countries should be diversified, and not based on a single product with volatile prices. We have to be aware of all controversial debates surrounding fossil energy, the environment and global warming. It is also time to stop the waste and extravagance that have accompanied oil income in the past. Such practices are against the ethics and teachings of Islam.

The world will continue to depend on oil for decades to come. The Islamic world accounts for over 70% of global oil reserves. Correspondingly, the dependence of the world on Islamic countries to supply this vital commodity will continue. Although the past windfalls will not be repeated, a handsome income to the oil-exporting Islamic countries is expected to continue for many years to come.

How can this income be used to foster the fortunes of Islamic countries, particularly in the domain of human development, since many Muslim countries are at the bottom of the ladder of world indices of this domain?

---

* Delivered by Moneef R Zou'bi; Director General IAS.

We sit together and we try to envision the kind of future we would like to share. Surely, no single nation-state can survive in the management of resources in total isolation from a regional and international context. We are all transparently interdependent – at best, *inter-independent!* While logic implies that rational beings would aggregate interests and work together to eliminate common fears, history demonstrates how an aggrandisement of one's interest often leads to the misfortune of others, and the 'success' of one party could become another's nightmare. It is therefore essential that we ask together: what futures do we want and how can we make them coexist? What is needed is a common approach based on a return to 'anthro-centrism' – putting human welfare first.

The good news is that science and technology – as demonstrated in the recent past – can offer much in this respect. In addition to scientific advancement in sustainable and efficient production and consumption, science and technology can play vital roles in development through raising awareness and providing channels for conversation for the purpose of arriving at the best development solutions. There is still much to do in mastering the fine art of conversation; in using technological advancement to brainstorm development options *within* our region as well as *with* other regions. Our goal must be to ensure an environment capable of sustaining human and other life through global and local policies that operate on the social, economic, political, cultural and even spiritual levels.

The young think tank (tt30) of the Club of Rome is an excellent example of open discussion and information exchange throughout the year amongst young pioneers all around the world and from different development-related backgrounds. Let me propose here, as I already have on several recent occasions, an emulation of the Club's European Environmental Education (EEE) in the form of an 'Electronic Environmental Education' programme for youth in our region.

In this framework, I have had the honour of launching two dialogue initiatives: the first is *Partners in Humanity*, which I recently launched in Amman with John Marks from Search for Common Ground, with the aim of rebuilding partnerships and promoting dialogue between Muslim countries and the United States. The second initiative is the *Parliament of Cultures* launched in Ankara with Professor Ihsan Doğramaci, following the idea of the late Yehudi Menuhin. In this forum men and women from all over the world will participate in interactive dialogue; thus strengthening international and intercultural friendship.

In the name of extraterritoriality and supranationalism, I have often called for a vision of a regional *aménagement des térritoires* – a regional management of our human values and economic resources, focusing on a cluster of water, energy and the human environment in our region in the same way that coal and steel brought Europeans together. Let us not forget, ladies and gentlemen, that *Al Ummah* is itself a supranational concept.

Today, it has become so easy for scientists in countries far apart to cooperate and form either virtual institutions, which can attract international grants, or virtual companies which would generate good income to these companies, their institutions and the national economies. One of our institutions, the Higher Council for Science and Technology in Amman, is currently starting a virtual company in biotechnology, thanks to considerations related to flexibility, cost-effectiveness and ease of networking, among other reasons.

A major concern remains: how do we guarantee the satisfactory transfer of such knowledge and technology to our part of the world? We must not only focus on what the North can do for us, but how *we* in the South can work with them. Another concern is: how can we protect culture, diversity and traditional knowledge in the process? Intellectual property rights and the transfer of knowledge from developing countries to the developed world are also issues that merit immediate attention.

The Islamic Academy of Science promises much in this regard, as its mission statement points out. Since its inception in 1986, the IAS programme has addressed many contemporary issues facing the Islamic world, with a view of not only benefiting the *Ummah*, but also all mankind by means of a well-informed, cooperative, pragmatic, innovative and humanitarian approach in scientific and technological development.

Over the past decade many conferences – international, pan-Muslim, and Third-World – have been held on the topic of energy and sustainability. Although these have been very useful in stimulating discussions and in familiarising scientists and academics with each other, the capacity-building outcomes have not been forthcoming. Issues of how to release the potential of entrepreneurship and promote creativity and innovations are still very much on our agenda.

These issues must be addressed with a strong interdisciplinary approach. We must address how science conditions the life of contemporary man. Leading scholars must address the ways in which science can and will shape the future of mankind.

At the dawn of the 21st century, the world of science and higher education is marked by a complex struggle, pull-and-push effect, between continuinity and change. It is all about new challenges, opportunities and new modes of 'learning to learn'. The idea of reforms, innovations, transformations and *evolution* (rather than *revolution*) tells us that higher education and science are in ferment in creating and constructing knowledge. At the heart of building knowledge societies, an interaction between continuity, change and quality in reforming education systems and building science-capacity should become an inherent part of human development.

I hope, ladies and gentlemen, we can work together towards our common goal of the common good.

Thank you *wa Assalamu Alaikum*.

Address of
Dr Abdel Salam Majali FIAS
President, Islamic Academy of Sciences

Your Excellency Dato' Seri Dr Mahathir Mohamad, Prime Minister of Malaysia,
Your Excellency (our host) Datuk Patinggi Dr Abdul Taib Mahmud, Chief Minister of Sarawak,
Excellencies,
Eminent Fellows of the Islamic Academy of Sciences,
Ladies and Gentlemen,

السلام عليكم و رحمة الله و بركاته

One year ago, I stood before an assembly of IAS Fellows and scholars in Islamabad, at the start of the twelfth conference of the Islamic Academy of Sciences. We were then talking about New Materials, and about the Culture of Science. We were addressing science and scientific issues before an international backdrop of doom and gloom. Maybe none of us then realised that our world would be subjected to such dramatic events over the following twelve months.

This year, we convene in this part of the Islamic world, upon the gracious invitation of the Chief Minister of Sarawak, a man of vision and foresight, and in the presence of world-class scientists. We may be geographically far from the lands of the cradle of Islam. Yet, we are at the heart of this garden of tolerance, the Malaysian state of Sarawak. By our mere presence we are following in the footsteps of trader/merchant forefathers who rode the high seas to come to this land of plenty. Although, it is true that they came in search of material profit, I am certain though, that the words of the Prophet (Peace Be Upon Him) to seek knowledge even in China were at the back of their minds, throughout.

We gather in Kuching, this green and lush city, determined as ever to propagate the message of science. To address issues important to our present and to our future.

We are signalling, through our meeting, our determination to focus, as scientists and scholars, on bettering ourselves and humanity. On building a future for the generations of tomorrow; a future in which our great Islamic civilisation would again occupy its rightful place amongst the elite, a bright future for us as Muslims and as human beings.

The array and calibre of the persons gathered in this room today reflect the profound admiration that the Islamic and international scientific community has for Malaysia and Sarawak.

Malaysia has been leading the way in terms of utilising science and technology for development. A people and a leadership united in objective, and focussed in strategies, Malaysia has managed to withstand some serious economic storms that have swept through South East Asia in the late nineties. She has been co-operating with her sister OIC-member countries in all fields, and in a manner that has been comprehensive and most of all effective. She will, in a week or two, host the OIC Summit, demonstrating yet again, her unwavering determination to help out and contribute to building a better future for the Ummah.

Many areas have been part of this multi-facet multi-discipline approach, and therefore, in keeping with the Academy's desire, and the famous Muslim tradition to promote interdisciplinarity, I have chosen "Seeking a Sustainable Future" as the theme of my remarks to you today.

Your Excellency
Ladies and Gentlemen

During the last 50 years, man used twice as much energy than in all prior history of civilization.

This process was triggered by the Industrial Revolution in the late 18th century, and the emergence of the fossil energy economy.

When it did, it made available power for the steam engine, which became the primary means of energy conversion for a century. Not only did this replace human and animal labour with mechanical power, but also caused the launch of steam ships and thus the beginning of a global transport system. Steam trains and modern overland transport soon followed, and finally came the large power plants driven by fossil fuels - and later by nuclear energy - that still function according to the principle of the steam engine.

Our electricity supplies today are based on 19th century technology. We use fossil fuels that have an uncertain future. Pessimists claim that the energy system prevailing in the world today is coming to an end, even though it accounts for over 90 percent of total supply. It no longer has a viable future for two solid reasons. First, no one can deny that reserves are limited. Second, we can no longer afford to burn all the reserves known today because the Earth's ecosphere simply could not bear it.

Nuclear energy, which is also a fossil energy form, since it is based on the fossil mineral uranium, is also exhaustible. If the number of nuclear power plants stays at the current level, uranium reserves will be exhausted in less than fifty years.

The world therefore cannot afford to wait until then to change the basis of its energy supply.

This is why we need to consider renewable energies. Perhaps then, there will be no need to look for another energy source. We know today that the potential of renewable energies is great. Even if the world population were to multiply, our world would still have enough available energy to sustain life. Renewable energy is inexhaustible as long as the solar system exists.

According to the latest findings in astrophysics, the solar system will survive for another 7 billion years – a virtually infinite time span by human standards. A journalist once asked Dr Hermann Scheer, the famous German scientist politician, when he mentioned this figure whether he had said 7 billion or 7 million years. When Scheer repeated that it was 7 billion, the journalist said that he was relieved. As if 7 million would have been a cause for worry!

We all know and agree that the greatest energy source is that which comes from the sun, or the sun itself. It is afterall a sustainable source. Making this potential the basis for most human activity would help man to behave as intelligently as Nature. Maybe it is time that we admitted that our collective intelligence lags behind Nature. Nature afterall relies almost exclusively on solar energy.

A number of international activities have been launched in recent years to get the global energy problem under control. Note worthy OIC initiatives in this domain are sadly lacking. On the UN level, activities centred around the search for alternatives particularly after the Global 2000 report and the work of the World Watch Institute emerged.

What was made increasingly obvious from such activities was that the world was heading towards a crisis. And because we are in a race against time, we must look for new strategies. The document entitled "Our Common Future," better known as the Brundtland Report, which was published by the United Nations in 1987, is a good starting point in this context.

It is a sad but true admission that almost all international activities in this domain – especially in our countries – have postponed facing the problem. We must put an end to this delay. Everything that could have been resolved or implemented on the national level in the eighties was postponed until after the conference in Rio de Janeiro in 1992. A wonderful document was adopted there, known as Agenda 21. Its drawback, however, is that it excluded the core issue, energy.

In our studies of a sustainable tomorrow, especially when we talk of environment and development, we tend to forget that energy and energy needs are at the core of sustainable life. The outcome of the 1992 Rio Conference missed that out. Indeed our own conference on the subject, which was held in Kuala Lumpur in August 1992, did not address the core linkage between energy, and environmental sustainability.

Whenever we analyse the real reasons for most of the problems listed in Agenda 21, we directly come to the conversion of fossil or nuclear energy into useable energy in virtually every case. The conclusion is logical and unequivocal: the core of the solution to the global ecological crisis is the adoption of renewable energies.

This must be coupled with promoting greater linkage between science, and energy policy-making.

This linkage should embrace holistic approaches to energy and sustainable development as well as take account of the specific socio-economic and cultural context of individual countries. Our countries' institutions and universities should work productively together in the area of renewable energies. This, so that policies and cooperation projects may be based on relevant evidence and research, and also be shaped by ethical considerations.

The field of renewable energy is one where ethical issues abound, such as those pertaining to unsustainable patterns of consumption and production and our obligations to generations yet to be born.

Dear Friends

We now appreciate that development is inconceivable in economic and material terms alone. We now know that there is a real need to reaffirm and strengthen the reciprocal links that govern the economic, social, ecological and cultural realms.

We also realize that the environment cannot be understood or preserved without taking into account the human cultures that shape it. This requires identifying and safeguarding all forms and expressions of human heritage; whether natural or cultural, tangible or intangible, and so creating a climate favourable to its survival and full development.

We must therefore convince our political leaderships in OIC countries to focus on placing tangible and intangible heritage in the forefront of the national, regional and local use of natural resources and cultural heritage. Sound practices of environmental protection and land management are vital for safeguarding heritage. In turn, heritage protection and conservation for sustainable development is a realm that needs careful consideration.

Dear Friends

The 1999 World Conference on Science discussed at length the topic of 'science for man.' In its final declaration on science and the use of scientific knowledge, this notion was expressed by that conference:

science for knowledge
knowledge for progress, which included science for peace, science for development; and science in society and science for society.

I believe that we must again highlight the ways in which science can help in developing and promoting the specifically human dimension of man, society, and the environment.

At the same time, we should also discuss the ways in which, in certain situations, use, misuse and abuse of science can be responsible for a decline in the quality of life, as happens in the case of damage done to the environment, the consequences of the invention and use of sophisticated weapons, etc.

The second part of this topic, 'man for science', involved identifying the impact of recent scientific discoveries and advances on our vision of man, both directly and indirectly.

As scientists from Muslim lands, we are aware of what progress means. Our Islamic civilisation is amply endowed with examples of prolific scientific achievements that had an impact on life.

From Al-Khawarizmi's Algebraic theories to Al-Zahrawi's surgical techniques. Indeed from the very early days of Islam when simple science was put to serve the cause of *Aqeedah*, concepts rose of how technological advancement affected our lives. It is this ideology and worldview that, during the first few Hijri centuries, provided a most powerful source of inspiration, especially for Muslims' quest for knowledge.

Recent decades have witnessed significant changes in knowledge production systems, especially in scientific research and related applications. And more changes in knowledge production and systems of research and development (R&D) are in motion. These changes are fuelled by the quickening pace of globalization.

Indeed, Globalization itself was fueled by new developments in information and communication technologies (ICTs), in biotechnology, and in the field of materials science and engineering including Nanotechnology. These are primary manifestations of transformational technologies. I think at some point we have to add Cultural Technology…

Developing countries must move toward a process of technology-supported progress, where different sectors can continually develop in response to knowledge production. They cannot simply watch wave after wave of transformational technologies pass without due regard! The choice is really ours, as it has always been.

We must ride these Information Technology, Biotechnology and Nanotechnology waves with confidence and determination. We must 'plug into' the transformational powers of these technologies, and not stand idly by, and see us left behind.

Your Excellency
Eminent Scientists
Ladies and Gentlemen

The new millennium is new only in name. There is nothing new in the anger and violence springing up everywhere. There is nothing new in unjustified or even justified actions that involve the use of force. Indeed, if we continue to depend on the rule of force, on power, as a deterrent, we will eventually be unable to disable violence. We – all of us in the East and the West - must become more sensitive to the concept of consequences: the consequences of injustice, poverty, illiteracy, lack of opportunity and despair, which can all lead to the contemplation of violence.

As a citizen of the world, and as a medical doctor, I learnt to look for causes, to diagnose, to ask why certain things happen. I realize that intolerance, prejudice and bigotry can also be seen as forms of illiteracy and ignorance, eroding social values, eating away at our humanity and stamping on our sense of ethical obligations and duties - to one another and to the world as a whole.

Our mission now as science leaders is to address the world. The divine message that is the core of our civilisation, and indeed our existence, promulgates respect for human life and most of all justice.

We must point out to despair generating conflicts in our midst. We must activate our goodwill-based bilateral interaction. If we are to contribute to global security, we must think of achieving local commodity and natural resource security. We must bridge science divides, digital divides, and maybe more importantly we must aim to bridge the hope divide.

I am confident that our meeting here will give our stand on this subject a considerable boost. I am confident that each of us as scientists, in his own way, can help in promoting understanding and tolerance.

I thank all of you for joining the IAS in its efforts, whether in the chair or from the floor, in a spirit of open-mindedness.

Thank you.

Introductory Remarks
of
Pehin Sri Dr Abdul Taib Mahmud Hon. FIAS
Chief Minister, State of Sarawak
Malaysia

"I call on Muslims to build a society that actively participates in science and technology. The gap between us and the developed nations cannot be bridged unless we realise that the Islamic struggle must embrace technological and scientific advancement. As a country progresses, science and technology become part and parcel of that effort as well as of developing the Muslim community into the future.

As such, the Muslim community has to inherit a correct approach in the Islamic civilisation.

It is ironical that now the Muslim community have to improve themselves to catch up with the best development of the world, while the success of the Western world today was attributed to Islam's struggle in the past.

I hope the IAS could help to promote scientific education within the Islamic countries by assisting those that are still behind while pushing those that have developed to the forefront of scientific knowledge.

Better results can be obtained through cooperation among universities in sharing a pool of scientific expertise in various areas to be distributed among the underdeveloped countries.

As an example, the State of Sarawak has embarked on its vision to attain the 'K-society' and 'K-economy' concept for the future.

This challenge requires knowledge and the transformation of our own education system. We have to find out strategic players who can enable our people to see opportunities for greater rewards if they possess the correct skills and knowledge. The education system has been revamped to put greater emphasis on science and technology.

We take pride in the fact that Sarawak was also embarking on a renewable source of technology through its research and development into palm oil as alternative fuel. We have succeeded in getting palm oil as fuel. Although it is at the preliminary stage of research, it can be developed further.

On the economic front, people who could master science and technology following the evolution of information technology and improvement in communication would be able to rule the market.

The changes are being fuelled by greater discovery in science and invention of new technology. A lot has to be done through scientific education. That is what I perceive as the greater consciousness of the relevance of science and technology.

Such knowledge could put the Muslim community on the track to peaceful development to benefit humanity.

Islamic knowledge can contribute towards greater achievement of the scientific knowledge in the Islamic world.

I am happy that IAS decided to convene its meeting Kuching, which could help to disseminate greater consciousness about the role of science among the local participants.

IAS will be able to help in the transformation of the outlook about what we can do in the struggle to attain socioeconomic developement."

Signal Transduction with Nitric Oxide, Guanylyl Cyclase and Cyclic Guanosine Monophosphate

AURORA R. SEMINARA, JOSHUA S. KRUMENACKER
and
FERID MURAD*
Department of Integrative Biology and Pharmacology and Institute of Molecular Medicine, University of Texas-Houston Medical School, Houston, 6431 Fannin St., TX 77030, USA.

1 ABSTARCT

Studies surrounding the formation and biological actions of nitric oxide (NO) have grown immensely over the past twenty years. Following the understanding of the biological effects of NO and nitrovasodilators on the regulation of cyclic guanosine monophoshpate (cGMP), numerous studies have exposed the complexity of this cell-signalling cascade in various systems. NO itself has been demonstrated to act as an intracellular second messenger, a local autocrine or paracrine factor, a neurotransmitter, and possibly a hormone acting at distant targets. The biological effects of NO can be paradoxically beneficial or detrimental, depending on the effector, its concentration and the surrounding microenvironment. The diverse actions of this signalling cascade make it a good target for drug discovery and research interest.

2 INTRODUCTION AND BACKGROUND

While working with cAMP as a signalling second messenger molecule in the late 1960s to early 1970s, the emergence of cGMP as another potential second messenger occurred. Our laboratory subsequently became interested in cell signalling through cGMP, since at the time, cGMP was being characterized with respect to its measurement in body fluids, its synthesis by guanylyl cyclase, and its hydrolysis by phosphodiesterases. We began by focusing our efforts on understanding how various hormones, neurotransmitters, and other ligands lead to the stimulation of cGMP synthesis by soluble guanylyl cyclase and describing what functions are physiologically regulated by cGMP. We have now spent approximately three decades answering the above and many additional important biological questions surrounding this unique and diverse cell signalling cascade.

Our initial experiments surrounding cGMP were what we referred to as “dumping” experiments, in which we would add various agents and hormones to cell homogenates, cell cultures or tissue preparations in attempt to correlate the accumulation of cGMP with some biological response of the preparation. Unfortunately, while us and others were not very helpful to identify the actual function of cGMP accumulation in physiology. We decided to focus our studies on the enzyme that converts GTP to cGMP, guanylyl cyclase. We hypothesized that if we could gain a better understanding of guanylyl cyclase, it would lead us in the right direction to elucidate its biological function and how it may be regulated by hormonal stimulation.

We learned quickly that most tissue preparations contained catalytic activity to produce cGMP, and this catalytic existed in both high-speed soluble and particulate fractions (1-5). In addition, these fractions exhibited different enzyme kinetics and properties. Detergents or mild protease treatments were able to solubilize and enhance the activity of the particulate fraction. We suspected there may be multiple isoforms of the enzyme, and subsequent work let to the elucidation of several different isoforms and independent gene products. We know today that several isoforms of both the soluble and particulate guanylyl cyclases exist.

---
* 1998 Nobel Prize Laureate in Medicine; and Hon. Fellow of the Islamic World Academy of Sciences.

3 EFFECTS OF NO DONORS ON THE SYNTHESIS OF cGMP

We suspected we were working with at least two isoforms of guanylyl cyclase, and continued to work with the enzyme in cell-free systems. It was difficult to prove, however, that some of our results were not due to contaminating factors in the crude preparations, such as phosphatases, nucleotidases, and cyclic nucleotide phosphodiesterases. The approach we took was to add general inhibitors of these contaminants in our preparation, such as azide, hydroxylamine, phosphodiesterase inhibitors, fluoride, etc. We were surprised to find that azide, hydroxylamine and nitrite activated most, but not all, of our crude preparations (6). This was an exciting period in the laboratory since we recognized that the addition of many hormones and other ligands would fail to increase cGMP synthesis in our crude preparation, and only had their effects in an intact cell system. We thought the intact cell systems most likely maintained a complex working signalling cascade that regulated cGMP that was disrupted during the crude preparations. An understanding of how azide activated cGMP synthesis, we determined, would allow us to also understand how hormonal regulation of the enzyme occurred (7, 8). Over the next several years, we began to fully understand the signalling cascade (3, 9) (Figure 1).

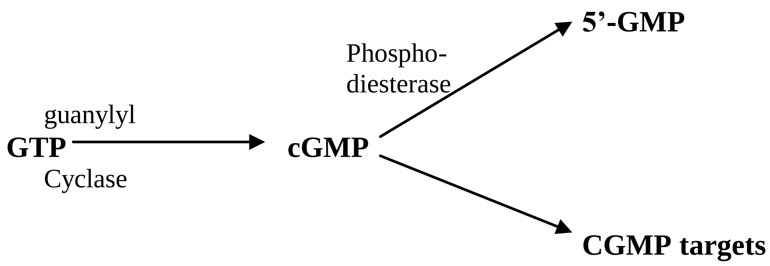


Figure 1. cGMP synthesis, metabolism, and function.

The activation of guanylyl by azide occurred following a brief time lag, which suggested azide may be modified or converted to another compound. Also, azide did not stimulate the enzyme in all our preparations. Furthermore, altering the levels of thiols, oxygen, and various other oxidizing and reducing agents (6, 10) changed the activation. Because of the differential regulation of guanylyl cyclase by synthetic agents, we also mixed crude supernatant fractions and then assayed them for activity. We found some very interesting results: If we mixed preparations of liver with cerebral cortex, we observed an increased activation of the enzyme. The opposite effect was observed when we mixed the liver preparation with a heart preparation; the enzyme activation by azide was lost (Table 1). We hypothesized that there was a requirement for a factor other than azide to activate the enzyme in liver extract that also allowed activation of the cerebral cortex extract. Also, another factor either directly blocked guanylyl cyclase or the enzyme was inhibited in another way in the heart extract, since mixing the heart and liver extract attenuated the activity of the liver extract (6, 11). We later purified these activating and inhibiting factors, and determined that they were catalase and haemoglobin, respectively (10-17). It became apparent that heme-containing proteins could regulate the enzyme soluble guanylyl cyclase by stimulating or inhibiting its catalytic activity.

Table 1. Effects of azide on soluble guanylyl cyclase activity

Tissue	cGMP (pmol/min./mg protein)	
	(-) azide	(+) azide
Liver	38.8	595.4
Heart	23	23.2
Cerebral cortex	46	42
Liver + heart	27.3	23.1
Liver + cerebral cortex	23	899

4 AZIDE AND NITROVASODILATOR EFFECTS IN TRACHEAL SMOOTH MUSCLE

Earlier, we had developed a fairly homogenous bovine tracheal smooth muscle preparation in which we could measure the biological activity of motility and cGMP accumulation in an organ bath following stimulation by hormones. We expected that the cGMP accumulation preceded the biological activity during hormonal stimulation, and suspected that the activity was a result of the increased cGMP levels (18-21). Because azide, hydroxylamine and nitrite had already been shown by us to increase cGMP accumulation in various tissue preparations, we decided to stimulate the bovine tracheal smooth muscle preparation with these guanylyl cyclase activators and measure motility and cGMP levels (10-21). We found that not only did these activators stimulate cGMP accumulation, but also let to the relaxation of the pre-contracted smooth muscle preparation. We found similar results in a gastrointestinal smooth muscle cell preparation as well (19-21). After determining that these agents led to smooth muscle relaxation, and that cGMP levels correlated beautifully with the relaxation, we began to analyze other smooth muscle relaxants such as nitroglycerin, nitroprusside, and hydrazines among others (15-21). All these agents led to elevated cGMP levels in smooth muscle as well as other tissues, activated guanylyl cyclase, and caused smooth muscle relaxation in tissue preparations. We termed these new guanylyl cyclase activators "nitrovasodilators" because of their biological effects. The effects of the nitrovasodilators did not require catalase to activate soluble guanylyl cyclase, but could be inhibited by haemoglobin and myoglobin.

5 BIOLOGICAL EFFECTS OF NO

The growing list of functional nitrovasodilators and the effects of additional heme-containing factors that altered the activity of guanylyl cyclase led us to believe that the direct activator of the enzyme and active intermediate compound could be NO (16-22). Indeed, our attempts to directly ventilate NO gas to our tissue preparations were a success. Not only did it increase cGMP levels and caused relaxation in the bovine tracheal smooth muscle system, but also increased cGMP levels in almost all tissue preparations examined (18-22). In an effort to better define the effects of NO on guanylyl cyclase activation, we purified the guanylyl cyclase isoforms to homogeneity and further examined the effects.

Even after purification of soluble guanylyl cyclase, we observed the activation of the enzyme by NO in the preparations (23). Essentially, the more contaminants that were removed from the preparations that trapped or complexed the NO, the less NO was required for its activation. We determined the EC_{50} for activation of soluble guanylyl cyclase by NO to be between 1 and 10nM, depending on the conditions of the assay (23). We became aware of the magnitude of this discovery, as we found the first activation of an enzyme by a free radical molecule.

6 COULD NO BE AN ENDOGENOUS ACTIVATOR OF GUANYLYL CYCLASE?

We proposed in 1978 that the effects of various hormones, autocrine and paracrine factors and neurotransmitters to elevate cGMP levels could be explained through the endogenous production of NO or a NO precursor in intact systems (15, 17). And, the appropriate hormonal stimulation could influence the production, release, or metabolism of NO. Furthermore, if NO was an endogenous activator of the enzyme, we thought that the endogenous levels would be around 1 to 10 nM, near the EC_{50} for activation of guanylyl cyclase. This made sense since higher levels of NO would suggest that the enzyme would always be activated, and make the physiological relevance more questionable. However, the colorometric assays to measure NO and its oxidation products, nitrate and nitrite, were not sensitive enough to measure the concentration needed (nM vs. µM to mM). Therefore, several years passed before we could reliably test this hypothesis.

7 L-ARGININE ACTIVATION OF SOLUBLE GUANYLYL CYCLASE

Deguchi and colleagues, who were examining guanylyl cyclase regulation, found that a factor from brain or neuroblastoma extracts could activate crude or partially purified preparations of soluble guanylyl cyclase (24). This endogenous substance was later identified as L-arginine. L-arginine mimicked nitrovasodilators in its activation of sGC. We confirmed this observation, but found that L-arginine failed to activate purified sGC, suggesting that other components were required for its activation (unpublished results). Hibbs et al found that the cytotoxic effects of macrophages on tumour cells correlated with the accumulation of nitrite and nitrate in the conditioned media (25). L-arginine increased the cytotoxic effects and NO metabolite accumulation whereas L-arginine analogs such as L-N-methyl arginine (LNMA) blocked these effects.

L-arginine was found to be the limiting factor in cGMP accumulation. Cells exposed to oxytocin, a reagent that increases calcium influx, demonstrated calcium-dependent NO production by L-arginine (26). The effect was maintained with 1 mM L-arginine whereas without it, cGMP levels diminished. In addition, administration of D-arginine, the inactive analog of L-arginine, caused a decrease in cGMP levels. It was evident that NO participates in a second messenger system whereby it forms NO via L-arginine to account for cGMP accumulation. The experiment also proved that L-arginine could regulate calcium influx for signalling mechanisms. Within several years, many laboratories including our own began to characterize, purify, and delineate this novel pathway that converted L-arginine to NO and citrulline (Figure 2).

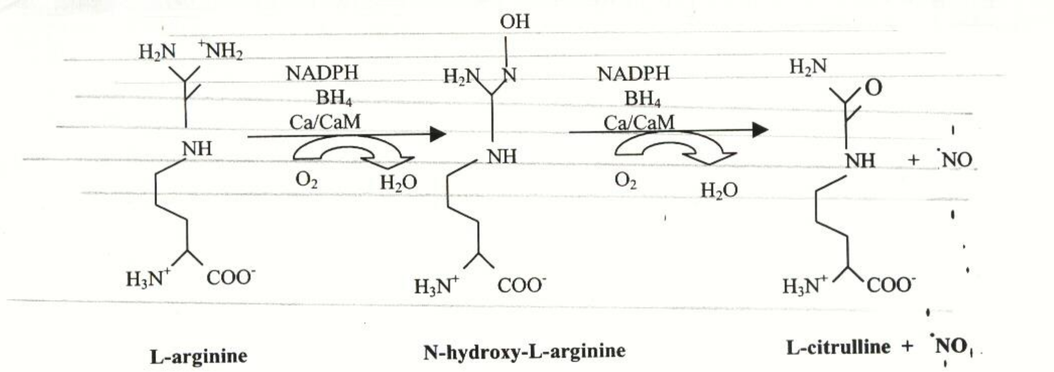


Figure 2. L-arginine forms L-citrulline + NO.

8 THE DISCOVERY OF THE NITRIC OXIDE SYNTHASES

One of the projects in our laboratory in the early and mid 1980s was to define the biochemical mechanism of nitroglycerin tolerance. We found that rat lung fibroblast cultures (RFL-6 cells), as well as other cell types could be used as model systems of tolerance (1, 3, 4, and 5). The RFL-6 cells possessed both soluble and particulate isoforms of guanylyl cyclase that could be activated to produce high levels of cGMP in response to nitrovasodilators and atriopeptins, respectively. We realized that these cells could be used as an assay for measuring NO production in various cell lines (27). This permitted us greater sensitivity for the quantification of NO in different tissue extracts and other samples. Using this method and other equally sensitive methods that were developed around the same time, we along with our colleagues learned that numerous cells, tissues, and cell free extracts could produce NO (28). This surge of activity resulted in the characterization and purification of NOS from a number of cells and tissue (1-5). This work elucidated at least three isoforms of the enzyme.

The first NOS isoform to be purified was the neuronal or brain NOS (nNOS, Type I NOS, or NOS-1). This was followed by inducible NOS (iNOS) or NOS-2 (Type II NOS), and then endothelial NOS (eNOS) or NOS-3 (Type III NOS). Some properties of the NOS isoforms are summarized in Table 2. Both NOS-1 and NOS-3 have been called constitutive or housekeeping enzymes, but their expression and synthesis can be regulated under various conditions. NOS-2 is probably absent in most cells until it is induced by endotoxin and/or various cytokines. Exposure to endotoxin (LPS), Interferon-γ, Interleukin-1, Tumour Necrosis Factor-α, and other pro-inflammatory cytokines causes a rise in NOS-2 mRNA levels, protein expression, and catalytic activity within 2 hour and reaches maximal levels in 6-18 hours (29). Various anti-inflammatory cytokines and glucocorticoids can decrease the induction of NOS-2. It is thought that some of the pharmacological and biological effects of these factors may be explained by increased or decreased NO formation. For example, the hypotension observed in septic shock as well as the ensuing multiple organ failure might be due to excessive o formation.

Table 2. Properties of Nitric Oxide Synthase Isoforms

Nitric Oxide Synthase Isoforms			
Type	**Alternative Names**	**Tissue/Cell Distribution**	**Activation**
NOS-1 (155kD)	Neuronal NOS Brain NOS Type I NOS	Central and peripheral neurons, NANC neurons, islets, endometrium, skeletal muscle	Constitutive, Calcium/calmodulin dependent
NOS-2 (125kD)	Inducible NOS Type II-NOS	Macrophages, liver, smooth muscle, endothelium, heart	Inducible by LPS, cytokines, and glucocorticoids Calcium/calmodulin independent
NOS-3 (133kD)	Endothelial NOS Type III-NOS	Endothelium, brain heart	Constitutive Calcium/ calmodulin dependent Modified by acylation and phosphorylation

The NOS isoforms have considerable sequence homology, about 50-60%. In addition, they are about 90% conserved among species (1-5, references therein). The carboxy terminal domain has considerable homology between the isoforms and is homologous to cytochrome P450. The amino terminal domain has less homology. The NOS enzyme is quite complex in that it uses heme as a prosthetic group and flavin mononucleotides, flavine adenine dinucleotide phosphate as cofactors or cosubstrates. Calcium and/or calmodulin can activate NOS-1 and NOS-3, while NOS-2 has no apparent calcium dependence since calmodulin is tightly associated with this isoform. The catalytically active isoforms exist as homodimers, with tetrahydrobiopterin and heme serving to facilitate dimmer formation. The homologous reductase and oxidase domains of the proteins with electron transfer between the substrate L-arginine and the redox cofactors result in the oxidation of the guanidine nitrogen of arginine to form L-hydroxyarginine, and then subsequently forms NO and citrulline.

Transgenic animals deficient for one or more NOS isoforms are viable and have no life threatening conditions associated with the deficiency. NOS 1 knockouts experience hypertrophy of the intestinal pylorus and have a smooth muscle defect (30). They may also have some memory impairments. NOS 2 knockouts appear to be developmentally normal, but have susceptibility to bacterial infections (31, 32). NOS 3 knockouts are hypertensive and also have a smooth muscle defect, which impairs blood vessel relaxation (33). The NOS 1 and 3 double knockout (33) has some memory defects.

9 NOS INHIBITORS

Recently, the development of selective NOS inhibitors has been a hot topic for research. Both arginine and non-arginine based antagonists have been reported as inhibitors with variable selectivity (1-5, references therein). Most inhibitors to date are competitive antagonists and may be partly selective for the one or another isoform. The most commonly used NOS inhibitors are the nonspecific N (G)-nitro-L-arginine methyl ester (L-NAME) and N (G)-monomethy-L-arginine (L-NMMA). Other somewhat specific inhibitors often used are the neuronal NOS inhibitor 7-nitroindazole (7-NI) and the inducible NOS inhibitors aminoguanidine and L-N- (6)-(1-iminoethyl) lysine (L-NIL). There are now several other NOS inhibitors commercially available, and many more that will soon be available. Recently, very specific inhibitors have been developed for at least two of the NOS isoforms, some of which are currently being used in clinical trials for the treatment of septic shock and certain cancers. This is a new and exciting field emerging in which pharmacological targeting of the NO pathway may soon be utilized in the clinic.

10 TARGETS OF NO AND SOLUDE GUANYLYL CYCLASE

Over the next several years and up to present, we along with other laboratories have demonstrated that numerous cells, tissues, and cell-free extracts could produce NO. Multiple biological and potential biological targets and processes that are regulated by NO or cGMP have emerged as a result (Figure 3). The most thoroughly studied process regulated by this signalling pathway is smooth muscle relaxation. However, the list is growing with not only NO and cGMP targeting enzymes and macromolecules, but also playing a critical role in several biological phenomena. NO is now known to be involved in many integral processes such as intestinal secretion and ion transport, renal tubular-glomerular feedback, hormone production and secretion, retinal phototransduction, neurotransmission, tissue injury, inflammation, pathogen cytotoxicity, tumour cytotoxicity, and transcriptional regulation of a variety of genes. These and other areas are currently subject to intense research interest.

Enzymes and macromolecules
Guanylyl cyclase
Cyclic nucleotide protein kinases
Cyclic nucleotide phosphodiesterases
Cyclooxygenase (COX II)
Heme proteins, iron centers, and thiol groups
DNA modifications and repair
Glutamate (N-methyl-D-aspartate) receptor regulation*
Phospholipase C
Processes
Smooth, cardiac,* and skeletal* muscle relaxation
Retinal phototransduction
Intestinal secretion and ion transport
Renal tubular-glomerular feedback*
Endothelial permeability*
Platelet adhesion and aggregation
Insulin secretion*
Hormone production and secretion*
Neurotransmission
Long-term potentiation and memory*
Transcriptional regulation*
Tissue injury and inflammation
Pathogen cytotoxicity
Tumour cytotoxicity
Calcium transport and redistribution

* In some cases, the effects of nitric oxide and/or cyclic GMP are well substantiated. How ever, some of the effects can be considered interesting but preliminary and are designated with an asterisk.

Figure 3. Targets of NO, soluble guanylyl cyclase, and cGMP.

11 CONCLUSIONS

The NO field, as we know it today, is a culmination of three decades of diligent research, beginning with the discovery of various substances that can increase cGMP levels by activation of guanylyl cyclase to the elucidation of the biochemical mechanisms of NO synthesis. As more sensitive methods of NO detection became available, NO was found in variety of tissues and cell types. Additional components of the NO signalling pathway were revealed, creating numerous targets for pharmacological manipulation. An escalation of interest in the field came with the delineation of this pathway. Presently, there is a myriad of agents that activate or inhibit one or more components of the NO cascade. These drugs are being studied for their effects on a variety of disease states such as hypertension, septic shock, inflammatory conditions, and cancer. We now know that NO is involved in countless fundamental biological phenomena, and the list continues to flourish. No continues to be an intense field of study, and will likely remain so throughout the next decade.

REFERENCES

1. Murad F. Cyclic GMP synthesis, metabolism and function. Adv Pharmacol. 1994; 26:1-335.
2. Ignarro L, Murad F. Nitric oxide: biochemistry, molecular biology, and therapeutic implications. Adv Pharmacol. 1995; 34: 1-516.
3. Murad F. The nitric oxide-cyclic GMP signal transduction system for intracellular and intercellular communication. Recent Prog Horm Res. 1994; 49: 239-248.
4. Murad F. Nitric oxide signalling: would you believe that a simple free radical could be a second messenger, autocoid, paracrine substance, neurotransmitter, and hormone? Recent Prog Horm Res. 1998; 53: 43-59.
5. Murad F. The 1996 Albert Lasker Medical Research Awards. Signal transduction using nitric oxide and cyclic guanosine monophoshate. JAMA. 1996 Oct.
6. Kimura H, Mittal CK, Murad F. Activation of guanylate cyclase from rat liver and other tissues with sodium azide. J Biol Chem. 1975; 250: 8016-8022.
7. Murad F. Cyclic guanosine monophosphate as a mediator of vasodilation. J Clin Invest. 1986; 78: 1-5.
8. Waldman SA, Murad F. Cyclic GMP synthesis and function. Pharm Rev. 1987; 39: 163-196.
9. Murad F, Forstermann U, Nakane M, et al. The nitric oxide-cyclic GMP signal transduction system for intracellular and intercellular communication. Adv Second Messenger Phosphoprotein Res. 1993; 28: 101-109.
10. Katsuki S, Arnold W, Mittal CK, Murad F. Stimulation of guanylate cyclase by sodium nitroprusside, nitroglycerin and nitric oxide in various tissue preparations and comparison to the effects of sodium azide and hydroxylamine. J Cyclic Nucl Res. 1977; 3: 23-35.
11. Murad F, Mittal CK, Arnold WP, Katsuki S, Kimura H. Guanylate cyclase: activation by azide, nitro compounds, nitric oxide, and hydroxyl radical and inhibition by haemoglobin and myoglobin. Adv Cyclic Nucl Res. 1978; 9: 145-158.
12. Kimura H, Mittal CK, Murad F. Increases in cyclic GMP levels in brain and liver with sodium azide, an activator of guanylate cyclase. Nature. 1965; 257: 700-702.
13. Katsuki S, Murad F. Regulation of cyclic 3’, 5’-adenosine monophoshate and cyclic 3’, 5’-guanosine monophosphate levels and contractility in bovine tracheal smooth muscle. Mol Pharmacol. 1977; 13: 330-341.
14. Katsuki S, Arnold WP, Murad F. Effect of sodium nitroprusside, nitroglycerin and sodium azide on levels of cyclic nucleotides and mechanical activity of various tissues. J Cyclic Nucl Res. 1977; 3:239-247.
15. Murad F, Mittal CK, Arnold WP, Braughler JM. Effect of nitro-compound smooth muscle relaxants and other materials on cyclic GMP metabolism: proceedings of the 7th International Congress of Pharmacology, July 1978, Paris, France. In: Stocklet JC, ed. Advances in Pharmacology and Therapeutics, Volume 3: Ions, Cyclic Nucleotides, Cholinergy. Elmsford, NY: Pergamon Press Inc; 1978: 123-132.
16. Arnold WP, Mittal CK, Katsuki S, Murad F. Nitric oxide activates guanylate cyclase and increases guanosine 3’, 5’-monophosphate levels in various tissue preparations. Proc Natl Acad Sci USA. 1977; 74: 3203-3207.
17. Diamond J, Holmes T. Effects of potassium chloride and smooth muscle relaxants on tension and cyclic nucleotide levels in rat myometrium. Can J Physiol Pharmacol. 1975; 53: 1099-1107.
18. Craven P, DeRubertis F. Restoration of the responsiveness of purified guanylate cyclase to nitrosoguanidine, nitric oxide and related activators by heme and heme proteins. J Biol Chem. 1978; 253: 8433-8442.
19. Katsuki S, Arnold W, Mittal CK & Murad F. Stimulation of guanylate cyclase by sodium nitroprusside, nitroglycerin and nitric oxide in various tissue preparation and comparison to the effects of sodium azide and hydroxylamine. J Cyclic Nucl Res 1977; 3: 23-35.

20. Katsuki S, Arnold WP, Mittal CK & Murad F. Stimulation of formation and accumulation of cyclic GMP by smooth muscle relaxing agents. Proceedings of the 2nd Japanese Cyclic Nucleotide Conference, July 7-9, Osaka, Japan, 1977; 44-50.
21. Katsuki S & Murad F. Regulation of cyclic 3', 5'- adenosine monophosphate and cyclic 3', 5'-guanosine monophosphate levels and contractility in bovine tracheal smooth muscle. Mol Pham, 1977; 13: 330-341.
22. Katsuki S, Arnold WP & Murad F. Effect of sodium nitroprusside, nitroglycerin and sodium azide on levels of cyclic nucleotides and mechanical activity of various tissues. J Cyclic Nucl Res, 1977; 3: 239-247.
23. Arnold WP, Mittal CK, Katsuki S & Murad F. Nitric oxide activates guanylate cyclase and increases guanosine 3', 5'-monophosphate levels in various tissue preparations. Proc Natl Acad Sci USA, 1977; 74: 3203-3207.
24. Braughler JM, Mittal CK & Murad F. Purification of soluble guanylate cyclase from rat liver. Proc Natl Acad Sci USA, 1979; 76: 219-222.
25. Deguchi T, Yoshiako M. L-Arginine identified as an endogenous activator for soluble guanylate cyclase from neuroblastoma cells. J Biol Chem. 1982; 257: 10147-10157.
26. Hibbs J, Traintor R, Varrin Z. Macrophage cytoxicity: Role for L-arginine deiminase and imino nitrogen oxidation to nitrite. Science. 1987: 235: 473-476.
27. Leitman DC, Agnost VL, Catalano RM, Schroder H, Waldman SA, Bennett BM, Tuan JJ, Murad F. Atrial natriuretic peptide, oxytocin, and vasopressin increase guanosine 3', 5'-monophosphate in LLC-PK1 kidney epithelial cells. Endocrinology. 1988; 122: 1478-85.
28. Ishii K, Sheng H, Warner T, Forstermann U, Murad F. A simple and sensitive bioassay method for detection of EDRF with RFL6 rat lung fibroblasts. Am J Physiol. 1991; 261: H598-H603.
29. Ishii K, Gorsky L, Forstermann U, Murad F. Endothelium-derived relaxing factor (EDRF): the endogenous activator of soluble guanylate cyclase in various types of cells. J Appl Cardiol. 1989; 4:505-512.
30. Schmidt HHHW, Warner TD, Forstermann U, Murad F. Regulation and subcellular location of nitric oxide synthases in RWA 264.7 macrophanges. Mol Pharmacol. 1992; 41:615-664.
31. Huang PL, Dawson TM, Bredt DS, Snyder SH, Fishman MC. Targeted disruption of the neuronal nitric oxide synthase gene. Cell 1993 Dec 31; 75 (7): 1273-86.
32. MacMicking JD, Nathan C, Hom G, Chartrain N, Fletcher DS, Trumbauer M, Stevens K, Xie QW, Sokol K, Hutchinson N, et al. Altered responses to bacterial infection and endotoxic shock in mice lacking inducible nitric oxide synthase. Cell 1995 May 19; 81 (4): 641-50.
33. Wei XQ, Charles IG, Smith A, Ure J, Feng GJ, Huang FP, Xu D, Muller W, Moncada S, Liew FY. Altered immune responses in mice lacking inducible nitric oxide synthase. Nature. 1995 June 1; 375 (6530):408-11.
34. Son H, Hawkins RD, Martin K, Kiebler M, Huang PL, Fishman MC, Kandel ER. Long-term potentiation is reduced in mice that are doubly mutant in endothelial and neuronal nitric oxide synthase. Cell. 1996 Dec 13; 87 (6); 1015-23.

Science and the Future of Humanity

MICHAEL T. CLEGG
Foreign Secretary
US National Academy of Sciences

1 ABSTRACT

The world of today is very different from the world of a century ago. As we try to anticipate the future, it is instructive to consider the huge transformations that have taken place over the past century. The discovery of antibiotics and improvements in sanitation are responsible for the control or eradication of many of the major diseases that afflicted humankind a century ago. As a consequence, infant mortality rates declined markedly and people live longer and lead more productive lives. At the same time, the numbers of people added to the human population has increased substantially over much of the 20th century, growing from about 1.5 billion in 1900 to about 6 billion in 2000. Agricultural productivity soared several fold during this same period, owing to the discovery of Mendelian genetics and its application to crop improvement, combined with environmental enhancements such as high inputs of nitrogen fertilizers. The ability of science and technology to produce increases in agricultural productivity that exceeded population driven demand growth has enabled a higher standard of living for many peoples across the globe.

As dramatic as these changes are, they represent only one dimension of a wider set of transforming forces rooted in advances in science and technology. Thus contemporary air travel allows an individual to reach all parts of the globe within a day. But emergent diseases can also travel around the world with the traveller, so no region is isolated from the threat of novel pathogens. Modern communication technologies allow the transfer of information and money over the globe in an instant creating a global economy that links people together across diverse cultures and regions. At the same time human conflict has become much deadlier with the invention of nuclear weapons and the other technologies of modern warfare and the effects on civilian populations are often devastating. While it is too early to tell, one can hope that the linkages and dependencies of a global economy will make global conflict obsolete, although regional and local conflict shows no signs of diminishing in the early 21st century.

This brief tour of 20th century advances illustrates the immense power of modern scientific knowledge. The pace of science and technology driven change over the past century is certainly unparalleled in human history. Yet it is also evident that the application of scientific knowledge is ethically neutral. Knowledge can be used to improve the human condition or for destructive purposes. The wise and ethical use of knowledge must rest on a dynamic partnership between those who possess scientific knowledge and those who seek to use that knowledge for societal purposes. How then can the world's science community contribute to an effective dialogue that will inform decision makers about the choices that humankind will face over the next century? One avenue is to use the tools of science to anticipate likely futures and to provide solutions to potential problems before they threaten human welfare.

What can science say about the next century and the role that the global science community should play in shaping that future? To begin the power of science to reveal the future is very limited. Transforming events can alter the course of history in ways that cannot be foreseen by science. We have witnessed many such events over the past several decades. The collapse of the Soviet Union or the World Trade Centre attacks were unpredictable events that set in motion changes that altered the course of history. Nevertheless, some elements of the future are foreseeable, at least in very general terms. The science of demography provides one case where future population growth scenarios are reasonably predictable, at least over the period of a generation or two.

2 POPULATION AND EQUITY

According to recent estimates the world population will reach approximately 9.3 billion people around 2050 (World Population Data Sheet, 2004). The precision of estimated population growth trajectories is not high, so it is better to consider ranges of reasonable values. An important empirical observation is that birth rates have declined in prosperous countries (the so called demographic transition). Current demographic projections depend on assumptions about the rate of decline in growth experienced by most developed countries over the last 50 years. Contingent upon differing scenarios about the rate of spread of prosperity and the associated reduction in birth rates, the world population will be somewhere between 7.6 billion and 11 billion in 2050 (Cohen, 1995; Bongaarts, and Bulatao, 2000). With the exception of the United States, which according to the Population Reference Bureau, is forecast to reach 420 million by 2050, almost all of the approximately 3 billion additional people will be born in countries of the developing world (Bongaarts, and Bulatao, 2000) (Figure 1). These are the countries least able to accommodate such growth and these are the regions of the world with the most severe problems of environmental degradation and resource depletion.

The implications of adding 3 billion more people to the poorest regions of the world are staggering. At least half of the people who arrive over the next 50 years will reside in cities that are ill equipped to provide basic services for their current inhabitants (Montgomery et al., 2003). New ways of delivering the essentials of life such as adequate food, health services, water, sanitation, transportation, education, and a myriad of other services will need to be developed very quickly. Failure to do so is likely to exacerbate a worrisome trend towards increasing global inequality. Humankind is collectively capable of solving these problems, but doing so will require new partnerships that are committed to deploying science-based solutions to urban problems.

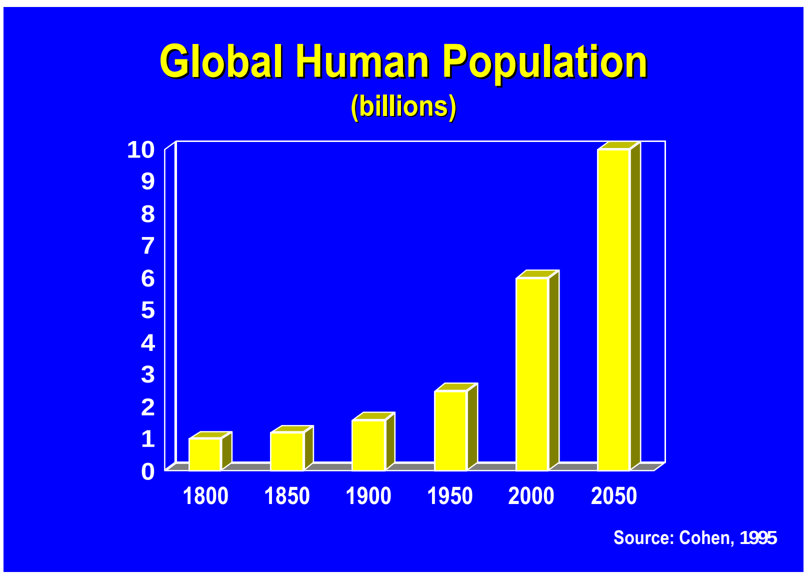


Figure 1. Global human population.

3 GLOBAL CLIMATE CHANGE

The science of climate change seeks to predict future climate given assumptions about the accumulation of various greenhouse gases in the atmosphere. It is now generally accepted that global climate is changing and that human activities are the major driver behind these changes (Cicerone, 2001). Human consumption of fossil fuels over the last century has contributed to substantial atmospheric increases in CO_2, a major greenhouse gas. If present patterns continue the atmospheric composition of CO_2 will double before the end of the 21st century. There is a slowly emerging consensus that a doubling of CO_2 will induce global temperature increases of approximately 3 deg C with a lower bound at about 1.5 deg C and an upper bound of 4.5 deg C (Kerr, 2004). This magnitude of temperature change will have large and unequal effects across the earth, impacting agriculture, water supplies, emerging diseases, storm severity, and ocean levels, to name just a few predictable impacts. In general, we can expect these changes to be disruptive in many regions and to cause substantial economic damage.

Beyond warning of the potential for climate change, science can also suggest means to mitigate the probable impacts. Obvious mitigations might include developing effective carbon sinks, developing fuel efficient vehicles, increasing the efficiency of heating and air conditioning systems to name just a few possibilities. But the science community cannot implement these actions. Implementation requires a healthy partnership with decision makers in countries throughout the world.

4 WATER

Adequate water supplies are absolutely essential for human survival. Water is fundamental to agriculture. Plants depend on water for basic metabolic needs and for photosynthesis. Today, forty percent of all food is grown on irrigated land, but irrigation increases are not keeping pace with population increases. Without adequate water, agricultural productivity will decline and nations without food security are doomed to failure. So the link between water and successful national economies is direct and compelling. Yet, today 470 million people live in water stressed areas and the United Nations projects that an incredible 2.7 billion people will face severe water shortages by 2025.

Beyond agriculture, we depend on water for many other services. To name just two, the sanitation systems of cities are based on water availability. In addition, water is essential for many industrial processes. Despite our absolute dependence on water, 25% of ground water resources are contaminated and 10% of surface water is polluted. Technologies exist for managing our water resources more efficiently. Substantial progress has been made in water reclamation and desalination and there are technologies for achieving substantial efficiencies in irrigation. Economic incentives need to be deployed to increase the efficiency of water use and to encourage the use of modern technologies.

5 AGRICULTURAL PRODUCTIVITY

One of the great achievements of 20th century science was the green revolution that harnessed simple genetic mutations -- such as dwarfing genes -- to environmental manipulations -- such as inputs of nitrogen fertilizers -- to greatly increase the production of many cereal grains. This single advance is largely responsible for moving countries like India from a position of food insecurity in the1960s to a position of agricultural surplus by the 1980s. Substantial efficiencies and production increases have been achieved in virtually all aspects of the global agricultural enterprise, owing to the application of modern science and technology.

Current trends in agricultural productivity suggest a slowing in the rate of increase in productivity, because most of the gains from green revolution technologies are now fully exploited. Furthermore, the global inventory of arable land per capita has declined from about 0.5 hectares per capita in 1950 to less than 0.3 hectares per capita in 1990 and the Food and

Agricultural Organization of the United Nations projects a further decline to between 0.14 – 0.21 hectares per capita by 2050, depending on actual population growth. This means that we will have to provide for each person's needs about one third the arable land available in 1950. To compound this problem there are looming water shortages in many areas of the world that will further impact rates of increase in agricultural productivity. Finally, some current agricultural practices are not sustainable in the long term owing to soil erosion and decertification (Figure 2 (a&b)).

Biotechnology-based advances in crop improvement appear to promise another round of science-based productivity growth, but there is strong opposition to transgenic crops in some parts of the world that may limit the potential of biotechnology. Moreover, research, development, and regulatory costs are high and this is an obstacle to the adoption of transgenic methods for all but a small set of commodities with very large market potential. So the current picture is mixed. Promising new technologies exist, but many obstacles must be overcome to continue to provide an adequate and secure food supply to all of the peoples of this planet. The science-based knowledge needed to solve many of these problems is available, but the political will to implement solutions has not developed apace.

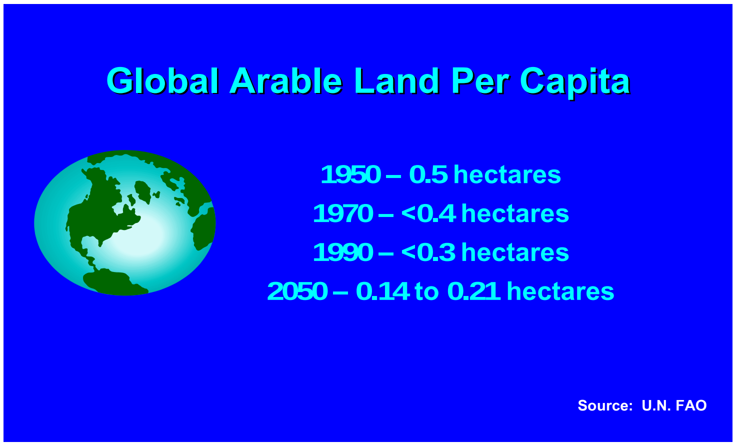


Figure 2 (a). Global arable land per capita.

Worldwide Land Degradation 1945-1995 (Million Acres)

Asia	480	750	500	1900	20
Africa	600	180	300	1350	22
S. America	180	100	150	600	14
Europe	125	200	160	550	23
N.+C. America	95	45	225	390	8
World	1670	1430	1360	4850	17*

* About 10.5% moderate to extreme

Figure 2 (b). Worldwide land degradation.

6 ENERGY SUPPLY

The world is very dependent on fossil fuel reserves as the primary source of energy used to power our contemporary economy. Within the next century these reserves are expected to decline to a level where present activities cannot be sustained. Depending in part on growth in demand in developing parts of the world, this transition may begin to occur within the next 25 to 50 years. Science will play a crucial role in identifying and developing novel energy sources and in providing new approaches to energy use efficiency. Almost certainly, changes in consumption practices will also be driven by economic scarcity and these may be disruptive.

7 LOSS OF BIODIVERSITY

The world we inhabit is defined by physical and biological systems that interact in complex and incompletely understood ways. For example, it is self-evident that climate is a major physical driver that influences agriculture and human health, but our ability to predict climatic trends is still rudimentary. Similarly, we know that biological diversity provides many essential services. Forests act as carbon sinks and release oxygen as well as providing valuable products, wet lands purify water, agricultural systems provide our food, to name just a few of these services. Detailed analyses show that species extinction rates over the last century equal or exceed those inferred during the major episodes of catastrophic extinction that occurred several times in the geological history of the earth (Clegg, et al., 1995). Moreover, the evidence is clear that these high extinction rates are a direct result of human activity. Still, we do not know how depletion of biodiversity may affect the systems that presently sustain our existence. But it is prudent to infer that a continuation of present trends cannot be in the long-term interests of humanity.

8 THE ROLE OF SCIENCE IN PUBLIC POLICY

The challenges described above represent a few of the foreseeable problems that humankind will encounter during this century. We cannot say which problems will be most severe or exactly when certain trends will become critical, but we can make broad predictions. By themselves each of these trends is manageable. We possess a fund of science-based knowledge that provides a rich basis for effective solutions. Yet, the interactions are more difficult to manage and predict. For example, water interacts with agriculture, as does climate. Energy demand is driven in part by population increases and in part by increasing prosperity. To anticipate the magnitude and nature of future problems it is essential to synthesize current knowledge and to develop science-based models that lay out the options for policy makers.

The US National Academy of Sciences has a long history of providing science policy guidance at a national level. The organization was founded in 1863 during the US civil war with a dual purpose (Figure 3). It is an honorary organization that recognizes scientific achievement through election to membership, but it is also an organization with a public service mission. Specifically, the Academy, through the National Research Council (NRC), provides objective nonpartisan advice to policy makers on issues of science and technology that impact public policy. The NRC draws on the entire US science community in providing experts for service on committees that study and define major issues, usually but not always, at the request of the US Government. The experts serve without compensation, except that they are reimbursed for expenses. This service role has evolved over the 140 years of our existence and it is still evolving. But the record clearly shows that US society has profited from the integration of sound scientific advice in the development of public policy. The advice ranges over a diversity of areas, including how to build the best transportation system for the nation, how to set standards for food safety, strategies for controlling nuclear weapons, setting standards for science education, safety of genetically engineered foods, human contributions to terrestrial carbon fluxes, how best to dispose of nuclear waste, the hydrogen economy and much more. In fact, last year more than 270 reports were issued by the NRC on these and a diversity of other topics (Figure 4). Recommendations of many NRC reports are incorporated into legislation and some prevent unwise legislation. This has provided an effective national model for the integration of science and public policy, but it does not address the fact that <u>many of the problems we will face over the next century transcend national boundaries.</u>

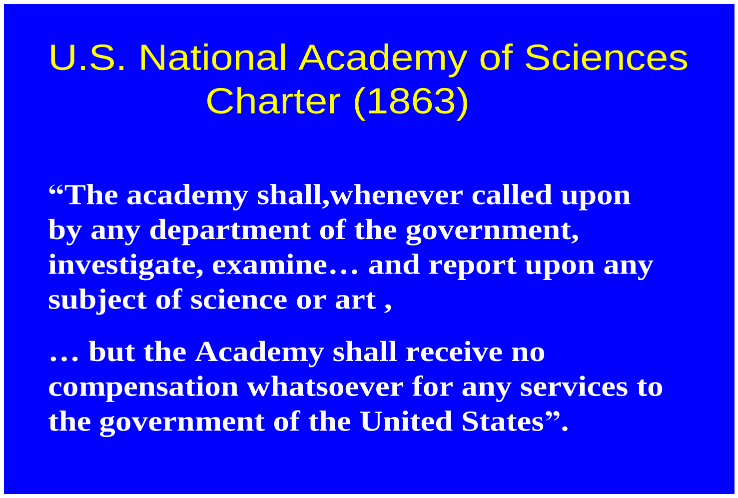


Figure 3. The US National Academy of Sciences Charter (1863).

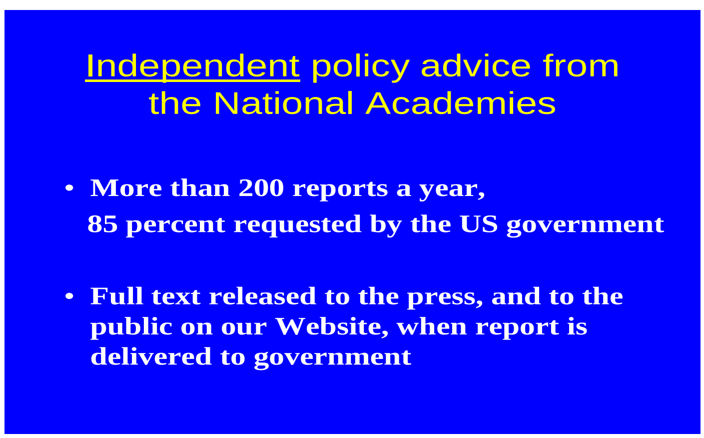


Figure 4. The output of the National Academies.

9 A GLOBAL SYSTEM OF SCIENCE ADVICE

We live in an increasingly interdependent world where groups of nations must act in concert to solve pressing problems. The United Nations has provided global leadership in the drive to achieve effective integration among nations in areas such as environment, health, energy, ecosystem management and the globalization of finance and trade. The UN sponsored World Summit on Sustainable Development held in Johannesburg in 2002 set a series of international goals -- such as halving the numbers of peoples without safe drinking water (estimated at one billion) and halving the numbers of peoples without access to adequate sanitation (estimated at two billion) by 2015 -- but the implementation of these and other goals requires the timely provision of sound scientific advice.

The science community is well adapted to an international role because science is fundamentally international in practice and scope. To a large extent the pressing questions of science are independent of culture. The laws that govern the physical world are the same in any culture, as are the rules of genetics or the intricacies of biochemical pathways or the logic of mathematics. The language of science is universal and communication among scientists has been international since at least the days of Galileo. But it has only been in the last 70 years that science has begun to develop international institutions that seek to serve broader needs. The International Council for Science (ICSU) was established in the 1930s to provide broader science integration. ICSU is based on a matrix of disciplinary unions and national committees and it has been very successful in codifying the language of science and in identifying global science projects such as the international geophysical year or the upcoming international polar year, thereby adding to our fund of knowledge about the earth.

About a decade ago, the world's science academies banded together to create a global consortium called the Inter Academy Panel (IAP) that reaches into the science communities of most of the nations of the world. This organization is built on the twin facts that most nations have science academies and academies typically include the scientific leadership of a country. So a network of academies connects the scientific leadership among most countries of the world. The IAP has established a framework for effective multilateral cooperation among the world's science academies by issuing consensus statements on global science issues. These statements carry the approval of the world's science community and provide an international voice for science on major contemporary issues. But, it quickly became apparent there was also a need for an international entity that could play a role similar to the NRC by undertaking in depth studies of global science policy issues. A second entity, the Inter Academy Council (IAC) was created to fulfil that role. The IAC has now issued two major reports and more are in the offing. The first report entitled *"Inventing a Better Future: A Strategy for Building Worldwide Capacities in Science and Technology*" was issued at a symposium chaired by Kofi Anan at the United Nations in February 2004. The second report "*Realizing the Promise and Potential of African Agriculture*" was specifically commissioned by the Chairman of United Nations to mobilize a scientific attack on declining food productivity in Africa. While these are the first steps of an organization that seeks to enlist the global science community in providing policy relevant solutions for international problems, the start is a promising one. But the science community still speaks with a muted voice and it will be imperative to amplify our international efforts many fold to effectively address the many challenges of the next century.

10 CONCLUSIONS

The next 100 years will present humankind with unprecedented challenges and some of these can be anticipated based on present scientific knowledge. As a consequence, the future is in our hands in a way that has not been true for earlier civilizations. Most of the foreseeable problems of the next 100 years have science-based solutions, but these will require new kinds of international cooperation and they will require more effective integration of scientific knowledge into the development of international policies. At the same time, there is an emerging movement to globalize major institutions of science such as science academies. This movement is an out growth out of the realization that the science community must play a substantive role in addressing the problems facing us over the next century.

REFERENCES

1. Bongaarts, J. and Bulatao, R. A. eds. (2000) Beyond Six Billion: Forecasting the World's Population National Academy Press, Washington DC. 258 pages.
2. Cicerone, R. J., E. J. Barron, R. E. Dickinson, I. Y. Fung, J. E. Hansen, T. R. Karl, J. C. McWilliams, F. S. Rowland, E. S. Sarachik, and J. M. Wallace. 2001. Climate Change Science: An Analysis of Some Key Questions. National Academy Press, Washington DC. 42 pages.
3. Clegg, M. T., G. M. Brown, W. Y. Brown, W. L. Fink, J. Harte, O. A. Houk, M. Lynch, MaGuire, D. D. Murphy, P. V. O'Brien, S. T. A Pickett, H. R. Pulliam, K. Ralls, B. B. Simpson, R. D. Sparrowe, D. W. Steadman, J. W. Sweeney. 1995. Science and the Endangered Species Act. National Academy Press, Washington DC. 288 pages.
4. Cohen, J. E. 1995. *How Many People Can the Earth Support?* New York: W. W. Norton. 532 pages.
5. Kerr,R. A. 2004 Three degrees of consensus. Science 305: 932-34; 2004.
6. Montgomery, M. R., R. Stren, B. Cohen, and H. C. Reed eds. 2003. Cities Transformed: Demographic Change and Its Implications in the Developing World National Academy Press, Washington DC. 552 pages.

Wind Energy for the Future

PREBEN MAEGAARD
President, World Wind Energy Association
Vice-president EUROSOLAR
Director, Folkecenter for Renewable Energy
Denmark

1 BACKGROUND

The most common windmills in operation today generate power from three blade horizontal axis windmills with the nacelle mounted on steel towers that can be cylindrical steel plate or lattice towers.

The modern windmill concept emerged in 1977 and has become industrial standard. The nacelle of horizontal-axis windmills usually includes a gearbox, asynchronous generator, and other supporting mechanical and electrical equipment. A German manufacturer of windmills has obtained a leading international position by using gearless, multipole synchronous ring generators.

All contemporary windmills have advanced control and safety systems with automatic orientation to the actual wind direction. They have a design lifetime of 20 years.

Figure 1. Wind farms with megawatt-size windmills by Bonus: Sited in open farmland (left); offshore installation (right). Photo by V.Kantor

Wind turbines are rated by their maximum power output in kilowatts (kW) or megawatts (1000 kW, or MW). For commercial utility-sized projects, the most common windmills sold are in the range of 600 kW to 2 MW - large enough to supply electricity to 600- 2000 modern homes. The newest commercial turbines are rated at 1.5-2.5 megawatts.

A typical 600 kW turbine has a rotor diameter of 45 metres and is mounted on a 50 metres or taller concrete or steel tower depending on the local wind resources and topography. The newest (in 2003) 4 to 5 megawatt-size prototypes have rotor diameters up to 120 metres.

Data of wind resources is usually gathered over a period of time using anemometers installed at the prospective site. Normally, one year is the minimum time a site should be monitored. In several countries the wind resource assessment happens by applying the wind atlas method, which secures a predictability of the power production with accuracy better than 10% of what in practice is achievable at the actual site.

Most commercial wind turbines operating today are at sites with average wind speeds higher than five metres/second (m/s) or 18 km/h. A prime wind site will have an annual average wind speed in excess of 7.5 m/s (27 km/h).

Figure 2. Manufacturing of modern megawatt-size windmills: Factory for 30-meter blades at LM (top). Photo by LM; assembly of Enercon nacelle (left); ring generator fabrication at Enercon (right). Photos by BWE.

Utility-size commercial wind projects are often constructed as wind farms where dozens turbines with 50 MW or more are erected at the same site. Wind projects have been successfully built to power a wide range of applications in diverse and often extreme environments.

One of the newest applications is to a place wind farms in shallow offshore areas with water depths of 30 metres or more. At sea, environmental impacts are often lower and the availability of a steady, non-turbulent wind flow allows windmills to operate more efficiently and generate 50% more power compared to good on-shore sites.

Although the wind resource for any site is intermittent, it can by following weather forecasts be highly predictable. Thus the output from windmills can be integrated into existing electrical grids with a high degree of dependability. A modern windmill's "capacity factor" (the percentage of time a windmill has delivered nominal power) is in the range of 20-35 percent depending on the concrete wind resources.

Electrical utility grids can generally without power quality problems absorb twenty percent of their generating capacity from intermittent sources such as wind. However, in Europe some local utilities that are connected to the national grid, receive over 100% of their power needs from local windmills. During periods of strong winds and low power consumption, the windmills may deliver up till 400% of the actual consumption of electricity with the prescribed power quality still being maintained.

Distributed power generation with connection of the windmills to the existing supply network is often being practised with proper calculation of peak values and the corresponding grid reinforcement. Quickly dispatched capacity such as hydro can allow a larger percentage of the overall capacity to come from windmills. The newest variable speed windmills can also help to stabilize grids in remote locations.

The feasibility of a wind project, however, can be influenced by access to the electrical grid. The need to install or upgrade high voltage transmission equipment can significantly add to the cost of a wind project. For off-grid and mini-grid applications, the combination of wind/diesel or other sources can provide a greater percentage of overall capacity.

2 TYPES OF WINDMILLS

Early windmills - less than twenty years ago - were fairly small (50-100 kW, 15-20 m diameter) but there has been a steady growth in size and output power. Several commercial types of windmills in 2003 have ratings over 1.5 MW and machines for the offshore market have outputs up to 3 MW.

Figure 3. Two hundred years of wind energy utilisation: Dutch type windmills for grinding (left); roof top mechanical farm windmill from 1910 - 39 for water pumping, threshing, grinding etc. (2nd left); "mother" of modern wind technology, 200 kW Gedser windmill in Denmark (right).

Windmill sizes have increased for two reasons. Large windmills are cheaper per installed KW and they deliver relatively more energy. The energy yield is improved partly because the rotor is located higher from the ground and so intercepts higher velocity winds, and partly because they are usually more efficient. The productivity of the 600 kW windmills is around 50% higher than that of the 55 kW windmills. Reliability has improved steadily and most windmill manufacturers now guarantee operational availabilities of 95%.

The majority of the world's windmills have three glass-reinforced polyester blades. The traditional mechanical power train includes a low speed shaft, a speed-up gearbox and an asynchronous generator, either four or six-pole. There are other possibilities, however. Wood-epoxy is an alternative blade material and some windmills have two blades.

Figure 4. Wind power pioneering examples: First contemporary windmill in South America was 75 kW unit at Fernando do Noronha, Brazil, 1992, by Folkecenter and Eolica (left); Vestas Darrieus-type windmill from 1978 (middle); Tvind 2 MW 3-bladed down-wind windmill from 1977 with advanced fibre-glass blade technology (right). Photo by V.Kantor 2002.

Towers are usually made of steel and the great majority are of the tubular type. Lattice towers, common in the early days, are now rare, except smaller windmills in the range 100 kW and below. The foundation is usually a reinforced concrete structure. The tower can also be bolted directly to solid rocks when available.

Variable speed windmills are becoming more common and most generate power using an AC/DC/AC system. Variable speed brings several advantages - it means that the rotor turns more slowly in low winds (which keeps noise levels down), it reduces the loads on the rotor;

the power conversion system is usually able to deliver current at any specified power factor. A few manufacturers build direct-drive windmills, without a gearbox. These are usually of the variable speed type with power conditioning equipment.

As the power in the wind increases with the cube of the wind speed, all windmills need to limit the power output in winds of 15 m/s and higher. There are two principal means of accomplishing this: Variable pitch control of the blades or fixed, stall-regulated blades.

Pitch-controlled blades are adjusted automatically as wind speeds increase so as to limit the power output and, once the "rated power" is reached. A reasonably steady output can be achieved, subject to the control system response. Stall-controlled rotors have fixed blades that gradually stall as the wind speed increases, thus limiting the power by passive means.

Figure 5. Wind speed anemometer and wind orientation vane on top of nacelle (left); tip-brake for over-speed protection (2nd left); hub for stall regulation (right); hub for pitch-control (2nd right).

3 ENERGY YIELD

Most windmills start to generate at a wind speed around 3 to 5 m/s - and shut down in very high winds, generally around 22 to 25 m/s. Energy yields do not in practice increase with the cube of the wind speed, mainly because energy is discarded once the rated wind speed is reached.

Figure 6. Computerized control panel for modern windmill (left); interfacing between windmill transformer and 10-kilovolt grid (middle); local power utility controlling distributed generation from 220 farmer owned windmills (right).

Levels of average wind speeds around 7 m/s are found in many coastal regions and sites around the North Sea; higher levels are to be found on many of the Greek Islands, in the Californian passes - the scene of many early wind developments - and on upland and coastal sites in the Caribbean, Ireland, Scotland, the United Kingdom, Spain, Argentina, the Red Sea, New Zealand and Antarctica.

Wind speed is the primary determinant of electricity cost, on account of the way it influences the energy yield so, roughly speaking; developments on sites with wind speeds of 8 m/s will yield electricity at one third of the cost compared to a 5 m/s site. Offshore wind speeds are generally higher than those on-shore.

Offshore wind energy is attractive in locations such as Denmark and the Netherlands where pressure on land is gradually becoming acute and other windy sites are limited. In these areas offshore winds may be 0.5 to 2 m/s higher than on-shore, depending on the orientation and distance from the coast.

Offshore wind farms have been completed, or are being planned in Denmark, Sweden, Germany, the United Kingdom, Ireland, and elsewhere. The first offshore wind farm in the North Sea was established in 2002 and consists of 80 windmills with a total capacity of 160 MW. In the Baltic Sea Denmark is in the middle of 2003 commissioning a similar wind farm. The annual electricity production is of 600 GWh each covering the power consumption of 300.000 standard families with an average of 4.000 kWh per family/year.

Figure 7. Two out of 20 offshore windmills, each 2 MW, at Middelgrunden between Sweden and Denmark. Photo by V. Kantor.

The electricity production costs of offshore wind projects are expected to decrease substantially in the future. Initially, however, the investment cost is higher than the cost of on-shore installations due to the lack of experience, higher expenses for new technology, complicated foundation systems and the lack of economies of scale. The provisions apply to wind turbines located at least three miles seawards from the baselines

4 SMALL WINDMILLS

There is no precise definition of "small," but it usually applies to windmills under about 30 kW in output. In developing countries small windmills are used for a wide range of rural energy applications, and there are many "off-grid" applications in the developed world as well - such as providing power for navigation beacons. Since most are not connected to a grid, many use DC generators and run at variable speed. A typical 800 W battery-charging windmill has a shipping weight of only 30 kg.

A new and unexpected application for small windmills has emerged especially in USA in the name of Home Power. Instead of buying power from the grid, individuals prefer to produce their own electricity from photovoltaics, small windmills or a combination of both which saves battery storage capacity. The DC power is supplied to a so-called power conversion centre that delivers 230 V AC with standard frequencies to the household or the local community. In this way house owners are taking control of the type of the energy source their demand for electricity is coming from.

Figure 8. Proven 2,5 kW PMG windmill for battery charging (left); Calorius 5 kW windmill with water brake for heat supply (middle); Whisper 0,9 kw wind battery charger with carbon fibre blades (right).

It is assumed that 100.000 families in the USA are self-reliant in terms of energy supply using renewable energy that has formed the background for a significant new industry for home power equipment. Because small size windmills are ideal for mass production similar to bicycles and other kinds of transportation equipment, prices may become very low compared to conventional energy supply technologies.

There are several manufacturers of windmills ranging from 100 Watt up till 10 kW some of them using advanced carbon fibre blades, and permanent magnet generators (PMG). This type of equipment will have great opportunities for paving the way for wind energy in the many un-served areas of the world. The electricity from small windmills will be higher than from large windmills but generally lower compared to photovoltaics wherever wind resources are available.

5 ENVIRONMENTAL ASPECTS

No energy source is free of environmental impact. However the environmental negative consequences of wind energy are compared to fossil and nuclear fuels very modest. As the renewable energy sources are widespread they require larger areas, which, however, can be cultivated like before the windmills were erected. Where proper attention is paid to the visual effects, windmills can be considered as a normal and lively part of the landscape.

In the case of wind energy, there still continues a discussion of the effects of noise. Modern windmills operate at extremely low noise levels of 45 dB(A) and therefore can be located few hundred meters from residential areas.

Possible disturbance to wildlife focuses especially at birds where killings are below 0.1% compared to animals ending their lives in road traffic accidents. Power lines transporting the electricity from the wind farms kill more birds than windmills.

The main perspective for developing the renewable sources is environmental; to reduce emissions of greenhouse gases and the substitution of atomic energy and fossil fuels. Future energy supply, resource problems, and environmental aspects have been the topic of several international conferences.

However the "Rio Declaration on Environment and Development" of 1992 and the follow-up conferences within the international community recognized neither the intimate link between energy and development nor the direct relation between conventional atomic/fossil energy supply and the vast majority of environmental problems:

- The threat to the atmosphere and the world climate;
- The increase of the ozone hole;
- The death of forests and the pollution of waters by acid rain;
- Urban air pollution with fatal consequences for human health and the quality of life;
- The toxic contamination of seas, lakes and rivers;

- Massive consumption of scarce water reserves in petroleum and coal production and processing;
- The risks of plutonium production, nuclear radiation and unresolved waste storage problems, burdening human civilization for thousands of years to come.

Problems of bio-degradation, deforestation and other vegetation loss over large land surfaces are also linked to inappropriate energy consumption patterns. Large quantities of biomass used for energy demands are not renewed. Therefore, under the conditions of nuclear and fossil energy use as well as non-renewed biomass, the target of a "sustainable development" cannot be reached except through the adoption of renewable energy.

6 ECONOMIC ASPECTS

Wind energy costs have declined steadily and a typical cost for on-shore wind farms is now around €1000/kW installed, and for offshore around €1400/kW. The corresponding electricity costs vary, partly due to wind speed variations, financial terms and partly due to differing institutional frameworks. Wind energy prices are converging with those from the thermal sources but it is not simple to make objective comparisons, as there are few places where totally level playing fields exist.

World wind energy capacity has been doubling every three years during the last decade. In 2002 almost 7000 MW new capacity of wind-power was installed worldwide bringing the total capacity to over 31000 MW by the end of 2002 delivering 0.4 % of world electricity demand. This is four times more than the 7600 MW total by 1997 and indicates wind energy as the strongest new energy growth source.

The countries with most wind power capacity are Germany - by far the largest, with 12000 MW - followed by Spain, the United States, Denmark and India. In Germany wind energy covers almost 6% of total power demand and in Denmark 19% (2002). With stronger political commitment worldwide, installed wind energy could attain an estimated 230000 MW by 2010 and 1.2 million MW by 2020.

Figure 8. Rotor of 36 meter diameter is hoisted by two cranes for assembly with nacelle (left); joining hub and blade (middle); windmills sited at the North Sea (right).

While wind energy is generally developed in the industrialized world for environmental reasons, it has attractions in the developing world as it can be installed quickly in areas where electricity is urgently needed. In many instances it may be a cost-effective solution if fossil fuel sources are not readily available. In addition there are many applications for wind energy in remote regions, worldwide, either for supplementing diesel power (which tends to be expensive) or for supplying farms, homes and other installations on an individual basis.

Wind energy at good wind sites is generally cost-competitive with the conventional sources of electricity generation. However, the pattern of development has been largely dependent on the legal frameworks provided by national governments to compensate for the negative conditions wind energy will find in competition with conventional fuels that causes environmental damages and also receive several types of direct and indirect subsidies.

7 INFLUENCE OF LEGISLATIVE STRUCTURES

Policies and strategies supporting the transition from the dominance of fossil fuels and atomic energy have in all countries decisive influence on the implementation of renewable and decentralized forms of energy.

This can be illustrated by the successful elements of the 1991 German legislation, "Act on Feeding in Electricity." It resulted in a breakthrough for wind power with 50% of the total European capacity as well as progress for other types of renewables.

In order to obtain an extensive use of renewable energy, some basic principles in supporting a development that is in accordance with the decentralized nature of renewable energy, have to be applied. The grid operators shall be obliged:

- To allow connection of wind power installations to their grid;
- To purchase electricity from these installations as a priority, and
- To pay a fair price as a compensation to the suppliers of this electricity.

This obligation shall apply to the grid operator, whose grid is closest to the location of the electricity generation installation, providing that the grid is technically suitable to feed-in this electricity.

The upstream transmission grid operator shall be obliged to purchase, and pay compensation for the amount of energy purchased by the grid operator. The minimum compensation amounts shall be payable for newly commissioned installations for a period of 20 years after the year of commissioning. By obtaining long-term price guarantees independent investors in wind energy may obtain conditions of financial solutions similar to what is found in the conventional power generation sector.

The initial legislation formed the background of the essential principles of the Renewable Energy Law, EEG, from 2000. However, the tariff structures are differentiated allowing specific renewable energy technologies compensation determined by the stimulus, which is required to maximize the implementation.

The law introduces a differentiated set of tariffs for wind power.

(1) The electricity generated from wind energy shall be at least 9.10 € Cent per kWh for a period of five years from the date of commissioning and thereafter gradually reduced following specific guidelines.
(2) For offshore wind farms commissioned before 2007, the period with the high compensation 9.10 € Cent per kWh is increased to nine years.

The intention of the law is to avoid payment of compensation rates that are higher than what is required for a cost-effective operation and to create an incentive for installing windmills at inland sites. The higher initial compensation rate will facilitate the financing of windmills that were previously being questioned by credit institutions.

There is a desire to include a dynamic mechanism in the legislation. When the new law has generated increased demand, the larger production volume can be expected to lead to a substantial reduction in manufacturing cost, and consequently, in electricity production cost, so that the compensation rates can be allowed to decrease accordingly.

Increased use of renewable energy will create jobs, especially in the sector of small and medium-sized enterprises. They play a crucial role in the economic structure of most European countries. Small and medium-sized enterprises are not only an important factor in crafts and trades; they also provide an impetus for a variety of industries, including the metal industry, electrical engineering, mechanical engineering, biochemistry, as well as the building industry.

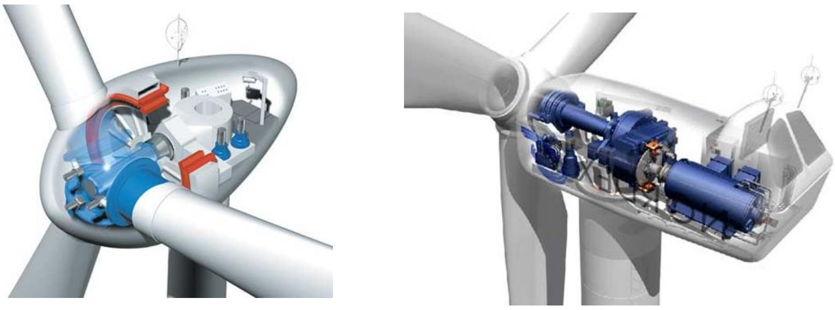


Figure 9. Two basic contemporary windmills concepts: Gearless with synchronous generator (left); with gearbox and asynchronous generator (right). Photos by BWE.

In three European countries – Germany, Denmark and Spain – (Denmark till 1st January 2000) national legislation has been adopted to introduce minimum prices for feeding into the grid electricity generated from renewable energy sources. It owes exclusively to the national legislation of these three countries that the European Union realized the emergence of a wind turbine manufacturing industry. It offers the leading technology in the world market.

This also confirmed that the introduction of minimum price systems increased the productivity. In all the three countries mentioned above the introduction of wind energy was based on minimum prices guaranteed by law. A market development was stimulated – initially in the wind energy sector – which resulted in an efficient industry with considerable export opportunities that has created jobs for over 40,000 people in Germany and 20,000 in Denmark.

As a result of the associated economies of scale and the global competition among manufacturers of windmills, production costs have been successfully reduced by 50 percent since 1991. Owing to technological progress, there is growing demand in the world market. In the period till 2010, demand for windmills alone may amount to over 100,000 MW.

Against this background, the market introduction of renewable energy sources should not be underestimated in terms of its importance for industrial policy. It can be assumed in view of global climate problems, oil depletion etc. that there will be a rapidly growing demand worldwide. It can be expected that the impact on other renewable energy sectors, will be similar to the effects experienced on the wind energy sector.

8 CONSEQUENCES OF VARIOUS LEGISLATION MODELS

Three countries with price regulations; Germany, Spain, and Denmark, represent over 75% of wind energy generation in Europe. Great Britain in comparison has excellent wind resources, however, with quantity regulations by tendering like a number of other European countries. These countries represent a modest share of wind power in Europe.

Table 1. Wind Energy in Europe: Comparison of price regulations with quantity regulations

	Country	Cumulated end of 2002 (MW)	Installed in 2002 [MW]	Installed capacity per area (kW/km²)	Installed capacity per capita (Watt/capita)
Countries with price regulations (Feed-in law)	Germany	12001	3247	33,6	146
	Denmark	2880	346	66,8	539
	Spain	4830	1493	9,6	122
	Sum	**19711**	**5086**		
Countries with quantity regulations (Call for tenders)	UK	552	78	2,2	9
	Ireland	137	12	1,9	36
	France	148	32	0,3	3
	Sum	**837**	**124**		

Source: Folkecenter for Renewable Energy and New Energy 2/2003.

With the purpose of protecting the environment, managing global warming and securing a reliable energy supply, Germany committed itself to at least doubling the percentage share of renewable energy in total energy supply by the year 2010.

In order to attain this objective, it became necessary to mobilise the renewable energy sources. Traditional hydropower from large dams today accounts for a significant share of the renewable energy sources. However, the utilisation potential of hydropower is almost exhausted. For this reason, it is necessary to additionally generate electricity from wind energy, solar energy, biomass, and small-scale hydro in order to attain the objective set for Europe as a whole by the year 2010. To this end, the currently used potential of these energy sources will have to increase fivefold.

The compensation rates of the previous German legislation had not been sufficient to stimulate a large-scale market introduction of electricity generated from other sources, especially photovoltaic and biomass. For this reason, the compensation rates were modified in the new Renewable Energy Sources Act, in order to promote large-scale generation of electricity from all kinds of renewable energy sources.

Sufficient data were available so that comparison was made between minimum price regions and quantity regulations. The tendering procedure used in countries with quantity regulations was refused, as it seems to lead to bureaucratic and costly process, both for the operators and for the authorities. However, the main problem is that each tendering round introduces maximum limits, i.e. quotas for the various technologies.

Small private operators or local communities, leading the implementation of wind energy in Germany and Denmark, are practically excluded from the tendering process, because they cannot keep up financially with the big central planning and developing companies, who are often backed by banks and energy suppliers with strong financial resources.

In the UK, implementation principles are still preferred and may be successfully applied for multi-megawatt projects in un-populated regions and offshore, but will cause obstacles from objecting citizens in high-density areas including most of Europe, Japan, and parts of USA.

In the UK, this has led to significant local acceptance problems for wind power compared to the occasional but harmless local frictions in Germany or Denmark. The local population in the UK is not included in the project planning and implementation and is not directly benefiting economically. So they often use their civil rights to protest against plans of wind energy to avoid the visual impact on their neighbourhood.

Finally, tenderers often submit unrealistically low tenders owing to the strong competition. In the end, the projects in UK are in most cases not carried out. Although the UK's wind resources are substantially much better than in Germany, less than 600 MW was installed in UK by end of 2002 compared to 12000 MW in Germany.

Figure 10. Windmill manufacturing is an emerging global industrial growth sector. Main shafts for megawatt size windmills by Bonus.

Both countries have access to the same wind energy technology, from the leading manufacturers, so the difference in implementation of a factor of 20 can only be explained by choosing inappropriate policies and strategies that are causing barriers to wind energy instead of stimulation to a market development and a home market for wind mill manufacturers.

Table 2. Global Wind Energy Statistics. Status per December 2002

Source: New Energy 2/2003

Country	Wind energy end of 2002 [MW]	Wind energy end of 2001 [MW]	Wind energy end of 2000 [MW]	Wind energy end of 1999 [MW]	Wind energy 2002** [MW]	Rate of growth* [%]	Population 2000 [millions]	Installed capacity per capita [Watt/capita]	Area [km²]	Installed capacity per area [kW/km²]	Gross National Product GNP 2000 [bn. $]	Installed capacity per GNP [MW/bn. $]
Germany	12,001	8,754	6,095	4,443	3,247	37.1	82.15	146.09	357,020	33.6144	1,872.99	6.41
Spain	4,830	3,337	2,502	1,476	1,493	44.7	39.45	122.43	504,782	9.5685	558.56	8.65
USA	4,685	4,275	2,581	2,551	410	9.6	281.55	16.64	9,809,155	0.4776	9,837.41	0.48
Denmark	2,880	2,383	2,306	1,700	497	20.9	5.34	539.33	43,096	66.8275	162.34	17.74
India	1,702	1,507	1,267	1,035	195	12.9	1,015.92	1.68	3,287,263	0.5178	456.99	3.72
Italy	785	682	418	283	103	15.1	57.68	13.60	301,336	2.6041	1,073.96	0.73
The Netherlands	686	484	443	411	202	41.7	15.92	43.09	41,526	16.5198	364.77	1.88
United Kingdom	552	474	409	347	78	16.5	59.74	9.24	242,910	2.2724	1,414.56	0.39
China*	468	400	352	262	68	17.0	1,261.10	0.37	9,572,419	0.0489	1,079.95	0.43
Japan*	415	275	142	68	140	50.9	126.77	3.27	377,837	1.0984	4,841.58	0.09
Sweden	328	293	241	215	35	11.9	8.87	36.98	449,964	0.7289	227.32	1.44
Greece	276	272	247	158	4	1.5	10.56	26.14	131,957	2.0916	112.65	2.45
Canada	221	207	128	124	14	6.8	30.74	7.19	9,984,670	0.0221	687.88	0.32
Portugal	194	131	83	67	63	48.1	10.01	19.38	92,345	2.1008	105.06	1.85
France	148	95	68	25	53	55.8	58.85	2.51	543,965	0.2721	1,294.25	0.11
Austria	139	94	77	42	45	47.9	8.09	17.18	83,858	1.6576	189.03	0.74
Ireland	137	125	119	73	12	9.6	3.79	36.15	70,273	1.9495	93.87	1.46
Australia	104	72	30	9	32	44.4	19.20	5.42	7,692,300	0.0135	390.11	0.27
Norway*	97	17	13	13	80	462.3	4.49	21.60	323,759	0.2996	161.77	0.60
Costa Rica*	71	71	51	51	0	0.0	3.64	19.53	51,060	1.3905	15.85	4.48
Egypt*	69	69	69	36	0	0.0	63.82	1.08	1,002,000	0.0689	98.73	0.70
Morocco*	54	54	54	14	0	0.0	28.71	1.88	458,730	0.1177	33.35	1.62
Belgium	44	32	13	9	12	37.5	10.25	4.29	32,545	1.3520	226.65	0.19
Ukraine*	44	41	5	5	3	7.3	49.60	0.89	603,700	0.0729	31.79	1.38
Finland	41	39	38	38	2	5.1	5.18	7.92	338,144	0.1213	121.47	0.34
New Zealand*	35	35	35	35	0	0.0	3.83	9.14	270,534	0.1294	49.90	0.70
Poland*	27	22	5	5	5	22.7	38.65	0.70	312,685	0.0863	157.74	0.17
Argentina*	27	27	16	15	0	1.7	37.03	0.73	2,780,400	0.0097	284.96	0.09
Brazil*	25	24	22	19	1	2.5	170.12	0.15	8,547,404	0.0029	595.46	0.04
Latvia*	24	2	0	0	22	1,100.0	2.42	9.93	64,589	0.3716	7.15	3.36
Turkey*	19	19	19	9	0	0.0	65.31	0.29	779,452	0.0244	199.94	0.10
Luxembourg	16	15	15	10	1	6.7	0.44	36.36	2,586	6.1872	18.89	0.85
Iran*	11	11	11	11	0	0.0	64.02	0.17	1,648,000	0.0067	104.90	0.10
Tunisia*	11	11	11	0	0	0.0	9.58	1.15	163,610	0.0672	19.46	0.57
Sum	**31,166**	**24,349**	**17,885**	**13,559**	**6,817**	**28.0**						

9 CONCLUSION

Wind energy is one cornerstone of the future energy supply, as a part of an energy mix that will include solar energy, hydropower, biomass, geothermal energy, etc. A variety of technologies are mature and available for implementation. They are being manufactured by leading industrial corporations and comply with the highest technical standards.

Since renewable energies do not need international infrastructures for the primary energy supply, they can be introduced more readily and swiftly than this was the case with nuclear/fossil energies when they originally were implemented. Due to their predominantly decentralised nature, their introduction can be accelerated further: the planning and construction of a conventional power stations takes usually many years, the installation of wind power systems just a few days or weeks.

However, there are to various degrees several barriers for an accelerated and successful renewable energy implementation:

- Fair competition in the international energy market is prevented by several direct and indirect subsidy schemes for the conventional energy industry that add up to US$300 billion a year.
- Very often, the knowledge of renewable energy’s potential, as well as its technical opportunities and economic benefits are not well disseminated – there is even an information deficit among politicians.
- Renewable energies are decentralised energy sources, whereas the existing energy utilities are focused on centralised structures. The companies, interest groups and political decision makers involved in the conventional energy system, often block changing the structure.
- The countries with an insufficient energy supply often try to follow the energy supply model of the industrialised countries. Frequently, the evident economic development opportunities emerging from a sustainable energy supply are not realised.
- The deficit of renewable energy information is often aggravated by misinformation directed at decision makers and populations.

Strategic cornerstones for the worldwide proliferation of renewable energy are to overcome the described restrictions, why it is necessary for politicians and renewable energy supporters to develop, prioritise and execute appropriate strategies. The development of such strategies should be based on the most successful implementation programmes and should take specific regional requirements into consideration.

To highlight and present solutions to urgent policy issues and strategies for the proliferation of renewable energy which includes a special need of defining and taking steps to establish a regular institutional infrastructure designed to the needs of a decentralized energy structure, the World Council for Renewable Energies, WCRE, in May 2004, ill bring together the world NGO community. A main topic will be to discuss and recommend the necessary economical support for investment and operation of the future renewable energy institutions that must be established.

Besides high-level research, there is also a massive need for a comprehensive regional, national and global network of independent ecosites offering demonstration and pre-commercial development of realistic and immediately applicable renewable energy solutions by applying principles of non-commercial international technology-transfer and being the linkage between research, industry and consumers at all levels. Such ecosites will be relatively small but must be wholly dedicated to the implementation of the renewable energies in recognition of their decentralized nature.

One of the most important proposals of the World Council for Renewable Energies, WCRE, was the initiative from 2001 for establishing an International Renewable Energy Agency (IRENA) as an international agency with a governmental membership base which will significantly strengthen the institutional basis of the renewable energy forms, that are far from sufficiently rooted in the structures and economies of the nations of the world.

Committed to the worldwide proliferation of renewable energy, the IRENA should be given a legal status similar to the International Atomic Energy Agency, which was established in 1957 as an autonomous organization under the United Nations to serve as an intergovernmental forum for the use of nuclear technologies.

A first official step was taken in 2002 by the German government that included the proposal of an International Renewable Energy Agency into its new government programme.

In April 2003 it was decided by the German Bundestag that concrete initiatives should be leading to the formation of an international agency dedicated to the worldwide implementation of the renewable energies.

REFERENCES

1. www.wwindea.org
2. www.folkecenter.net
3. www.eurosolar.org
4. www.sbs.co.za/wwwec2003 (programme of the World Wind Energy Conference, Capetown, South Africa, 23.- 26. November 2003).
5. Act on Granting Priority to Renewable Energy Sources (Renewable Energy Sources Act). Deutscher Bundestag. Berlin 2000.
6. Table: "Wind Energy in Europe. Comparison of price regulations with amount regulations", New Energy 1/2000. Published by BWE.
7. Solar Zeitalter 1/2000. Published by EUROSOLAR.
8. New Energy 2/2003. Published by BWE.

Energy Strategies for the Muslim Ummah

ISHFAQ AHMAD*
Prime Minister's Secretariat
Islamabad, Pakistan

1 ABSTRACT

In a world dynamically shaping its socio-cultural and economic trends, the centrality of energy has assumed greater importance than ever before. Unquestionably much of the accomplishments of modern civilization have been achieved through the efficient and extensive harnessing of different forms of energy to enhance human capacities and ingenuity. The Muslim Ummah is generously blessed with priceless oil and gas resources in virtually immeasurable quantities. More than 70% of the entire world's proven oil reserves and about half of proven natural gas reserves are in Islamic countries. At the current production rates, these proven reserves are expected to last for more than fifty years.

In the wake of such opportunities, it is imperative that the Muslim countries begin to preserve their resources and channel efforts towards developing and acquiring technologies, which aim at utilizing non-fossil and renewable sources of energy such as hydro, nuclear, wind, solar and cleaner newer approaches such as fuel cells, which would not only allow reduced environmental degradation but also sustained economic progress. This paper also focuses on the various alternate energy options available for the Muslim world, especially those countries that are not abundantly blessed with natural resources, and suggests means and methods for effectively and efficiently utilizing them for future sustained development with special reference to climate change and other environmental considerations.

This paper gives the energy consumption pattern of OIC countries, compares their fossil fuel resources with the world and reviews the projected global and OIC energy requirements. Then on the basis of economic and environmental considerations and the energy research and development (R&D) trends, it brings out the urgent need for diversification of future energy mixes in the OIC countries and presents essential features of desirable energy strategies of these countries.

2 INTRODUCTION

Most of the fifty seven (57) member countries of the Organisation of Islamic Conference (OIC) are located in Asia or Africa. These countries, sharing the common faith, are also blessed with oil and gas resources more than any other set of countries grouped together. However, contrary to the common perception, only twenty five (25) of these countries are exporters of oil and gas, including a few that also export coal as well. Of these 25 countries, only five of the OIC countries fall in the group of High-income countries. Twenty three of these are Middle-income while twenty nine are Low-income countries. The World Bank classifies various economies on the basis of per capita Gross National Income: Low-income countries have per capita income of less than US $745, Middle-income countries have per capita income of US $ 746 to 9,205, while High-income countries have per capita income of more than US $9,205 [Ref. WDR2003]. The majority of the OIC countries are importers of energy and most of these countries fall in the category of Low-income countries. Due to the generally low level of science and engineering education and scientific research and

---

* Special Advisor to the Prime Minister of Pakistan, and Fellow of Islamic Academy of Sciences.

development (R&D) culture, essentially all of the OIC countries are importers of energy technologies.

The twentieth century witnessed rapid socio-economic transformation in many parts of the world. The era of economic and industrial growth changed the world into a more comfortable place and improved the quality of life. The demand for energy increased and most of it was met by burning fossil fuels viz. coal, oil or gas. In most of the developing countries, substitution of traditional fuels such as fuel wood, crop residues and animal wastes, by commercial fuels increased and there was increased use of more convenient forms of energy like oil, gas and particularly electricity. However, these convenient forms of energy are either still not available or affordable by a substantial fraction of the population of developing countries for meeting their basic energy needs. It is estimated that some 1.6 billion people of the world are still without access to electricity and some 2.3 billion people rely extensively on traditional fuels [Ref. IEA2002]. A significant fraction of these people facing energy poverty are live in OIC countries.

The burning of fossil fuels needed to meet the energy needs is also accompanied with the emission of smoke/particulates and gases that harm the local and regional environment and contribute to global warming. It was in the later part of the last century that anthropogenic contribution to these gases was considered harmful to global climate. The adverse effects of fossil fuels have made policy makers and planners in a number of industrialized and some large developing countries e.g. China and India to rethink their strategy to meet the future global energy needs. As increased use of fossil fuels will be environmentally unsustainable, this has necessitated the increased use of non-fossil fuels namely hydro, nuclear, wind, solar and biomass, etc.

Nuclear technology had a head start in the 1960s as a more mature non-fossil fuel technology than the rest of the alternative energy options but due to high investment costs, safety concerns and lack of demonstration of radioactive waste disposal, growth of this technology is facing difficulties. As renewables are being promoted by industrialized countries for their national and overseas markets, they have a good chance of supplying the world with significant share of its energy needs during the 21st century. These technologies may prove themselves to be environmentally benign but they still have a long way to go before they become economical.

3 ENERGY CONSUMPTION PATTERN OF ISLAMIC COUNTRIES

With a population of around 1.3 billion, OIC countries have a share of 21% in population and only 4% in income, as measured by GNP of the world. These countries consume one-tenth of the world's commercial energy [Ref. UN2002 and WDR2003]. Table 1 gives population, GNP, GNP/Capita, energy consumption and recent status as net importer or exporter of energy of the OIC countries. It may be noted that 32 of the OIC countries are not well endowed with energy resources and have been labelled as energy resource-poor countries and most of these also have very low income levels. Table 2 gives the share of population, income and energy use of the energy resource-rich and resource-poor OIC countries. Resource-poor countries have nearly half the per capita income and one-third the energy use compared to the resource-rich OIC countries.

The primary energy mix of OIC countries (Figure 1) shows that some 45% of energy demand is met by gas, 43% by oil, 7% by coal and 4% by hydro. Contribution of nuclear energy is less than 0.1% - a small contribution by Pakistan. A point of special concern here is that the OIC countries are almost exclusively dependent on oil and gas for their energy (up to 88%).

Table 1. Basic Features of Islamic Countries

No	Country	OIC Joining Date	Population 2001 (Million)	GNP 2001 Bill US $	Per Capita GNP US $	Commercial Energy Use 1999 Thousand TOE	Comm. Energy Cons./capita 1999 Kg of OE	Energy Resource Endowment
1	Afghanistan	1969	27.2	n.a	n.a	360	13	IMP
2	Albania	1992	3.0	4.2	1400	889	296	IMP
3	Algeria	1969	31.0	50.4	1626	36973	1193	EXP
4	Azerbaijan	1992	8.0	5.3	663	10827	1353	EXP
5	Bahrain	1972	0.7	6.2	9370	8584	12022	EXP
6	Bangladesh	1974	133.0	49.9	375	10290	77	IMP
7	Benin	1983	6.0	2.3	383	336	56	IMP
8	Brunei	1984	0.3	7.8	22475	1867	5412	EXP
9	Burkina Faso	1974	12.0	2.4	200	344	29	EXP
10	Cameroon	1974	15.0	8.7	580	1664	111	EXP
11	Chad	1969	8.0	1.6	200	41	5	IMP
12	Comoros	1976	0.5	0.2	412	27	51	IMP
14	Djibouti	1978	0.6	0.6	888	127	197	IMP
15	Egypt	1969	65.0	99.4	1529	39669	610	EXP
16	Gabon	1974	1.3	4.0	3164	1425	1130	EXP
17	Gambia	1974	1.3	0.4	328	85	63	IMP
18	Guinea	1969	8.0	3.0	375	394	49	IMP
19	Guinea-Bissau	1974	1.2	0.2	165	87	71	IMP
20	Guyana	1998	0.8	0.6	837	557	727	IMP
21	Indonesia	1969	214.0	144.7	676	88451	413	EXP
22	Iran	1969	65.0	112.9	1737	101064	1555	EXP
23	Iraq	1975	23.8	59.0	2484	23892	1006	EXP
13	Ivory Coast	2001	16.0	10.3	644	4015	251	IMP
24	Jordan	1969	5.0	8.8	1760	4476	895	IMP
25	Kazakhstan*	1995	15.0	20.1	1340	33868	2258	EXP
26	Kuwait	1969	2.0	35.8	17900	21928	10964	EXP
27	Kyrgyzstan	1992	5.0	1.4	280	2589	518	IMP
28	Lebanon	1969	4.0	17.6	4400	5100	1275	IMP
29	Libya	1969	5.4	n.a	n.a	12389	2290	EXP
30	Malaysia	1969	24.0	86.5	3604	45532	1897	EXP
31	Maldives	1976	0.3	0.6	2042	155	548	IMP
32	Mali	1969	11.0	2.3	209	186	17	IMP
33	Mauritania	1969	3.0	1.0	333	985	328	IMP
34	Morocco	1969	29.0	34.6	1193	9686	334	IMP
35	Mozambique	1994	18.0	3.7	206	984	55	EXP
36	Niger	1969	11.0	2.0	182	341	31	IMP
37	Nigeria*	1986	130.0	37.1	285	14667	113	EXP
38	Oman	1972	2.5	23.2	9462	7416	3024	EXP
39	Pakistan	1969	141.0	59.6	423	37273	264	IMP
40	Palestine	1969	n.a	n.a	n.a	n.a	n.a	IMP
41	Qatar	1972	0.6	5.7	9500	22104	36963	EXP

42	Saudi Arabia	1969	21.0	149.9	7138	89660	4270	EXP
43	Senegal	1969	10.0	4.7	470	1115	112	IMP
44	Sierra Leone	1972	5.0	0.7	140	145	29	IMP
45	Somalia	1969	9.1	n.a	n.a	n.a	0	IMP
46	Sudan	1969	31.7	10.3	327	1306	41	IMP
47	Suriname	1996	0.4	0.7	1688	618	1471	IMP
48	Syria	1972	17.0	16.6	976	16948	997	EXP
49	Tajikistan	1992	6.0	1.1	183	3257	543	IMP
50	Togo	1997	5.0	1.3	260	1373	275	IMP
51	Tunisia	1969	10.0	20.1	2010	5730	573	IMP
52	Turkey	1969	66.0	168.3	2550	61043	925	IMP
53	Turkmenistan	1992	5.0	5.0	1000	14279	2856	EXP
54	Uganda*	1974	23.0	6.3	274	517	22	IMP
55	United Arab Emirates	1972	3.0	85.6	28753	35180	11821	EXP
56	Uzbekistan	1996	25.0	13.8	552	52160	2086	EXP
57	Yemen	1969	18.0	8.3	461	4130	229	EXP
	Total OIC		1304	1407	1079	839108	644	
	World		6133	31500	5136	8382752	1367	
	Share in World		**21%**	**4%**		**10%**		

* Countries with significant non-Muslim population.

IMP = Net importers of Energy

EXP = Net exporters of Energy

TOE = Tonne of Oil Equivalent.

[a] Data is for the year 2000

[e] Estimated Data

na Data Not Available

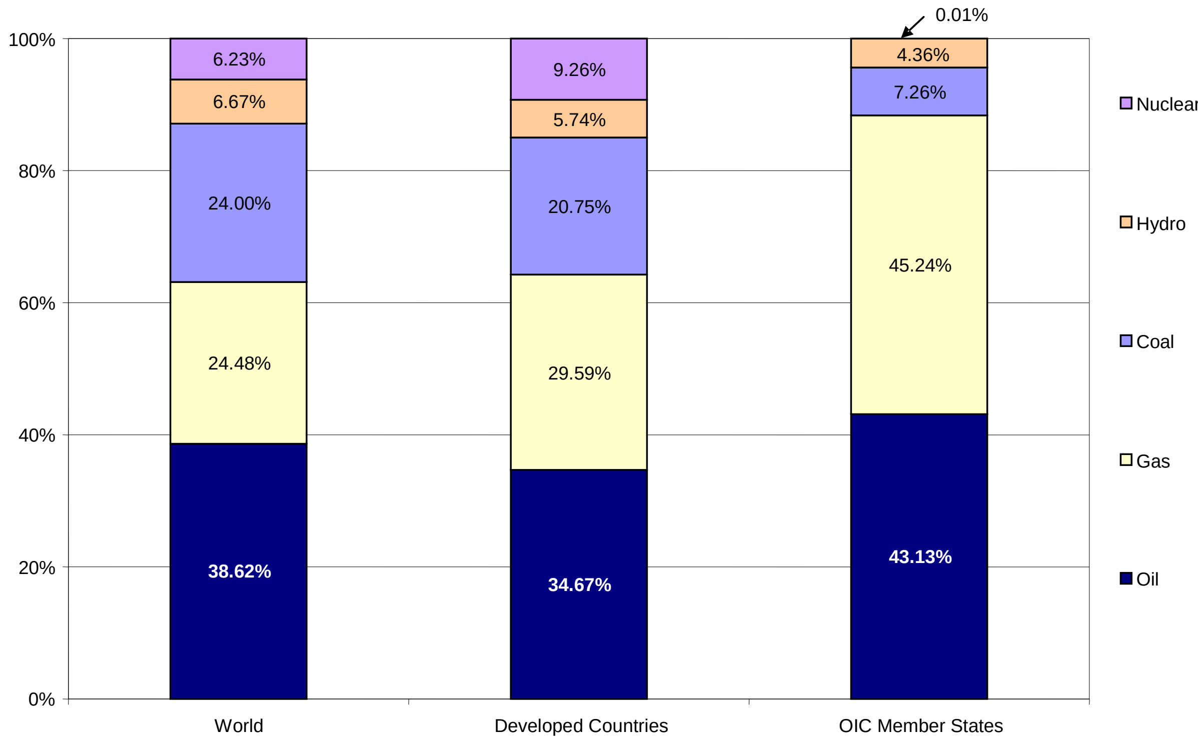
Sources: OIC web site http://www.oic-oci.org and [Ref. UN2002 and WDR2003].

Table 2. Population GNP, Energy Consumption of Resource-Rich and Resource-Poor OIC Countries

	All OIC Members	Resource- Rich Countries		Resource- Poor Countries	
			Share		Share
No. of Countries	57	25	43.9%	32	56.1%
Population (Million)	1304	696	53.3%	608	46.7%
Total GNP (Billion US$)	1407	997	70.9%	410	29.1%
Per Capita GNP (US $)	1079	1433	-	674	-
Total Commercial Energy Consumption (Million TOE)	839	639	76.1%	200	23.9%
Per Capita Consumption (Kg. of Oil Eq.)	644	919	-	329	-

* Resource-Rich countries are those, which are net exporters of energy

Sources: [Ref. BP2003 and WDR2003].



* Turkey has been included in OIC Member states only

Figure 1. Primary Commercial Energy Mix (1999).

Source: [Ref. UN 2002]

and the contribution of coal, hydro, nuclear and renewable energy sources is either very small or negligible. In comparison, the contribution of oil and gas in the Developed countries is about 64%, coal 21%, nuclear around 9%, hydro 6%, while renewables are slowly becoming significant. {Developed countries in this paper refer to OECD countries, excluding Turkey, East Europe and the Russian Federation}. Out of the 52 TWh of geothermal and 25 TWh of wind based generation world wide, in 2000, the share of OIC countries was 9% and 0.3%, respectively [Ref. WEC2001b].

The share of electricity generation of OIC countries in the world is about 7% which is significantly lower than their share of 10% in the world energy consumption [Ref. UN2002]. Table 3 gives the installed electricity generation capacity, total generation and hydro generation of OIC countries and their comparison with the world for the year 1999.

4 FOSSIL FUEL RESOURCES OF THE WORLD AND MUSLIM COUNTRIES

Geologists have a range of estimates about the Ultimate Recoverable Resources (URR) of Oil and Gas. One recent estimate of URR of oil is 298 - 523 billion TOE* with a mean value of 411 billion TOE and of URR of gas of 267 - 545 billion TOE with a mean value of 400 billion TOE [Ref. USGS2000]. The difference of URRs and cumulative discoveries (cumulative production plus reserves) indicates the extent of new reserves which may be discovered in future, through exploration activities. Some 218 billion TOE (97 billion TOE of cumulative production and 121 billion TOE of reserves) of oil has been discovered so far. Thus the yet to be discovered oil reserves could be as low as 81 billion TOE to as high as 305 billion TOE. Similarly, some 171 billion TOE (46 billion TOE of cumulative production and

* Tonne of Oil Equivalent (Editors).

125 billion TOE of reserves) of gas has been discovered so far. Thus the yet to be discovered gas reserves range between 27 - 144 billion TOE. It is this uncertainty in the future discoveries of oil and gas reserves, in the wake of increasing global energy demand, which leads to security of supply concerns and the unpredictability of the future price of oil and gas globally.

As far as the world's proven oil and gas reserves are concerned, at the current production rates, these can last for 40 and 62 years, respectively [Ref. BP2003]. As shown in Table 4 the OIC countries have about 75% of the world's total oil reserves. At the current production levels these reserves will last for more than 80 years while those of OECD will last for only 9 years.

Table 3. Electricity Generation Capacity, Total Electricity Generation and Hydro Generation of Muslim Countries (1999)

Rank	Country	Generation Capacity (GW)	Generation (TWh)	Hydro Generation (TWh)
1	Iran	30.6	117.6	5.0
2	Indonesia	25.2	95.9	13.9
3	Turkey	25.1	116.4	34.7
4	Saudi Arabia	22.9	121.6	
5	Kazakhstan	19.0	47.5	6.1
6	Egypt	17.6	69.0	15.3
7	Pakistan	15.7	65.4	22.4
8	Malaysia	12.7	65.2	7.5
9	Uzbekistan	11.7	45.3	5.7
10	Iraq	9.5	30.5	0.6
11	Kuwait	8.5	32.1	
12	Algeria	6.0	24.7	0.1
13	Nigeria	5.9	16.1	5.5
14	United Arab Emirates	5.8	31.9	
15	Azerbaijan	5.2	18.2	1.5
16	Syria	4.9	21.6	2.7
17	Libya	4.6	20.0	
18	Tajikistan	4.4	15.8	15.4
19	Morocco	4.0	13.2	0.8
20	Turkmenistan	3.9	8.9	0.0
21	Kyrgyzstan	3.7	13.2	12.1
22	Bangladesh	3.5	15.4	0.8
23	Oman	2.4	11.2	
24	Mozambique	2.4	7.4	6.9
25	Lebanon	2.3	9.0	0.3
26	Tunisia	2.3	10.1	0.1
27	Qatar	1.9	8.2	
28	Albania	1.9	5.4	5.2
29	Jordan	1.7	7.1	0.0
30	Bahrain	1.4	6.0	
31	Cote d'Ivoire	1.2	2.9	1.7
32	Yemen	0.8	3.0	0.0
33	Sudan	0.7	2.1	1.1
34	Cameroon	0.6	3.4	3.3
35	Afghanistan	0.5	0.5	0.3
36	Brunei	0.5	2.4	
	Total OIC	271.0	1084.2	169.3
	World	**3,301**	**15,031**	**2,702**
	Share of OIC	**8%**	**7%**	**6%**

The 36 countries covered in this table represent the following share of OIC Countries: 91% Population, 98% GNP, and 99% Commercial Energy Use.

Source: [Ref. UN2002]

Gas reserves also show similar trend. OIC countries have more than half of the world's gas reserves. At current production levels the OIC gas reserves will last for more than 60 years while those of OECD countries will last for only 14 years.

Table 4 also shows the estimates of reserves of oil and gas in 2002, compared to the estimates published in 1975. As, during the last 28 years, the sum of re-evaluation of reserves and new discoveries has been greater than the consumption, the global reserves of oil and gas have increased. Similarly the coal reserves have also remained at nearly the same level during the last two decades. At the current level of production, the world coal reserves are estimated to last for more than 200 years. The OIC countries, as a group, are not well endowed with coal. Figure 2 gives the shares of OIC countries, Developing countries (excluding OIC countries) and Developed countries in coal, gas and oil reserves of the world.

Figure 3, compares the fossil fuel reserves per capita of different groups of countries. The per capita fossil fuel reserves of Developed countries (286 TOE/capita) are larger than those of the OIC countries (157 TOE/capita). However, most of the reserves of Developed countries consist of coal, while those of OIC countries consist of oil and gas. Keeping in view the almost exclusive use of oil in transportation and in many other applications and the fact that alternative fuels for transport are still at R&D stage, the oil reserves of OIC countries are expected to remain the focus of attention for the foreseeable future. Similarly, most of the gas reserves lie in the OIC countries and the Russian Federation and these regions will remain the centre of gas trade, which is expected to expand substantially in the coming years.

5 PROJECTED ENERGY REQUIREMENTS OF THE WORLD AND MUSLIM COUNTRIES

The world consumption of energy in the year 2002 was about 10. 4 billion TOE comprising 9.4 billion TOE in the form of commercial fuels and about 1 billion TOE in the form of traditional fuels [Ref. BP2003 and EC2003]. Essentially all the traditional fuels are used in the Developing countries.

The energy demand projections critically depend on assumptions related to population growth, economic growth, energy prices, efficiency of energy use and technological developments. The Reference scenario of recent energy demand projections, till the year 2030, by the European Commission [Ref. EC2003] shows that world primary energy demand will increase by about 73% i.e. 1.8% per annum and world electricity demand will increase by 134% i.e. 2.9% per annum. Based on the regional split of these projections, it has been estimated that in Developing countries (i.e. world excluding OECD, the Russian Federation and East European countries) the primary energy demand will grow by 2.6% per annum, i.e. increase by a factor of 2.1 and electricity demand will increase by 4.5% per annum.

Table 4. Proven Fossil Fuel Reserves and Reserves to Production Ratios

	Oil Reserves (Billion TOE)		**R/P**
	1975	**2002**	**2002**
OECD Countries	11	9	9
Russian Fed. & East Europe	11	8	21
Developed Countries	22	17	12
OIC Countries	61	106*	81
Non-OIC Developing Countries	8	19	5
Developing Countries	69	125	59
World	91	143	40

* Essentially all of these are located in Resource-rich OIC countries

	Gas Reserves (Billion TOE)		**R/P**
	1975	**2002**	**2002**
OECD Countries	6	14	14
Russian Fed. & East Europe	20	44	84
Developed Countries	27	58	39
OIC Countries	20	73**	56
Non-OIC Developing Countries	10	9	3
Developing Countries	30	83	105
World	57	140	62

** More than 95% of these are located in Resource-rich OIC countries

	Coal Reserves (Billion TOE		**R/P**
	1985	**2002**	**2002**
OECD Countries	214	216	220
Russian Fed. & East Europe	139	87	517
Developed Countries	352	303	263
OIC Countries	1	26***	20
Non-OIC Developing Countries	140	172	49
Developing Countries	142	198	161
World	494	501	211

*** More than 90% of these are located in Resource-rich OIC countries
* Turkey is included in OIC countries instead of OECD
R/P shows the Reserves to Production ratio

Sources: [Ref. BP2003 and earlier issues of 1986, 1996]

As the OIC countries are a sub-group of Developing countries same growth rates can be assumed for the projection of energy demand of OIC countries. So the primary energy demand in OIC countries in the year 2030 will be some 1,760 million TOE and the electricity demand will be some 4,000 TWh, at the generation level.

What will be the energy mix of the world in the year 2030 and beyond, is difficult to project. Apparently, fossil fuels will continue to meet more than 80% of this increased demand, and oil will continue to remain as the single largest source of energy, although its share is expected to decline. Oil will continue to be the fuel of choice in the transport sector. The Middle East will be called upon to meet most of the increase in the global oil demand in the coming decades.

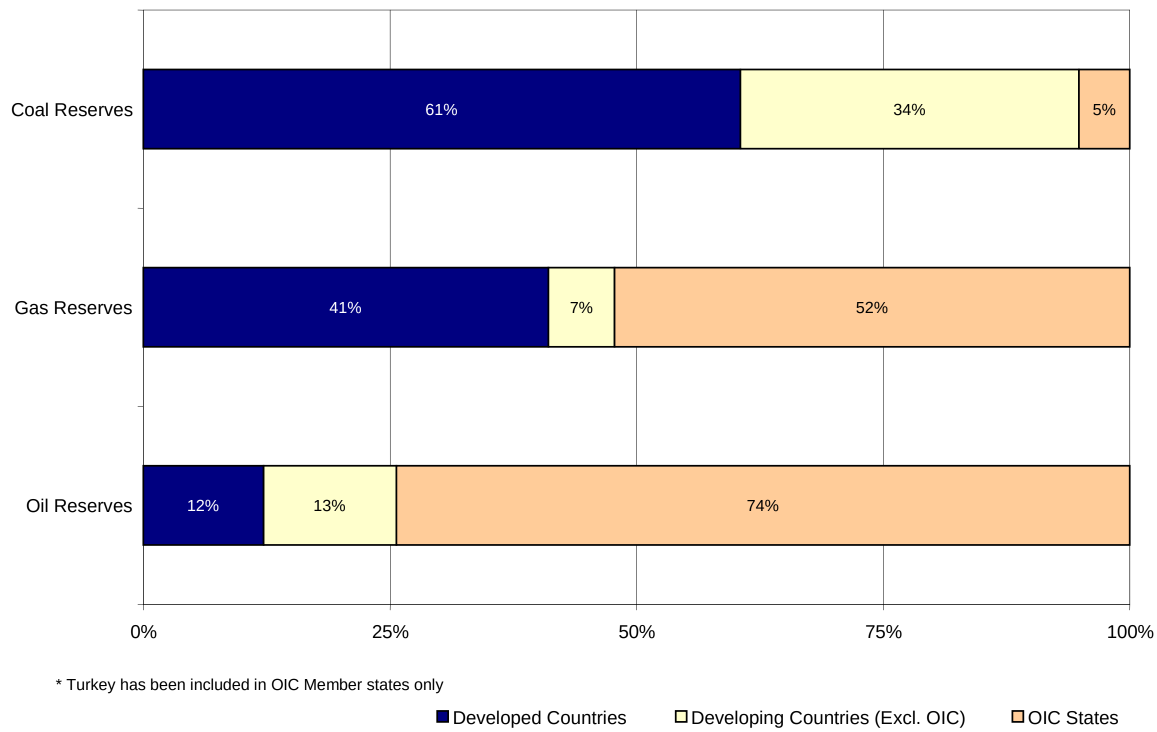


Figure 2. Fossil Fuel Reserves Comparison (Share of World).

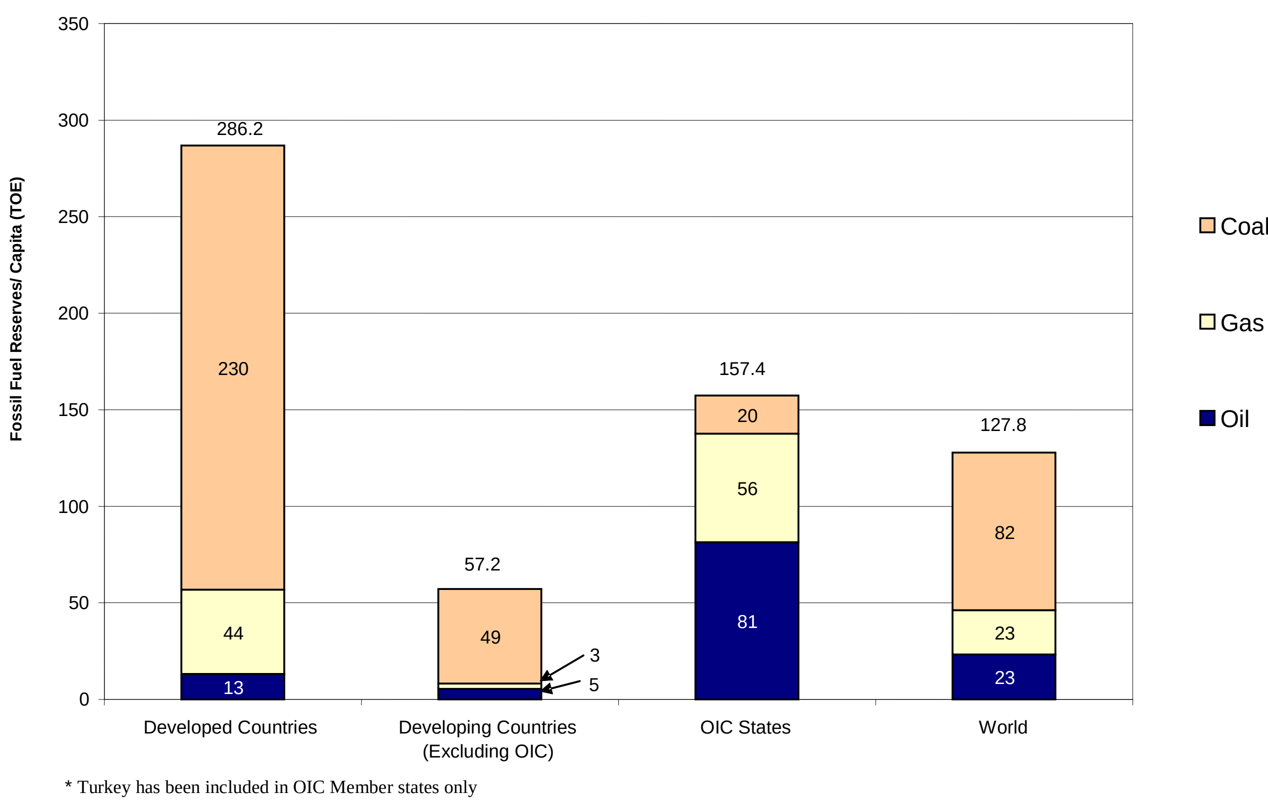


Figure 3. Fossil Fuel Reserves per Capita of Different Groups of Countries.

Natural gas demand is also expected to increase. New power plants based on natural gas will be major users of additional gas supplies over the next three decades. The use of gas will also increase especially in developing countries. The share of coal may either remain the same or may change slightly. Coal use will remain concentrated in power generation, where it will remain as the dominant fuel. The deployment of cleaner coal technologies may make coal an attractive option.

The worldwide prospects of nuclear power development are presently uncertain. Nuclear power is a proven technology with operating experience of nearly 11,000 reactor-years and is also free of emissions of greenhouse gases. The growth of nuclear power slowed down due to the reasons of operational safety concerns after the accidents at Three Mile Island in the US, in 1978, and at Chernobyl in the Ukraine in the former Soviet Union, in 1986; higher investment costs; and lack of demonstration of disposal of high-level radioactive waste. The outstanding improvements in performance of nuclear power plants, since the early 1990s, have helped to dispel the safety concerns and also made the operating costs highly competitive with other options. The life of nuclear plants built in the 1970's and later is being extended by 10 to 30 years in many countries. With the current low interest rates the financing costs of nuclear plants have decreased and the demonstration of the high-level radioactive waste disposal also appears to be possible within the next decade or so.

The perception of risk of nuclear weapons proliferation due to nuclear power is not based on facts. The five nuclear-weapon states recognized by the Nuclear Non-Proliferation Treaty (NPT) developed their nuclear weapons first and then the nuclear power reactors. All the OIC states are NPT members, except Pakistan which has already crossed the nuclear threshold. If the obligations of NPT are adhered to faithfully, OIC countries should, in principle, have no political problems in acquiring nuclear power technology for their economic development. The following OIC countries have expressed their interest in the utilization of nuclear power at some stage either through undertaking planning studies or development of human resources or some nuclear facilities: Algeria, Bangladesh, Egypt, Kazakhstan, Indonesia, Iraq, Libya, Jordan, Malaysia, Morocco, Sudan, Syria, Tunisia, Iran and Turkey [Ref. IAEA2000 and other sources]. Pakistan already has two nuclear power plants in operation while Iran has a nuclear plant with two units under construction.

Renewable energy sources may play an increasingly important role in the future energy mix of the globe. Although an expectation of around 40% of the world energy needs being met by renewable energy sources by the middle of the century have been expressed [Ref. UK1999], high installation and operating costs will contribute to the slow growth of renewables. If installation costs come down, as experience is gained and as research in the field persists, then these sources can have a significant share of the world energy market. The current expectation is that wind power and modern biomass use may grow, especially in OECD countries.

6 ENVIRONMENTAL CONSIDERATIONS

All sources of energy i.e fossil, nuclear or renewables, have associated with them some adverse environmental impacts. Fossil fuels, currently providing the world with most of its energy needs, are also the biggest culprits in damaging the environment. Fossil fuel burning for commercial energy use accounts for the man-made emission of 85% of sulphur, 75% of carbon dioxide, and 12% of nitrous oxide into the atmosphere [Ref. UNDP2002].

Emissions of sulphur dioxide and nitrogen oxides, both contribute to the acid deposition through rain, fog, snow or dry deposition and that may fall locally or travel long distances in clouds.

Greenhouse gases such as carbon dioxide, methane, nitrous oxide etc. are responsible for the increase in the mean temperature of the globe. The Inter-governmental Panel on Climate Change (IPCC) estimates the increase in atmospheric concentration of carbon dioxide from 280 parts per million in the pre-industrial era to 368 ppm now. This has resulted in a rise in the global mean surface temperature by 0.4-0.8 C in the period 1861-2000, and in the global mean sea level by 10-20 cm in the same period as well as a decrease in the snow covers by 10% since 1960s [Ref. IPCC2002]. This global warming also generates climate changes like increase in extreme weather events, changes in rainfall patterns, and a wide range of impacts on plants, wildlife, and humans.

It is estimated that a 60 per cent reduction in emissions of greenhouse gases, mainly carbon dioxide, must be achieved in the next 50 years in order to stabilize atmospheric concentrations of greenhouse gases at 1990 level and preventing further environmental damage [Ref. UNDP2002]. With the energy demand in the Developing countries increasing by a factor of 2.1 and electricity demand increasing by a factor of 3.7, by the year 2030, achieving the emission reduction targets is a major challenge for the future energy policy.

Available options with which these emission reductions may be achieved are: (i) more efficient use of energy, especially at the end-use level; (ii) accelerated development and deployment of new energy technologies, e.g. advanced nuclear reactors and cleaner and efficient fossil-fuel technologies such as combined cycle power plants based on gas, super critical coal-fired power plants or integrated coal gasification combined cycle plants that produce lower carbon dioxide emissions; (iii) increase utilization of renewable energy sources such as hydropower, wind, biomass, geothermal and solar, having no or very little carbon dioxide emissions.

7 ENERGY TECHNOLOGY DEVELOPMENTS

In the 1970s and 1980s there was concern that oil and gas reserves would run out in a few decades, forcing the world to exploit more polluting and expensive un-conventional energy sources of tar sands, oil shale and heavy oils and to use synthetic fuels obtained from gasification or liquefaction of coal. Today, due to the developments in a wide range of energy exploration, production, conversion and end-use technologies, the fear of resource extinction is not of immediate concern and at current consumption levels the oil and gas reserves would last for nearly five decades. The concern has now shifted towards averting the onset of global climate change from emissions of greenhouse gases and bringing down the energy costs to keep it affordable by the majority of the world's population and to support increasing industrial growth.

Investment in energy technology R&D is a risky venture. It is difficult to predict technologies which will be winners in future. However, where some experience is available, investment in energy R&D is worth making in view of the high rewards. Each country, based on its specific needs should identify the areas of its interest. For gas exporting countries the interest may lie in refrigeration technologies or ship building for their liquefied natural gas (LNG) trade. For countries with dispersed populations renewable technologies may be the focus. For countries with relatively larger grids and poor energy resources advanced nuclear power plants may be of interest.

The pace and quality of technological improvement of any venture is coupled with the spending on research, development and demonstration (RD&D) in that field. The future of any field of energy to be economical, safe and environmentally friendly also depends on the spending on energy related RD&D. In industrialized countries the R&DD covers several energy technologies including energy conservation, fossil fuels, renewable energy, nuclear energy, power and storage technologies including fuel cells and related basic research. In these countries public sector spending on energy R&D has been declining during the period of 1980 to 2000 from some US$15,000 million per year to US$7,000 million [Ref. UNDP2002]. However, the private sector R&D expenditures have shown different trends. In the US, the private sector energy R&D, which is of approximately the same level as public sector R&D investment, has also been declining. In Japan, the private sector R&D investment is higher than public sector R&D investment and has been increasing during 1985 to 1997. In the Republic of Korea, the private sector energy R&D investments are much lower than public sector R&D investments, but have been increasing [Ref. WEC2001b].

Current world wide acceptability of fossil fuel technologies for electricity generation is due to their economic viability. But these technologies have emerged over many years through research and large investments in R&D. New technologies are relatively more costly as compared with mature ones. However, with technological improvements and experience, costs decrease and they become more acceptable and compatible in the market. Especially when the public resistance level of the technology is already very low. Also as the global base of these renewable sources becomes wider, the generation costs will become lower. In the last decade the renewable energy generation based on wind has become a viable alternative for electricity generation, at many locations.

One interesting area of RD&D is the development of hydrogen based fuel cells. The fuel cells can be used to drive automobiles or for generating electricity for domestic, industrial or even public utilities. In fuel cells, electricity is produced by a chemical reaction using hydrogen. The hydrogen may be obtained from electrolysis of water or from fuels such as natural gas, methanol, ethanol, gasoline, and even coal. The electricity from electrolysis of water may come from renewables or nuclear for large scale hydrogen production. Most of the leading automobile manufacturers have developed fuel cell vehicles and are currently testing them in small demonstration fleets. Demonstration hydrogen refuelling stations are currently operating in the US, Japan and Singapore, with a commercial station in Reykjavik, Iceland.

8 ENERGY STRATEGIES FOR THE MUSLIM UMMAH

In view of the arguments presented in the paper, each OIC country should formulate its own energy policy considering the long-term national socio-economic and technological self-reliance objectives. These policies, with mutual collaboration, should result in achievement of desired energy mix for supporting socio-economic development. Some of the features which may be common amongst the energy policies of various countries are as follows:

- Efficiency in energy supply, conversion, and use should be increased. At the residential level pubic awareness and improvement in the efficiencies of end-use devices be promoted. While in the industrial and commercial sectors promotion of energy efficiency and conservation should be made through a combination of incentives and regulations.
- Preservation of the local and regional environment through the use of cleaner fuels or emission control technologies and waste management should be adopted. For the longer term sustainability of the world, low greenhouse gas emitting technologies or non-fossil energy sources must be promoted.
- OIC member states should invest more on energy related RD&D. Research institutions should be established or strengthened for undertaking research in existing or promising new technologies such as combined cycle plants, nuclear, wind, solar, fuel cells etc. This will enhance the ability of OIC countries to assimilate and adapt these technologies quickly and efficiently.
- For each region of the OIC, least cost and reliable sources of energy must be identified and developed for affordable energy supplies.

In conclusion it is proposed that an OIC Energy Forum should be established. The objectives of the Forum could be: (i) to provide expert advise in the field of energy planning to member countries; (ii) to undertake technical, economic and financial feasibility studies of energy projects; (iii) to assist in capacity building, in the areas such as project planning, power plant construction and commissioning etc. (iv) and, to facilitate private sector investments in energy projects.

In short the Forum should promote collective self reliance in the energy sector in Muslim Ummah.

9 ACKNOWLEDGEMENT

The author wishes to gratefully acknowledge the indispensable contributions made by Mr. Ahmad Mumtaz, Chief Scientific Officer and Director Applied Systems Analysis Group (ASAG), Pakistan Atomic Energy Commission, in preparation of this paper.

REFERENCES

1. [BP2003]: BP Statistical Review of World Energy, British Petroleum 2003.
2. [EC2003]: World Energy Technology and Climate Change Policy Outlook 2030, DG for Research, Energy, European Commission, Brussels, 2003.
3. [IAEA2000]: B. J. Csik in Nuclear Power in Developing Countries: Its Potential Role and Strategies for its Deployment. Proceedings of International Seminar held in Mumbai, India, 12-16 October, 1998.
4. [IEA2002]: World Energy Outlook 2002, International Energy Agency, OECD.
5. [IPCC2002]: Climate Change: IPCC Third Assessment Report, April 2002.
6. [UKWDR2003]: New & Renewable Energy Prospects for the 21st Century, UK, 1999.
7. [UN2002]: 1999 Energy Statistics Yearbook, UN, New York, 2002.
8. [UNDP2002]: Energy for Sustainable Development, UNDP, 2002.
9. [USGS2000]: US Geological Survey, World Petroleum Assessment 2000.
10. [WDR2003]: World Development Report 2003, The World Bank.
11. [WEC2001a]: Energy Technologies for the 21st Century, WEC, August 2001.
12. [WEC2001b]: Survey of World Energy Resources, WEC, 2001.

Energy Policy Implications: The Turkish Experience

A.KORKUT ÖZAL *
Founding Chairman, AKOZ Charity Foundation (WAKF)
Kısıklı Caddesi No. 18 Blok B Kat 3 Altunizade-Üsküdar
İSTANBUL-TÜRKİYE

1 ABSTRACT

This paper deals with the energy policy implications of the Turkish energy policy practices with its achievements and failures.

Turkey's strategic location makes it a natural "Energy Bridge" between major oil producing areas in the Middle East and Caspian Sea regions on the one hand, and consumer markets in Europe on the other. Turkey's port of Ceyhan is an important outlet both for current Iraqi oil exports as well as for potential future Caspian oil exports.

Despite the above unfavourable economic, political and international problems the performance of the Turkish energy sector in general has been comparatively better than the performance of the global economy as a whole. During 1973-2000 the rates of growth of the total primary energy supply (TPES) as well total primary energy consumption (TPEC) of the world were both 1.9%. While the same values for the same period for Turkey were 4.4% and 3.7 % respectively.

Turkey's strategic location makes it a natural "Energy Bridge" between major oil producing areas in the Middle East and Caspian Sea regions on the one hand, and consumer markets in Europe on the other. Turkey's port of Ceyhan is an important outlet both for current Iraqi oil exports as well as for potential future Caspian oil exports. Turkey's Bosphorus and Çanakkale Straits are major shipping "choke points" between the Black and Mediterranean seas. Finally, Turkey is a rapidly growing energy consumer in its own right.

Figure 1. Turkey and its provinces.

* Professor of Civil Engineering (Water, Power and Land Resources Development), Former Minister of Interior of Turkey and Founding Fellow of IAS

Table 1. Turkish economic performance 1973-2003

TABLE-1 TURKISH ECONOMIC PERFORMANCE 1973-2003																			
			GNP				FOREIGN TRADE					DEBT MANAGEMENT							
	Populatio	EX.Rate	Constant		Current		EXP	IMP	EXP	EXP+IMP=TT		INT	EXT	TOTAL Debt		Interest		(WPI)	
YEARS	1000	MillTL/$	BilTL-87	%GNP	KatTL	($)/.cap	M$	M$	%GNP	M$	%GNP	KatTL	Bill$	Bill$	%GNP	%GNP	%TD	(%)	YEARS
1973	38.072	1,40E-05	42.255	5	4,E-04	734	1.317	2.086	5	3.403	12	4,E-05	3	6	20			21	1973
74	39.036	1,40E-05	43.633	3	5,E-04	980	1.532	3.778	4	5.310	14	4,E-05	3	6	16			30	74
75	40.078	1,50E-05	46.275	6	7,E-04	1.184	1.401	4.739	3	6.140	13	7,E-05	3	8	17	0	3	10	75
76	40.915	1,60E-05	50.438	9	9,E-04	1.312	1.960	5.129	4	7.089	13	1,E-04	4	10	19	0	2	16	76
77	41.768	1,80E-05	51.944	3	1,E-03	1.488	1.753	5.796	3	7.549	12	1,E-04	5	12	20	0	2	24	77
78	42.640	2,50E-05	52.562	1	2,E-03	1.604	2.288	4.599	3	6.887	10	2,E-04	6	13	20	0	2	53	78
79	43.530	3,50E-05	52.324	0	3,E-03	1.760	2.261	5.069	3	7.331	9	4,E-04	14	26	32	1	2	64	79
1980	44.438	7,80E-05	50.870	-3	5,E-03	1.570	2.910	7.909	4	10.820	16	5,E-04	16	23	34	1	2	107	1980
81	45.540	1,42E-04	53.317	5	8,E-03	1.598	4.703	8.933	8	13.636	24	9,E-04	17	23	40	1	2	37	81
1982	46.688	1,65E-04	54.963	3	1,E-02	1.412	5.746	8.843	9	14.589	23	1,E-03	18	26	41	1	2	25	1982
83	47.864	2,30E-04	57.279	4	1,E-02	1.299	5.728	9.235	9	14.963	25	3,E-03	18	32	53	2	3	31	83
84	49.070	3,75E-04	61.350	7	2,E-02	1.238	7.134	10.757	12	17.891	30	4,E-03	21	32	54	2	4	62	84
85	50.306	5,28E-04	63.989	4	4,E-02	1.356	7.958	11.343	12	19.301	29	7,E-03	25	39	58	2	3	40	85
86	51.433	6,81E-04	68.315	7	5,E-02	1.487	7.457	11.105	10	18.562	25	0,011	32	48	63	3	4	27	86
87	52.561	8,73E-04	75.019	10	8,E-02	1.668	10.190	14.158	12	24.348	28	0,017	40	60	70	3	4	39	87
88	53.715	0,001	76.108	1	1,E-01	1.693	11.662	14.335	13	25.997	29	0,028	41	61	67	4	6	71	88
89	54.893	0,002	77.347	2	2,E-01	1.979	11.625	15.792	11	27.417	25	0,042	41	61	56	4	6	64	89
1990	56.098	0,003	84.592	9	4,E-01	2.710	12.959	22.302	9	35.262	23	0,055	44	65	43	4	8	52	1990
91	57.063	0,004	84.887	0	1	2.666	13.598	21.047	9	34.645	23	0,052	50	63	41	4	9	55	91
92	57.922	0,007	90.323	6	1	2.766	14.714	22.871	9	37.585	23	0,129	56	74	46	4	8	62	92
93	58.782	0,011	97.677	8	2	3.093	15.345	29.428	8	44.773	25	0,255	67	91	50	6	12	58	93
94	59.641	0,030	91.733	-6	4	2.195	18.105	23.270	14	41.375	32	1	66	27	21	8	11	121	94
95	60.500	0,046	99.028	8	8	2.841	21.637	35.709	13	57.346	33	1	73	30	17	7	12	86	95
96	61.425	0,082	106.080	7	15	3.005	23.224	43.627	13	66.851	36	3	79	39	21	10	16	76	96
97	62.411	0,152	114.874	8	29	3.110	26.261	48.559	14	74.820	39	6	84	41	21	8	12	85	97
98	63.391	0,261	119.303	4	54	3.247	26.973	45.921	13	72.894	36	12	96	44	22	12	17	64	98
99	66.106	0,419	112.044	-6	78	2.836	26.587	40.671	14	67.258	36	23	103	55	29	14	16	52	99
2000	67.461	0,627	119.144	6	126	2.986	27.774	54.503	14	82.277	41	36	119	178	89	16	18	51	2000
2001	68.610	1,316	107.783	-10	176	1.954	31.334	41.399	23	72.733	54	122	115	208	155	23	15	68	2001
2002P	69.780	1,650	116.165	8	273	2.375	35.762	51.270	22	87.032	53	150	131	222	134	19	14	30	2002P
2003P	70.968	1,422	124.812	7	359	3.646	46.523	67.342	18	113.865	44	175	133	256	101	18	17	24	2003P

2 ENERGY SECTOR

2.1 General

With its economy now the world's 17th largest and 71 million people, Turkey's energy needs are increasing rapidly. Prior to Turkey's recent severe economic difficulties, the country's energy consumption had been growing much faster than its production. The growth of her energy-demand is by 8% per annum whereas the world average is 1.8%. This makes Turkey a rapidly growing energy importer.

2.2 Primary energy

Turkey is heavily dependent on imported oil and gas. There are major oil and gas pipelines going through Turkey and additional pipelines are being constructed or are being planned.

There is some production of lignite which is used in power plants and industry. Turkey estimates that there are potential indigenous sources for 246 billion kilowatt-hours (kWh) per year of electric power generation (105 billion kWh from lignite, 16 billion kWh from hard coal, and 125 billion kWh from hydroelectric resources).

2.3 Demand and supply

With total primary energy supply (TPES) growth rates of 4% and over per annum and total primary energy consumption (TPEC) growth of around 4% over the last three decades, Turkey is among the fastest growing energy markets in the world, and the fastest in the IEA. The government expects demand growth to accelerate in the coming two decades, with an average annual TFC growth rate of 8% between 1999 and 2005, 5.8% between 2005 and 2010, and 5.9% between 2010 and 2020. This implies a 2.7-fold increase of TFC from 57.4 mtoe (million tonne of oil equivalent) to 214.1 mtoe. Turkey's per capita TPES was 1.19 mtoe in 1999, and is expected to grow to 3.65 in 2020. An historical summary of Turkey's total primary energy supply (TPES) and consumption (TPEC) are shown in Table 2.

Table 2. TPES and TPEC 1990-2001 (mtoe)

Table 2- TPES and TPEC 1990-2001 mtoe												
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
TPES Supply	25	26	28	26	27	27	27	28	29	28	27	26
TPEC Consumption	51	51	55	58	58	62	66	69	71	71	77	73
Total Imports	26	25	27	32	31	35	39	41	42	43	50	47
Hard Coal	4	4	4	4	4	4	6	7	7	6	9	6
Natural Gas	3	4	4	4	5	6	7	9	9	11	13	14
OİL	19	18	19	23	22	24	26	26	26	26	28	27

2.4 Energy efficiency

Turkey has major potential for energy efficiency improvements. Turkey should pay particular attention to this area since the potential energy savings are estimated at 40%. Exploitation of this potential could reduce environmental emissions and improve security of supply. The potential for renewables is also significant. The single most important policy imperative is to establish cost-covering prices for all energy products and services. This is not necessary for reasons of economic efficiency alone, but is equally necessary in order to bring about appropriate investment in energy-efficient and renewable technologies.

In Turkey, per capita energy consumption (measured as TPES/population) in 1998 was equal to 1.11 toe, much less than the average of 5.10 toe for all IEA countries. But its growth is much faster than the IEA average and is projected to remain fast in the coming two decades as the economy develops. Energy intensity (measured as toe/$1,000 GDP at 1990 prices and exchange rates) in 1998 was 0.35 toe, compared with an IEA average of 0.24 toe, and has increased slowly in recent years.

3 OIL

3.1 Reserves

Turkey has proven reserves of approximately 229 million barrels of oil, most of which is in the Hakkari basin in the southeast of Turkey. These fields consist of small deposits which have tended to become depleted over the years, increasing extraction costs. However, approximately 20 oil companies in Turkey have been exploring for new deposits in southern and southeastern Turkey, in the European provinces, and in the Black sea shelf region.

3.2 Production and consumption

The main oil company is the government-owned Turkish State Petroleum Company (TPAO), which accounts for approximately 80% of Turkey's oil production. Royal Dutch Shell and Exxon Mobil produce most of the rest.

3.3 Refineries and downstream processing

Most of the oil refining in Turkey is done by the Turkish Petroleum Refineries Corporation (TÜPRAŞ), which owns four of the six oil refineries in Turkey. Recently, TÜPRAŞ was partially privatized in an IPO with 31.5% sold to investors for $2.3 billion. The other major refinery company in Turkey is Anadolu Tasfiyehanesi AS (ATAŞ), which is partly owned by Exxon Mobil (51%), Shell (27%), BP Amoco (17%), and the Turkish company Marmara Petrol (5%). Petrol Ofisi AŞ (POAŞ), the formerly state-owned petroleum distribution company, is now mostly privatized; 51% of POAŞ was sold to investors in 2000 in an IPO that raised $1.26 billion for the Turkish government. POAŞ currently operates most gas stations in Turkey.

A summary of Turkey's oil refineries is shown in Table 3.

Table 3. Turkey's petroleum refineries

Refinery	Owner	Location	Refining Capacity(1000b/d)
Izmit	TÜPRAŞ	Kocaeli	226,440
Aliaga	TÜPRAŞ	Izmir	226,440
Kirikkale	TÜPRAŞ	Kırıkkale	113,220
Mersin	ATAS	İçel	100,000
Batman	TÜPRAŞ	Batman	22,015
Narli	Narli PetroleumRefining	n/a	6,000

4 COAL

4.1 Reserves and mining

Turkey has both hard coal and lignite deposits. The hard coal is mostly located in the western part of the country, in the Zonguldak Basin, which has more than 700 million metric tons of workable reserves, about 80% of which can be coked. Lignite deposits are widespread and plentiful; reserves are estimated at more than 8 billion metric tons (7th largest in the world), most of which is economically mineable, though only about 7% has a heat content of more than 3,000 kilocalories per kilogram.

4.2 Production and consumption

The Turkish Hard Coal Institute operates five underground mines in Turkey, and is the only hard coal production entity in the country. The two most important lignite fields in Turkey -- the Afşin-Elbistan and Sivas-Kangal coal fields. But not enough coal is mined to meet demand. Turkey imports more than 16 million tons of hard coal each year, mostly from Australia, the United States, South Africa, and Russia. An historical summary of coal production and consumption in Turkey is shown in Table 4.

Table 4. Coal production and consumption in Turkey, 1990-2001 (in millions of tons)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Anthracite	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Bituminous	**3.33**	**3.20**	**3.35**	**3.17**	**3.13**	**2.48**	**2.69**	**2.77**	**2.38**	**2.19**	**2.49**	**2.60**
Lignite	**48.26**	**47.78**	**53.57**	**50.45**	**56.81**	**58.23**	**59.44**	**63.29**	**71.90**	**71.70**	**67.10**	**69.97**
Total Production	**52.58**	**50.98**	**56.93**	**53.62**	**59.93**	**60.71**	**62.13**	**66.06**	**74.28**	**73.90**	**69.59**	**72.57**
Total Consumption	**60.29**	**63.70**	**66.20**	**60.57**	**65.57**	**67.34**	**73.28**	**80.10**	**86.27**	**83.69**	**79.87**	**81.14**

5 NATURAL GAS

5.1 General

Natural gas is Turkey's preferred fuel for new power plant capacity for several reasons: environmental (gas is less polluting than coal, lignite, or oil); geographic (Turkey is located near to huge amounts of gas in the Middle East and Central Asia); economic (Turkey could offset part of its energy import bill through transit fees it could charge for oil and gas shipments across its territory); and political (Turkey is seeking to strengthen relations with Caspian and Central Asian countries, several of which are potentially large gas exporters). Natural gas transmission in Turkey is the responsibility of a state-owned Turkish pipeline company, BOTAŞ.

The 560 million cubic meters (mcm) of natural gas that was produced in Turkey in 2000 met only 3.8% of domestic consumption. The rest was imported either by pipelines or as liquefied natural gas (LNG). Turkey's natural gas consumption is expected to grow rapidly, quadrupling within the next 20 years, with 40 billion cubic metres (bcm) consumption projected for the year 2020. Presently, the largest share of Turkey's imported natural gas comes from Russia. However, Turkey is trying to diversify its sources, and is considering Turkmenistan, Kazakhstan, Uzbekistan, Egypt, Nigeria, Iraq, and Iran as possible sources. Under a 25-year deal signed in 1996, Turkey plans to buy 3 bcm of natural gas per year from Iran through 2007, after which the amount will increase to 10 bcm annually. In December 2001, gas deliveries from Iran finally began, after repeated delays. Gas purchases from Iran could total $23 billion over the life of the arrangement. An historical summary of natural gas production and consumption in Turkey is shown in Table 5.

Table 5. Dry natural gas production and consumption in Turkey, 1990-2001

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Production	111	66	31	23	2	-	-	-	150	299	154			
Consumption	3373	4132	4521	4952	5251	6793	7906	9721	1027	1238	1456	1602	1737	2150

(million cubic metres**)**

"Dry" gas means gas with condensates removed

5.2 Production and consumption

Turkey consumed 17,378 million cubic meter (mcm) of natural gas (nearly all imported) in 2002, accounting for around 17% of Turkey's total energy consumption (Turkish gas consumption in 2003 is estimated at around 21.5 bcm). To date, Turkey has signed deals for around 56 bcm per year of natural gas imports beginning in 2005. Of this total, over 20% is already coming from Russia via Bulgaria (studies on expanding the Russia-Bulgaria-Turkey "Main Line" are underway), 17% from Iran, and 9% from Algeria and Nigeria combined as liquefied natural gas (LNG). Turkey has one 3 bcm/year capacity LNG terminal, adjacent to the existing Marmara Ereglisi combined cycle gas turbine power station.

6 NUCLEAR

Turkey has no commercial nuclear power plant in operation. In July 2000, Turkey cancelled its plans for building a 1,400 mwe (mega watt electrical) nuclear power plant at Akkuyu Bay on its Mediterranean coast north of Cyprus. Prior to the cancellation, three international consortia were bidding for the $2.5 billion contract.

7 HYDROELECTRIC AND OTHER RENEWABLE ENERGY SOURCES

7.1 Hydroelectric power

Turkey has about 1% of the total world hydroelectric potential. There are many rivers in Turkey and five separate watersheds. Devlet Su Isleri (DSI), the General Directorate of State Hydraulic Works, is Turkey's state water agency, and has the responsibility for developing all of water resources in the country. As of the end of 2001, Turkey had 125 hydroelectric power plants in operation, ranging in size from the 2,400 megawatt (mwe) Atatürk Power Plant (presently the 6th largest capacity hydroelectric facility in the world) all the way down to many small facilities of less than 2 mwe in capacity. Most are owned and operated by DSI.

Hydroelectric power plants in Turkey currently account for about 40% of Turkey's electricity capacity. The Turkish government hopes to see hydroelectric capacity expanded to 35,000 mwe by the year 2010. Ultimately, the construction of more than 300 additional hydroelectric power plants are projected for Turkey to make use of the potential remaining hydroelectric sites; these have a potential of about 69,000 gigawatt-hours (gwh) per year. This long term plan would bring about an additional 19,300 mwe of hydroelectric capacity online at a cost of more than $30 billion. DSI is presently undertaking one of the largest water resources development projects in the world, the GAP or Southeastern Anatolian Project, which, when completed, will include 22 irrigation dams and an additional 19 hydroelectric power plants on the Tigris and Euphrates Rivers and their tributaries.

7.2 Wind energy

Turkey has a considerable potential for electricity generation from wind. A study carried out in 2002 concluded that Turkey has a theoretical wind energy potential of nearly 90,000 mwe and an economical wind energy potential of about 10,000 mwe. The most promising region is in northwest Turkey, including the area around the Sea of Marmara. Turkey has a goal of deriving 2% of its electricity from wind power and is now encouraging the construction of BOT wind power plants by private power developers.

7.3 Geothermal energy

Turkey, possessing one-eighth of the world's total geothermal potential, has significant potential for geothermal power production. Much of this potential is of relatively low enthalpy that is not suitable for electricity production but is still useful for direct heating applications. At the end of 1999, Turkey's total installed capacity for direct heating was 820 thermal megawatts (mwth), of which about 390 mwth provided heating for 51,600 residences, about 100 mwth provided heating for about 45 hectares of greenhouses, and about 330 mwth was used to provide heated water for about 200 spas. By 2010, as many as 500,000 residences could be heated by geothermal power, which would represent the use of about 3,500 mwth. Turkey hopes to generate 500 mwe from geothermal energy by the year 2010 and 1,000 mwe by the year 2020.

8 ENERGY CONVERSION, TRANSMISSION AND DISTRIBUTION

8.1 Oil pipelines

Turkey has tried to diversify its oil supply by participating in various pipeline projects, including ones through Iran. Besides pipelines, Caspian Sea oil for Turkey comes via tanker. This requires using the Bosphorus, the narrow strait that connects the Black Sea and the Sea of Marmara. The Iraq-Turkey Crude Oil Pipeline runs from Kerkük, Iraq, to the Ceyhan marine terminal in Turkey; it began operation in 1976. In 2000, 286 million barrels of oil were transported via the pipeline, which actually consists of two parallel pipelines, the first line 986 kilometres long and the second 890 kilometres. A map of Turkey's existing and planned oil and gas transmission pipeline system is shown in (Figure 2).

Figure 2. Turkey's existing and planned oil and natural gas pipelines.
Source: BOTAŞ

8.2Gas pipelines, terminals, and storage

There are several existing gas pipelines in Turkey. The Eastern Anatolia gas pipeline brings gas into Turkey from Iran and is the main natural gas pipeline in eastern Turkey; the pipeline presently extends as far west as Ankara. The 842-kilometer natural gas pipeline runs from Russia through the Ukraine, Romania, and Bulgaria into Turkey. An extension of this pipeline brings gas to Ankara and to Hamitabat, where it supplies a combined cycle power plant. In 1996, another 209-kilometer extension of this pipeline to the western Black Sea region called the Izmit-Karadeniz Ereglisi natural gas transmission line was finished, and following that, a 208-kilometer extension, the Bursa-Çan natural gas transmission line, was added to take the pipeline to the city of Çan. In 2000, a 107-kilometer extension to the port city of Çanakkale called the Çan-Çanakkale natural gas pipeline was completed.

8.3"Blue Stream" pipeline

The $3.3 billion Blue Stream pipeline, which will transport 16 billion cubic meters per year of natural gas 1,200 kilometres from Russia to Turkey, was completed in October 2002. The pipeline starts at Izobilnoye near Krasnodar in southern Russia and runs overland on the Black Sea coast 370 kilometres to Dzhubga. Construction of the deep-sea portion of the Blue Stream pipeline began in June 2002. The undersea portion consists of twin pipelines running 375 kilometers under the Black Sea from Dzhubga, Russia, to the Turkish port of Samsun; this undersea portion reaches a depth of 2,150 meters, making it the world's deepest pipeline. From Samsun, the pipeline then runs overland to provide gas to Ankara. The Blue Stream pipeline was jointly built by Russia's Gazprom and Italy's ENI, with each having a 50% share; the project was undertaken because of Turkey's 1997 agreement with Russia to buy 565 bcf (billion cubic feet) per year of natural gas. By 2009, Blue Stream had been expected to reach peak capacity of 565 bcf per year, but this is now somewhat doubtful given Turkey's lower gas demand forecasts. Over the course of the 25-year agreement signed in December 1997, Turkey was to import 14.1 tcf of natural gas from Russia via Blue Stream, with the pipeline eventually extended to other Mediterranean countries, including Greece.

In March 2002, Turkey signed a $300 million deal with Greece to extend an Iranian natural gas pipeline to Greece. The pipeline will go 125 miles inside Turkey and cross the Dardanelles Straits into Greece. This will extend the pipeline from Karacabey in western Turkey to the city of Komotini in northeastern Greece. The pipeline is expected to carry 17.5 bcf of gas per year, and could be completed by 2005.

Besides pipelines, Turkey also receives imported natural gas in the form of LNG. There is a terminal at Marmara Ereglisi on the Sea of Marmara. This terminal has the capacity to provide 105 bcf per year of LNG from Algeria.

9 ELECTRICITY

9.1 Installed capacity

Turkey's rapid growth in electricity demand, which has led to almost a doubling of installed generating capacity over the past decade, is expected to continue for the foreseeable future. A summary of installed electricity generating capacity in Turkey is shown in Table 6.

Table 6. Installed electricity generation capacity in Turkey, 1990-2001

(in thousands of mwe)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Hydroelectric	6.60	6.76	7.11	8.38	9.68	9.87	9.86	9.94	10.10	10.31	10.54	11.18
Nuclear	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Geothermal/Solar/ Wind/Biomass	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.04
Conventional Thermal	9.19	9.54	10.08	10.32	10.64	10.98	11.07	11.30	11.77	13.02	15.56	16.05
Total Capacity	**15.81**	**16.32**	**17.21**	**18.71**	**20.34**	**20.86**	**20.95**	**21.25**	**21.89**	**23.35**	**26.12**	**27.26**

9.2Generation and consumption

Net electricity generation in Turkey has more than doubled over the past decade, but is not sufficient to keep up with expected demand. An historical summary of electricity generation and consumption in Turkey is shown in Table 7.

Table 7. Electricity generation and consumption in Turkey, 1990-2001 (in billion kwh)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Net Generation	55.2	57.8	64.7	71.1	75.2	82.9	91.2	99.1	106.5	111	119	116.6
hydroelectric	22.9	22.52	26.3	33.6	30.3	35.2	40.1	39.4	41.8	34.3	30.6	23.8
Nuclear	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
geo/solar/wind/biomass	0.1	0.1	0.1	0.1	0.1	0.3	0.2	0.4	0.3	0.3	0.3	0.4
conventional thermal	32.3	35.2	38.2	37.3	44.7	47.4	50.9	59.3	64.3	76.6	88.1	92.4
Net Consumption	50.6	54.0	60.0	65.7	69.4	76.4	84.7	94.4	102.0	105.	114.	112.6
Imports	0.2	0.8	0.2	0.2	0.0	0.0	0.3	2.5	3.3	2.3	3.8	4.6
Exports	0.9	0.5	0.3	0.6	0.6	0.7	0.4	0.3	0.3	0.3	0.4	0.4

9.3 Industry overview

A very large increase in electric generating capacity over the next twenty years has been planned in Turkey. As shown in the Table 8, the largest growth is planned for natural-gas fired generation.

Table 8. Electric power capacity development in Turkey

Fuel Type Note: 1 GWh = 1,000 MWth = 1 million kWh	**2010**		**2020**	
	InstalledCapacity (MWe)	**Generation (GWh)**	**Installed Capacity (MWe)**	**Generation (GWh)**
Coal	16,106	104,035	26,906	174,235
Natural Gas	18,856	125,548	34,256	225,648
Fuel Oil & Diesel	3,125	17,993	8,025	49,842
Nuclear	2,000	14,000	10,000	70,000
Hydro & Renewables	24,982	85,719	30,031	104,043
Total	**65,069**	**347,294**	**109,218**	**623,768**

Presently there are five fossil-fuelled power plants in Turkey with generating capacities greater than 1,000 mwe. The largest of these is the 1,400 Bursa combined cycle power plant, located near the village of Ovaakca in Bursa province. Many other thermal-electric power plants are under construction or in the planning stages. Five of these will be greater than 1,000 mwe capacities. Cogeneration of combined heat and power (CHP), or "auto production" as it is known in Turkey, has been advanced by governmental support and the continuing need for additional electricity generation within Turkey. As late as 1994, there were only four cogeneration plants in operation, with a total capacity of only 30 mwe. Since then, incentives were offered in the form of a 100% tax deduction and duty exemptions for auto production facilities and guaranteed purchasing of any surplus electricity by TEDAŞ. These improved the climate for cogeneration in Turkey so much that by mid 2001, there were 90 operating cogeneration plants (with a total capacity of 2,400 mwe), 55 cogeneration plants under construction (with an additional capacity 2,060 mwe), and 153 cogeneration plants (representing another 10,400 mwe) under evaluation by the Ministry of Energy and Natural

Resources (MENR). Many of these are or will be located in so-called "organized industrial zones" or "OSBs." The total installed cogeneration capacity is expected to reach up to 6,000 mwe by 2005, which would represent about 20% of Turkey's total installed electricity generating capacity.

10 ENVIRONMENTAL ISSUES AND CONCERNS

Turkey's installed thermoelectric generating capacity has doubled since 1987, and with that came an increase in air emissions, though not a doubling. Historical and projected anthropogenic sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and non-methane volatile organic compounds (NMVOCs) emissions in Turkey are shown in Table 9.

Table 9. Anthropogenic air emissions in Turkey, 1990-2010 (in thousands of metric tons)

Component	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2010
SO2	765	841	821	768	992	1,016	1,172	1,234	1,361	1,347	995
NOx	628	633	651	731	715	777	847	852	834	911	2,044
CO	3,130	3,110	3,225	3,460	3,363	3,552	3,684	3,722	3,644	3,607	10,986
NMVOCs	462	457	479	527	516	581	613	620	615	613	1,925

Source: EMEP (Cooperative Program for the Monitoring and Evaluation of Long-Range Transmission of Air Pollutants in Europe) - Oslo, Norway Projections for 2010 from Gothenburg Protocol.

Turkey has made much progress over the last two decades in setting up infrastructure for addressing its environmental problems -- an environment law was enacted in 1983 and the Ministry of Environment was created in 1991. There are also non-governmental environmental organizations that have emerged. Turkey is a party to many international environmental agreements, including Air Pollution, Antarctic Treaty, Biodiversity, Desertification, Hazardous Wastes, Nuclear Test Ban, Ozone Layer Protection, Wetlands, and Ship Pollution. An historical summary of CO_2 emissions from fossil fuel use in Turkey is shown in Table 10.

Table 10. Fossil fuel-related carbon dioxide emissions in Turkey, 1990-2001
(in millions of metric tons of carbon)

Component	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CO2 from coal	16.08	18.47	17.16	16.19	15.59	15.97	18.48	22.05	22.84	20.85	20.08	19.44
CO2 from natural gas	1.82	2.22	2.43	2.71	2.88	3.71	4.47	5.34	5.66	6.71	7.95	8.49
CO2 from petroleum	17.35	16.94	17.94	20.27	19.40	21.51	22.82	21.99	21.13	21.36	22.15	22.14
Total CO2 from all fossil fuels	**35.26**	**37.63**	**37.53**	**39.17**	**37.87**	**41.19**	**45.76**	**49.38**	**49.63**	**48.91**	**50.18**	**50.07**

Note: components may not add to total due to rounding.
Source: DOE/EIA.

The CO_2 intensity of energy in Turkey is higher than the OECD average and the CO_2 intensity of GDP is fairly high. Although it is lower than the OECD average, some room exists for improvements both in the energy efficiency of the economy and in CO_2 intensity.

Therefore, either of the last two options outlined above could be viable, and environmentally beneficial. As the climate debate remains a high-profile international issue – and is likely to its future entry into the European Union – the government will need to consider the implications of these options as it develops a domestic energy policy. In the interim, a wide variety of greenhouse gas emissions reduction policies and measures is available: energy efficiency and conservation measures, increasing the shares of new and renewable energy sources in the energy supply base, switching from high- to low-carbon fuels (e.g. from coal to gas), adoption of emissions

Turkey has substantial renewable energy resources--especially hydroelectric power--and it is currently constructing a series of dams and hydroelectric power plants. As Turkey looks towards possible European Union membership, it will need to continue utilizing this cleaner energy as a means to achieve sustainable economic development. Turkey also has a great degree of potential for energy efficiency improvements.

11 REGIONAL ISSUES AND DEVELOPMENTS

11.1 Trans-Caspian gas pipeline (TCGP)

On May 21, 1999, Turkey's state natural gas and pipeline company BOTAŞ signed an agreement on building a \$2-\$2.4 billion, 1,050-mile, gas pipeline from Turkmenistan, underneath the Caspian Sea, across Azerbaijan and Georgia (both of which would collect transit fees), and on to Turkey. Gas deliveries of 565-1,060 bcf per year are possible, with additional gas possibly being sent onwards to Europe. The consortium is led by US Company Bechtel and includes General Electric, Shell, and PSG International. A top Turkish energy official stated that the Trans-Caspian Gas Pipeline (TCGP) from Turkmenistan was still the preferred option for Turkey despite the potentially huge (as high as 35 trillion cubic feet -- tcf) Shah Deniz gas field in Azerbaijan, which is located hundreds of miles closer (and on the western side of the Caspian Sea) to Turkey than Turkmenistan. Currently, however, progress on the TCGP appears stalled indefinitely, with the international consortium essentially having suspended operations, and with Turkey already oversupplied with gas from Iran and Russia ("Blue Stream").If Turkish demand does not support the level of natural gas imports for which it has contracted (from Iran and others), Turkey could become an important transit centre for natural gas exports to Greece and beyond.

11.2 Greece and beyond

Along these lines, Greece and Turkey signed a binding agreement in late February 2003 which calls for extending the natural gas pipeline from Iran to Turkey into Greece. Reportedly, the 177-mile-long pipeline will go 125 miles inside Turkey and cross the Dardanelles Straits into Greece. This will extend the pipeline from Karacabey in western Turkey to the city of Komotini in northeastern Greece. The pipeline is expected to carry 17.5 bcf of gas per year, and could be completed by 2005.

11.3 South Caucasus (Baku-Tbilisi-Erzurum) pipeline

After months of negotiation and delay, Azerbaijan and Turkey signed a long-term natural gas purchase and supply contract on March 12, 2001 (granted final approval on the Turkish side in February 2003). Starting in 2006, two years later than the original target date, Azerbaijan is to deliver 70 bcf of natural gas to Turkey, rising to 177 bcf in 2007 and around 230 bcf per year from 2008 through 2020. Natural gas for the deal is to come mainly from Azerbaijan's \$3.2 billion, BP-led Shah Deniz Phase I field development project (given the financial green light in February 2003). To transmit the gas, the \$900 million South Caucasus (Baku-Tbilisi-Erzurum) pipeline would stretch some 630 miles, including 290 miles in Azerbaijan and approximately 170 miles in both Georgia and Turkey.

11.4 LNG from Egypt

Egypt, with huge gas reserves of its own, represents yet another possible source of gas for Turkey, either by pipeline or via LNG tanker. This latter option would include construction of a $1.2 billion liquefaction terminal near Port Said on the Mediterranean coast, and a degasification facility at Aliaga (near Izmir) in Turkey.

11.5 "BTC" oil pipeline

In 1998, Georgia, Azerbaijan, Kazakhstan and Turkmenistan signed an agreement to build an oil pipeline from the Caspian Sea across Georgia and Turkey to western markets; this pipeline would go from Baku (in Azerbaijan) via Tbilisi (in Georgia) to Ceyhan (in Turkey). This so-called "BTC Pipeline" is estimated to cost about $1.4 billion, with major investors including BP Exploration (38%), SOCAR-Azerbaijan (25%), and six other oil companies, including TPAO. This pipeline would carry 1 million barrels of oil per day; the total length will be 1,730 kilometres, of which 1,070 kilometres will be in Turkey. It is expected that 30% of the pipeline cost will be financed by the investors with the remaining 70% will come from the US Exim Bank, Japan's Exim Bank, the International Finance Corporation, and the EBRD. The Host Government Agreements were signed with Azerbaijan, Georgia, and Turkey in October 2000. Construction of the BTC pipeline began in September 2002 and it is expected to be completed within 32 months. Turkish pipeline company (BOTAŞ) is the turnkey contractor for the construction of the pipeline within the Turkish territory.

12 ENERGY POLICY AND ITS IMPLICATIONS

12.1 The National Energy Policy

The National energy policy should aim to raise the living standards of the people by working to fully integrate its energy, environment and economic policies. The policy is a long-term, comprehensive strategy. The policy will encourage cleaner and more efficient energy use. Its national goals may be summarized as: To introduce new and environmentally friendly technologies to increase energy supplies, To modernize conservation by; increasing energy efficiency through applying new technologies and raising productivity, reducing waste, and trimming the cost, To modernize energy infrastructure, To accelerate the protection and improvement of the environment, and To increase the energy security of the nation.

12.2 Targets to be achieved

Turkey has been pursuing policies in order to meet its expanding energy need based on diversified, reliable and cost-effective supply sources. The gap in Turkey's energy supply and demand is one of the key elements which determine its energy policy. As a country with an emerging and rapidly growing economy, Turkey's primary energy consumption which was 77 million tones of oil equivalent (mtoe) in 2000 is expected to reach 179 mtoe by 2010, and 319 mtoe by 2020.

12.2 Policy objectives

The main objectives of Turkish energy policy are:

- In meeting the demand domestic energy resources has the highest priority. This is to be achieved through a mix of public, private, and foreign capital.
- Existing sources are to be developed while accelerating the penetration of new and renewable sources.

- In order to avoid dependence on energy imports from a single source or country, energy sources must be diversified.
- Privatization in the power industry and Private Sector investment must be encouraged.
- Preparations are to be made for the introduction of nuclear power.
- The reliability of electricity supply must be enhanced through upgrades in the power transmission and distribution grid as well by accelerating capacity construction
- Energy efficiency in end use and transformation should be achieved through reduction of losses in energy production, transmission and consumption.
- The protection of the environment and public health should be given priority
- Turkey's geopolitical location to establish the country as a pivotal transit area for international oil and gas trade ("Eurasia energy corridor").

12.3 Energy institutions

- **Ministry of Energy and Natural Resources (MENR)**: Established in 1963 and reports directly to the prime minister.
- **Research, Planning and Co-ordination Board**
- **Directorate-General of Energy Affairs.**
- **Directorate-General of Mining Affairs**
- **Directorate-General of Petroleum Affairs (PIGM).**
- **Electric Power Resources Survey and Development Administration (EIEI)**

The following state-owned companies and Institutions are active in the energy market:

- **Turkish Electricity Generation and Transmission Corporation (TEAS**
- **Turkish Electricity Distribution Corporation (TEDAS)**
- **State Hydraulic Works (DSI)**
- **Turkish Coal Enterprise (TKI)**
- **Turkish Hard Coal Enterprise (TTK)**
- **Turkish Petroleum Corporation (TPAO)**
- **Turkish Pipeline Corporation (BOTAS)**
- **Turkish Petroleum Refining Company (TUPRAS)**
- **Turkish Atomic Energy Authority (TAEK)**
- **The State Planning Organization (DPT)**

12.4 Economic problems and reforms

Since the establishment of the Republic, there have been attempts to industrialize and modernize the country. As a result, modern industries today coexist with pockets of subsistence farming. Major cities of western Turkey are cosmopolitan centres of industry, finance and trade, whereas the eastern part of the country is comparatively underdeveloped. Because of the apparent imbalance in the opportunities, there has been massive migration from the depressed parts of the country to the urban centres of western Turkey over the last decades.

Between about 1930 and 1980, successive governments have concentrated their efforts on industrialization through publicly-owned State Economic Enterprises (SEEs) which accounted for some 40% of total manufacturing output in 1980. The main policy of economic development was the replacement of foreign imports by domestic goods. That policy has resulted in a relatively closed economy, inertia in developing export industries, and persistent trade deficits. SEEs, were often overstaffed and inefficient. In many cases they accrued losses that were a significant drain on the government's budget. In spite of these drawbacks, industrial development was relatively rapid. Turkey was severely affected by the oil price increase of 1973. In the years following the first oil crisis, economic conditions deteriorated, with high unemployment, a nearly fivefold increase in the balance of payments deficit between 1973 and 1979, large external debt and annual inflation rates exceeding 100% in 1980.

Even prior to its recent economic crisis, Turkey faced numerous economic challenges, including: a large "underground" economy (estimated at 30%-100% the size of the reported economy); sharp income inequalities (between urban and rural areas in particular); low levels of private investment (Turkey hopes to increase this dramatically); a large, inefficient state sector; overly complicated legal and administrative procedures; a lack of foreign investment; and a failure to generate sufficient jobs for the country's rapidly growing population.

To redress the situation, a series of stabilization programme was undertaken with support from the International Monetary Fund (IMF). A decisive step was taken with the 1980 economic reform programme to open the Turkish economy to international markets. Under this programme, the government's role in the economy was reduced, subsidies and price controls were cut back, the financial sector was liberalized and foreign exchange controls were lifted, exports and foreign direct investment were encouraged and monetary policies and exchange rates were adapted to match this strategy of opening. A privatization programme was launched in 1985.

The reform programme was successful in restoring economic growth, fostering foreign trade and reducing external deficits to a certain degree. The share of exports in GNP which was stagnant at 3-5% level before 1980 rose to 13% in 1988, while imports rose from about 12% to almost 16%. The economy has also undergone a significant shift away from agriculture towards the industrial and the services sector in the last three decades, share of agriculture in the GNP went down from 25% in 1980 to 13% in 2000 although some 30% of the active population is still employed in agriculture.

Yet a number of factors, especially unsustainable fiscal and economic policies, resulted in persistently high inflation rates, leaving the Turkish economy vulnerable to external shocks such as the 1991 Gulf War, which isolated Turkey from some of its conventional regional trading partners. Although government debt was less than 60% of GDP and therefore of tolerable size in principle, at these interest rates the cost of debt service became very large, leading to renewed strain on public finances and renewed public sector borrowing.

Despite the high inflation, GDP grew relatively robustly at an average rate of 5% between 1983 and 1998. However, GDP growth was cyclical with bouts of vigorous growth, interrupted by sometimes severe recessions triggered by financial instability or deflationary policies. As a result, real GDP per capita grew at an average rate of 1.5% over the 1990s, below the OECD average, below Turkey's growth potential, and below the rates of some other emerging economies.

The chronic high rates of inflation and ever growing size of public debts have been two major economic concerns of Turkish governments. Inflation has been a continuing problem for long, and Turkey also has a high foreign debt burden Throughout the last decades, successive Turkish governments have embarked upon programmes to reduce inflation and stabilize Turkey's macro-economic performance. In many cases, these programmes involved IMF support (stand-by arrangements) and contained plans to privatize SEEs, with the purpose of carrying out structural, micro-economic reform and opening the economy to the private sector, as well as raising revenue needed for fiscal rebalancing.

The $5.6 billion that was secured from privatization agreements in the year 2000 alone equalled the total amount that had been collected from privatization between 1986 and 1999. The government remained strongly committed to the programme and announced its intention to accelerate the pace of privatization in 2001. Of the amount secured in 2000,$3.5 billion was actually collected that year, and of that amount, some $300 million was from the transfer of operating rights for power plants. Inflation had overshot the target but was lower than at any time since the mid-1980s. Renewed, relatively strong GDP growth of about 7% completed the relatively favourable result for 2000.

Turkey's economic situation further deteriorated after 2001 due to serious banking sector problems, current account deficiencies, political mismanagement and corruption. A crisis erupted in the form of liquidity problems in the banking sector, presumably because of a widening current account deficit and delays in the privatization programme. A massive outflow of foreign capital threatened to jeopardize the economic recovery and the success of the stabilization programme. On 22 February 2001, the government was forced to abandon the exchange rate controls, and the Turkish lira was devalued by more than 78%. Further reform and adaptation of Turkey's economic institutions were under way. In particular, the government began taking anticorruption actions in early 2001, leading to investigations into the energy sector, especially in tendering and licensing.

On July 18, 2002, the IMF stated that Turkey's economic stabilization and reform program was "broadly on track," although this appears optimistic given the country's difficulties meeting its fiscal targets. Turkey has pledged to cut state spending and subsidies, reform the country's banking sector, accelerate privatization of state-owned industries, lower the inflation rate, reduce the country's heavy debt burden, and in general create "a stable macroeconomic environment conducive to economic growth.

The government also committed to a range of structural reforms spanning the agricultural, banking and energy sectors, and including reform of the social security and tax systems. Turkey's real GNP is expected to grow by about 4.1%, with an inflation rate of 24%.

12.5 The Development of the energy sector

During the last three decades or so the rate of increase in the consumption of the primary sources of energy in Turkey has been 3.8%. While the Indigenous sources of energy supply has grown by 1.9%.

Consequently the gap between demand and supply has grown rapidly. The share of indigenous supply which was 48% of total demand has fallen to 33% in 2000. The imported Primary energy which was 26 million toes in 1990 has reached to 50 million toes in 2000 which represent an annual rate of increase of 7%. The composition of imports has also changed. In 1990 imports the share of Oil, Hard Coal and Natural Gas were 75%, 14% and 11% have been changed in 2000 as 57%, 12% and 31%.

12.6 Energy sector problems

The energy sector is operated by government controlled organizations and institutions. There are too many regulatory organizations that cause complexities, delays and losses.

In the financing of the future investment of the energy sector it is estimated that a total investment of 300 billion US$ may be needed. In arranging that investment, the sources of government institutions are far from being adequate. Furthermore those institutions are not effective and nor flexible enough to render the needed service. Consequently full fledged privatization of public organizations of energy sector is an urgent necessity.

The obstacles to the energy sector's proper development cannot be confined to economic, financial and technical aspects only. There are important organizational, constitutional, and Legal obstacles as well.

The production of energy is a commodity production activity which can not be qualified as a public service. Consequently the Constituonal and Legal barriers that prevent the involvement of private sector in Energy sector must be removed. For the achievement of a full fledged Liberal Economic framework of a free Competitive market, the model of BOT (Build Operate Turnover) should be converted to BOO (Build Own Operate) and the model of TOR (Transfer Operating Rights) should be converted to TPR (Transfer Property Rights).

The present "Petroleum Law" which regulates petroleum activities of foreign companies in Turkey has, by time, lost its attractiveness to explore oil in Turkey. On the other hand Oil exploration in Turkey has proven to be a highly risky, costly and high technology demanding involvement. Because of that a revision of the present law to make Turkey attractive for foreign oil companies has become a necessity.

Since Turkey is targeting to be a full member of the European Union (EU) eventually, everything related to its energy policy and its implementation should be in full compatibility with EU system

12.7 Electric energy

The Consumption of Electric energy has been the fastest growing element of the energy Sector. Between 1980 and 2000 the average annual growth rate was %8.7 which corresponds to the doubling of the total consumption every 7.5 years. The share of electricity in the TPEC which was about8-9 % in 1990 has reached to 14% in 2000. The primary source distribution of power generation is 80% Thermal (30% Coal, 10% Oil and derivations, 40% Natural Gas. 67% of generation capacity is thermal and 43% is hydro. In recent years because of not keeping pace of hydro generation capacity development with the growth of the demand, the construction of, "rapidly commissioned" Natural Gas Power Plants were given priority.

12.7.1 Policy implications

For Electricity following policy implications have been identified:

- Some Indigenous Primary energy resources (Hydraulic, Lignite, and Wind) are having large potential and they have not been properly exploited. Turkey estimates that there are potential indigenous sources for 246 billion kilowatt-hours (kwh) per year of electric power generation (105 billion kwh from lignite, 16 billion kwh from hard coal, and 125 billion kWh from hydroelectric resources). Special incentives to open-up the rapid and large scale exploitation of those resources should be developed and implemented. Special incentives for the exploitation of renewable resources should be developed.
- The efficiency of power consumption is much lower than that of the EU Countries. The efficiency should be raised by; reducing the waste, trimming the cost and applying new technologies to raise the productivity.
- Through the use of BOO and TPR and giving priority to large scale Hydropower Station and providing special unit prices to enable the investors to overcome the financial burdens of the first 10 years provide a strong incentive for rapid and large scale development of Water Power Resources.
- The energy sector institutions and companies should be restructured (including privatization) as to render a highly streamlined joint operation of a free and competitive energy market. Private enterprise should be actively involved and participate in decision making processes.
- The construction of mini and minor power stations based on indigenous primary resources should be speeded up by special incentives (cost-tariff guaranties). The production of machinery and equipments of those power stations by local means should be also given incentives.
- The construction and operation standards of national power grids should be raised to EU levels and full integration with European power network should be given high priority.

12.8 Energy sector restructuring

Turkey has been studying electric restructuring since 1997 in an effort financed by the World Bank. The proposed structure would move most generation into the private sector, with a state generation company retaining the authority to run nuclear power. It is also planned that the regional distribution companies will be privatized. However, earlier efforts to privatize regional distribution systems are still in negotiation; none of the regions has yet completed a transfer to the private sector.

Following the adoption of the 2001 electricity market law, the electricity market was opened in 2002 to around 20%. However, limitations on the possibility for eligible customers to import from producers outside Turkey, as well as for generators to export power to customers outside Turkey, have not been lifted.

Turkey has also set up an energy regulatory board to monitor the energy sector. It should be noted that the adoption of the two key laws and the establishment of an energy regulatory board were conditions for IMF (International Monetary Fund) support for Turkey. In general, Turkey's priority in restructuring the energy sector is to attract investment and reduce State control. The two new laws have paved the way for this but there still remains much to be done.

12.9 Energy sector's compatibility with the European community

Efforts had to be made to ensure the compatibility of the sector with the European community internal energy market. The European strategy gave high priority to the approximation of laws in this sector. The first step towards this objective was to draw up a detailed inventory of the existing legislation.

The 1999 Report emphasized that the objectives of Turkish energy policy were largely in line with those of the EU. They were concerned with security and diversification of sources of supply, market principles, environmental standards and improving efficiency. The modification of the constitution, which paves the way for privatization, and international arbitration procedures have been important steps forward in this connection. A list of Turkish and Community legislation in this field drawn up by Turkey with a view to alignment on the *acquis*[1] will be evaluated by the commission. Much still remains to be done in this area.

The October 2002 Report emphasized that Turkey has made significant progress in further aligning its legislation with the EU *acquis* in this area, particularly in the internal energy market.

Turkey has made progress with aligning on the *acquis* and in its preparations for the internal energy market through the adoption of two major framework laws for the electricity and gas sectors concerning in particular restructuring and the players in the sectors. The laws provide for the opening up to competition and the private sector of certain aspects of the energy market such as electricity generation and distribution. The state still has control over certain aspects of the energy market. Despite these advances, major aspects of community legislation concerning the internal energy market are not covered by the two laws, e.g. provisions concerning access to networks. They should be aligned to a greater extent on the two key community directives concerning the internal energy market establishing common rules for the internal electricity market (Directive 96/92/EC) and the internal gas market (Directive 98/30/EC). International Energy Agency (IEA) which is a subsidiary of OECD has

---

[1] **European Community Acquis:**

The fundamental components of Community law in the energy sector are the provisions of the Treaty and Community secondary legislation, referring, in particular, to competition and State aid, to the internal energy market - notably the directives on electricity, transparency of prices, gas and electricity transport, hydrocarbons, the granting of licences, emergency intervention measures and, in particular, obligations concerning emergency stocks, etc. - and to nuclear energy, energy efficiency and rules on respecting the environment. Community legislation in the field of nuclear energy comprises a framework of regulatory and political instruments which include international agreements. It currently covers the issues of health and safety (particularly radiation protection), the safety of nuclear plants, the management of radioactive waste, investment, the promotion of research, the creation of a common nuclear market, and the questions of supply, safeguards and international relations. The Association Agreement between the Community and Turkey and the Additional Protocol of 1970 set out the major objectives of this Association which include, among other things, the establishment of a customs union in three successive stages. The achievement of the final phase of the customs union on 31 December 1995 required Turkey to incorporate a significant amount of established Community law into its legislation, particularly in all the fields connected with the functioning of the customs union (customs, trade policy, competition and protection of intellectual, industrial and commercial property). The transposition of the Community *acquis* in other areas will be achieved through the implementation of the European strategy proposals.

The European strategy for Turkey (adopted by the Communication of 4 March 1998) provides for the stepping up of cooperation and the harmonization of legislation with the *acquis* in certain areas. It contains the first operational proposals with respect to this matter. This strategy was welcomed by the Cardiff European Council, which invited the Commission to carry it forward and to table any proposals deemed necessary for its effective implementation. The European strategy covers the energy sector. Where **security of supply** is concerned, Turkey has already introduced major measures and its oil reserves are more or less at the level of the 90 days required by the *acquis*. Turkey also has an important role to play in the EU's security of supply since it is a transit country for oil and gas from the Caspian Sea, the Black Sea and Central Asia. The construction of the Blue Stream gas pipeline to bring natural gas from Russia to Turkey is continuing. In 2002, Turkey has taken steps to further diversify its supply resources and to strengthen its role as a transit country for the transportation of oil and gas. Implementing legislation on Gas Market Licensing was issued in September 2002.

provided a full evaluation of Turkish energy sector. A summary of the recommendations of that comprehensive work is given in Appendix A.

12.9 Privatization

The energy sector in Turkey used to be dominated by dtate-owned companies. Turkey had to open up the energy sector to foreign investment in order to meet the increasing demand for energy consumption. A privatization programme was nevertheless devised with a view to privatizing areas such as coal, oil, electricity and gas.

Turkey's Electricity Market Law went into effect in March 2001. This law sets up a path toward a free market in power generation and distribution. Under the law, the state-owned Turkish Electricity Generation and Transmission Corporation (TEAŞ) was split into separate state-owned companies for electricity generation (TEUAŞ), electricity transmission (TEIAŞ), electricity distribution (TEDAŞ), and electricity trade (TETAŞ). Eventual privatization of the generation and trade companies is expected, but transmission of electricity will continue to be run by the state. The new law also set the stage for a new organization, the Energy Market Regulation Agency (EMRA) that oversees the power and natural gas markets, including setting tariffs, issuing licenses, and assuring competition.

The Energy Market Regulatory Board, which runs the EMRA, was commissioned on November 19, 2001. In May 2002, the EMRA issued drafts of the Energy Market Licensing Regulation and the Electricity Market Tariffs.

In 2001, the Turkish parliament passed a law which will eventually privatize most of BOTAS, the state-owned natural gas company. By 2009, the law would split BOTAŞ into separate units for gas importation, transport, storage, and distribution. Eventually, all the units except transport would be privatized. The plan is to sell off 10% of the BOTAŞ market share each year, leaving only 20% at the end.

12.10 Financing models and ownership issues

Turkey expects a very large growth in energy demand as its economy expands, especially for electricity and natural gas, and has adopted a policy of encouraging foreign investment in power plants and natural gas pipelines to meet the anticipated demand. Three models were offered: "Build-Operate-Transfer" (BOT), "Build-Own-Operate" (BOO), and "Transfer of Operating Rights" (TOR).

Turkey was among the first countries to introduce the BOT system in 1984, through the Electricity Act (Law No. 3096). The BOT system is not restricted to electricity or energy projects; it is also used for other infrastructure investment such as motorways, bridges, tunnels or water treatment plants. Under this model, private investors build and operate power plants. After remaining in private ownership for a number of years corresponding to the economic lifetime of the investment (typically 15 to 20 years), these power plants are transferred to state ownership, i.e. to TEAŞ under current arrangements. Turkey's Ministry of Energy and Natural Resources (MENR) had intended that most of the new power plants would be built by foreign developers on a BOT basis. But between 1984 and 1996, only six power plants with a total capacity of slightly less than 400 MW were actually built under this system: five small hydro plants and one combined-cycle gas turbine (CCGT).

In the early 1990s, the continued vigorous growth in electricity demand reinforced the government’s interest in encouraging BOT construction projects. To this end, the 1984 Electricity Act was complemented by the 1994 BOT Law (Law No. 3996). The BOT Law contains a number of provisions that were designed to encourage BOT investment. These include exemptions from customs duties and deferral of VAT payments on certain types of imported equipment. Most importantly, the law provides that the Turkish Treasury can back up the power purchase contracted between the BOT investor and TEAŞ or TEDAŞ with a

Treasury guarantee[2]. At the end of 1999, despite a large number of plans for BOT projects and numerous applications by foreign investors, only 14 BOT power plants with a total capacity of about 1,600 MW were operating; a further nine projects with a combined capacity of some 990 MW were under construction, vastly less than anticipated. Turkey's project for a first nuclear power plant at Akkuyu, launched repeatedly under BOT design, failed three times. The reasons for this failure are complex.[3]

A similar concept for privatization is the TOR, where a private developer or consortium receives a power plant in exchange for a transfer fee (usually set via a bid process), then operates and maintains the facility as necessary during the predetermined transfer term. At the end of that term, the power plant is transferred back to the state without any further cost or additional requirements. It had been anticipated that many of Turkey's existing power plants could be privatized in this manner, but the IMF is against this approach because of the time limits imposed on the operating rights. Instead, the IMF favours a "full privatization" approach, and may insist on this as a condition for providing Turkey any funds. So far, only two power plants have been privatized under the TOR approach. The BOO approach has been more favourably received by power developers, as this does not impose any time constraints on the project. As a result, the economics of power production is usually more favourable than for the BOT approach, which results in a lower cost of power generation.

12.11 Pricing and taxation of energy

To alleviate the effects of oil price fluctuations and the pronounced exchange rate fluctuations of the Turkish lira against the dollar on domestic oil prices, the government linked this tax to a pre-existing mechanism, called the Fuel Price Stabilization Fund (FPSF), as of 5 February 2000. The FPSF was established through Decree No 98/10745 of 1 July 1998. The purpose of this fund is to stabilize domestic oil prices. The Fuel Price Stabilization Fund is financed through a compensatory FPSF tax. The tax rate fluctuates and is inversely proportional to developments in international oil prices and the exchange rate of the Turkish lira against the dollar. The tax does not apply to fuels used in generating electricity. Ex-refinery ceiling prices are now linked to CIF Mediterranean product prices. The ceiling price changes if the rolling seven-day average of the import price rises or falls more than 3%. When end-user oil product prices do not rise as rapidly as crude oil prices, payments are made from the FPSF to reimburse refiners' and retailers' revenue shortfalls. The fund is financed through the FPSF tax, especially during periods of low oil prices when the tax rate is high. Through this change, oil product prices were linked to international market prices and short-term fluctuations were limited to a price band. Ex-refinery prices, distributor and retailer margins are also indexed to

---

[2] However, in late 2000, Turkey suffered an economic crisis when several major banks failed. As a result, Turkey announced a new policy of no longer offering sovereign guarantees to finance future BOT power plant construction, and reduced to 10 years from 20 the guarantee period for cost recovery. This changed the financial picture so much for 29 projects that had already received approvals that none of them have proceeded.

[3] There have also been legal problems with the BOT concept. Turkish courts have ruled that BOT projects are "concessions" and are subject to judicial review, though it is possible that Turkey's 1999 constitutional amendments may place limits on any reviews. Under Turkish law, private investment in public utilities is considered a government concession. According to the constitution, all government concessions were until recently based on public administrative law, not private law, and subject to review by Turkey's Administrative High Court, the Danıştay (sometimes also referred to as the Council of State). Under Turkish law, the Danıştay is also responsible for dispute settlement. All types of BOT projects listed in the 1994 BOT Law were automatically defined as concessions. These legal arrangements significantly reduced the number of foreign-financed BOT projects, compared to the government's expectations, and the number of applications by investors. Not only did review by the Administrative High Court slow down the approval process, which could be very long – obtaining the Danıştay approval could take years. The Danıştay could also revise contracts. In numerous cases, the Danıştay fundamentally changed contracts that foreign investors had spent years negotiating. A number of projects also received unfavorable assessments by the Court. Following an unfavorable Danıştay assessment, the State Planning Organization would block the Treasury guarantee, which would generally lead to investor withdrawal and, ultimately, to failure of the project. This was the case for the Akkuyu nuclear power plant, as well as for other energy projects, including three wind farms, in 1998.

the U.S. dollar in order to protect refineries, distributors and retailers, as well as tax revenues, from the effects of inflation. The purpose of this measure was to enhance price stability and predictability, as well as to eliminate the economic disadvantage of the inland refineries caused by transportation.

Refineries, distributing companies and retailers are free to compete below the ceiling price. In 1999 and early 2000, the FPSF tax was applied only to diesel, and the rate was very low (about 1% of the end-user price). The reason for this was the high volatility of crude oil prices at the time. By applying this low-rate tax, the government tried to relieve the burden on ultimate consumers

Turkey ranks fourth-highest in industrial electricity prices but fifteenth in residential prices. TEAS publishes its end-1999 direct sales prices per kWh for industrial customers as US cents 6.87 for high-voltage customers and US cents 7.15 for intermediate and low-voltage customers, whereas its sales prices to distributors are in the range of US cents 4 per kWh, and sales prices to TEDAŞ are around US cents 3.5 per kWh33. However, the gap between cost and prices is likely to be much larger than suggested by these data. The cost of purchasing additional electricity from BOT, BOO and TOR generators is much higher (except for diesel peaking plants), and can reach US cents 11-12 per kWh. Since these plants are urgently needed because of the lack of supply capacity, and are therefore dispatched frequently, TEAŞ's full costs are likely to be significantly higher than the average cost listed in Table 10. As a consequence, TEAŞ's income statements have long shown significant losses; in 1999, losses amounted to more than 61 billion Turkish lira. These losses are eventually borne by TEAŞ's shareholder, the Republic of Turkey, thus contributing to the government budget deficit, and, eventually, to inflation.

APPENDIX A

RECOMMENDATIONS by IEA[4] (International Energy Agency)

Energy Market and Energy Policy

- Continue the process of liberalization, restructuring, and privatization in the energy sector. Prevent any delays in the introduction of competition. Create a favourable environment for investment and ensure that the regulation of the gas and electricity markets is coordinated. _ Ensure that energy prices reflect full costs and eliminate subsidies and cross subsidies, both direct and indirect. Take measures to increase transparency in energy regulation and in price setting.
- Closely monitor energy supply and demand and revise the forecasts to take account of the progress of liberalization, energy efficiency improvements, structural changes in industry and other major factors in order to better inform all players' investment decisions.
- Continue and expand co-operation with neighbouring countries in all major energy policy areas.

Energy and the Environment

- Increase the resources for the Ministry of the Environment and strengthen collaboration with the Ministry of Health on air quality issues.
- Strengthen the mandate and the capability for inspection and verification of compliance of the agency or agencies responsible for the application and enforcement of air pollution legislation. Establish additional regional branches to address environmental issues in the provinces.
- Accelerate retrofitting of existing coal power plants with flue gas desulphurisation (FGD) and electrostatic precipitation (ESP) equipment and make efforts to increase the energy efficiency and the environmental performance of new coal plants through early adoption of advanced, clean coal technologies.
- Continue harmonizing standards and regulations for environmental quality with those of the EU and other international bodies.
- To reflect its respect for the spirit of the United Nations Framework Convention on Climate Change (UNFCCC), Turkey should continue striving to limit the growth of greenhouse gas emissions, and, where possible, take additional measures. In particular, the government should develop an implementation strategy that allows it to assume a greenhouse gas emissions target no later than the second commitment period of the Kyoto Protocol.
- Strengthen collaboration agreements with neighboring countries to limit energy-related pollution. In particular, seek agreements with countries bordering the Black Sea to reduce marine pollution, increase the inspection and verification of safety and environmental regulations in tankers, and consider raising standards and increase resources for port authorities.

Energy Efficiency and Renewables

- Consider enacting appropriate energy conservation laws and establish or tighten efficiency standards for industrial boilers and electric motors. Increase the resources of energy efficiency organizations.

---

[4] Energy Policies of IEA Countries (TURKEY 2001 REVIEW)
OECD/IEA 2001 (http://www.iea.org/books/Countries/2001/turkey.pdf)

- Enhance Turkey's participation in international co-operation programmes on energy efficiency, in particular on efficiency standards and labels for household appliances and motor vehicles.
- Consider establishing fiscal and economic incentives for conservation measures in all sectors.
- Expand energy auditing programmes for industry, commercial enterprises and homes, information campaigns and training of energy managers.
- Promote the formation of energy service companies to invest in such opportunities.
- Carefully assess the potential as well as the costs of renewable sources. In particular:
- Consider steps to accelerate construction of economic hydro projects consistent with the protection of the riverine environment. Periodically re-evaluate the economic potential of hydropower.
- Evaluate the extent to which wind power resources might be economically expanded.
- Evaluate the market potential for solar-thermal heating and cooling technologies.
- Establish competitive bidding procedures for the selection of renewable projects that are to benefit from government support.

Coal

- Continue the restructuring process of the coal mining sector and the privatization of viable mines. Consider outright privatization of the mines that have not been transferred through the transfer of operating rights procedure.
- Clarify the process by which the prices for hard coal and lignite are determined. Suppress all subsidies on hard coal and eliminate residual subsidies on lignite, both explicit and implicit, as well as any purchasing requirements or preferential treatment. Social issues should be considered independently from energy prices.
- Promote the adoption of clean technologies for coal use in electricity generation.

Oil

- Pursue the strategy of more transparent, stable and efficient regulation and greater private participation in the oil sector. In particular:
- Ensure full transparency of oil product price setting, and refrain from any intervention besides the automatic pricing formula.
- Enforce the existing provisions for Third Party Access to the oil pipeline system and the gas grid.
- Complete the privatization of the oil sector. Complete the privatization of TUPRAS, the Turkish Petroleum Refining Company. To reduce its dominant role in the refining market, refrain from building new refineries under TUPRAS's ownership before privatization.
- Ensure that the Turkish Petroleum Corporation (TPAO) can integrate vertically into the upstream and downstream market and that it can eventually be privatized.
- Accelerate upgrading of existing refineries to increase the production of oil products that meet international standards, including those for sulphur and lead content.
- Pursue the possibilities of crude oil transit through Turkey. Redirect attention to the commercial feasibility of the projects. In particular, seek to ensure further supplies for shipping. Give high priority to security of supply when establishing new pipelines.

Natural Gas

- Attach greater priority to the commercial and financial side of international gas supply and pipeline projects.
- Continue along the path of liberalization of the natural gas market. Prevent any delays in the introduction of competition.

- Create a favorable market environment for investment. Take measures to ensure a smooth transition to competition.
- Unbundle the Turkish Pipeline Corporation (BOTAS), as foreseen. Ensure that BOTAS's transmission and marketing activities are fully separated and that its trading activities can eventually be privatized. Establish clear, transparent, non-discriminatory prices for grid services, and similar conditions for grid access.
- Ensure that the regulator is effective and fully independent from business Interests and from government, that it has clearly defined rights and responsibilities and that it is insulated from political pressure. The regulator should be given the necessary means to carry out its tasks.
- Strive to make natural gas available to smaller gas consumers via extended distribution grids.

Electricity

- Take all necessary steps as soon as possible to implement the new competitive power market. In particular:
- Separate the Turkish Electricity Generation and Transmission Corporation (TEAS) vertically as soon as possible. Unbundle distributors' accounts for distribution and retailing, and separate the State Hydraulic Works' (DSI) accounts for hydro power activities from irrigation activities, to enhance cost transparency.
- Establish an independent regulator and independent system operators. Prevent any delays in the introduction of competition. Take measures to ensure a smooth transitional period. Separate the competitive market from the captive market during the transition period.
- Establish transmission tariffs based on a clear, transparent, and non-discriminatory price formula. These tariffs must provide effective incentives for the establishment of production and transmission capacity, including interconnections, to meet future demand.
- Allow the market to determine when, where and what type of power plants are built without government interference. Base the choice of nuclear power on sound and clear economic criteria, including all related externalities. Clearly define nuclear technology choices and waste disposal options before building nuclear power plants. Increase transparency in communication with the public on these issues.
- Clarify the mechanism by which the generating assets of TEAS, and possibly DSI, will be privatized over time, and establish a clear timetable for doing so. In particular, clarify whether the assets are to be placed under private control through transfer of operating rights or through outright sale.
- Take measures to ensure that the development of the electricity sector and its transition to competition lead to improvements in security of electricity supply, productive efficiency, and environmental performance of power plants.
- In parallel with implementation of the new Electricity act, consider expanding access to the competitive market beyond the limits currently set in the act, according to a clear timetable.
- Expend all possible efforts to facilitate and enhance international co-operation in the area of electricity trade and interconnection. Create a favourable market environment for investment.

Technology and R&D

- Strengthen R&D activities aimed towards the adaptation of new and advanced technologies to Turkey's specific needs, and concentrate efforts on a more limited number of activities, particularly in the following areas:
- Clean coal technologies.
- Flue gas desulphurisation.
- Fluidized bed combustion.

- Fossil fuel combustion efficiency.
- Wind and solar thermal.
- Energy efficiency and conservation in all sectors.
- Co-operate more closely with industry on R&D.
- Increase efforts to demonstrate and deploy new technologies that are relevant to the Turkish market.
- Gradually increase the funds for research, demonstration, and deployment as the economy grows.
- Exploit more fully the opportunities for bilateral and multilateral international co-operation.

Natural Gas: A Commodity that is Changing the Face of Qatar

IBRAHIM SALEH ALNAIMI
University of Qatar
PO BOX 2713
Doha - Qatar

1 INTRODUCTION

Qatar, a small Arabian Gulf state, has gone through three cycles that have shaped its economy since the beginning of the 20th century. The first one started at the end of the 19th century and lasted until the end of World War II during which Qatari as well as all Gulf citizens worked entirely in the pearl diving industry which brought good income to the people of Qatar and the Gulf region. By the late 1940s, oil was discovered in Qatar and a new cycle started with the people of Qatar abandoning the pearl diving and most going to work in the oil industry which brought the country the prosperity that converted it into an oil producing state. Qatar became a member of OPEC which is the oil cartel that influences the economy of the world so to speak. This era has lasted until the present time however with less emphasis on oil and more on gas which is the feature of the third cycle that started by the mid-1980s.

2 NATURAL GAS

Natural gas is becoming the backbone of the economy of Qatar. Since its discovery in 1970, the North Field is considered the single largest unassociated offshore natural gas field in the world. Its proven reserves are about 900 trillion standard cubic feet of recoverable gas. It covers a total area of 6,000 km^2. According to industrial sources, it will last for about 200 years on the average consumption of the year 2002, which is about 15 million tons per year. The real investment in the gas sector started in the early 80s of the last century when the first plant for gas production was built on an offshore platform to produce about one billion cubic feet per day for local consumption. Two major projects were then initiated to meet the international market demand for natural gas. Qatar Gas was established in 1984 (www.qatargas.com), and Ras Gas in 1993 (www.rasgas.com). The main shareholder of both companies is Qatar Petroleum (owned totally by the government of Qatar) with the other shareholders being the major oil and gas companies such as Exxon Mobil, Total, Fina, Elf, Mitsui, Marubeni, Koras, Itochu Corporation and Nissho Iwai. The total investment in these projects had exceeded US$40 billion. A huge infrastructure was established in the Ras Laffan area where the gas is brought from the North Field offshore platforms to the Ras Laffan industrial area and then processed, desulfurized and stripped from the oil condensates and pumped through a pipeline to the Umsaeed industrial area where some of it is used in the petrochemical plants such as Qatar Fertilizer Company, Qatar Petrochemical Company, LNG Plant, Qatar Steel Company, Q-Chem, Qatar Vinyl Company, etc. These petrochemical industries use the natural gas as their feed stock or energy provider. All water desalination and power generation complexes use natural gas as the energy provider for their turbines. Qatar is one of the few countries around the world that is using only natural gas as the energy source of all its industries. A large quantity of the gas is liquefied and shipped via gas vessel ships to the international markets of Japan, Korea, India, China, Spain, England, Italy, USA, and many other countries. A new project is underway to ship the gas through a pipeline to the neighbouring United Arab Emirates and from there to Oman and ultimately to Pakistan. A second pipeline is under study to ship the gas to Kuwait and possibly Bahrain and Saudi Arabia.

Another major project which is under study is to build a mega power station to produce electricity and distribute it throughout the Gulf region using underwater and land cables.

3 DEVELOPMENT IN QATAR

Qatar is planning big projects for the years to come. In the next 10 years it will spend more than $50 billion on new gas and petrochemical industries.

For the last 20 years, the gas projects have been the focus of planners in Qatar. The country went through very hard times and austerity measures were applied heavily on all aspects of life. There was simply no money in the country as all of it was invested in the establishment of the Ras Laffan industrial area. With the improvement of oil prices in early 1999 and with the gas projects almost completed and production started, Qatar's economy became more balanced and a surplus in the budgets started to show. More jobs were brought to the market and many Qataris had good opportunities to find well-paid jobs. Banks and the private sector started to benefit from the projects by providing services to firms that built these projects. The hotel and tourism business started to flourish with more visitors to the country to attend conferences, meetings, seminars, exhibitions and many other activities all year long. This led to an average hotel occupancy in the five and four star hotels of around 80% throughout the year.

The years following 1999 have not seen any deficit in the budget of the country. In fact a surplus in the budget has been achieved in the last 3 fiscal years. This surplus has helped the government to focus on the infrastructure of the country and many major projects have been executed. In addition, many housing projects have been established to provide higher living standards for the citizens.

4 EDUCATIONAL SECTOR

Educational establishments are undergoing major restructuring. School buildings are being demolished and new styled and modern buildings are being built according to the latest architectural designs that meet international standards in school buildings and provide the best environment for the educational process. These buildings are equipped with all the latest technological equipment. The curriculum has been totally revised and a new system of education has been adopted. The compound is composed of three schools (primary, elementary (junior high) and secondary (high) schools). Each compound is run independently from the others. Its budget is allocated every year according to its performance. A central evaluation body is in charge of evaluating the performance of the schools. Accordingly, the compound is classified on a ranking system which leads to the budget and services that it will receive from the Educational Council. The council overlooks, assists, and evaluates the performance of the school compounds. It also provides the curricula and the educational materials to the schools and it sets the standards for the teachers, administrators, and assistants.

5 HIGHER EDUCATION SECTOR

Higher education in Qatar has advanced tremendously through the establishment of international campuses of highly reputed universities such as Cornell University, University of Texas A&M. The newly established multi-billion dollar Educational City will host these satellite campuses and it will host one of the largest science parks in the world. Cornell University established a medical campus in Qatar in the academic year 2002/2003 that is considered to be the first outside of the USA. Other universities are following in the footsteps of Cornell University. The University of

Texas A&M is opening its satellite campus in Doha in the academic year 2003/2004. It will start with an engineering college that will offer students various engineering programs. The year 2005 might see further development in the Educational City that is under construction. The University of Colombia might open its campus in Qatar to provide programs in the field of Information Technology and Business Administration. The Educational City is intended to be a city of advanced higher education universities that provides a wide spectrum of educational programs. These programs should first of all serve the need of the Qatari people and then Gulf citizens as well as the whole world, since these universities are open to international students as well as Qatari ones.

6 UNIVERSITY OF QATAR

The development at the only state university, University of Qatar, is also taking strides toward a bright future. More new buildings are under construction to accommodate more students. New and advanced programs have been introduced where students can experience a wide spectrum of specializations which include technical and engineering programs, information sciences, allied health sciences, art and humanities subjects, environmental studies, banking, law and Islamic studies (www.qu.edu.qa). Students in the University of Qatar are enjoying free education with all the benefits of state of the art equipment in the science and engineering labs and a highly advanced and internationally connected library. The teaching staff are of high calibre. They represent an international mix of different schools and cultures.

7 FUTURE PLANS FOR QATAR

Qatar is planning more gas and petrochemical projects for the years to come. It is estimated that it will spend more than US$50 billion on projects such as conversion of gas into liquid hydrocarbons (fuel) and more petrochemicals plants using natural gas as feed stock. Along with these projects, Qatar is going to organize the Asian Games in 2006. These games are looked at as an opportunity for the people of Qatar to show the world how developed this country really is. Therefore, many infrastructure projects are under way. The Doha International Airport is undergoing extensive renovation to upgrade it to international level. A huge complex is also under construction to be used as the Olympic village and later on to be used as a multi-hospital complex that will accommodate many hospitals such as children's hospital, elderly hospital and a heart disease hospital. The capacity of the complex will be more than 1000 beds with state of the art facilities.

Many sport facilities are also under construction. You can imagine Qatar at the moment as being a huge workshop with construction everywhere that includes roads, high-rise buildings, tourist attractions, shopping complexes and more.

8 CONCLUSION

Qatar is experiencing its third economic cycle, the natural gas cycle. This cycle adds up to the previous two, the pearl diving era and the oil era, to shape the Qatari economy since the beginning of the 20th century. Qatar is considered to have one of the highest incomes per citizen in the world. Its people live a lavish life with high pay, no taxes, good services, safety, democracy, free education and medical treatment and many other benefits.

The effective management of this commodity and good planning is really changing this tiny peninsula in the Arabian Gulf into a gigantic producer and distributor of natural gas around the world.

Energy research for Development: Petroleum Exploration in the Senegal Basin

OUSSAYNOU FALL DIA

1 INTRODUCTION

Petroleum operations in Senegal are governed by law N°98-05 of January 08 establishing the Petroleum Code which has been reviewed for a more stimulating juridical and fiscal conditions. Five (5) onshore and fourteen (14) offshore blocks of the Senegal Sedimentary Basin blocks are presently opened and offered for tender.

This paper provides a comprehensive presentation of the geology and petroleum potential of the sedimentary basin and the current state of petroleum exploration and evaluation.

The Diam Niadio and Gadiaga gas fields, the Dome Flore heavy and light oil accumulations, the new potential in Deep water sections and the plays in the Paleozoic basin, should provide incentives to the future search for hydrocarbons in this underexplored petroleum province.

2 REGIONAL GEOLOGY

The Senegal Sedimentary Basin occupies the central part of the large Northwestern African coastal basin (MSGBC), which extends from Reguibat shield in its Northern limit to Guinea fracture zone to the South. It is a typical passive margin opening westward to the Atlantic Ocean and which Eastern limit is represented by the Mauritanides chains.

The MSGBC basin is a Mesozoic-Cenozoic continental margin basin overlying a Paleozoic basin. It has undergone a complex history related to the prerift (Upper Proterozoic-Paleozoic), synrift (Permian-Lower Jurassic) and postrift (Mid Jurassic-Actual) stages of basin development and can be divided in a number of sub-basins or compartments aligned North-South and delimited by East-West faults system or other types of structural dislocations may or not be related to synrift tectonic. These structural dislocations may or not be related to ocean fracture zones or transform faults. Nevertheless, five subdivisions can be made which are separated by major tectonic elements along the continental margin.

The Senegal sedimentary basin is constituted by:

- The Dakar-Banjul compartment, the largest portion, which extends between 16°N and 13°N transverse faults which can be correlated with the possible prolongations of the oceanic fracture zones called Blake-Spur or Cayor-Rosso in the North and Jacksonville off Southern border of the Gambia. This compartment contains a large number of igneous intrusions including recent volcanic activity in the Dakar peninsula. It is also noted by thrusting in the subsurface onshore under the base Mesozoic unconformity and by large North-South low amplitude structural highs. Recently acquired 2D seismic lines by Australian Fusion Oil in the deep offshore of The Gambia indicate for the first time the presence of salt diapirs in the compartment.
- The Casamance-Bissau compartment, which extends from 13°N to Guinea-Bissau, is characterized by the presence of salt diapirs in Casamance offshore and by the striking N50° Kidira-Velingara-Bissau lineament, a major tectonic element of the Mauritanides chain, which played an important role in the opening of the Atlantic limiting southward the central Atlantic rift.

2.1 The prerift section

The Paleozoic is known from outcrops in Bowe basin. It includes rocks of Cambrian to Devonian age. The most complete sections in Senegal basin are recognized in Diana-Malari (DM-1) and Kolda (KO-1) wells which penetrated formations Ordovician (Pita group), Silurian (Telimele group), and Devonian (Bafata group) age.

The analysis of the Shell reprocessed lines, together with interpretation of Petrosen's 1990 lines infer the existence of more complete Paleozoic series with probably synrift section West of Diana-Malari-1. Several structural traps including tilted fault blocks or faulted anticlines are seen under base Mesozoic unconformity at average depths from 1850 meters in the Saint Louis / Louga area to more than 5OOO m in the Diourbel area.

2.2 The synrift section

Sediments of the synrift do not outcroup in Senegal basin, and with the exception of the salt diapirs, they have not been encountered. The geological considerations regarding this section are made by analogy with similar geological settings and some onshore lines show the possibility of the existence of synrift sequences in sectors of the onshore basin.

2.3 The postrift section

This postrift sequence consists principally of a Jurassic-Lower Cretaceous age, followed by a clastic wedge of Cretaceous age, capped by the Tertiary carbonates and shales. The exploration efforts resulted in the discovery of the oil and gas fields in the Maastrichtian of Diam Niadio and the Dome Flore heavy oil reservoired in the Oligocene Foraminiferites.

3 THE PALEOZOIC BASIN

The Paleozoic basin is represented by the sub-basins of Toundou, Diourbel-Saloum and Casamance-Bowe. The prospective surface for Paleozoic targets extends from North to South, East of 16°Meridian along a belt of 100 km wide.

Two main tectonic styles have been recognized:

- An extensional system in eastern Casamance in which a pre-hercynian structural style of horts and grabens and titled fault blocks was preserved;
- And a compressional regime in the rest of the Senegal basin resulting from the combined effect of Caledonian and Hercynian orogenies.

3.1 Reservoirs and seals

The sandstone reservoirs are abundant following the sections measured in the Bowe basin, from DM-1 and KO-1 wells and from the regional geology. The Ordovician quartzitic sandstones well cemented and in general with no primary porosity are intensely fractured and then constitute good secondary reservoirs having excellent deliverability.

The Devonian contains important sandstones beds, fine to coarse grained, often oolithic, with porosities estimated between 15 and 20%, which can form interesting reservoirs for hydrocarbons generated by Silurian shales. They can be capped by the Upper Denovian shaly formations.

Presence of Permo-Carboniferous sediments, which can provide good reservoirs and seals if we extrapolate from equivalent sections in similar geological settings as in Essaouira basin in Morocco, Western Sahara, Gabon or Cabinda, is not excluded.

It is interesting to note that the Hassi Messaoud Algeria's biggest oil field was generated by Silurian graptolitic shales and accumulated in fractured quartzitic sandstones of Cambrian and Devonian age.

3.2 Source rocks and maturation

The Silurian shales are the best regional source rocks known. The measurements carried out in samples from DM-1 well and Bowe basin show these rocks are very rich in organic matter (TOC between 1% and 3%). The high level of maturation observed (Vitrinite reflectance between 0.95 and 1.3) at relatively shallow depths could be explained by high geothermal paleogradients related to doleritic intrusions or by a hot spot. It seems rather to be local conditions, which should not be generalized to the whole Paleozoic basin. These high maturation phenomena were not observed in Florida where the Silurian shales have normal sedimentary characteristics. The periods of generation are wide and variable for the Silurian and should begin from 350 MY to 125 MY continuing until present, and oil windows should occur between 1850/2400 to 3400/4000 meters.

Another source rocks are also known, in other basins, in Devonian and Carboniferous sections.

Analysis of models carried out in Senegal and Guinea has shown that this immense Paleozoic basin could have generated important quantities of hydrocarbons as early as before rifting and during long periods of the Mesozoic.

3.3 Traps

15 anomalies have been identified, distributed along Casamance, Diourbel-Saloum and Louga blocks, traps and prospective plays in formations of Ordovician to Carboniferous age which consist of thrusted anticlines, complex faulted anticlines, four way closures, and tilted fault blocks.

4 THE MESOCENOZOIC BASIN

The major structural features are constituted by:

- The proeminent Leona and Rufisque cretaceous plugs that have domed the overlying sections;
- Several structural culminations South of the Dakar peninsula which include:
    - The Mbour structure
    - The Grand Large structure, near the edge of the Jurassic-Lower Cretaceous carbonate platform and closed against Albo-aptian series;
    - The Ndiass structure, corresponding to a gravity high probably caused by uplift of a crustal block. It was strongly affected by late Cretaceous / Tertiary uplift as most of the Maestrichtian section has been eroded off;
- A trend of listric normal faults that occur along the Cretaceous paleoself edge. Some upper Cretaceous hydrocarbon accumulations in Thies-Diam Niadio areas are trapped in roll over structures associated to this faulting
- The Dakar peninsula, with its recent volcanic activity may be located on a proeminent East-West structural feature dividing the basin into fundamentally different Northern and Southern segments. The East-West striking fault South of CVM-1 well may be a major tectonic feature representing a dextral shift of the continental margin of about 40 km, superimposed volcanism impedes correlation of structural trends from one side to the other;
- A proeminent line of salt diapirs in Casamance offshore. The salt, of possible Triassic or Lower-Jurassic age, pierces the Tertiary formations in the Northern part and the Maestrichtian in its Southern part.

4.1 Reservoirs and seals

They are encountered in:

- The Jurassic-Lower Cretaceous carbonate section sealed by Cenomanian-Turonian shales. However, the Lower Cretaceous shales overlying the carbonates beds and the micritic limestones in the carbonate sequence itself can provide good seals for hydrocarbons trapped in more porous and permeable horizons;
- The Upper Cretaceous sands and shales sequences;
- The Lower Tertiary clastics and carbonates;
- The Upper Tertiary shaly sequences.

The Jurassic-Lower Cretaceous carbonate platform was never fully penetrated but few wells have shown fair porosities in limestones (10%) and locally good porosities in dolomites (up to 23%). Reefal targets on the shelf edge remain to be investigated.

Rapid facies changes occur within the Albo-aptian sequence with permeable sands in the Eastern onshore progressively shaling out westward.

The Upper Cretaceous sandy sequence in the Eastern part of the basin becomes an interbedded sand and shale unit on the shelf further westward. Thick Maestrichtian sands occur at Diam Niadio and Dome Flore, with porosities ranging from 20 to 30%. Further West at the shelf break, individual sand units are much thinner.

The Paleocene-Eocene contains porous carbonate and sands. An excellent Oligocene reservoir (Foraminiferites) is present at Dome Flore. Miocene shales are an efficient seal and locally may include turbitide sand reservoirs.

4.2 Source rocks and maturation

The most significant hydrocarbon shows within the basin are found in Casamance offshore and Cap Vert peninsula onshore wells.

In Casamance diapiric salt has certainly induced a modification of maturation gradients. The best source rocks are encountered in Cenomanian-Turonian and Albian sediments, however none of the intervals analysed is fully mature. The general trends observed in the basin show that the maturity conditions are clearly improving southward.

In the Northern part of the Sedimentary Basin, the variation in maturation gradients could have been caused by series of geological factors including uplifts, erosions and local heating by magmatic intrusions. The sample analysis available, covering intervals ranging from Lower Jurassic to Eocene show low to moderate matter contents with a greater interest in the upper part of the middle Cretaceous.

Better maturity conditions at acceptable depths are obtained at proximity of magmatic intrusions in North and salt domes in South where geothermal gradient can reach 40°C and even 42°C per Km.

4.3 Traps

The Mesozoic basin contains diverse play types and trapping mechanisms. These include salt related structures, structures related to volcanic intrusions, growth fault related traps, slope truncation traps along the present shelf edge, Mesozoic pinchouts along most of the Eastern margin, a lower Cretaceous-Jurassic carbonate bank plays with possible development of carbonate buildups along the Cretaceous shelf edge and slope.

5 BLOCKS AND PERMITS

5.1 The Shallow Offshore Blocks

5.1.1 The Casamance offshore shallow blocks

Many seismic surveys was conducted in the area and eight wells drilled over the blocks.

Recent works performed by Australian Roc Oil concluded to the presence of four (4) prospects and among them two (2) particularly interesting at the Cenomanian level at 1000 m depth.

5.1.2 The Dome Flore Block

The main structural features are constituted by Flore and Gea salt domes. This sector of Casamance offshore is surely the part of the sedimentary basin, which has given the greatest number of hydrocarbons shows. The Flore salt dome contains a heavy oil accumulation reservoired in the Oligocene limestones called “Foraminiferites” which is estimated between 500 millions to 1 billion barrels. The light oil accumulation in Maestrichtian sands, 33.6° API, has been encountered by well

SF-4 drilled in May 1970 at a depth of less than 700m. Light oil shows are also reported in two Albian sandstones beds of well CM-7 drilled on the dome flank.

The wells drilled on Dome Gea Southeast of Flore domes indicate the presence of the heavy oil in the Oligocene "Foraminiferites" as well as light oil shows in Lower Miocene sands. Casamance Petroleum Ltd shot 300 Km2 of 3D seismic in 1992 and Pecten's Baobab-1 well drilled in 1996 confirmed the presence of the heavy oil in the Gea salt dome zone and indicate that the area covered by this heavy oil could be appreciable.

5.1.3 The Northern offshore shallow blocks

They extends along 220 Km, from the boundary with Mauritania to the Northern border of The Gambia and is constituted by Sangomar, Rufisque, Cayar and Saint-Louis bocks.

The operations carried out in the different sectors permitted to collect appreciable quantities of geological and geophysical information. The analysis of all these data does not allow however at actual stage of basin exploration to draw clear conclusions upon the potential of that zone.

The transform fault South of Cap Vert peninsula divide the Northern offshore into two relatively different types of sub-basins.

5.2 The Deep Offshore Blocks

5.2.1 The Deep offshore North

In the Deep offshore North blocks (Saint-Louis, Cayar, Rufisque and Sangomar), 2000 Km of 2D new seismic have been shot and interpreted plus an aeromagnetic survey over Cayar and Saint-Louis and Palmarin located respectively under about 1500 m and 2400 m water depth.

5.2.2 The Casamance deep offshore block

Western Geophysical shot a speculative seismic in 1997-1998 consisting of 3000 Km of 2D for Casamance deep and AGC zone.

Petrosen is in contact with companies interested to the Casamance deep zones.
In the AGC deep area, the contractual zone denominated Cheval Marin has been granted to Italian AGIP in association with Austrialians Woodside and Croix du Sud contractual zone to Australian Fusion.

The seismic in this area shows deepwater turbitide sandstone reservoir and a complex structural history with dynamic salt.

5.3 The Onshore Blocks

5.3.1 The Casamance onshore blocks

The analysis of existing lines show a thick package of reflections under base Mesozoic unconformity West of DM-1 corresponding probably to a more complete Paleozoic sequence, with the possibility of presence of a synrift section.

The reservoirs and seals are constituted by the Ordovician quartzitic sandstones and interbedded shales, the Silurian shales, the Devonian sandstones and shaly sequences of Upper Devonian.

Aside the Silurian and Lower Devonian shales of the prerift sequence, the Cenomano-Turonian of DM-1 presents a level at 452 m with excellent source rock characteristics which could have produced liquid hydrocarbons.

5.3.2 The Diourbel-Saloum blocks

The configuration of the strongly dipping reflections below the Mesozoic unconformity indicates thrusting which intensity diminishes from North to South, as the folds decrease in amplitude. However, these formations are very little known. The only Carboniferous indication has been encountered at the base of well DL-1 located on the Eastern flank of the Diourbel syncline. The geological, geophysical and geochimical aspects considered in the analysis of the Casamance onshore are generally valid for the Diourbel-Saloum blocks. Several successions of deep reflectors “cuspate in shape” are identified in the vicinity of well DL-1, and where partly at least are supposed to represent Carniferous to synrift sediments.

The top of the anterift seismic markers franges between 3500 and 7500 m.

5.3.3 The Louga block

The Louga block includes the Toundou basin, containing very likely Paleozoic series under the Mesozoic sequence, superimposed to the negative Moukmouk gravity anomaly.

A photogeologic/geomorphologic evaluation of the area carried out by Minpetro exposed the existence of a structure in the Mesozoic South-West of Toundou-Besset-1 (TB-1) well. That faulted anticline structure is centred on seismic line L72-1-22 between shot points 80 and 180.

For the Toundou basin, the reprocessed lines show clear reflections supposed to the prerift sections. The Paleozoic prospect denominated “prospect A” is centered on lines D71-1-07/08, between shot points 900 and 1180, with 200 Km2 closed surface and a vertical relief of 500m, at a minimum depth of 1850 m.

5.3.4 The Senegal East block

Scarcity of data (no seismic and very few gravity and magnetics) characterizes this block. However, the existence of a Paleozoic microbasin cannot be excluded due to fact that the well Tambacounda-2 seems to have penetrated Paleozoic sediments at 596 m under Paleocene sediments.

Petrosen has just finished a preliminary study of Senegal East basin using Landsat and radar satellite imagery and gravity data.

This study shows the existence of two (2) sub-basins, which can contain up to 1000 m sediments.

5.3.5 The Sebikhotane block

A petroleum Sharing Agreement covering this block has been signed with the Consortium Maurel & Prom – Orchard in July 2002.

This block has many wells drilled and several seismic lines acquired including 3D covering square kilometres around Diam Niadio area since 1986.

Oil and gas have been discovered and produced in the Diam Niadio area essentially in sands and sandstones interbedded in the Maastrichtian shales. The DN-14 gas well drilled in Diam Niadio East prospect tested the Maastrichtian C1 sands with a maximum flow rate of 17 mmcft/day.

East Diam Niadio field, Ndoyene-1 (Ndo-1) tested the C1 sands at a rate of 6.34 mmcft/d and Wayambam61 (wy-1), located near Retba lake, in turn flowed 15 mmscft of gas with production of 1 m3/h condensate.

5.3.6 The Thies block

The Thies block was first granted to Petrosen in 1993. With the cooperation of PCIAC, the interpretation of different studies and surveys resulted in the identification of four prospects named respectively Gadiaga, Diender, Sebissou and Mont-Rolland. A drilling program of four exploration wells have been defined and the first well Gadiaga-2 (Gd-2) was drilled between November 96 and January 97 at a total depth of 2180 meters in Lower Senonian. Several interesting levels were encountered and six of them tested in the Senonian section with to levels in the Campanian giving commercial gas proving for the first time that Senonian reservoirs can have good hydrocarbon saturations in some sectors of the basin.

A production sharing agreement has been signed in February 2001 with Fortesa Corporation, a Houston based company, for the production of the Gadiaga gas field and to continue the exploration of the Thies block. A gas pipeline of 4.5 inch diameter measuring 34 Km long connects the Gadiaga-2 well to the Kabor storage facilities. The gas is then sent through a 6-inch pipe to feed the gas turbine of Senelec at Cap des Biches to generate electricity. The well is producing 60 000 cubing meters per day.

6 CONCLUSION

The Petroleum exploration started at year 1952 with the French organism BRP (Bureau de recherche pétrolière). Many works have been done by companies, onshore and offshore which conducted in 1961 to the Diam Niado Oil and Gas discoveries, and few years later, to the Dome Flore heavy oil accumulation in Casamance Offshore sub-basin, in 1967. In 1997, PETROSEN discovered the Gadiaga gas field in Northern part of Thies block. The Diam Niadio field has produced between 1986 and 2000 about 7.6 BCF of natural gas, and 62 642 bbls of light oil (34° API). The Gadiaga well was put in production in october 2002 and flowed about 60 000 cubic meter a day.

142 exploratory wells have been drilled in the Senegal Sedimentary Basin with 16 wells drilled for sulfur prospecting offshore Casamance. Most of them are concentrated in the vicinity of Cap-Vert Peninsula, and in Casamance offshore, with more than 67% of the total wells drilled. The Senegal Basin outside these two zones remains relatively underexplored.

Indeed, fewer than 30 wells are really significant from a petroleum point of view, which related to the 225,000 km2 of surface basin area estimated to the 200 meters bathymetric contour. It represents an average explored surface of 7500 km2 per well.

Between 1971 to 2002, 47520 line kilometers of 2D seismic and 2840 square kilometers of 3D have been shot over the basin. The 3D seismic covers specially the Dome Flore and Cheval Marin Block in the AGC area and Diam Niadio East field.

Nuclear Energy For The Future

IQBAL H. QURESHI*
Pakistan Institute of Nuclear Science and Technology, (PINSTECH)
P.O. Nilore, Islamabad, Pakistan

1 INTRODUCTION

Energy is an essential requirement for all socio-economic development activities. Energy is needed to improve our living standard by providing basic requirements of our every day life such as cooking, lighting, heating, and other household appliances as well as for transportation and industrial productions. According to the World Energy Council, energy should be accessible to everyone including the poorest people. However there is a large disparity of the availability and consumption of energy among the developed and developing countries. It is estimated that about 2 billion people in the world still have no access to electricity and other forms of commercial energy (1). This disparity can pose a significant threat to world peace due to political and social instability.

For sustainable development, it is necessary to ensure supply of adequate amounts of energy at a reasonable cost. Further, the energy generation should be environmentally friendly, that is it should not cause climate change or deteriorate environment and human health. The demand for energy is increasing with increasing population. It is estimated that by the year 2020, the world population will become 7.4 billion which will require 50 to 75 percent more energy (2). The global electricity generation in 2001 is estimated to be 15690 Tera watt hour (TWh) of which 39% is generated by coal, 8% by oil, 17% by gas, 17% by hydropower, 17% by nuclear energy and 2% by solar, wind, geothermal and biomass (3). Electricity generation in Pakistan in the year 2001-2002 was estimated to be 72.4 TWh of which 36% is produced by oil, 34.3% by gas, 26.2% by hydropower, 0.4% by coal and 3.2% by nuclear energy (4).

2 THERMAL POWER PLANTS

2.1 General

Fossil fuels have been the major source of electricity generation due to their higher energy density which offered economy and convenience. At present about 64% of the global energy is generated by fossil fuel combustion. The annual global consumption of fossil fuel is estimated to be 3.27 billion tonnes of coal, 270 million tonnes of oil and 815 trillion cubic meters of natural gas (3). The combustion of this fossil fuel results in the annual release of about 23 billion tonnes of carbon dioxide (CO_2) .In addition, large quantities of other air pollutants such as sulphur dioxide (SO_2) ,oxides of nitrogen (NO_x), carbon mono-oxide (CO). Particulate matter and organic compounds are also released. Thermal energy in Pakistan is produced by the combustion of 6.2 million tonnes of oil, 600 billion cubic feet of gas and 2.6 million tonnes of coal which together release about 90 million tonnes of CO_2 annually.

Thermal power plants are the major source of air pollution which has local, regional and global environmental impacts. These impacts have been with us ever since the use of fossil fuels for the generation of electricity, but the environmental considerations gained momentum only since the seventies. The amount of pollutants released depends upon the nature of fossil fuel used i.e. gas, oil or coal. The combustion of coal releases highest amount of

---

* Scientist Emeritus and President Pakistan Nuclear Society.

environmental pollutants (5). It also produces very large quantities of solid waste containing toxic elements including uranium and thorium which should be isolated from the environment. A 1000 MWe coal fired power plant releases about 100 times more radioactivity into the environment than a nuclear plant. It is estimated that 37300 tonnes of uranium and thorium are annually released from coal burning in the world, of which 7300 tonnes is released from the United States (6). The release of radioactivity from coal burning has been overlooked by environmentalists.

2.2 Health and environmental impacts

Substantial amounts of oxides of sulphur and nitrogen are also released from combustion of fossil fuel (Table 1). Both SO_2 and NO_2 when inhaled irritate the respiratory system and can cause symptomatic broncho-constriction. Physio-chemical interaction of these gases in the atmosphere produces acid mist which is brought to the ground along with rain, which causes damage to crops and forests, erosion of buildings and structures. Carbon monoxide is a toxic gas, which when inhaled reacts with haemoglobin in the blood stream to form carboxyl haemoglobin and reduces the transport of oxygen to the cells causing nervous disorder. Impact of particulate matter on the environment and human health varies with the nature and size of the particles. Fine particles with diameter 1-5 μm penetrate into human lungs and can be absorbed into the blood stream and may cause various disorders. Traces of heavy toxic metals in particulates when ingested affect the biochemical functions and some of these may induce mutagenic changes. Studies by the Harvard School of Public Health indicate that pollutants from the combustion of coal cause about 15000 premature deaths annually in the United States alone (6).

Table 1. Release of air pollutants from 1000 MWe Yr power plants based on gas, oil and coal. (Tonnes) (5)

POLLUTANTS	GAS	OIL	COAL
CO_2	$5.2x10^6$	$6.9x10^6$	$7.8x10^6$
CO	-	500	1500
SO_2	15	28000	83000
NO_x	15000	18600	20250
ORGANIC COMPOUNDS	210	525	300
PARTICULATES	375	900	2250
SOLID WASTES	-	6900	$2.7x10^5$

FLY ASH RECOVERY 99%,
NO FLUE GAS DESULPHURIZATION
COAL WITH 2% S,
OIL WITH 1% S

2.3 Global warming

Power plants are major source of greenhouse gases, which interfere with the natural process of heat exchange between the earth's atmosphere and outer space. Thus their presence in substantial quantities in the atmosphere changes the balance between incoming solar radiation and outgoing infrared radiation causing greenhouse effect, which may increase the average global surface temperature by a few degrees, and may cause global warming. The amount of heat trapped by a greenhouse gas depends upon its Global Warming Potential (GWP), which are carbon dioxide 1, methane 21, nitrous oxide 310, hydrofluoro-carbons 1300, tetrafluoro methane 6500, chlorofluoro-carbons 9300, and sulphur hexafluoride 23900 (7). Increasing atmospheric concentrations of these gases may cause global warming and climate change which could affect sea level, precipitation pattern, agriculture productivity, and human health. Therefore reduction of the atmospheric concentrations of greenhouse gases has become an international priority. In order to reduce the emission of greenhouse gases a protocol was adopted in 1997 at Kyoto Conference on Climate Change. According to this protocol the industrialized countries should reduce the emission of six greenhouse gases, namely carbon dioxide, methane, nitrous oxide, hydrofluoro carbons, perfluoro-carbons and sulphur hexafluoride by 5% from the 1990 levels by the year 2008 to 2012. To achieve the reduction of this magnitude will require a substantial restructuring of energy production and use in these countries. Clean Development Mechanism (CDM) was also introduced to help developing countries achieve sustainable development while limiting emission of greenhouse gases.

2.4 Conversion efficiency

The CO_2 emission depends on the carbon contents of the fuel and the fuel to electricity conversion efficiency as well as on plant load factor. The emission factor decreases when efficiency and load factor increases. The efficiency is influenced by the nature of the fuel, maintenance of the plant and other local conditions. The development of new technologies may increase the efficiency up to 55% for coal and 65% for gas fired combined cycle plants (8). The gas plants appear to be attractive from the point of view of efficiency, capital cost and short construction period but the other factors such as security of supply, price fluctuations, and emission of greenhouse gases should also be considered.

3 RENEWABLE ENERGY

3.1 General

Large-scale emission of CO_2 from fossil fuel plants is a serious threat to climate change and global warming. The solution to this problem is to develop and increase the generation of electricity from low carbon or carbon free fuels. Hydro, solar, wind and nuclear are carbon free sources of energy which can avoid the emission of CO_2, SO_2, NO_x etc. but these have other environmental impacts. The environmental impact of renewable energy sources is small during the stage of power generation but their impact can be significant at the stage of equipment production and plant construction as the amount of materials used per unit of effective power generation is much larger than for other energy systems.

3.2 Hydropower plants

Hydropower is a carbon free source of electricity generation which does not release CO_2 and other noxious gases in the atmosphere during the electricity generation stage. About one quarter of the world's hydro-potential has already been utilized for electricity generation. At present hydropower contributes 17% to the global energy mix. Largest amount of hydel-electricity is generated in Canada: 360 TWh, Brazil: 300 TWh, USA: 275 TWh and China: 225 TWh (10). In Brazil, hydel-power contributes about 80% of the national electricity generation. Construction of more hydro-dams will increase the share of hydel-electricity. The cost of generation is relatively cheaper as many of these dams are dual purposes which are used for irrigation as well as for electricity generation.

Construction of large dams cause displacement of hundred of thousands of peoples which has social and cultural impact. Many square miles of land and forest get submerged under water and ecology of the area is changed which causes loss of habitat. Further the decay of organic material by anaerobic bacteria will release significant amount of methane which has 21 times greater global warming potential than CO_2. In view of large scale emission of methane and other environmental impacts, International Funding Agencies are reluctant to provide financial assistance for the construction of large hydropower plants.

3.3 Solar, wind and geothermal sources

3.3.1 General

Renewable sources namely Solar, Wind, Geothermal and Biomass provide about 2% of the world energy. The conversion efficiency for electricity generation of these sources is low. Therefore considerable R&D efforts have been made to improve the existing technologies and to develop new technologies for the effective utilization of solar and wind energy. With the development of new technologies their share could increase but to a limited extent in future. These sources collect extremely dilute energy and as such these require large areas of land and numerous collectors to concentrate this energy.

3.3.2 Solar energy

Solar energy contributes about 500 GWh to the global electricity generation. Highest amount of electricity is produced in Japan (200 GWh) and USA (100 GWh) from photovoltaic cells. The major component of photovoltaic solar energy systems is the solar module which consist of a number of solar cells connected in series. A large solar-energy system will require substantial number of such modules.The manufacture of photovoltaic cells, produces highly toxic metal waste and solvents which require special disposal technology. A 1000 MWe solar electric plant would generate 6850 tonnes of hazardous waste from metal processing and a comparable solar thermal plant will produce 435000 tonnes of hazardous manufacturing waste which will cause significant environmental pollution.

3.3.3 Wind energy

Wind energy is used in 29 countries for the generation of electricity. The global electricity generated by wind turbines is estimated to be about 25 TWh. Highest generation has been observed in five countries namely Germany: 7.4 TWh, USA: 4.5 TWh, Denmark: 3.0 TWh, India: 1.9 TWh and Spain: 1.5 TWh. Since Wind is a dilute energy source, large scale generation of electricity will require many windmills and large area of land. A wind energy plant of 1000 MWe capacity will require installation of more than 4000 large windmills which will occupy several thousand square miles of land. In densely populated countries like Denmark and Netherlands best sites on land due to public resistance are not available for the installation of more plants. Therefore these and some other countries are developing economically less favourable off shore projects (11). Windmills, beside causing noise pollution have an undesirable visual impact and are mighty killer of birds.

3.3.4 Geothermal energy

Geothermal sources of energy utilize the internal heat of the Earth which emerges in geyser areas or under volcanoes. High temperature geothermal sources used for the generation of electricity are mainly confined to young volcanic, seismic and magmatic active areas. At present 21 countries have been utilizing geothermal energy for electricity generation. Global generation of electricity from this source is estimated to be 51 TWh. Highest generation has been observed in USA: 16.8 TWh, Philippines: 10.5 TWh, Italy: 4.4 TWh and Mexico: 5.6 TWh. The cost of generation is higher than other sources. In a modern cost effective plant the cost is about 4 cents (US$ 0.04) per kilowatt hour (11).

The United States has made a massive R&D investment for the generation of electricity from renewable sources. In spite of this investment, renewable sources remain uncompetitive and contribute only marginally to the US energy supplies which indicates that these sources will make limited contribution in the future energy mix.

4 NUCLEAR ENERGY

4.1 Background

Nuclear energy contributes 17% to the global electricity generation. This contribution will substantially increase in the future in view of the reduction of greenhouse gases emission from fossil fuel plants according to the Kyoto Protocol. It is a carbon free source of energy which does not release greenhouse and other noxious gases into the atmosphere. The cost of nuclear electricity generation is becoming comparable with that of fossil fuel plants. The production cost of nuclear electricity generated from existing plants in the USA is already fully competitive with fossil fuels. The cost of nuclear electricity is 1.9 cents (US$0.019) compared to the national average of 2 cents (6). According to the World's Nuclear News Agency (April 2003) the cost of nuclear electricity in USA has fallen from a peak of 3.4 cents in 1987 to 1.68 cents per KWh in 2001. Economic comparative assessment of various energy sources at power plant level carried out at International Atomic Energy Agency (IAEA) using DECADES database shows that nuclear power is a competitive option for generating electricity in many countries (8).

4.2 Nuclear fuel

Nuclear fuel is a very intense source of energy which can produce enormous energy from a small volume of fuel. One tonne of nuclear fuel produces energy equivalent to 2 or 3 million tonnes of fossil fuel. One kilogram of uranium in a modern light water reactor generates 400,000 KWh of electricity and if it is recycled it can generate more than 7,000,000 KWh, whereas combustion of one kg each of firewood, coal, and oil can generate 1 KWh, 3 KWh, and 4KWh respectively. Therefore running a 1000 MWe plant for a year requires 2.6 million tonnes of coal and 2.0 million tonnes of oil whereas it will require only 30 tonnes of natural uranium. The large differences in the volume of nuclear fuel and fossil fuels requirements explain the vast difference in the environmental impact of these energy sources.

Fossil fuel and nuclear fuel reserves are limited. The known oil and gas reserves, at the present rate of consumption are expected to last for about 40 years whereas coal will last for a much longer period. Therefore exploration activities have been intensified in many countries to locate new oil and gas reserves. Uranium reserves are expected to last for about 65 years. However if the spent fuel is reprocessed and uranium and plutonium are recycled then this period can be extended up to 300 years. The present annual requirement of uranium is 65000 tonnes which will increase to 75000 tonnes by the year 2020. The major producers of uranium are Canada, Australia, USA, Commonwealth of Independent States and Niger which produce about 85% of world uranium. In order to meet increasing uranium demand production has to be increased and new reserves have to be developed. Important production related developments are in progress in Australia, Canada, Kazakhstan, Mongolia, USA, and Uzbekistan which will increase the production of uranium. In addition to mine production and uranium inventories held by various countries, significant amount of highly-enriched uranium from the dismantling of nuclear weapons is also available which may be converted to low enriched uranium for use as reactor fuel. The United States has purchased 500 tonnes of highly enriched uranium from the Russian Federation in 1997. This uranium will be blended down to make low enriched uranium for the fabrication of nuclear fuel for pressurized light water reactors.

4.3 Nuclear waste

The operation of 1000 MWe nuclear plant produces about 30 tonnes of high-level radioactive wastes in the form of spent fuel elements and 800 tonnes of low and intermediate level waste. All the operating nuclear plants in the world produce about 3000 cubic meters of waste annually whereas US industry annually produces about 50 million cubic meters of solid toxic waste (6). The volume of high level waste is small and compact compared to wastes produced by modern industries. Spent fuel can be more easily isolated from the environment than waste from fossil fuel plants. Spent fuels are chemically stable and the thermal condition of storage improves with time due to the decay of fission products. The management of spent fuel involves a series of technical operations starting from the discharge of spent fuel assemblies from the nuclear reactor and ending either with the direct disposal of the fuel known as open fuel cycle or with the reprocessing of the fuel known as closed fuel cycle. Another option is to store it in an interim storage facility till a decision is made either to reprocess it or directly dispose of it. The intention of closed fuel cycle was to recycle the separated plutonium and uranium in fast-breeder rectors. Because of the delays and cancellations of breeder programs plutonium and uranium are being recycled in thermal reactors. The radioactive waste from reprocessing operations is vitrified as phosphate glass or borosilicate glass which can be safely disposed of in a geological repository. IAEA has published three safety documents for the management of spent fuel. These include a guide on the safe storage of spent fuel, a guide on the safe operation of these facilities and a document on the preparation of safety analysis reports for the spent fuel storage. These measures have been helpful in the safe storage and management of spent fuel.

A large amount of spent fuel can be easily and safely stored behind multiple barriers in specially designed wet or dry storage facilities. Such facilities exist in many countries. A large wet storage facility “CLAB” in Sweden can store 5000 tonnes of spent fuel whereas a dry storage facility in Canada can store 1025 tonnes of fuel. In Pakistan the spent fuel has been stored in a wet facility for the last 25 years. Finally the spent fuel can be stored or safely disposed of in underground repository. The US Department of Energy (DOE), after thorough investigations, has selected a site at Yucca Mountain in Nevada for the final disposal of spent fuel and other high level radioactive waste. For more than 20 years extensive scientific studies on the geology, hydrology, biology and climate of Yucca Mountain have been conducted which indicated that highly radioactive waste can be safely stored at this site (12). On the basis of these studies, the US Government, in July 2002, allowed the DOE to take the next step in establishing a safe repository at Yucca Mountain. The DOE is now in the process of obtaining a license from the Nuclear Regulatory Commission to proceed with construction of the repository. After the completion of this project, spent nuclear fuel and high level radioactive waste from 77 locations in the US will be safely deposited in the deep underground facility. Experts throughout the world agree that deep underground storage of high-level radioactive materials is a feasible and safe method of final disposal of such waste.

4.4 Reprocessing of spent fuel

Spent fuel contains uranium and plutonium which can be separated from the fission products by reprocessing of the fuel. The separated uranium and plutonium can be recycled by making mixed oxide fuel. Recycling of plutonium is being carried out in Belgium, France, Germany, Japan and Switzerland whereas the Russian Federation and the United Kingdom are recycling uranium. At present 16 countries with the exception of the USA are reprocessing the spent fuel (13). Reprocessing, however, has become an international political problem due to the risk of nuclear weapon proliferation. Reprocess operations in the USA were suspended in 1977 when President Carter deferred indefinitely the recycling of spent nuclear fuel due the risks of proliferation. As a result of this decision large amounts of spent fuel have been accumulated in the USA. The majority of other nations assessed the risk of nuclear weapon proliferation differently and did not fellow the US example. These nations continued reprocessing of spent fuel for the separation of plutonium and uranium which also reduces the volume and radio toxicity of nuclear waste. No plutonium has ever been diverted from British or French reprocessing facilities or fuel shipments which indicates that the risk of proliferation has been exaggerated. However the risk of proliferation is not zero but it can be significantly minimized by continues strengthening of non-proliferation regime.

4.5 Nuclear non-proliferation

Proliferation of nuclear weapons has been a serious concern which has affected the development of nuclear technology in many countries. There is a worldwide concern that the current and future nuclear power operations could provide essential technologies and knowledge to many countries which may be used for the development of nuclear weapons. In order to prevent the spread of nuclear weapon, the Nuclear Non-Proliferation Treaty (NPT) and Nuclear Safeguard regime have been established. According to this Treaty all States which have signed the NPT and IAEA nuclear safeguard protocols will open their facilities to regular IAEA inspection. Non-nuclear weapon states should refrain from nuclear weapon development and all states should refrain from assisting potential proliferates from acquiring key technologies and know-how of weapon development. Inspection of nuclear facilities and nuclear materials accountability by IAEA has significantly reduced the possibility of diverting material from civilian programs to any military purpose. After the detection of uranium enrichment activities in Iraq, the safeguard regime has been further strengthened to detect any undeclared uranium enrichment and reprocessing operations. With these measures, development of nuclear weapons today would encounter greater barriers and enhanced prospects of early detection before such a program could succeed.

The NPT is a discriminatory treaty. It prohibits the horizontal proliferation of nuclear weapons but it is silent about the vertical proliferation. Nuclear weapon states are developing more and more sophisticated weapons whereas these powers are keen to avoid horizontal proliferation of nuclear weapons. This dual policy of nuclear weapon states is adversely affecting the establishment of nuclear power plants for the generation of electricity in developing countries. In view of the discriminatory nature of the NPT many countries including Pakistan and India have refused to sign the NPT. These countries rightly believe that the NPT should be a non-discriminatory treaty.

4.6 Nuclear safety and radiation exposure

Safe operation of nuclear power plants and reprocessing facilities are of prime importance to dispel the misgivings in the mind of the public regarding the safety of nuclear power. The public acceptability of nuclear power was adversely affected after the Chernobyl Nuclear Reactor accident in 1986 which created grave public concerns regarding the radiation exposure and cancer risk. The release of radioactivity from this accident caused 31 deaths from radiation exposure and affected many people in Russia and some countries in Europe. The accident occurred due to human error in operating a fundamentally faulty reactor design. The reactor has the tendency to spontaneously increase the power level when the temperature in the core increases. At the time of the accident the power of the reactor rose to more than one million megawatts and the fuel evaporated. Since it had no containment structure, all the radioactivity was released to the environment. However the Three Mile Island reactor accident in USA did not release any significant amount of radioactivity in the environment due to proper containment structure. This demonstrated that containment structure and properly engineered safety systems could prevent the release of radioactivity in the environment. After the Chernobyl accident, reconstruction and safety enhancement measures were implemented at all the RBMK reactors. Probabilistic safety assessments (PSA) were performed which provided useful information in identifying design and operational weaknesses and setting priorities for improvements. These measures have significantly reduced the core damage frequency and serious accidents at RBMK.

Safety systems of all the nuclear power plants (NPP) were reviewed after this accident and measures were taken to enhance the safety. Changes in the design of NPP including the installation of emergency core cooling systems and remote control rooms, better operational rules and procedures along with the implementation of administrative measures have substantially improved safety conditions of operations.

In addition to this, probabilistic safety studies and severe accidents studies are integral part of NPP safety and part of the review plan of the regulators. International Safety Assessment Review Teams (IPSART) organize peer reviews of PSA performed in member states of the IAEA and assist them in the application of PSA results and methods. According to the IAEA convention on Nuclear Safety, all countries should observe certain basic standards, report on safety matters and submit these for peer review. The standards are kept up to date and incorporate the experience of the nuclear world. The national authorities can seek guidance and support in these standards from the IAEA. The present advanced light-water reactors are sufficiently safe as these do not release off site radioactivity even in the case of a severe accident (6).

The normal operation of nuclear power plants release some radioactivity in the environment which may cause radiation exposure to people. However the additional radiation doses to the population from the power plants are only a very small part of the natural background. The natural background radiation levels in many areas vary from 2 milli sievert per year (mSv/y) upto 5 mSv/y. The radioactivity released from the nuclear power plant will expose the public to an additional radiation dose of about 1 to 3 micro sievert per year. Large scale studies of various population groups exposed to low doses of radiation have been carried out in many countries by the International Agency for Research on Cancer which indicates that there is no increased risk of cancer from low doses of radiations (14). In fact some studies show that exposure to low doses of radioactive radiation improves health and lengthens life, probably by stimulating the immune system similar to vaccines action.

5.1 General

At present 442 nuclear power reactors are operating in 31 countries whereas 35 new units are under construction (15). These plants are generating 357 Gwe-year which is about 17% of global production. The share of nuclear electricity in the national energy mix of various countries is mentioned in Table 2 which indicates that Lithuania and France generate more than 75% of their electricity by nuclear energy. Nuclear Power is especially attractive for resource deficient countries such as France, South Korea and Japan.

Table 2. Nuclear Share In Energy Resource Poor And Energy Resource Rich Countries in 2002 (15)

ENERGY RESOURCE POOR		ENERGY RESOURCE RICH	
• LITHUANIA	78%	• SWEDEN	44%
• FRANCE	77%	• FINLAND	31%
• BELGIUM	58%	• SPAIN	27%
• SLOVAKIA	53%	• UK	24%
• UKRAIN	46%	• CZECH REPUBLIC	20%
• BULGARIA	42%	• USA	20%
• R.O. KOREA	39%	• RUSSIA	15%
• HUNGARY	39%	• CANADA	13%
• SWIZERLAND	36%	• S. AFRICA	7%
• JAPAN	34%	• MEXICO	4%

The present generation of nuclear electricity in Pakistan is estimated to be about 2300 GWh which is 3.2% of the national generation (4). This share is expected to increase to about 6% in the next 15 years through the establishment of more nuclear power plants. Pakistan is the only Muslim country which has two nuclear power plants. A 125 MWe* pressurized heavy water reactor (KANUPP) with natural uranium fuel was commissioned in 1972 whereas a 300 MWe pressurized light water reactor (CHASNUPP) with 3% enriched uranium fuel started operations in 2000. Both these reactors are operating under IAEA safeguards. The establishment of a second nuclear power plant was delayed for a very long time due to international politics. The developed countries, in the mid seventies, adopted a policy of denial of nuclear technology to Pakistan and some other countries. As a result of this policy the nuclear power program in Pakistan was adversely affected. The supply of fuel for KANUPP was stopped and an agreement for setting up of a fuel fabrication plant was unilaterally revoked. Pakistan then made significant R&D efforts to develop the front end of the nuclear fuel cycle which involves uranium mining, extraction of uranium from the ore to produce yellow cake, refining it to nuclear grade and fuel fabrication. .KANUPP has been operating with the indigenously fabricated nuclear fuel for more than 15 years. Since

* Mwe means Mega watt-year electriacl (Editors).

KANUPP has completed its designed life of 30 years, work has already been started to extend it operations for another 10 years and to upgrade the safety and other systems. Plans have also been finalized for the construction of a third reactor of 300 MWe. Iran is another Muslim country which started construction of two nuclear power plants about 20 years ago but the work was suspended during the Iranian revolution. Construction of one reactor has started again with the assistance of the Russian Federation.

5.2 New generation of reactors

In view of the increasing energy demand due to population growth and global climate change threat from greenhouse gases, the production of nuclear electricity would increase from the current 357 to about 2000 Giga watt-year electrical (GWe) by the year 2050. To meet the increasing demand a new generation of nuclear power plants has been or is being developed (16).

The present small and medium size power plants under construction such as AP-600, VVER-640, PHWR-500 and CANDU-6 incorporate the basic technology of the current large nuclear plants. In order to extend the benefits, viability and importance of nuclear power for the long term it is necessary to conduct innovative R&D for new reactor designs. This need has been recognized by the nuclear industry and significant R&D studies are being conducted in a number of countries namely Argentina, Canada, China, France, India, Italy, Japan, Republic of Korea, Russian Federation, South Africa and the USA. These studies have been directed towards the development of innovative nuclear fuel cycle and new reactor designs. Attention has been focused on the development of small modular units which have long life nuclear fuel cores, enhanced safety and proliferation-resistant features. These units are excepted to have factory built structure and components for fast installation which will reduce the construction time and cost. Small nuclear reactors being developed in various countries include the following:

- **Carem-25**, 25 MWe pressurized water reactor in Argentina
- **KLT-40,** 40 MWe Pressurized water reactor in the Russian Federation
- **SMART**, 100 MWe Pressurized water reactor in the Republic of Korea
- **AHWR,** 235 MWe Pressurized heavy water reactor based on thorium fuel in India
- **PBMR**, 114 MWe high temperature gas-cooled pebble bed reactor in South Africa.
- **GT-MHR** 285 MWe gas cooled reactor through combined efforts in USA, Russian Federation, France and Japan.

New generation of medium and large nuclear reactors are also being developed with the goal of reducing capital cost through economy of scale. The following four reactors are in the advanced stage of development and testing:

- **ACR** 700 MWe by AECL Canada
- **SWR-1000** 1013 MWe by Framatom in France
- **AP- 1000** 1090 MWe by Westinghouse in USA
- **ABWR** 1350 MWe General Electric in USA.

All these reactors appear to have desired safety and other features and will increase the generation of nuclear electricity. It will be important to select those that are the best candidates for future development and demonstration.

PBMR has received worldwide attention as it claims to have all the desired features. It is a modular helium gas cooled pebble bed reactor which is being developed by a South African

Company named Eskom which estimates that this plant will produce electricity at around 1.5 cents (US$ 0.015) per KWh. This reactor has a once-through fuel cycle and advanced safety features due to the use of ceramic coated fuel particles with a high heat capacity. It does not require emergency core cooling systems and it cannot physically melt down. Small modular plants designed for safety, proliferation resistance and ease of operation will be especially beneficial for small developing countries.

6 CONCLUSION

The demand for energy is increasing with the increasing population. To meet this demand, it is necessary to increase the generation of electricity utilizing thermal, renewable and nuclear energy sources. Gas fired combined cycle power plants, due to their relatively higher fuel to energy conversion efficiency, will make a substantial contribution in the generation of electricity.. However the emission of greenhouse gases from thermal energy sources pose a serious threat of global warming and climate change. Further, the known oil and gas reserves at the present level of consumption may last for about 40 years. Hydro and nuclear energy which do not release greenhouse gases at the generation stage, appear to be attractive for the generation of electricity. The known uranium reserves may last for about 65 years and with the recycling of uranium it may be extended to about 300 years. Their contribution in the global energy mix will significantly increase in the future.

Nuclear power plants have been in operation for more than 40 years. This long operating experience shows that nuclear energy is safe, reliable and environment friendly. Cost economic comparative assessment of various energy sources indicates that nuclear power is a competitive option for generation of electricity in many countries. New generation of small, modular power plants will extend the benefits of nuclear power to smaller developing countries. Nuclear energy will play an increasingly important role in the generation of electricity in the future.

The development of nuclear power, although justified by environmental and economic considerations of the overall energy situation in a given country, has become more a matter of political debate rather than one of technical significance. The anti-nuclear lobby has created unfounded fear in the mind of public regarding the safety of nuclear power. This fear has to be displayed by generating favourable public opinion through the widespread use of print and electronic media. The nuclear energy professionals and managers of nuclear power programs should use these media to explain the safety of nuclear power, correct position of the global energy reserves and the alternative sources of energy that are left for our future generation.

REFERENCES

1. G.Doucet, IAEA Bulletin**. 42** , No:2, (2000) 2
2. H.Blix. Nuclear News, Am.Nucl. Soc. **40** , No: 10 (1997)
3. Energy Statistic Year book, ENERDATA, Grenoble, France (2002)
4. Pakistan Energy Yearbook, 2002, HDIP. Ministry of Petroleum and Natural Resources. Government of Pakistan.(2003)
5. A. M. Khan and A.I. Jalal. "Nuclear Energy and its impact in improving Environment", Proc. 2nd Pak. Nuclear Society Seminar. Islamabad, Ed: M.A. Chaudhry (1995)
6. R.Rhodes and D. Beller, IAEA Bulletin**, 42** , No. 2 (2000) ,43
7. J.V. Spadaro, L. Langlois and B. Hamilton, IAEA Bulletin, **42** , No: 2, (2000),19
8. H.H. Rogner and A.M.Khan, IAEA Bulletin, **40** , No: 1 (1998),3
9. Electricity and the Environment, Key issue papers, Proc. Senior Expert Symposium IAEA, Vienna, STI/PUB/899 (1991)
10. Keyword Energy Statistics, International Energy Agency, Paris (2001)
11. World Energy Assessment "Energy and the challenge of sustainability" UNDP-UNDESA-W.E.C, REPORT (2000)
12. Yucca Mountain Science and Engineering Report. Dept. of Energy USA. (2002)
13. P.H.Dyck and M.J. Crijns, IAEA Bulletin **40** , No: 1 (1998),24
14. A. Strupczewski, IAEA Bulletin, **41** , No.1 (1999) 19
15. International DATAFILE, IAEA Bulletin**, 44** , No. 2, (2002), 59
16. D. Majumdar, et.al. IAEA Bulletin, **42** , No. 2, (2000), 51

Nuclear Power and the Environment
Prospects and challenges

SAMIA MOHAMED RASHAD*
Atomic Energy Authority, Cairo, Egypt
Email: Samia_Rashad@hotmail.com

1 ABSTRACT

Worldwide there were 441 operating nuclear power plants (NPPs) at the end of 2002 supplying 16 percent of global electricity generation; the cumulative operating experience now stands at over 10,000 reactor years. The most significant recent trend has been that of steady increases in availability factors. Without such improvement in availability factors, nuclear power would not have maintained its 16% share of global electricity. Some 83% of nuclear capacity is concentrated in industrialized countries. By contrast, almost 2 billion people in developing countries remain without reliable energy supplies - a major factor in their aspirations for social and economic development.

Nuclear power can be considered the only source that can provide electricity on a large scale with comparatively minimal impact on the environment. But any major future expansion in the use of nuclear power will depend heavily on the innovation in reactor and fuel cycle technology. Innovation should ensure that new reactor and fuel cycle technologies incorporate inherent safety features, proliferation - resistant characteristics, and reduced generation of waste. Consideration should also be given to physical protection and other characteristics that will reduce the vulnerability of nuclear facilities and materials to theft, sabotage, and terrorist acts. In this paper, consideration will be given to: economic competitiveness, safety, waste management, proliferation resistance, health effects, and sustainable development and environmental protection; the nuclear innovation efforts will also be highlighted.

2 INTRODUCTION

The world's population crossed the 6 billion mark in the 1999. Most current estimates suggest that around 2 billion people will be added over the next 30 years with another billion in the following 20 years. Virtually, all this increase will be in the developing countries with the bulk of this in urban areas. The core challenge for development is to ensure availability of productive work opportunities and a better quality of life for all these people [1]. Two aspects are very important: quality of life should be above a minimum threshold and there should be equitable opportunities for all. At present however, inequality is widening. The average income in the richest 20 countries is now 37 times that in the poorest 20 and this ratio has doubled in the past 40 years. Inequalities can give rise to conflicts and therefore it is necessary to address development concerns of all nations.

Inequality seen in income level is also seen in per capita energy consumption. Statistics published by the IAEA [2] indicate that per capita energy consumption in North America in 2001 was 343 GJ and it is expected to grow to 346-387 GJ by 2020. Per capita energy consumption in Africa is expected to change from 27 GJ in 2001 to 26 –32 GJ in 2020, In the Middle East, and South Asia from 25 GJ in 2001 to 30-38 GJ in 2020. These forecasts do not indicate any perceptible improvement in the status of inequality. Energy is the engine for the growth. It multiplies human labour and increases productivity in agriculture, industry as well as services .With sustainability issues staring at us, the above situation can be corrected only if the energy supply becomes abundant and within the reach of all.

* Head of Nuclear Regulations and Emergencies Division and the National Radiological Emergency coordinator

GDP is assessed to be the fundamental driver of energy demand, GDP itself being a function of population size, technology and what might be termed “development capability.”

With population growth slowing more rapidly than imagined even a few decades ago, maintaining high GDP growth will depend more on the second two factors. On balance GDP growth and with it energy demand is expected to continue the slowing trend of the past four decades. Even so, in the absence of evidence of saturation of energy demand, energy consumption is expected to continue to increase, with electricity and transportation energy increasing their shares and stationary fossil fuel uses diminishing.

The future of nuclear power will depend on a number of factors, including ensuring the continued safety of operation at nuclear facilities, the development and demonstration of clear national and international strategies for the disposal of high level radioactive waste, the ability to compete economically with other energy sources, and successful communication of the benefits of nuclear power to civil society. But any major future expansion in the use of nuclear power will depend heavily on an additional factor, namely the innovation in reactor and fuel cycle technology. This is the innovation that successfully maximizes the benefits of nuclear power while minimizing the associated concerns. Innovation should ensure that the new reactor and fuel cycle technologies incorporate inherent safety features, proliferation resistant characteristics and reduced generation of waste. Consideration should be given to physical protection and other characteristics that will reduce the vulnerability of nuclear facilities and materials theft, sabotage and terrorist acts.

Innovation efforts must be more than purely technical. The evaluation of new design aspects by the nuclear industry should be accompanied, throughout the nuclear community, by a re-evaluation of technology policy issues. These issues play a significant role in economic costs, investor confidence, and public acceptance of nuclear technology. A high level of confidence must be achieved in the reliability of construction schedules, licensing review procedures, regulatory oversight, liability issues and other factors that affect the cost and efficiency of nuclear facility design, construction, start up, operation and maintenance [3,4,5].

3 ROLE OF NUCLEAR POWER

Worldwide there were 441 operating nuclear power plants (NPPs) at the end of 2002 supplying 16 percent of global electricity generation. In 2002, 20% of the USA’s electricity was nuclear, 27% of Spain’s, 31% of Germany’s, 34% of Japan’s, 39% of the Republic of Korea’s, 44% of Sweden’s, and 77% of France’s. Cumulative operating experience now stands at over 10,000 reactor-years. Six new NPPs were connected to the grid in 2000, three in 2001, and six in 2002. Long-term projections for nuclear power, particularly in the event of international agreement to significantly limit greenhouse gas (GHG) emissions, are more bullish than near-term trends. While economics is a key factor, public concerns about safety, waste, sustainability, and proliferation will need to be addressed. The most significant recent trend has been that of steady increases in availability factors. The cumulative impact of such increases since 1990 is equivalent to having built 33 new NPPs, each of 1000 MW (e). Without such improvements in availability factors, nuclear power would not have maintained its 16% share of global electricity.

Currently, growth is centred in Asia. Of 33 reactors currently under construction worldwide, 20 are located either in China, Taiwan - China, the Republic of Korea, the Democratic People’s Republic of Korea, Japan, or India. Seventeen of the last 26 reactors to be connected to the grid are in the Far East and South Asia. And the greatest growth in nuclear electricity production in 2001 occurred in Japan. Within Asia, capacity and production are greatest in Japan (54 NPPs) and the Republic of Korea (18 NPPs). Seven NPPs are in operation in China; four more are under construction. Taiwan - China has six NPPs with two more under construction. India has 14 small NPPs (up to 220 MW (e)) operating, and eight under construction).Highest growth of nuclear power is expected to occur in the

Asian region, from a study using an optimization model developed by Intergovernmental Panel on Climate Change, the share of Asian nuclear market is around 60-70% of total world nuclear power generation in 2050 (Figure 1).

In the USA, there is currently no construction. The key development has been market liberalization. The average availability factor rose from 72% in 1990 to 90% in 2001, and nuclear generation costs dropped to record lows. The US Nuclear Regulatory Commission (NRC) has granted license extensions, over 60 years, to fourteen US reactors, and sixteen more applications are under review.

Western Europe has 146 reactors. Overall capacity is likely to remain near existing levels, even with long-term nuclear phase-outs planned in Belgium, Germany, and Sweden. Eastern Europe and the economies in transition have 68 operating NPPs. Ten more are under construction. In the Russian Federation, there has been an increase of nuclear electricity production of 30% since 1998, thus ending the stagnation following the Chernobyl accident. Most of this increased production has resulted from increased plant availability.

In Latin America there are six operating NPPs and one under construction. Two NPPs are operating in South Africa.

In an increasingly competitive and international global energy market, a number of key factors will affect not only the energy choice, but also the extent and manner in which different energy sources are used. These include optimal use of available resources, reduction of overall costs, minimizing environmental impacts, convincing demonstration of safety, and meeting national, and global policy needs. For nuclear energy and other options, these five factors will determine the future of energy mix and strategies, at the national and global levels

4 NON –ELECTRIC NUCLEAR HEAT APPLICATIONS

Nuclear energy plays an important role in electricity generation. It has proven to be safe, reliable, economical and has only a minimal impact on the environment. Most of the world′s energy consumption, however, is in the form of heat. The market potential for nuclear heat was recognized early. Some of the first reactors were used for heat supply, e.g. Calder Hall (United Kingdom), Obninsk (Russian Federation), and Agesta (Sweden). Now, over 60 reactors are supplying heat for district heating, industrial processes and seawater desalination. But the nuclear option could be better deployed if it would provide a larger share of the heat market. In particular, seawater desalination using nuclear heat is of increasing interest to many countries.

Since the early days of nuclear power development, the direct use of heat generated in reactors has been widely practised and expanding. In addition to the forerunners, UK and Sweden, many other countries have found it convenient to apply nuclear heat for district heating or for industrial processes, or for both, in addition to electricity generation [7, 8]. They include Bulgaria. Canada , China , the Czech Republic , Germany , Hungary , India , Japan , Kazakhstan , the Russian Federation , Slovakia, Sweden , Switzerland and Ukraine . Though less than 1% of the heat generated in nuclear reactors worldwide is at present used for district and process heating, its operating experience exceeds about 600 reactor – years and there are signs of increasing interest in these applications. About 33% of the world′s total energy consumption is currently used for electricity generation. This share is steadily increasing and is expected to reach 40% by the year 2015. Of the rest, heat consumed for residential and industrial purposes and the transport sector constitute the major components, with the residential and industrial sectors having a somewhat larger share. Practically the entire heat market is supplied by burning coal, oil, gas, or wood.

The residential and the industrial sectors constitute the two major components of the overall heat market. Within the residential sector , while heat for cooking has to be produced directly where it is used , the demand for space heating can be and is often supplied from a reasonable distance by a centralized heating system through a district heating transmission and distribution network serving a relatively large number of customers .District heating networks generally have installed capacities in the range of 600 to 1200 megawatt-thermal (M

W(th)) in large cities, decreasing to approximately 10 to 50 MW (th) in towns and small communities. The temperature range required by district heating systems is around 100 to 150 ˚C. Within the industrial sector, process heat is used for a very large variety of applications with different heat requirements and with temperature ranges covering a wide spectrum.

5 WASTE MANAGEMENT

The wastes from peaceful uses of nuclear energy tend to receive the lion's share of public scrutiny, even when they are properly managed, contained, and have radioactivity levels similar to those from other sources that are not managed as well. The amount of radioactivity in waste accumulated as a result of nuclear power production around the world during the last half century is also on the order of 1000 EBq; this inventory is growing at a rate of approximately 100 EBq per year.

The volume of civilian radioactive waste is not very large either. All the high-level waste accumulated so far though intensely radioactive could be accommodated in a large store of around one hectare, or one city block. This is the result of the efficiency of nuclear fuel and the strict strategy of concentration and confinement of waste followed by the civilian nuclear industry. Operating a 1000 megawatt electric nuclear power plant requires around 27 tons of fuel per year. An equivalent fossil fuel plant would consume per year approximately 2.6 million tons of coal (or 5 trains of 1400 tons each per day) or 2 million tons of oil (or 10 supertankers per year).

Not surprisingly, these differences are seen in the wastes being generated. The nuclear will produce around 27 tons of high-level radioactive waste, 310 tons of intermediate level, and 460 tones of low level waste, whereas the equivalent coal plant will release into the environment 6 million tones of greenhouse gases, 244,000 tons of sulphur oxides, 222,000 tons of nitrogen oxides, and 320,000 tons of ash containing 400 tons of toxic heavy metals. These ashes contain large amounts of concentrated NORMs which may commit the human race to higher collective doses than those attributable to wastes discharged into the environment by nuclear plants generating the same amount of electricity.

5.1 Minimizing radioactive waste

5.1.1 General

A strong requirement for waste minimization arises from the generally accepted principal objective of radioactive waste management: "… to deal with radioactive waste in a manner that protects human health and the environment now and in the future without imposing undue burdens on future generation [11]" This rule is properly reflected in most of the relevant IAEA documents and also in basic regulatory and legislative documents in many countries. A waste minimization strategy should be established to serve as a conceptual basis for coordinated planning and implementation of desired measures. The following topics, among others, may be covered:

5.1.2 Administrative consideration

These include the legislative basis for waste management and waste minimization, including proper and sound waste clearance and discharge policies; identification of responsibilities and commercial arrangements between utilities and waste managers; economic assumptions (economic support, tax rates, discount rates); the quality assurance system; and qualification and training of staff .

5.1.3 Technical and safety consideration

These include the power plant capacity and performance, reactor type, location; design principles of the nuclear facility and individual components; the expected operational lifetime of facilities; the waste conditioning strategy (national and also facility-specific); and the waste.

5.1.4 Reduction of waste sources

The most straightforward method for lowering waste processing and disposal costs is to reduce the generation of wastes in terms of volume and activity at the source .Considering waste minimization requirements in the design and construction phase of nuclear facilities may have a direct impact on future waste production during both operational and decommissioning periods .The main design-related technical options are [12]:

- The proper choice of materials (resistance to corrosion , high-quality surface treatments, low tendency to activate and/or produce radionuclides that may cause problems);
- Application of the most effective , reliable and up-to- date technology to assure that equipment will remain operable as long as possible without replacement and /or maintenance;
- High performance of components and prevention of unintended use of waste, and minimization of leakage /drainage to avoid repairing active components and producing additional waste; and
- Strong separation of active and non-active media and segregation of active media according to their nature and activity.

Typical practical steps that can contribute to the reduction of operational radioactive waste generation are to:

- Limit the number and size of the controlled areas and identify all points in the working areas and all stages in the process where it is possible to prevent material from becoming radioactive waste;
- Establish waste accounting and tracking systems to quantify sources, types, amount, activities and characteristics of waste;
- Apply recent technological processes (good operational practice) and modify maintenance and refurbishment procedures leading to waste reduction;
- Reuse recovered materials (e.g. boric acid, special metals, fission material) to reduce waste generation and decrease operational costs;
- Recycle and reuse liquids within the process (such as decontamination solutions and laundry water) to reduce the volume and potential environmental impact of discharged liquids;
- Establish a system of sorting waste and separating waste streams to prevent improper mixing and to assure more efficient characterization and subsequent processing;
- Establish a rigorous system for segregation of non-active and active contaminated waste in the controlled area; and
- Increase the flow of information among staff regarding waste reduction philosophies, techniques and improved methods, and emphasize the training of staff in waste reduction practices.

5.2 Minimization of waste volumes for storage or disposal

Storage and disposal costs are often the main, though not the single reason for operators to reduce the volume of generated wastes. In the face of public and political opposition to construction of facilities, for environmental or other reasons, the effort to maximize the use of space in existing storage and disposal facilities has taken on added importance for waste management organizations. Various treatment and conditioning techniques enable substantial reduction in the final volume of conditioned waste.

5.3 Basic principles of waste management

The overall objective of nuclear safety is to protect individuals, society, and the environment from harm by establishing and maintaining effective defence against radiological hazards from nuclear installations. The overall objective of waste management is to deal with radioactive waste management in a manner that protects human health and the environment now and in the future without imposing undue burdens on future generations. Basic principles are as follows [3, 4, and 11]:

1. Radioactive waste shall be managed in such a way as to secure an acceptable level of protection for human health.
2. Radioactive waste shall be managed in such a way as to provide an acceptable level of protection of the environment.
3. Radioactive waste shall be managed in such a way as to assure that possible effects on human health and the environment beyond national borders will be taken into account.
4. Radioactive waste shall be managed in such a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today.
5. Radioactive waste shall be managed in such a way that will not impose undue burdens on future generations.
6. Radioactive waste shall be managed within an appropriate national legal framework including clear allocation of responsibilities and provision for independent regulatory functions.
7. Generation of radioactive waste shall be kept to a minimum practicable.
8. Interdependencies among all steps in radioactive waste generation and management shall be appropriately taken into account.
9. The safety of facilities for radioactive waste management shall be appropriately assured during their lifetime.

All technical issues for the safety of all processes and activities under normal and accidental conditions must be taken into account and properly addressed. Such issues are strongly technology dependent and may change from one waste management strategy to another. For some processes, removal of decay heat may be required, in others, prevention of criticality may be an issue, or, in the transport of radioactive waste between two different processes, design of special casks might be required. Optimization of the waste management system designs should be viewed in the context of optimization of the complete energy system. The factors to be considered include:

- Radiotoxicity, as a function of time , of the wastes generated;
- Ability of the waste form to retain radionuclides under normal and accident conditions;
- Mobility of the toxic elements through environmental pathways;
- The time over which long – lived radionuclides remain in interim storage;
- The degree to which the wastes are kept in a passively safe state, and
- Occupational exposure in waste management facilities.

The costs of managing all wastes in the life cycle should be included in the estimated cost of energy from the energy system, in such a way as to cover the accumulated liability at any stage of the life cycle.

6 ENVIRONMENTAL IMPACTS

Although the use of electricity is relatively benign, its generation is one of the world's environmentally damaging activities. While the energy sector contributes 49% of greenhouse gases, electricity generation alone produces more than 25% of energy-related carbon dioxide emissions. During the past 20 years, half of all increases in energy related carbon dioxide emissions were from emissions to the environment have been the principal focus of energy impact studies: other significant impacts such as land disturbance and population displacement together with their economic and social implications are less emphasized. Major impacts such as depletion of natural resources and large fuel and transport requirements that influence a wide range of areas including occupational and public safety as well as national transport systems, are generally ignored. [13] .The quantity of toxic pollutants and waste generated from fossil-fuel plants are much more than the quantities from other energy options. In general, the pollution depends on the impurity level of the fuel, with natural gas cleaner than oil and oil cleaner than coal. Table 1 presents emissions in kg/GWh of power-generating systems, for the full energy-chain, including the fuel cycle and the construction of the plant.

Table 1. Emissions in kg/GWh of power-generating systems, for the full energy-chain, including the fuel cycle and the construction of the plant

Emissions(kg/GWh)	Wind	Solar	Coal	Nuclear
SO_2	10.9-23.5	300-380	704-709	33-50
NOX	16.0-34.2	300-380	717-721	64-96
Dust	2.0-4.3	60-80	150	6-8

A 1000 MW(e) nuclear-power plant does not release noxious gases or other pollutants and produces annually only some 30 tons of discharged high-level radioactive spent-fuel along with 800 tons of low and intermediate level radioactive waste. Significant reductions in the volume of low level waste to be managed can be made through compaction. In the USA, low-level solid waste from nuclear power plants has been reduced 10-fold over the past decade to 30m³ annually of compacted waste per plant- a total of some 3000m³ from all operating plants. Industrial operations in the USA are estimated to produce annually more than 50 000 000 m³ of solid toxic waste [14].

The fossil fuels with their combustion-associated CO_2 emissions, and inherent CH_4 emissions associated with their production and transport are a separate category of high GHG emission factors, ranging from 500 to 1200g CO_2 equivalent/kW (e) h. Future energy-efficiency improvements could lower these emission factors considerably, but it is unlikely that the large gap between fossil fuels and the other energy sources can be bridged. A major factor of uncertainty of natural gas is the release of gas during production and transportation. Table 2 gives a list of the potential environmental impact of electricity generating system. 2

Table 2. Potential environmental impacts of electricity generating system

Fossil	Hydroelectric	Renewable: solar, wind, geothermal Biomes	Nuclear (full energy chain
-Global climate change -Air quality degradation (coal, oil) -lake acidification and forest damage (coal, oil) -Toxic waste contamination (coal ash and slag, abatement residues) -Groundwater contamination -Marine and coastal pollution (oil) -Land disturbance -large fuel and transport requirements. -Resource depletion	-Population displacement. -Land loss and change in use. -Ecosystem changes and health effects. -Loss of biodiversity -Dam failure. -Decommissioning	-Air quality degradation (geothermal, biomes) -Extensive land use -Ecosystem changes -Fabrication impact (Solar photovoltaic cells) -Noise pollution (wind)	-Severe reactor accident release -Waste repository release.

The emission factors of non-fossil fuel energies which are mature, viz. wind, geo-thermal and nuclear energy, are very low. They are in the range of 10-70 g CO_2 equivalent /kW(e)h. The emission factors of hydropower and sustainable biomes are uncertain due to difficulties in accounting for the emissions of CH_4 from anaerobic biodegradation from the hydropower water reservoir and in –soil biomes (mainly roots), respectively . Hydropower and sustainable biomes energy have emission factors in the range of 10-400 and 40-80 $_g$ CO_2 equivalent /kW(e)h, respectively . The renewable-energy sources, which are still under development , viz. solar and ocean energies , show emission factors of 100-300 $_g$ CO_2 equivalent /kW(e)h (Figure 2). Generally, accounting for methane sources in the complete fuel chain increases GHG emission factors substantially.

Table 3 shows the CO_2 emissions from selected plant types, together with their expected costs of electricity generation in the year 2000. It is clear that a trade-off will still often be required between low cost and low CO_2 emitting electricity-generating technologies, despite the projected fall in the cost of renewable electricity. Scatter within the emission factors from different studies of an individual energy source can be attributed to different methods and data bases. Data bases often are not up to date. Uncertainties in the global warming potential of CH_4 also add to the scatter in the emission factors. The direct emissions of CO_2 from nuclear-power generation are very low. However, it releases some CO_2 if indirect processes are taken into account. The life cycle CO_2 emissions-coefficient from nuclear power is 2.7% of that of coal-fired power generation.

Table 3. Projected costs of and CO_2 emissions from selected electricity-generating sources [6]

	Net efficiency (%)	Cost in the year 2000 (U$kWh)	CO_2 emissions (g/kWh)
Pulverized coal	36-43	4.0-6.5	795-950
Atmospheric fluidized-bed combustion	36-43	4.6-5.3	795-950
Pressurized fluidized-bed combustion	40-45	4.9-5.1	760-850
Integrated gasification coal combustion	44-49	4.9-5.1	700-775
Combined-cycle gas-turbine	50-61	3.7-7.3	330-405
Light-water reactor	__	5.6-7.4	0
Large hydro	__	3.8-8.7	0
Centralized photovoltaic system	__	11.3-62.8	0
Geothermal	__	2.4-4.9	0
Wind	__	4.4-7.6	0
Large biomass	__	7.5-7.8	0

7 NUCLEAR SAFETY

7.1 General

Accidents at Three-Mile Island and Chernobyl demonstrated the high level of hazards of existing nuclear power industry. Then two important theses were put forward. Future nuclear reactors shall have distinction in kind with the existing one ; nuclear technology shall be the forgiving one i.e. that some single errors of operator shall not cause high probability of accident severe consequences. Recognizing the necessity to take thoroughgoing decisions has brought the IAEA to a decision to develop the "User Requirements" [3, 4, 17, and 18].
The existing requirements can be summarized as follows:

- A design life of 60 years;
- Reliable and flexible operation, with high overall plant availability, low level of unplanned outages, short refuelling outages, good controllability (e.g., 100-50-100% load following capability). and operating cycles extended up to 24 months;
- Increased margins to reduce sensitivity to disturbance and the number of safety challenges;
- Improved automation and man-machine interface which, together with the increased margins, provide more time for the operator to act in accident/incident situations, and reduce the probability of operator errors;
- Core damage frequency less than 10^{-5} per reactor-year and cumulative frequency of large releases following core damage less than 10^{-6} per reactor- year; and
- Design measures to cope with servers accidents.

User requirements for future nuclear installations represent an idealization of what is desirable in safety taking into account both national /regional trends and what is likely to be technologically achievable.

7.2 Basic safety functions

Fundamental safety functions for nuclear reactors are to control reactivity, remove heat from the core; and confine radioactive materials and shield radiation. For fuel installations (including spent fuel storage at reactor sites), they are to control sub-criticality and chemistry; remove decay heat from radio-nuclides; and confine radioactivity and shield radiation .To ensure that fundamental safety functions are adequately fulfilled ,an effective defence-in-depth strategy should be implemented, combined with an increased use of inherent safety characteristics and passive systems in nuclear designs.

7.3 Defence-in-depth

Defence-in- depth provides an overall strategy for safety measures and features of nuclear installations .The strategy are twofold : first ,to prevent accidents and ,second , if prevention fails, to limit their potential consequences and prevent any evolution to more serious conditions. Accident prevention is the first priority.

An increased use of inherent safety characteristics will strengthen accident prevention in future nuclear installations. A plant has an inherently safe characteristic against a potential hazard if the hazard is rendered physically impossible. An inherent safety characteristic is achieved through the choice of physical and chemical properties of nuclear fuel , coolant and other components.

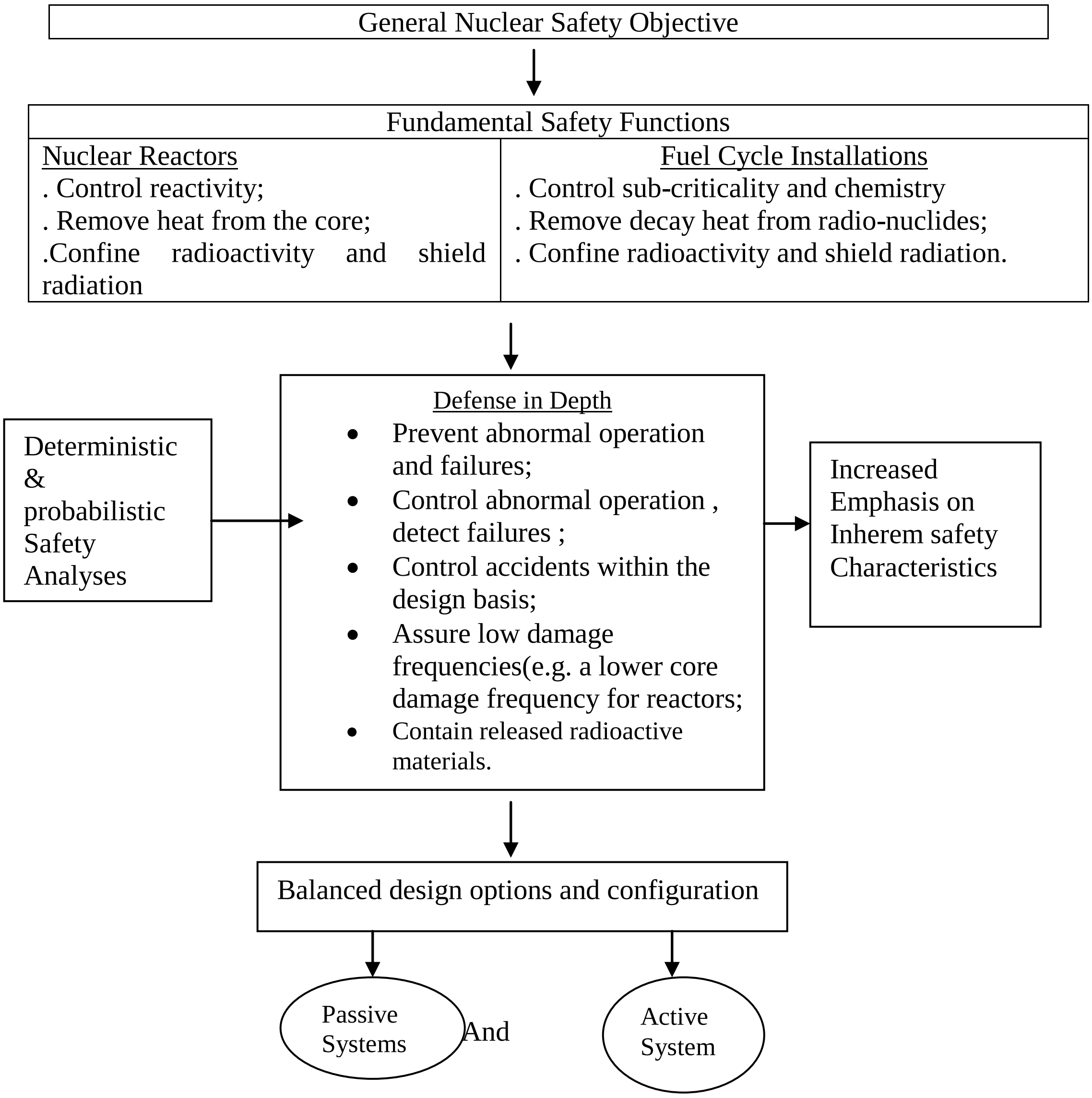


Figure 3. Approach to development of user requirements for innovative nuclear energy system in the area of safety.

The resulting approach to safety of innovative nuclear energy system is outlined in Figure 3 The general direction for innovation to enhance defence-in-depth is presented in Table 4.

7.4 Application of basic safety approach to fuel cycle facilities

There is a common agreement that the defence-in-depth strategy should be also used for fuel cycle facilities but defence-in-depth should be applied taking into account the major differences between fuel cycle facilities and reactors, namely:

- The energy potentially released in a criticality accident in a fuel cycle facility is less than that in a reactor power runaway;
- The routine release may be larger due to mechanical or chemical processes;
- The likelihood of release of chemical energy is higher; and
- The power density in orders of magnitudes less in comparison to a reactor core.

The basic strategy, however, remains the same, namely : all levels of protection should be implemented to keep the whole risk as low as reasonably achievable, social, and economic factors taken into account. In addition, dependence on human action in assuring the different levels of defence-in- depth should be reduced.

Table 4. Innovation to direction enhance the levels of defence in depth

Level of defence-in-depth	Objectives	Innovation Direction (INPRO)	
1	Prevention of abnormal operation and failures	Enhance prevention by increased emphasis on inherently safe design characteristics and passive safety features	
2	Control of abnormal operation and detection of failures	Give priority to advanced control and monitoring systems with enhanced reliability, intelligence and limiting features	
3	Control of accidents within the design basis	Achieve fundamental safety functions by optimized combination of active & passive design features; limit fuel failures; increase grace period to several hours	
4	Control of severe plant conditions, including prevention and mitigation of the consequences of severe accidents.	Increase reliability of systems to control complex accident sequences; decrease severe core damage frequency by at least one order of magnitude, and even more for urban-sited facilities.	
5	Mitigation of radio-logical consequences of significant releases of radioactive materials	No need for evacuation or relocation measures outside the plant site.	

7.5 Basic principles

There are five basic principles, namely:
Innovative nuclear reactors and fuel cycle installations shall:

1. Incorporate enhanced defence-in-depth as a part of their fundamental safety approach and the levels of protection in defence-in-depth shall be more independent from each other than in current installations;
2. Prevent, reduce or contain releases (in that order of priority) of radioactive and other hazardous material in construction, normal operation, decommissioning and accidents to the point that these risks are comparable to that of industrial facilities used for similar purposes ;
3. Incorporate increased emphasis on inherent safety characteristics and passive safety features as a part of their fundamental safety approach ;
4. Include associated RD&D work to bring the knowledge of plant characteristics and the capability of computer codes used for safety analyses to at least the same confidence level as for the existing plants ;
5. Include a holistic life-cycle analysis encompassing the effect on people and on the environment of the entire integrated fuel cycle.

8 SUSTAINABILITY AND COST OF NUCLEAR ENERGY

Nuclear energy has the advantage that large amounts of energy can be released from small amounts of relatively abundant and cheap material. In the period after the Second World War, there were suggestions that nuclear electricity would be “too cheap to meter [19]:-

The reality has proved somewhat different. Fifty years on, after very large investments, the cost of the electricity produced remains high. Only under special conditions, nuclear energy has proved to be able to compete well with fossil fuelled alternatives.

At present the economics of nuclear power is likely to become even less favourable, as for the alternatives costs have come down if competitive conditions are strong .Moreover, in the current context of liberalization of the electricity and energy market, nuclear's capital intensity constitutes a clear disadvantage . Consequently, at current and expected gas prices, new nuclear power plants cannot compete against natural gas-fuelled combined cycle technologies in those places where gas supply infrastructures are in place [3, 4, and 6].

Over the years, new nuclear power plants have become progressively more capital intensive, taken longer to build than other conventional power generating facilities, involved increasingly prescriptive and cumbersome procurement, and entailed longer and costlier regulatory and licensing procedures. All these factors tend to increase financial and commercial risks, and delay innovation [25].On average, the capital costs for building new nuclear plants of current reactor fuelled plants design are 2-4 times more than fossil .The challenge for industry is to reduce these costs to a generally competitive level. Without innovation, nuclear power is unlikely to meet this challenge.

Quantification of the external costs of today's fossil energy plants would improve the economics of nuclear plants. But these benefits will not be so great with various advanced fossil fuel technologies involving fuel decarbonisation and CO_2 sequestration [3, 26] .Thus direct economic costs will continue to be important in determining the future of nuclear power. CO_2 constraints as well as cost increase could change the growth estimate quite significantly. 20% cost reduction could increase global nuclear power growth by more double worldwide.

In conclusion, as stated in the World Energy Assessment published in 2000: "If nuclear power it to become economically viable again, innovations will be needed that can provide electricity at costs competitive with other future near-zero-emission energy technologies. Moreover this has to be done in ways that are consistent with meeting concerns about nuclear safety, proliferation and diversion, and radioactive waste disposal [4, 19]. Based on the approaches and conditions in many of the studies, it is concluded that present day nuclear technology use is not compatible with sustainable development. For nuclear energy to qualify as a sustainable energy option, concerns regarding safety, waste management, and disposal, proliferation and diversion, and public acceptance must be addressed in ways that enable nuclear energy to compete on an economic basis. It requires new concepts and ideas, technological innovation, as well as improved institutional arrangements and risk management strategies.

9 PROLIFERATION RESISTANCE

Proliferation resistance is defined as that characteristic of a nuclear energy system that impedes the diversion or undeclared production of nuclear material, or misuse of technology, by states intent on acquiring nuclear weapons or other nuclear explosive devices.

The degree of proliferation resistance results from a combination of, inter alia, technical design features, operational modalities, institutional arrangements, and safeguards measures. These can be classified as intrinsic features and extrinsic measures [20, 21].

Intrinsic proliferation resistance features are those features that result from the technical design of nuclear energy systems, including those that facilitate the implementation of extrinsic measures.

Extrinsic proliferation resistance measures are those measures that result from states decisions and undertakings related to nuclear energy systems.

Safeguards is an extrinsic measure comprising legal agreements between the party having authority over the nuclear energy system and a verification or control authority ,binding obligations on both parties and verification using , inter alia. on- site inspection.

A1000 Mwe Light Water Reactor discharges about 200 Kg of plutonium a year This amount is enough to produce twenty nuclear explosives .A global installed LWR capacity of 3,000 Gwe would produce about 500.000 Kg of plutonium a year. With breeder reactors instead of LWR's, this figure could increase to about 5 million kg plutonium a year. This would create a high diversion risk of fissile materials and nuclear weapons [3] .In addition, also in other parts of the nuclear fuel cycle technologies and materials can be misused, i.e. applied for non-peaceful purposes. Therefore, a nuclear system should be developed that is far more diversion resistant. It requires stronger institutional arrangements to keep peaceful and military uses separate and to prevent the misuse of nuclear possibilities. It also requires the development and application of advanced technologies aimed at limiting opportunities of acquiring nuclear weapons under the guise of peaceful nuclear energy applications and stealing weapon-usable nuclear materials

In this context, a number of "diversion –resistance criteria for future nuclear power" was formulated [17] that- somewhat modified –can be summarized as follows:-

1. Development of an advanced nuclear and fuel cycle technology that produces far less fissionable, weapons-usable materials in spent fuel; as an indication, less than a critical mass per year per GW of capacity.
2. The new technology should in principle be applicable in each modern society in a sound manner, 'culture proof' and without discriminatory conditions among nations.
3. Fissionable weapons-usable material that is not contained in spent fuel and facilities to enrich uranium or to separate plutonium shall not exist outside international centres that are maintained under tight physical security of the IAEA.
4. As far as possible, fissionable weapons-usable material produced in reactors should be contained in spent fuel.
5. Spent fuel shall be stored in international centres.

10 HEALTH EFFECTS AND RISK COMPARISON

There has been no credible documentation of health effects associated with routine operation of commercial nuclear facilities anywhere in the world .Widely accepted investigations , such as the comprehensive 1990 National Institutes of Health (NIH) study of some one million cancer deaths in people living near nuclear power plants in the USA, demonstrate no correlation between cancer deaths and plant operation. Investigations carried out in Canada, France, Japan and the United Kingdom support the NIH results .In considering health effects from nuclear power activities; any postulated risks from low level radiation exposures must be put into perspective with known risks from the toxic pollutants released from other parts of energy production cycle. Unfortunately the task of comparison is difficult, as there is vastly more scientific information about health effects from radiation than from the various toxic pollutants.

Health effects from energy related pollutants, as with radiation, are exposure dependent. For high levels of toxic pollutant exposure there is doubt about the potential health effects .Acute respiratory disorders are well documented for high levels of atmospheric pollution ,as are a number of respiratory disorders at more moderate levels .Heavy metal ingestion can cause a wide range of substance specific health disorders Arsenic-containing coal used in the Czech Republic for many years caused high levels of contamination, and arsenic specific health effects have been documented in children living in affected areas.

The higher overall death rates observed in areas with persistent atmospheric pollution, particularly from cardiovascular and pulmonary disorders, is a strong indicator that long term health effects from continuous low level exposures do develop. The WHO, in its 1997 report on sustainable development, estimates that deaths due to indoor and outdoor air pollution from energy activities account for 6% of the total 50 million annual global deaths.

The multiple indirect effect from energy related environmental pollution are even more difficult to assess.

Beyond doubt, the Chernobyl accident was severe accident in all its dimensions. For Comparison purposes, a review of other energy related systems as well as industrial accidents is needed .While the perception of nuclear accidents may not change, such a review provides some perspective. In the industrial sector, the well known 1984 Bhopal accident at a chemical plant in India caused some 3000 early deaths and several hundred thousand severe health effects. In the energy sector, dam failure and overlapping have caused thousands of deaths and massive disruptions in social and economic activities with the displacement of entire towns –the Variant dam overlapping in Italy and dam failures in Gujarat and Orissa in India are three such examples, each with several thousand fatalities. Severe coal mine accidents, causing several hundred deaths, are not rare. Explosions and major fires in the oil and gas industry have involved both occupational and public fatalities and injuries. A pipeline gas leak explosion in the Urals involved 500 fatalities. Energy sector accidents have also led to severe environmental damage, such as the 1989 "Exxon Valdez "oil-tanker accident in Alaska [16-15].

If risk assessments are considered only short-term severe accident fatalities (Table 5), the reported data would indicate that hydroelectric and gas fuel cycles have led to the largest single event fatality numbers. However, to draw conclusions about the relative safety of the various energy systems, fatalities and morbidity – occupational as well as public – over the longer term must be considered. Equally important are the maturity of the technology, the quality and maintenance of equipment and the safety and environmental controls.

Table 5. Short Term Fatalities (1970 – 1992)[a]

		Fatalities		Average Fatalities per Gw(e) per annum
	Events	Range	Total	
Coal	133	5-434	6 418	0.32
Oil	295	5-500	10 273	0.36
Natural gas	88	5-425	1 200	0.09
Liquid propane gas	77	5-100	2 292	3.1
Hydro	13	10-2500	4 015	0.8
Nuclear	1	31	31	0.01

[a] :The total is some 10 times higher if accidents with less than 5 fatalities are included.

11 CONCLUSIONS

The future potential of nuclear power largely depends on regional energy demand growth, CO_2 Constraints, and relative competitiveness of nuclear power. In particular, carbon tax could change the relative competitiveness of nuclear power quite significantly and 20% reduction of nuclear power generation cost could also increase future nuclear growth substantially.

In general, it is desirable to have a standardized reactor design all over the world, so that production scale merit can be maximized. For nuclear technology to make a substantial contribution to energy supplies, innovation is essential-innovation that is global in scope, responsive to concerns and collaborative in its approach. Environmental impacts caused by nuclear power generation and its related fuel cycle activities become key factors for future nuclear installation.

Environmental concerns should be addressed for the sustainable development of nuclear power. Active R&D is underway on a number of new nuclear reactor and fuel cycle technologies and international cooperation would be helpful to facilitate those efforts.

REFERENCES

1. Sustainable Development in a Dynamic World – World Development Report – 2003, World Bank.
2. Energy, Electricity and Nuclear Power Estimates For the period up to 2020 , Reference Data Series No. 1 July 2002 , IAEA .
3. International conference on Innovative Technologies for nuclear Fuel Cycles and Nuclear power, 23-26 June 2003, IAEA Vienna, Austria (Proceeding in preparation)
4. International Atomic Energy Agency , Guidance for the evaluation of innovative nuclear reactors and Fuel cycles ", Report of Phase 1A of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) , IAEA – TECDOC- 1362 , June 2003 .
5. OECD International Energy Agency , OECD Nuclear Energy Agency , Innovative Nuclear Reactor Development Opportunities for International Cooperation , OECD/IEA, Paris, 2002.
6. Rashad S.M., Hammad, F.H; Nuclear Power and the environment; Comparative assessment of environmental and health impacts of electricity generating systems, Applied Energy 65 (2000) 211- 229.
7. International Atomic Energy Agency , Status of non electric nuclear heat applications : Technology and safety , IAEA – TECDOC – 1184, Nov. 2000
8. International Atomic Energy Agency, nuclear Heat applications: Design Aspects and operating Experience, IAEA- TECDOC-1056, IAEA, Vienna, 1998 .
9. International Atomic Energy Agency, Waste solutions, IAEA Bulletin, Vol. 42 No. 3, 2000, Vienna, Austria.
10. Rashad S.M., Radioactive west management Overview , Proceedings of Energy and Environment Development Conference , 3-6 August 1999 , Port Elizabeth , South Africa .
11. International Atomic Energy Agency, the principles of radioactive waste management, safety series No. 111-F, IAEA, Vienna, 1995.
12. International Atomic Energy Agency, changing Realities, IAEA Bulletin, Vol. 40, No. 1, 1998 Vienna, Austria .
13. International Atomic Energy Agency, Comparison of energy sources in terms of their full-energy-chain emission factors of greenhouse gases IAEA-TECDOC-892, Vienna, IAEA, 1996.
14. International Atomic Energy Agency, Net energy analysis of different electricity generation systems, IAEA- TECDO- 754, Vienna, IAEA, 1994 .
15. Rashad S.M., lessons learned from selected nuclear , radiological, and industrial accidents, Proceedings of seminar on safety , Quality and Risk Cultures , Cairo , Egypt , 1996 .
16. International Atomic Energy Agency , Nuclear Technology Review 2002, IAEA , Vienna , 2002 .
17. International Atomic Energy Agency , safety of Nuclear Power Plants : Design Requirements , safety standards Series No . NS – R – 1 , IAEA , Vienna , 2000 .
18. International Nuclear Safety Advisory Group , Basic Safety Principles for Nuclear Power Plants 75- INSAG – 3 Rev. 1, INSAG –12 , INSAG series NO. 12 , IAEA, Vienna , 1999.
19. Samejima K., et al, Economic Viability of Innovative nuclear reactor and fuel cycle Technologies, paper presented at the conference on Innovative Technologies for Nuclear fuel Cycles and Nuclear Power, 23-26 June 2003, IAEA, Vienna .
20. International Atomic Energy Agency Department of Safeguards , Proliferation Resistance Fundamentals for Future Nuclear Energy Systems , STR – 332 , IAEA , Vienna (2002) .
21. United States Department of Energy Nuclear Energy Research Advisory Committee , Technological Opportunities to Increase the Proliferation Resistance of Global Civilian Nuclear Power Systems , Report by the Tops Task Force of the Nuclear Energy Research Advisory Committee , NERAC (2001).

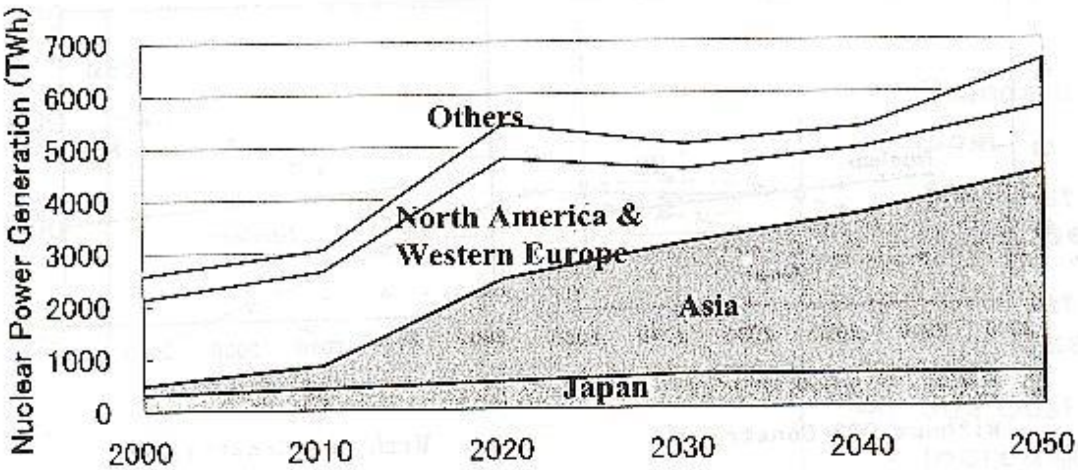


Fig3 Regional Nuclear Power Generation Prospects

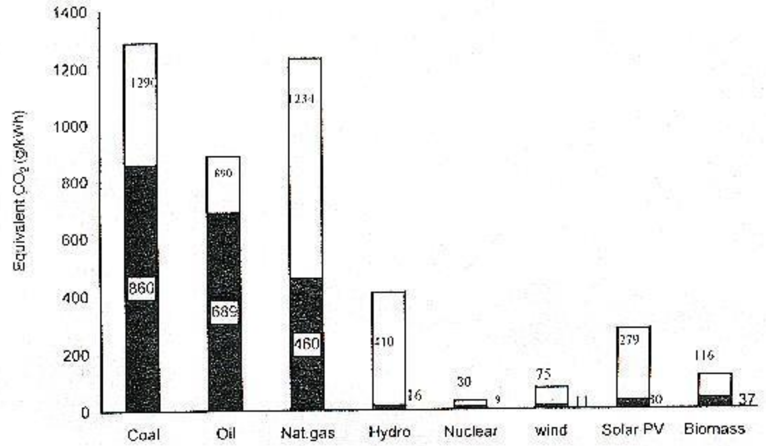


Fig (4) Full Energy Chain CO_2 Equivalent Emission Factors (IAEA)

Figure 1. Regional nuclear power generation prospects.

Figure 2. Full energy chain CO2 equivalent emissions factors (IAEA).

Small and Medium Sized Reactors in Developing Countries

REŞAT UZMEN*
Çekmece Nuclear Research and Training Centre (ÇNAEM)
Istanbul, Turkey

1 ABSTRACT

Developing countries are generally characterized by limited financial capability, high increase in population and rapidly expanding energy demand requirements. Projections made by different organizations demonstrate clearly that the primary energy consumption in developing countries, particularly in developing Asia will double over the next quarter century.

In order to meet their energy needs for enhancing the living conditions of their peoples, these countries have to choose energy production systems that do not overburden their financial capabilities. Another constraint lies in reducing CO_2 emission.

Therefore, the use of nuclear energy both for producing electricity and process heat could be considered as a viable solution for developing countries in curtailing the production of greenhouse gases associated with the combustion of fossil fuels. It is thus expected that nuclear energy will play an increasing role in mixing of energy sources beyond 2015. But there are some key issues, which will affect the choice of nuclear power such as reactor safety, resource utilization, nuclear power generation economics and environmental impacts. Small and medium sized nuclear reactors associated with innovative concepts that will overcome the issues related to nuclear power generation seem to be the most appropriate energy production systems in cogeneration (heat and electricity) with various applications such as hydrogen production and desalination.

2 INTRODUCTION

Looking at the general situation of developing countries, it can be seen that the most marked aspect is poverty. Poverty alleviation and development depend on universal access to energy services that are affordable, reliable, and of good quality. On the other hand, almost every industrialised country has poor and disadvantaged populations. But the energy aspects of poverty are radically different for industrialised as compared to developing countries. In the near future, better living standards and increased employment opportunities for developing countries will inevitably be linked to the provision of substantially more energy services. Taking into account the population growth, the anticipated increase in energy services will require more than twice as much energy production over the next half century.

One of the major issues on energy production and use is the environmental impact. It is universally admitted that fossil fuel burning affects the atmosphere through emission of greenhouse gases along with other noxious gases and toxic pollutants which are considered as serious obstacles to sustainable development concept on a regional and on a global scale. Efforts made by industrialised countries to improve energy efficiency and to increase the share of renewable technologies might not be sufficient and in many cases not adequate to compensate for the expected increase in the energy demand for developing countries. The global challenge is to develop strategies that will encourage a sustainable energy future, less dependent on fossil fuels.

From point of view of sustainability criteria, the entire fuel cycle of nuclear energy production stands as an environment friendly production of energy. This is an especially impressive fact, since there are very limited emissions of greenhouse gases and other pollutants. Despite the advantages of nuclear power in electricity production, its use is mostly concentrated in industrialised countries

* Dr. Ing-Chem., Turkish Atomic Energy Authority President's Advisor.

principally due to the high technology requirements and high capital investment among other negatively affecting factors.

Furthermore, high share of industrial demand in overall energy demand and concentrated large demand for energy in the form of heat, favours cogeneration or heat-only reactors. Specific temperature requirements present a very large spectrum for heat application, ranging from about 100^{o}C for district heating, to up to 1000^{o}C for process steam for enhanced oil recovery and oil refinery processes. One should not also omit the promising desalination and hydrogen production processes by using nuclear power.

Currently the size of nuclear reactors is defined according their electrical output; the largest power reactors are rated at about 1400-1500 MW_e and the range of small and of medium sized reactors is about half of the power of the largest reactors. More precisely, the IAEA definition ranges Medium Reactors (MRs) as those reactors having an electrical output of between 300 MW and 700 MW, Small Reactors (SRs) having an electrical output of between 150 MW and 300 MW and Very Small Reactors (VSRs) that have an electrical output of less than 150 MW [[1]]. In the early stages of nuclear era (before 1970s), nuclear power reactors constructed were predominantly in the range of small and medium reactors. But, during the late 1970s and 1980s nuclear power reactors entering service in order to satisfy the requirements of industrialised countries (USA, Japan, Germany, and France) were of larger size. However, in 1990s, the balance shifted towards the small and medium sized reactors (SMRs) especially in developing countries, which opted for nuclear power in electricity production.

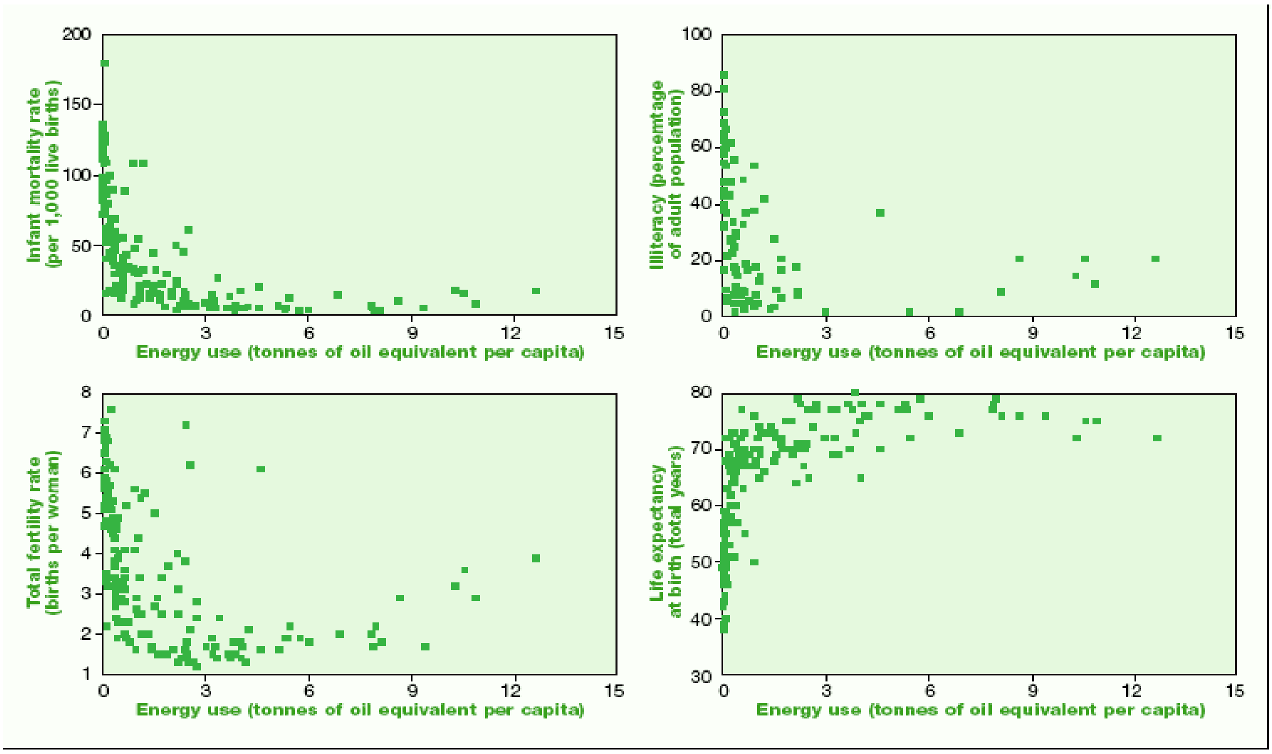
The key benefits of SMRs for developing countries are mainly due to their lower power output suitable for their electrical grid system, their simplified design and their high safety margins, their reduced cost and construction schedules, and finally their potential use in heat production. Currently, 13 SMRs are under construction in four countries (as of December 2002) and several new designs are considered for the next generation of SMRs.

This paper intends to describe the competitiveness and advantages of SMRs compared to other energy generation systems including renewable energy systems in the framework of climate change and increase in energy demand in 21st century.

3 ENERGY NEEDS OF DEVELOPING COUNTRIES IN THE 21ST CENTURY

3.1 General

The relationship between poverty and energy use has already been pointed out in the above section; the importance of energy as an essential prerequisite for poverty eradication and socio-economic development has also been emphasized in the Johannesburg Plan of Implementation and the Johannesburg Declaration on Sustainable Development at the end of the World Summit on Sustainable Development (WSSD) in August and September 2002. As illustrated in Figure 1, there is a fatalistic linkage between energy use per capita and infant mortality, illiteracy, total fertility and life expectancy.



Note: Data on commercial energy use are for 1994; data on social indicators are for 1995. *Source: World Bank, 1997.*

Figure 1. Commercial energy use and infant mortality, illiteracy, life expectancy and fertility in industrialised and developing countries.

3.2Energy demand and projections for energy consumption

The history of primary energy demand in the world differs from one geographical region to other and also among the economic groups, depending on several factors such as population growth, economic and social developments, financial and institutional conditions, etc.

Energy demand increased 3 times all over the world, while the increase in developing countries was fivefold, between 1960 and 1998.

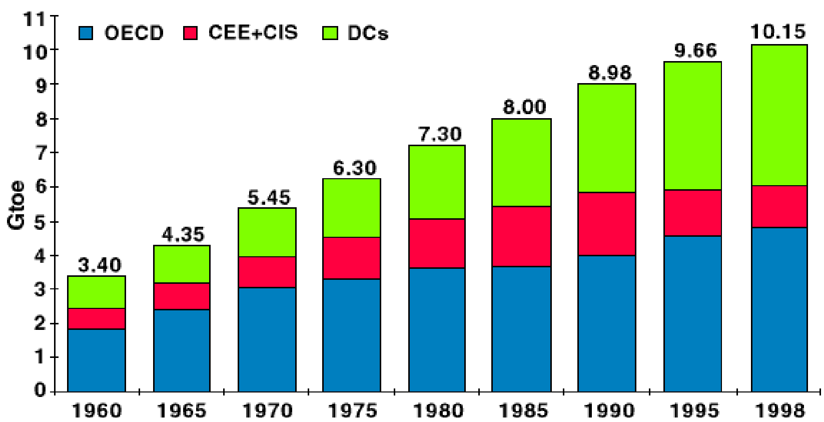


Figure 2. Primary energy demand by economic group.
Source: World Energy Council, Energy for Tomorrows World, Energy Demand Analysis, 1998.

Global energy demand is expected to increase rapidly in the next 20 to 50 years, due to population growth and the fact that the most developing countries will cross the threshold of industrialisation by this time.

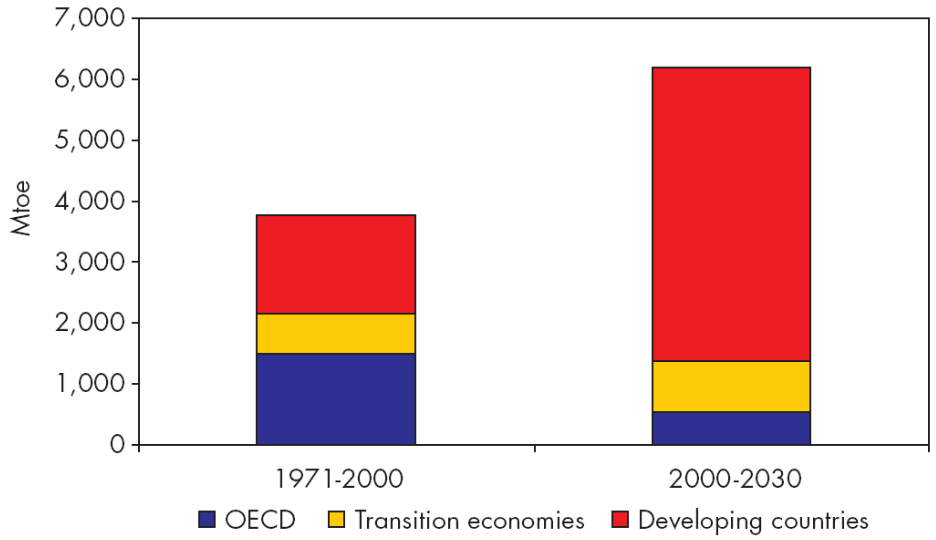


Figure 3. Increase in world primary energy production.
Source: IEA, World Energy Outlook 2002.

There are several energy demand and production scenarios for the future, developed by some international organisations, based principally on carbon dioxide emission projections. However, the fact that the increase in energy demand will be higher in developing countries by the middle of this century remains unchanged. The share of developing countries in world energy demand will also be continuously growing in the same period of time.

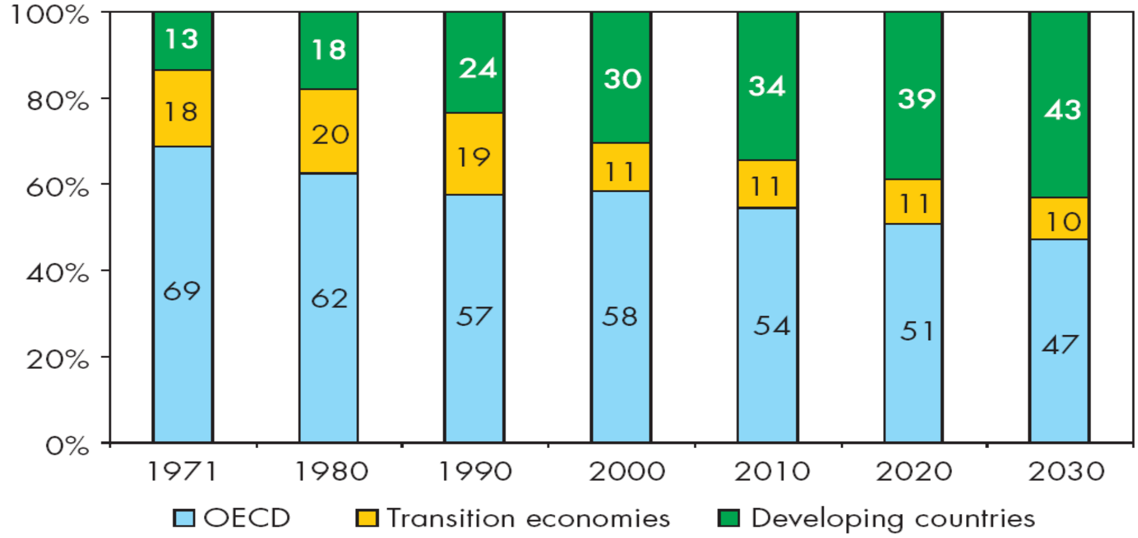


Figure 4. Regional shares in world primary energy demand.
Source: IEA, World Energy Outlook 2002.

Rapid economic and population growth in some developing countries will encourage industrialisation and urbanisation and consequently faster increase in electricity demand, electricity being a clean and convenient final form of energy [2].

Heat is another energy form for industrialisation and urbanisation, whose generation is almost exclusively dependent on fossil fuel burning.

3.3 Major issues in production and use of energy

"The relationship between energy production and use and sustainable development has two important features. One is the importance of adequate energy services for satisfying basic human needs, improving social welfare, and achieving economic development—in short, energy as a source of prosperity. The other is that the production and use of energy should not endanger the quality of life of current and future generations and should not exceed the carrying capacity of ecosystems."[3]

All kinds of energy generation or conversion systems have some risks and produce wastes along their production chain, starting from extraction of resources and continuing on to the provision of energy services.

According to several energy generation projections, fossil fuels will continue to remain the primary sources of energy in electricity and heat production in the mid term, despite the sustainable energy development concept.

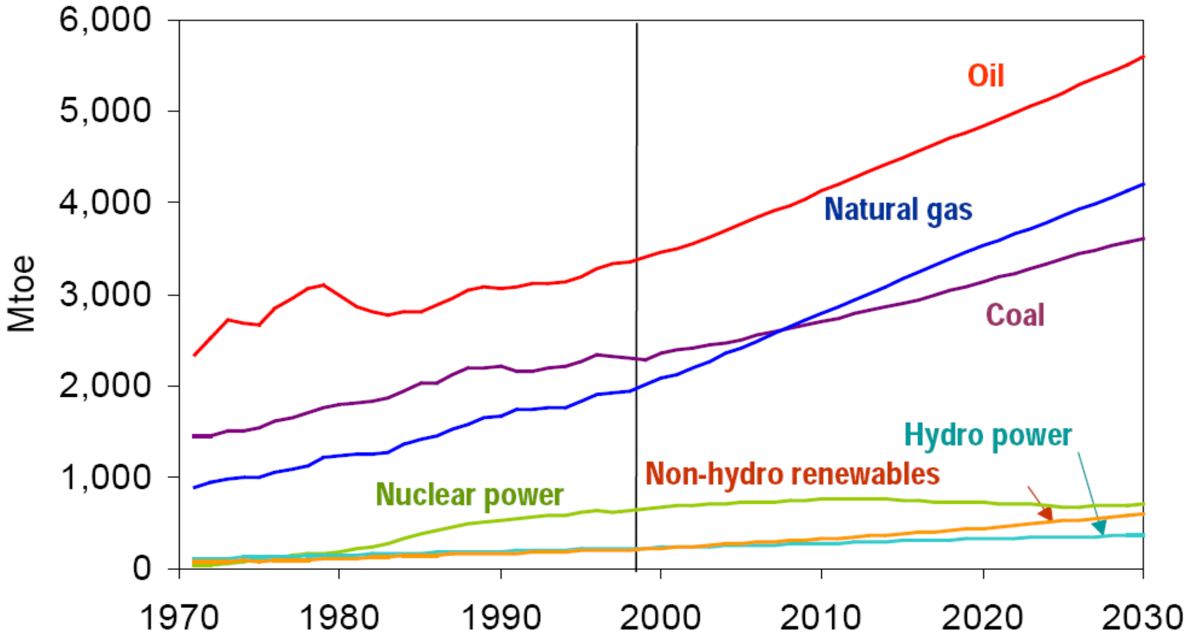


Figure 5. World Primary Energy Demand by Energy Source.
Source: IEA, World Energy Outlook 2002.

As it is universally recognized, combustion of fossil fuels is mainly responsible for greenhouse gas emission, which accelerates human induced climate change, as well as air pollution and regional acid rains.

If the current energy policies are maintained, the dominant use of fossil fuels by the end of 2030 will cause the emission of 38 billion tons of CO_2. But the share of developing countries in global emission will surpass the industrialised countries' share after 2020.

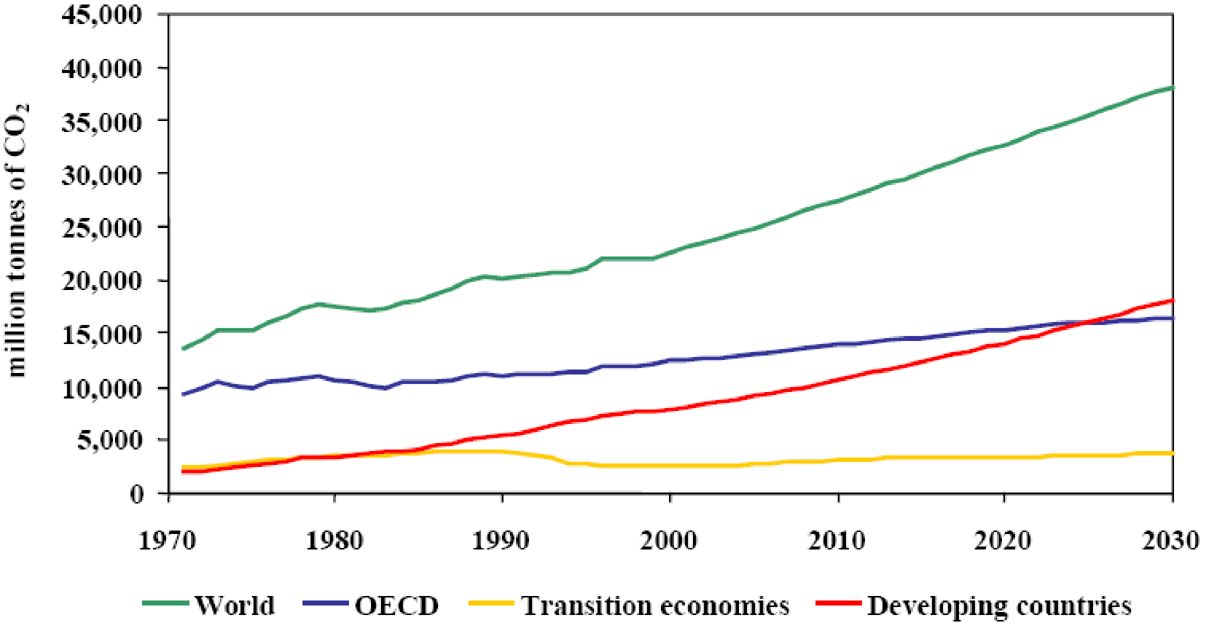


Figure 6. Energy-related CO_2 emission by region.
Source: IEA, World Energy Outlook 2002.

All countries should consider and revise their energy policies so as not to contribute anymore to the increase of greenhouse gases in the atmosphere.

Another important issue in energy production is the availability of energy resources and supply sustainability. First of all, fossil fuel resources are not unlimited; even the efficient use of production and conversion energy technologies will not be sufficient to extend the utilisation period of fossil fuels. Nevertheless, uranium resources seem to be largely enough for several centuries to supply nuclear power all over the world. If we can consider recovering uranium dissolved in seawater (several billion of tonnes uranium) and using thorium in breeder reactor technology, one can say that there are practically unlimited resources.

Secondly, the fossil resources are not evenly distributed and the access to the primary energy resources sets up some political, economical, and technological problems especially for developing countries.

Table 1. Geographical distribution of world energy resources

	Oil	Natural gas	Coal	Uranium
Proven reserves	End of 2001 world total **1050,3 billion barrels**	End of 2001 world total **155,64 trillion m^3**	End of 2002 world total **984 453 million tonnes**	End of 2000 world total **4 363 000 tonnes**
North America	*4,3 %*	*4,6 %*	*26,2 %*	*18,1 %*
Central and South America	*9,4 %*	*4,5 %*	*2,2 %*	*6,2 %*
Europe & Eurasia	*9,3 %*	*39,2 %*	*36,1 %*	*36,5 %*
Middle East	*65,4 %*	*36,0 %*	*--*	*0 %*
Asia-Pacific	*3,7 %*	*8,1 %*	*29,7 %*	*21 %*
Africa	*7,4 %*	*7,6 %*	*5,8 %•*	*17,9 %*

Source: Oil, natural gas and coal BP statistics 2002; uranium OECD/NEA-UAEA 2001.

4 THE ROLE OF NUCLEAR POWER IN ENERGY MIXING

4.1 Background

In order to give a comprehensive picture on how things may look in the future in terms of energy use under the concept of sustainable development, various institutions and organisations have developed and are developing numerous scenarios taking into account different driving forces of energy demand and consumption, ranging from population development to technological innovation. Scenarios produced on the basis of sustainable development use generally socio-economic development models (growth in GDP per capita, industrialisation, urbanisation related to the increase of population, cost of generated energy units and prices of energy services, etc.).

One of the well-known future energy scenarios takes place in the study achieved by IIASA* and WEC** in which six scenarios of energy system alternatives were envisaged under three main cases. It is necessary to keep in mind that energy systems are complex, there is more or less uncertainty in their behaviour, and relevant information on them is often incomplete. Therefore scenarios might be very useful tools for understanding alternative energy developments and their implications, learning about the behaviour of complex systems, and for policy-making.

Three cases are designated as A, B and C. Case A includes three variant scenarios and reflects a high-growth future of vigorous economic development and rapid technological improvements. Case B represents a middle course, with intermediate economic growth and more modest technological improvements. Case C is ecologically driven with two variants: C1, with new renewable energy systems and a phase out of nuclear energy by 2100; and C2, with renewable energy systems and innovative nuclear energy systems [4]. Case C scenario represents a “green” and mostly sustainable development pattern, which is an aspiration of humanity; and its variants (C1 and C2) are highly compatible with the environmental protection criteria. Although nuclear energy is considered as an environment friendly energy generation system, it does not take place in the C1 scenario beyond 2050 and it is included in C2 scenario if innovative techniques are available for nuclear reactors.

The major issues of nuclear energy and the ways to revitalize nuclear power in order to take part of its advantages in energy mixing will be discussed in the following sections.

4.2 Major issues in the use of nuclear power

4.2.1 Economic competitiveness

One of the major issues that curb the development of nuclear power in the world is economical or financial constraints. Due to the relatively high investment cost of nuclear power plants (*nuclear power plants generally cost two or four times more to build than fossil-fuelled plants*), countries with economic problems, high indebtedness and scarce financial resources have generally difficulties to invest in that kind of capital-intensive projects. Additionally, privatisation and deregulation of the electricity market discourages the construction of actual commercial nuclear power plants, because of the high capital requirements and long-term return of investment. Nevertheless, as the share of nuclear fuel cost on the electricity generation being remarkably less than fossil fuels, nuclear electricity production cost becomes reasonably competitive among other alternative sources, with the exception of hydroelectricity.

Another factor affecting the economics of power plants is the construction time. Construction times are shorter for gas-fired plants, 2 to 3 years; and for coal-fired plants, around 5 years, than for nuclear units, 5 to 7 years.

* International Institute for Applied Systems Analysis, Laxenburg, Austria.

** World Energy Council.

Table 2. Summary of 3-energy development cases in 2050 and 2100 compared with 1990

		Case A High growth	Case B Middle growth	Case C Ecologically driven
Population (billions)	1990 2050 2100	5.3 10.1 11.7	5.3 10.1 11.7	5.3 10.1 11.7
Gross world product (trillions of 1990 dollars)	1990 2050 2100	20 100 300	20 75 200	20 75 220
Gross world product (annual percentage change)	1990–2050 1990–2100	High 2.7 2.5	Medium 2.2 2.1	Medium 2.2 2.2
Primary energy intensity (megajoules per 1990 dollar of gross world product)	1990 2050 2100	19.0 10.4 6.1	19.0 11.2 7.3	19.0 8.0 4.0
Primary energy intensity improvement rate (annual percentage change)	1990–2050 1990–2100	Medium –0.9 –1.0	Low –0.8 –0.8	High –1.4 –1.4
Primary energy consumption (exajoules)	1990 2050 2100	379 1,041 1,859	379 837 1,464	379 601 880
Cumulative primary energy consumption, 1990–2100 (thousands of exajoules)	Coal Oil Natural gas Nuclear energy Hydropower Biomass Solar energy Other Global total	8.9 – 30.7 27.6 – 15.7 18.4 – 28.7 6.2 – 11.2 3.7 – 4.2 7.4 – 14.3 1.8 – 7.7 3.0 – 4.7 94.0 – 94.9	17.5 15.3 15.8 10.5 3.6 8.3 1.9 4.3 77.2	7.1 – 7.2 10.9 12.2 – 12.9 2.1 – 6.2 3.6 – 4.0 9.1 – 10.1 6.3 – 7.4 1.4 – 2.2 56.9
Energy technology cost reductions (through learning)	Fossil Non-fossil	High High	Medium Medium	Low High
Energy technology diffusion rates	Fossil Non-fossil	High High	Medium Medium	Medium High
Environmental taxes (excluding carbon dioxide taxes)		No	No	Yes
Sulphur dioxide emissions (millions of tonnes of sulphur)	1990 2050 2100	58.6 44.8 – 64.2 9.3 – 55.4	58.6 54.9 58.3	58.6 22.1 7.1
Carbon dioxide emission constraints and taxes		No	No	Yes
Net carbon dioxide emissions (gigatonnes of carbon)	1990 2050 2100	6 9 – 15 6 – 20	6 10 11	6 5 2
Cumulative carbon dioxide emissions (gigatonnes of carbon)	1990–2100	910 – 1,450	1,000	540
Carbon dioxide concentrations (parts per million by volume)	1990 2050 2100	358 460 – 510 530 – 730	358 470 590	358 430 430
Carbon intensity (grams of carbon per 1990 dollar of gross world product)	1990 2050 2100	280 90 – 140 20 – 60	280 130 60	280 70 10
Investments in energy supply sector (trillions of 1990 dollars)	1990–2020 2020–50 2050–2100	15.7 24.7 93.7	12.4 22.3 82.3	9.4 14.1 43.3
Number of scenarios		3	1	2

The three cases unfold into six scenarios of energy system alternatives: three case A scenarios (A1, ample oil and gas; A2, return to coal; and A3, non-fossil future), a single case B scenario (middle course), and two case C scenarios (C1, new renewables; and C2, renewables and new nuclear). Some of the scenario characteristics, such as cumulative energy consumption, cumulative carbon dioxide emissions, and decarbonisation, are shown as ranges for the three case A and two C scenarios.

Source: Nakićenović, Grübler, and McDonald, 1998.

4.2.2 Safety

The Three Mile Island and Chernobyl accidents with their negative effect on public confidence raised concerns on safety of nuclear reactors. But the analysis of causes and consequences of these accidents served significantly towards the improvement of reactor safety. Anyway, if nuclear energy is to play a role in sustainable development, the health and environmental impacts of nuclear facilities and transport of nuclear materials, which are very small in routine operation, should remain below socially acceptable limits even in accidental cases [5]. It is worth mentioning that 10,696 reactor-years of operating experience has been accumulated by the end of 2002 and nuclear power generally has an excellent safety record. Comparative assessments of the health and environmental risks of different electricity generation systems show that nuclear power and renewable energy systems are at lower end of the risk spectrum.

4.2.3 Radioactive waste

From a sustainable development point of view, radioactive waste management should ensure the confinement and disposal of waste materials in order to reduce their harmful impact on humans and the environment at any time. The main problem for nuclear energy is to keep long-lived radioactive waste isolated from the biosphere in the very long term. Considering the hazardous waste, such as heavy metals or toxic particles, remaining in the biosphere indefinitely and almost without control produced by other energy generating systems, the management of radioactive wastes arising from the use of nuclear energy represents a high degree of sustainability, since they can be effectively isolated from the biosphere at affordable costs using available technologies. Actually the approach taken by most countries is geological disposal using both natural and engineered barriers to isolate the wastes for many thousands of years.

4.2.4 Proliferation risk of nuclear weapons

Proliferation risk of nuclear weapons is often perceived by international community as an obstacle to the development of nuclear energy. The international non-proliferation regime strengthened by the Treaty on Non-Proliferation of Nuclear Weapons and comprehensive IAEA safeguards agreements, assures an effective control on technology transfer and export of sensitive materials and equipment. On the other hand, the new challenge is to design new nuclear facilities with more proliferation resistant features.

4.3 Innovative concepts and nuclear energy development criteria

To help promote the utilisation of nuclear energy in a sustainable manner in the 21st century and beyond, it is necessary to understand the reasons of major issues that may hamper the development of nuclear energy in the future. In 2000, with the guidance of this idea, some countries joined efforts under the umbrella of the IAEA to initiate the *International Project on Innovative Nuclear Reactors and Nuclear Fuel Cycle (INPRO)*[*]. The aims of INPRO are to seek the possibilities that will ensure the availability of nuclear energy in fulfilling energy needs in 21st century in compatibility with the environment, and “to bring together both technology holders and technology users to consider jointly the international and national actions required to achieve desired innovations in nuclear reactors and fuel cycles.” In the first phase of the project, the efforts are concentrated to define user requirements for economics, environment, fuel cycle and waste, safety, non-proliferation and for crosscutting issues in the innovative concept of nuclear reactors.

Some conclusions from the draft report of INPRO, which is still continuing, are reflected in the present paper.

[*] Participating countries and organisations in INPRO are as follows (*May 2003*): Argentina, Brazil, Bulgaria, Canada, China, Germany, India, Republic of Korea, Pakistan, Russian Federation, Spain, Switzerland, The Netherlands, Turkey and European Commission.

The following table gives an idea on the investments costs for different electricity production power plants in 2000 and 2050.

Table 3. Investment costs for electricity generation

	Investment costs in the power sector ($/kW)	
	2000	2050
Coal	1000-1650	1000-1650
Oil	600-800	440-730
Gas	710-1150	640-910
Nuclear	1600-2800 700-2000 700-2000	1200-1640 700-860 324-860
Biomass	1570-1760	1240-1300
Solar	2900-5100	1150-1780
Wind	1400	750

Source: Guidance for the Evaluation of Innovative Nuclear Reactors and Fuel Cycles, Report of Phase 1A of INPRO, TECDOC-1362, IAEA, 2003

In the nuclear case, three different rows correspond to different reactor technologies. Capital costs of nuclear power plants vary with design, component suppliers, construction methods, labour and management skills and relations, quality assurance, and regulatory and approval processes.

Therefore it can be concluded that investment cost of nuclear power plants will be reduced drastically from now to 2050, while the investment cost for fossil burning power plants will stay at almost the same level.

With regard to the safety requirements of innovative concept, the following formulations have been expressed:

"Future nuclear reactors and fuel cycle installations shall be

- So safe that they can be sited in locations similar to industrial facilities;
- Have a lower risk associated with fuel damage than current plants;
- Prevent releases of radioactivity that could necessitate evacuation of people living nearby;
- Ensure safety to people and the environment of the whole fuel cycle;
- And should incorporate increased emphasis on inherent safety characteristics as a part of their fundamental safety approach."

In order to minimise radiological effects of radioactive waste on humans, this principle is exposed:

"Waste management systems should be designed to assure that their associated radiological effects on humans are below the levels acceptable today. Because the waste management systems are integral parts of overall energy system, their designs should be optimised from a radiological perspective as a part of the optimisation of the overall energy system."

Finally, to prevent proliferation risk of nuclear weapons during the use of nuclear energy systems by diverting or undeclared production of nuclear material or misuse of technology;

- The future nuclear energy systems will continue to be unattractive means to acquire materials for a nuclear weapons programme;
- Extrinsic proliferation resistance measures, such as control and verification measures, will remain essential;
- Development and implementation of intrinsic features should be encouraged [6].

The above mentioned principles or views, which were picked out from the report of INPRO will be taken into consideration during the design of future nuclear reactors whatever the size.

5 THE IMPORTANCE OF SMALL AND MEDIUM SIZED REACTORS

5.1 General

The general overview on energy options in the 21st century and the situation of nuclear energy, given in the above sections, in the scope of sustainable development, shows that near term global pattern of energy supply is not sustainable. However, there are many efforts to diversify energy production systems in order to mitigate the burden of energy production and use on environment and on financial situation of developing countries. In this context the use of nuclear power will gain an important role in meeting large demand of energy in the form of electricity or heat, especially for developing countries, in the long term, if some issues related to nuclear power are solved. At that point, the size and cogeneration capabilities of small and medium sized nuclear reactors (SMRs) emerge as an attractive solution for mixing energy sources in the future. In the following subsections advantages and technical features of SMRs are largely described.

5.2 Definition of SMRs

Ranges of SMRs are somewhat arbitrary but practically the upper limit of the SMRs is taken as approximately being half of the power of the largest reactors in operation, that means reactors up to 700 MW_e are generally considered as SMRs.

Medium size reactors (300-700 MW_e) are power reactors, which are mainly designed and operated for electricity generation. They are also suitable for supplying both electricity and heat (cogeneration), but the main product remains electricity. As such, they are intended for introduction into interconnected electric grid systems of suitable size (at least 6 to 10 times the unit power) and operated as base load plants. If they were operated in cogeneration mode, the heat supply would be up to about 20 % of the energy produced.

Small reactors (150-300 MW_e) are either power or cogeneration reactors that may have a substantial share of heat supply.

Very small reactors (<150 MW_e) of current designs are not to be regarded as competitors of large, medium or even small power reactors, if only electricity production is considered into interconnected electrical systems.

5.3 Factors affecting the economics of SMRs

Since 1970s, many nuclear power plant vendors have envisaged the advantage of the economy of scale. This realistic approach demonstrates that both specific capital and specific operating costs of a nuclear power plant tend to decrease with increasing reactor output. However, there are several other factors which may modify the specific capital and operating costs of a nuclear power plant that favour SMRs. These factors, which tend to substantially reduce energy costs, are not of equal importance to small reactors and medium reactors.

5.3.1 Factors affecting the economics of medium reactors

Through the elimination of systems and components, it is possible to make large savings from capital cost. In a similar way, significant reductions can be made in operating and maintenance costs by the elimination of systems and components. But, the degree of simplicity that can be obtained in medium sized reactors relative to large reactors is limited for the same technology.

Some proposed medium reactors are designed to make available the use of modularisation, in which a significant portion of the plant is built as modules, outside of the principal buildings of the nuclear power plant. Modularisation serves to reduce capital cost and to shorten the construction schedule due to improved construction efficiency.

It is generally accepted that standardisation of nuclear power plant fabrication and operation can significantly reduce both the capital and operating costs whatever the size. If there is a continuous production, standardisation can be easily achieved for a particular medium sized reactor.

With the exception of financing or other non-technical delays, medium sized reactors have historically shorter construction schedules than large reactors, due to the reduced number of components that must be installed.

5.3.2 Factors affecting the economics of small reactors

Some new small reactor designs permit major reductions in the number of systems and components. Simplification is considered as a major advantage of small reactors design efforts.

With their relative small size and a high degree of simplification, small reactors are found very appropriate to factory/assembly line production. For example, recent studies indicate that a manufacturing and assembly facility having a capital cost of US$300 million could complete the production of twenty-five small reactors per year, utilizing modern assembly line operations. The small size of most small reactors provides the delivery of small reactors in the form of a small number of essentially completed modules. On the other hand, factory production of small reactors would also permit a substantial reduction in on-site construction costs, relative to those of large nuclear plants. It is evaluated that on-site costs can be limited to between 15 % and 20 % of the total cost of a small reactor.

Assembly line fabrication, simplicity of some small reactor designs, minimization of site construction work and the necessary standardisation of maintenance and operating procedures, facilitates a level of standardisation in small reactors.

Small reactor designs, which combine the simplicity and compatibility with assembly line production, may have construction schedules that are competitive with those of combined cycle gas turbine plants (typically in the range of 18 to 24 months). The availability of module testing prior to delivery may serve to substantially reduce on-site commissioning time.

Due to reduced exclusion radius requirement designs, small reactors can help to lower siting costs. Moreover, if safety features could be met under an innovative concept, small reactors should be treated no differently than other major industrial facilities, thereby providing siting flexibility.

The possibility to locate small reactors in proximity to major electricity users eliminates long distance transmission lines and greatly reduces distribution line loading.

The technical and economic feasibility of cogeneration by utilizing large nuclear reactors is severely limited because of their high amount output of electricity and waste heat. For example, it is not practical to utilise a significant portion of either the high pressure steam production or the 2,500 MW_{th} of waste heat typically rejected by a 4,000 MW_{th} nuclear plant as process heat. Large size nuclear power plants actually in use are not suitable for effective cogeneration and their utilisation in cogeneration has been largely limited to low temperature applications such as district heating. Relatively small energy output of small reactors and their advantage to be build close to the industrial zones according to demand, overcome this difficulty. In addition, the availability of high temperature heat output of some small reactor technologies is in a position to provide energy to a broad range of process heat users, including many high temperature applications.

In order to increase economical competitiveness of small reactors, manpower costs associated to their operation have to be minimized. Small reactors equipped with unattended remote control systems can take advantage of the security provided by the small reactors structures.

Small reactor designs must give a special focus on the minimisation of maintenance cost. It can be easily realised that to provide significant number of maintenance staff at each small reactor unit is not compatible with economic parameters. Hence, small reactor designs must make great effort to provide major maintenance for a significant number of small reactors from central maintenance facilities.

Small reactor designs should attempt to maximise the refuelling interval; as a minimum, the refuelling intervals for the small reactors should be 3 years or longer.

Staff requirements per MW_e for some small reactors may be equal or lower than those for multiple unit large capacity nuclear power plants; as a result the total manpower requirements necessary for the small reactors may be significantly less than those for medium and large capacity nuclear power plants.

5.4 Available technologies for SMRs

There is a wide range of technologies available to SMRs designs, each with unique operating capabilities and safety features. The thermodynamic efficiency of SMRs operated in an electricity only mode and the energy utilisation of SMRs operated in cogeneration or process heat applications increases with increasing core outlet temperature; this serves to reduce the specific capital cost of SMRs. In a general manner, there are two distinct technologies in SMRs: those utilizing water as coolant and moderator and those employing non-water coolants with high temperature capability and graphite moderator.

5.4.1 Water cooled reactor technologies

There are several SMRs units currently in operation or under construction, utilising established water-cooled technologies; these range in size from the **PHWR**[*] 220 (207 MW_e net) to the CANDU[**] 6 (670 MW_e net). The available information suggests that SMRs utilising established water-cooled technologies, are not economically competitive in sizes below 450 MW_e net.

But there are tremendous efforts to achieve simplification and enhance the safety of water-cooled reactors in the range of SMRs. Among the proposed **PWR**[***] designs, integrated PWR designs are the most attractive designs in which the identifying feature is the accommodation of the principal nuclear steam supply system components within a single large pressure vessel, in addition to the core; these components include the primary coolant pumps (if required), the steam generators, and the pressuriser. Some examples of integral PWR designs include SIR (UK), CAREM (Argentina), SMART (Korea) and VPBER-600 (Russia).

5.4.2 Non-Water cooled technologies

A number of conceptual reactor designs have been proposed over the last several years that take advantage of the higher temperature capability offered by non-water coolants; in these concepts graphite is preferred as the moderator. The strong negative temperature reactivity coefficient of the graphite can provide an inherent shutdown capability to reactors utilising graphite as moderator. *Such reactors can achieve shutdown based on the temperature increase of the core following postulated accidents, without the need for control system or operator actions.*

The helium cooled, graphite moderated **high temperature gas reactor (HTGR)** has an extensive experience base; demonstration HTGRs established excellent operating records in the USA (Peach Bottom) and in Germany (AVR15). Current HTGR designs utilise a steel reactor pressure vessel (Figure 7). Both the German and the US HTGR designs are based on the TRISO fuel particles, with an outside diameter of less than one mm, have a uranium or thorium oxide core with four coatings (Figure 8). *The silicon carbide coating serves as the containment function that is provided by the containment buildings of water-cooled reactors*. Typical helium conditions at the core outlet are 6.2 MPa and 850°C.

---

[*] Pressurised heavy water reactor.

[**] Canadian deuterium natural Uranium reactor using heavy water as moderator.

[***] Pressurised ordinary water cooled Reactor.

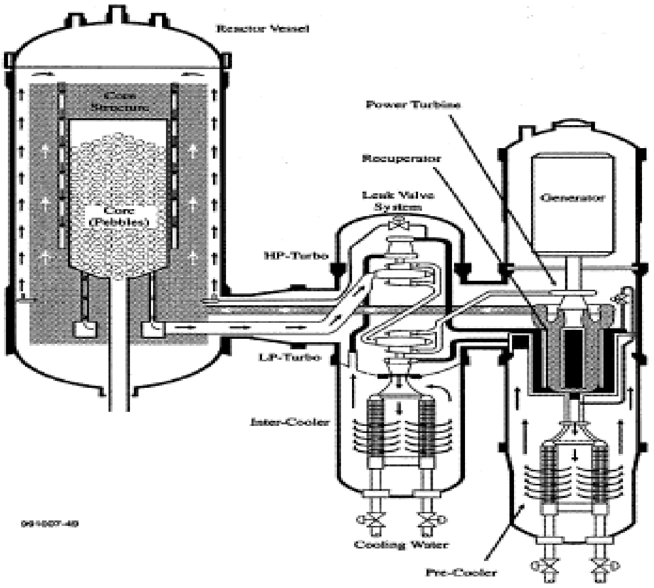


Figure 7. Section through direct cycle HTGR (ESKOM, South Africa).
Source: Small and Medium Reactors: Development Status and Application Aspects, J. Kupitz

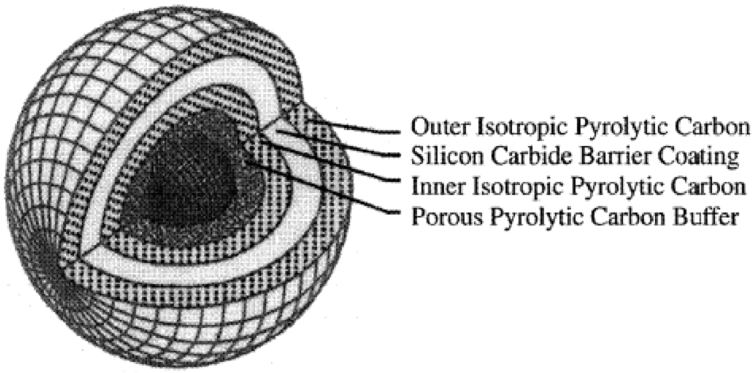


Figure 8. TRISO fuel particle.
Source: Small and Medium Reactors: Development Status and Application Aspects, J. Kupitz.

The German designed HTGR plants utilise a “pebble bed” core; TRISO particles, enclosed in a graphite matrix, are contained in tennis ball sized “pebbles” which occupy the reactor core volume within the graphite reflector structure; the helium coolant flows through the pebble bed. The pebble bed HTGR, called also **Pebble Bed Modular Reactor (PBMR)** is refuelled on-power.

The US HTGR plants designed by General Atomics have a prismatic core, consisting of hexagonal graphite elements that contain the fuel and coolant flow passages. The TRISO fuel particles are contained in a graphite matrix within fuel compacts that occupy vertical wells in the fuel element. The prismatic HTGR is batch refuelled off-power.

Lead cooled, graphite moderated integral reactor (LEADIR) is a pool type reactor that has a similar core configuration to the prismatic HTGR core design, utilising TRISO fuel. Lead, with a boiling point of about 1620°C at atmospheric pressure, allows the reactor to operate at the maximum temperatures permitted by the fuel and the coolant system materials.

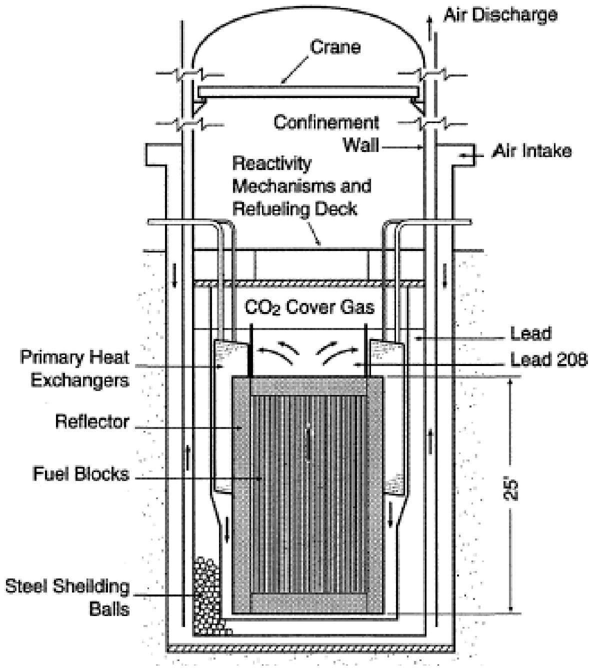


Figure 9. Section through LEADIR.
Source: Small and Medium Reactors: Development Status and Application Aspects, J. Kupitz.

All non-graphite material in LEADIR operates below a maximum temperature of 500°C. Graphite is buoyant in the lead coolant; the reactor structures are therefore designed to assure that the graphite core is maintained in the design location under all postulated events. A CO_2 cover gas is provided above the molten lead free surface. As with the HTGR, inherent reactor shutdown of LEADIR is provided by the strong negative reactivity temperature coefficient of the graphite moderator.

Early development of **molten-salt cooled, graphite moderated molten-salt reactor (MSR)** was centred in the USA at Oak Ridge National Laboratories (ORNL). MSR fuel, as uranium or thorium fluoride, is dissolved in the molten-salt coolant. The configuration of the MSR is similar to that of LEADIR, except that the fuel compacts are eliminated from the graphite core elements, and the coolant passage size is adjusted to give the required ratio of coolant/fuel to moderator. A helium cover gas is maintained above the free surface of the molten-salt coolant.

The MSR is easily refuelled on-power through the addition of a small amount of uranium fluoride to the coolant stream. Studies indicate that a MSR could operate for a period of thirty or more years without the removal of fission products from the molten-salt coolant, *this feature contributes to the proliferation resistance of the MSR.*.

Heat is transferred from the molten-salt coolant to the secondary heat utilisation circuit via heat exchangers. Inherent shutdown capability is provided in MSR by the negative reactivity temperature coefficient of the graphite, in combination with the thermal expansion of the molten-salt in the core. The latter reduces the fissile content of the core as coolant temperature increases. In the very unlikely event that coolant is lost from the core, it quickly solidifies, and the reactor shuts down due to the loss of reactivity. There are some accumulated experiences during the operation of ORNL's MSR in the 1960s, which had produced 8 MW_{th} and operated with a core outlet temperature of 650°C.

5.5 Programmes for SMRs in some countries

Several countries have active small reactor and medium reactor development programmes. Many of these reactors are in the size range of 300 MW_e to 700 MW_e. Nevertheless, the technologies used may be valid for small reactors. The medium sized reactors that are currently in operation and under construction consist of the CANDU 6 (PHWR, 670 MW_e net) and the VVER 440-model 213 (PWR, 388 MW_e net). There are eight CANDU 6 units in operation on four continents and three units under construction. There are many VVER 440 units in operation. The latest VVER 440, which entered in service in 1999 in Slovakia, has been modified, particularly in the control and electrical systems.

The units of the latest PHWR design manufactured by India, the PHWR 500 (PHWR, 47 MW_e net) are currently under construction, expected to be in service about 2006.

The only commercial small nuclear power plants that are presently in operation and under construction, are the PHWR 220 (PHWR, 207 MW_e net) developed by India, and the CN 300 (PWR, 279 MW_e net) units developed by China. There are eight units PHWR 220 in operation in India. There are two operating CN 300 units; one is located at Qinshan in China, and the second in Pakistan.

The **People's Republic of China** has developed a very well established SMR programme. A PWR type Qinshan 1 reactor of 279 MW_e output has been entirely designed, constructed, and operated by China, and another one constructed by China is connected to grid in Pakistan. Additionally, there are three medium sized nuclear reactors (two PWRs of Chinese design, and one CANDU 6 PHWR supplied by Canada) in operation and two others are under construction (one PWR and one CANDU 6). There is also special interest in district heating reactors in China to help to ease the enormous logistical problems of distributing the eleven billion tons of coal used each year for heating. A 5 MW_{th} integrated water-cooled reactor was used for several winter seasons for district heating. A 200 MW_{th} demonstration heating project is in progress. A 10 MW_{th} pebble-bed high temperature gas cooled reactor for process heat application has entered in service early in 2003. Several applications, including electricity generation and district heat generation are planned for the first phase; "methane forming" is planned for the second phase.

India has eight PHWR 220 reactors (207 MW_e net) in operation, and has four PHWR 220 MW_e units, developed within India, under construction; in addition, two PHWR 500 (470 MW_e net) are under construction.

Japan has a high population density and a shortage of suitable sites for nuclear reactors due to the large fraction of the landmass existing as mountainous terrain. This has led to a preference for large reactors in order to maximise the power output on the available sites. Nevertheless, there is a strong and diverse programme of reactor development supported by the big industrial companies, and by the national laboratories and the universities. Three large industrial companies developed conceptual LWR designs in the SMR range and Japan Atomic Energy Research Institute (JAERI) has several innovative designs underway. Several different designs are currently under development in the SMR range; namely SPWR and MRX (integral PWRs), MS 300/600 (simplified PWRs), HSBWR (simplified BWR), MDP, 4S and RAPID (small sodium-cooled fast reactors). Preliminary investigations show high level of safety, operability, and maintenance.

The **Republic of Korea** has four medium sized CANDU PHWRs in operation. Mountainous countryside of Korea generally constrains the installation of large stations to maximise the power produced by the available sites. However an advanced integral reactor termed System Integrated Modular Advanced Reactor (SMART) is being developed, based on PWR technology, the power output of SMART falls in the small reactor range. SMART is intended for desalination or for cogeneration applications.

The **Russian Federation** has substantial experience is the development, design, construction and operation of several reactors in the SMR size category. These reactors are used for electricity, heat production and ship propulsion. Currently implemented projects consisting of two reactors (KLT-40) mounted on a barge are intended to provide electricity in remote locations. Barge mounted reactors may be a near term solution for other countries needing energy but presently without the infrastructure for the introduction of large nuclear plants. Besides KLT-40 (up to about 160 MW_{th}) there are other small sized reactors under design in Russia, suitable for mounting on barges; these include the NIKA 75 (75 MW_{th}), UNITHERM (15 MW_{th}) and RUTA-TE (70 MW_{th}).

Argentina Atomic Energy Commission (CNEA) has developed CAREM (integral PWR). Conceptual designs for the CAREM 25 (25 MW_{th}) and CAREM 100 (100 MW_{th} and 25 MW_e) were undertaken. The intended uses of the CAREM reactors are electricity generation, industrial steam production, seawater desalination, and district heating.

Canada continues the evolution of the mid sized CANDU 6 PHWR. Development activities on the CANDU 3 (450 MW_e) have been terminated.

South Africa's electrical utility, ESKOM, is proceeding with the design of a pebble bed direct cycle HTGR, referred as the PBMR, with an output of about 200 MW_{th}. ESKOM believes that this design is economic, and meets all safety and regulatory requirements.

A consortium consisting of General Atomics (USA), Framatome (France), Fuji Electric (Japan), and Russia are developing the design for a prismatic core direct cycle HTGR with an output of about 100 MW_{th}. In parallel, Framatome and Siemens (Germany) have initiated work on a 300 MW_{th} direct cycle HTGR.

6 NON-ELECTRIC APPLICATIONS OF SMRs

6.1 General

In general, about 30 % of the total primary energy produced is used for electricity generation. The remaining 70 % is used for transportation and for domestic and process heating. The share of nuclear power in electricity production is about 17 %, and this represents only about 5 % of the total primary energy produced. As it is described in sections 2 and 3, global energy demand is expected to grow in the next 20 to 50 years, due mainly to population growth and the fact that most developing countries will cross the threshold of industrialisation by this time. Besides the increase of the share of electricity in the total energy demand, there are three important factors that may also lead to an increased market potential for non-electric energies and their associated applications: [7]

- The demand for non-electric energy will grow substantially in absolute terms owing to the population growth and increasing standards of living.
- At present, fossil fuels are extensively used for transportation, heating and domestic applications. This trend will continue to increase in the short term. In the longer term, converted forms of non-fossil fuel energy are expected to grow in importance. In particular, the use of hydrogen is likely to begin to erode the dominance of fossil fuels. These expectations will create incentives for industries to develop and promote alternative technologies for non-electric energy. Nuclear energy will thus have a large potential for introducing in this market.
- The future market will include not only growth in energy demand but also the need to replace existing plants.

Most SMR designs that are operating and those that are proposed are suited for low and medium temperature applications. However, heat, unlike electricity, cannot be economically distributed over large geographic areas, and must be used within a few kilometres of where it is produced. For this reason, *the percentage of the energy produced by a nuclear reactor that can be used as domestic or industrial heat increases with reduced reactor size;* hence, small reactors are often more suited to many heat applications. High temperature (800^{o}C to 1000^{o}C) heat production capability of some small reactor design expands the range of SMR cogeneration applications, in both geographical and functional terms, relative to those of large nuclear power plants. Generally, cogeneration is able to increase energy utilisation, and hence to reduce overall specific capital and operating costs.

The temperature ranges of representative reactor types, and the temperature requirements for representative process applications are illustrated in Figure 9.

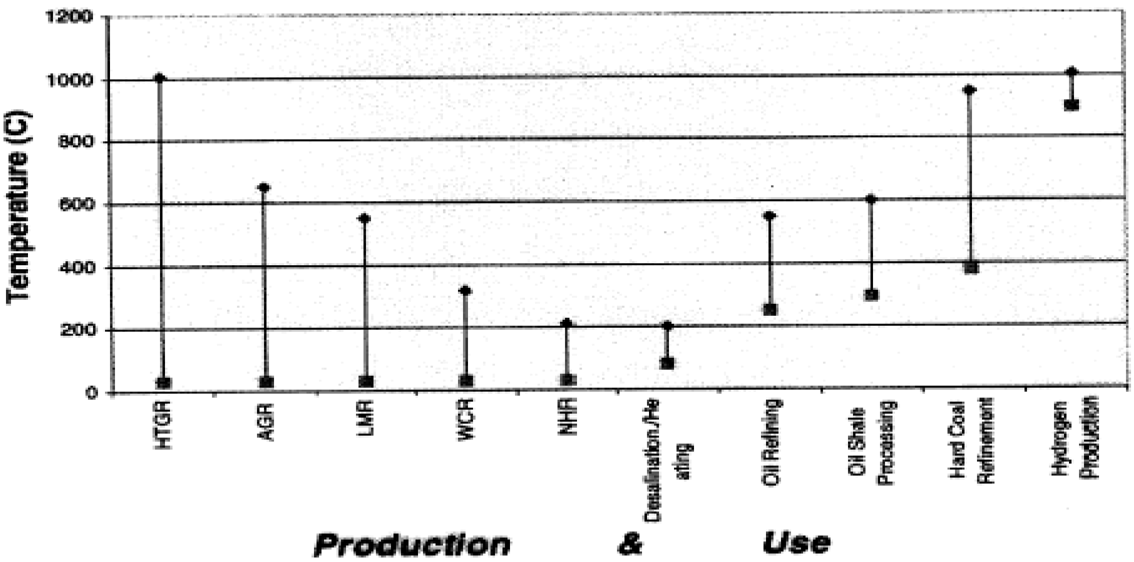


Figure 10. Temperature ranges for representative nuclear reactors and industrial applications.
Source: Small and Medium Reactors: Development Status and Application Aspects, J. Kupitz
HTGR: High Temperature Gas Cooled Reactor; AGR: Advanced Gas Cooled Reactor; LMR: Liquid Metal Reactor; WCR: Water Cooled Reactor; NHR: Nuclear Heating Reactor.

Nuclear heat applications in all aspects have been largely reviewed and discussed in the following IAEA publications: Status of Non-electric Nuclear Heat Applications, IAEA-TECDOC-1184, November 2000; Market Potential for Non-electric Applications of Nuclear Energy, Technical Report Series No. 410, IAEA, 2002.

6.2District heating

The heating and cooling of both residential and industrial facilities occupy a large portion of energy consumption in many countries. In district heating, steam or hot water are supplied at temperatures from about 85^{o}C to 220^{o}C. The technical viability of using nuclear heat for the supply of hot water and steam for district heating has been demonstrated both in dedicated nuclear heating plants and in heat and power cogeneration plants. Worldwide, district heating systems range in size from about 600 MW_{th} to 1200 MW_{th} in large cities, and from about 10 MW_{th} to 50 MW_{th} in towns and villages.

Recent studies demonstrated that, in some cases nuclear district heating may be competing not as much with fossil fuel boilers as with gas or electric heaters, including electric heaters powered by nuclear power plants [8]. Bulgaria, China, Hungary, Russian Federation, Slovakia, Switzerland and the Ukraine are the countries where nuclear district heating is effectively applied.

The principal main near-term markets for nuclear district heat sources is as replacements for existing fossil-fuelled sources. Small reactors, because of their relatively small output and characteristics that allow siting in or near densely populated areas are ideally suited to these applications. Moreover, for cogeneration reactors, especially in the SMR range, seem better than for heat-only reactors, mainly because of economic reasons.

6.3Water desalination

Worldwide, regional water use per capita ranges between some 150 m^3/capita/a (Africa) and 1,850 m^3/capita/a (North America). As it is recognized that 500 m^3/capita/a water supply, including agriculture, may become a primary constraint to life, the above figures can be compared with indicators of water sufficiency [9]. Nevertheless, another consideration is the sustainability of water supply. A recent United Nations study suggested that the use of more than 40 % of the annual renewable resources should be considered as unsustainable. Under this criterion some regions, in particular Middle East and parts of Africa, South America and Southeast Asia, the use water in an unsustainable manner, which can lead to a decrease in water availability and a deterioration of water quality. Another consequence of fresh water shortage is epidemic diseases caused by contaminated water, which kill more than 5 million people every year, especially in developing countries.

A breakdown of world water resources demonstrates that 97,5 % as salt water (oceans, seas), 1,75 % as inaccessible fresh water (ice caps, glaciers, deep aquifers) and only 0,75 % as potentially available fresh water (lakes, rivers, reservoirs, etc.).

On the other hand, if the projections of freshwater availability for 2025 and beyond are taken into consideration the problem of availability is likely to become even more serious in the future, in particular in Africa, the Middle East and Asia*.

Many technologies for seawater desalination are available. Technically and economically proved desalination technologies are Multistage Flush (MSF), Multi-effect Distillation (MED) and Reverse Osmosis (RO). Energy requirements of these technologies are summarised in Table 4.

Table 4. Energy requirements for the common desalination processes

Parameter	Unit	Process RO	Process MSF	Process MED
Electricity requirements	KW.h(e)/m^3	4 – 7	3 – 6	0.9 – 4.5
Heat requirements	KW.h(th)/m^3 GJ/m^3	- -	45 – 120 0.16 – 0.43	25 – 160 0.09 – 0.58
Total energy needed	KW.h/m^3 GJ/m^3	4 – 7 0.01 – 0.02	50 –125 0.2 – 0.5	26 – 165 0.1 – 0.6

Note: For the latest desalination technologies energy requirements are lower than shown in this table. Seawater RO currently requires not more than 3 to 4 kW.h/m^3. MSF draws 2.5 kW.h/m^3 in parasitic power.

Source: Market Potential for Non-Electric Applications of Nuclear Energy, Technical Report Series No. 410, IAEA, 2002

The most energy-efficient desalination process is RO, which requires from 4 to 7 kW$_e$.h/m^3 of electrical energy, depending on water quality, feed seawater salinity and temperature, and plant configuration. In general, desalination technologies need low temperature heat and/or electricity. These types of energy can be provided by practically all existing and prospective nuclear designs. Among the designs recently considered are a 220 MW$_e$ HWR in India, a 10 MW$_{th}$ heat only in Morocco, a 200 MW$_{th}$ heat only PWR in China, a 100 MW$_e$ PWR in Republic of Korea, three concepts of floating nuclear power plants with a 35 MW$_e$ PWR (KLT-40), two sizes (15 MW$_e$ and 90 MW$_e$) of Nika PWRs and a 55 MW$_{th}$ heat only pool type reactor, Ruta, in the Russian Federation, among others.

For all desalination options and in all regions there are competitive nuclear solutions, both in comparison with coal and gas fired power plants. Especially, SMRs are well suited to provide all of the energy demands in that area.

6.4 Industrial Process Heat Applications

The characteristics of the market for process heat demand are quite different from district heating. The demand for process heat is not very dependant on climate or population size as a key variable.

The industries that are the main consumers of heat are:

- The food and related products industry,
- The paper and related products industry,
- The chemical industry,
- The petroleum and coal processing industry,
- The primary metal industries.

* Projections mad by the International Water Management Institute, 1998.

For reactors in SMR size range, and in particular for small and very small reactors, the share of process heat generation would be larger, and heat could even be the predominant product. Consequently, the prospects for SMRs as cogeneration plants supplying electricity and process heat are considerably better than those of large reactors. Current and advanced light or heavy water reactors offer heat in the low temperature range, which corresponds to the requirements of several industrial processes (*see Figure 9*). Nuclear process heat production is closely tied to the prospects of deploying SMRs.

The economics of nuclear energy for non-electric industrial applications will therefore improved by the development small, low cost reactors and especially small, high temperature reactors In this regard, and for the near term, development of HTGR technology will help to ensure the introduction of nuclear power in heat supplying.

6.5 Hydrogen production

Hydrogen consumption is predicted to increase rapidly over the next 30 years, due principally to its attractive features:

- Hydrogen combustion is generally clean compared to fossil fuel combustion; there is no greenhouse gas or NO_x emissions.
- Technologies similar to those used for the combustion of fossil fuels can be used for hydrogen combustion to generate heat, electricity and propulsion energy.
- Hydrogen is storable, which makes it available for transportation.
- Hydrogen can be produced either from natural gas and other fossil resources by using heat, or from water by electrolysis.
- Hydrogen could thus be a third product from power plants, in addition to electricity and heat.

There are several chemical processes that convert fossil fuels into hydrogen by using high temperatures (500^{o}C to 1200^{o}C):

- <u>Conversion of natural gas</u>: steam reforming; CO2 reforming; partial oxidation; reduction of metal oxides; thermal cracking; methanol dissociation.
- <u>Conversion of coal</u>: steam-coal gasification; hydro-gasification; steam-iron process; gasification in a molten-iron process; coal cracking process; by-product from coal production.
- <u>Conversion of oil</u>: partial oxidation of heavy oils; hydrocracking of heavy oil;
- <u>Conversion of other feedstocks</u>: conversion of municipal solid waste and biomass; conversion of hydrogen sulphide.

Decomposition of water also plays an important role in hydrogen production, for which several technologies are used:

- <u>Electrolysis of water:</u> alkaline water electrolysis; high-pressure electrolysis; solid polymer water electrolysis; high temperature electrolysis.
- <u>Thermochemical cycles:</u> thermochemical hybrid process.
- <u>Photolysis:</u> photoelectrochemical systems; photocatalytic systems; photobiological systems. [[10]]

Hydrogen production requires a primary energy source; this means that for hydrogen to become a noticeable part of the energy system, another non-hydrogen energy source is required. Possible sources of primary energy for hydrogen production are fossil fuels, nuclear energy and renewable energy sources. If the global concern is to reduce greenhouse gas emissions, there is no reason to use again fossil energy sources for converting them to hydrogen. Moreover, because nuclear reactors are producing both heat and electricity based on a well-proven technology, the use of nuclear energy is particularly appropriate for hydrogen production.

The production of hydrogen by nuclear reactors can be realised by the various technological processes, which provides considerable flexibility:

- Using electricity from nuclear power plants;
- Using high temperature heat from an HTGR for steam reforming;
- Using hybrid processes (heat plus electricity) for high temperature electrolysis, thermochemical cycles, etc.

As an example of nuclear hydrogen economy, Figure 10 illustrates a concept based on hydrogen generation by using a nuclear power plant (HTGR) in small sized.

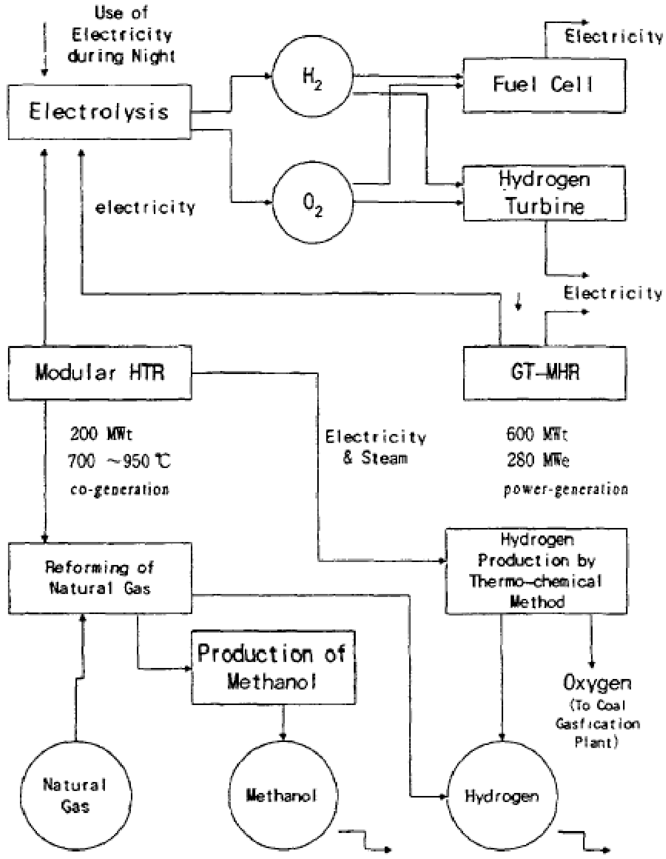


Figure 11. Flow chart of a chemical industrial complex based on modular HTGRs as the energy source

Source: Hydrogen as an Energy Carrier and its Production by Nuclear Power, TECDOC-1085, IAEA, 1999; p.293.

6.6 Other innovative applications

There are several non-electric applications of nuclear energy that they have not yet been demonstrated, but can be promising such as tar sands and heavy oil extraction, coal liquefaction and coal gasification, methanol production, aluminium and steel production. All these technologies use steam at relatively high temperatures. That makes the use of small and medium sized reactors possible.

7 RESULTS AND CONCLUSION

In this paper, an overview of the energy needs of developing countries in the 21^{st} century, the constraints encountered to fulfil the increasing demand of energy and the role of nuclear energy in energy mixing, are detailed. It seems obvious that there is a renewed interest by many utilities, process heat users and developing countries in SMRs. The scientific approach presented in this paper leads to the following concluding remarks:

- SMRs must be competitive with alternate nuclear and non-nuclear energy sources in all important areas, and gain public acceptance in order to be commercially viable.
- New SMR designs should be taken into consideration the innovative concepts and approaches based on user requirements.
- Evolutionary and innovative design improvements in SMRs concepts, coupled with stable nuclear fuel prices, will result in an improved competitiveness of non-electric nuclear applications, especially in hydrogen production.
- As a result of the increasing trend toward cogeneration by energy producers, SMRs and particularly small reactors constructed in 2015 and beyond will be operated in a cogeneration mode.
- The development of nuclear reactors of small and medium size would therefore facilitate the non-electric applications of nuclear energy.
- Depending upon the regions and conditions, nuclear energy is already competitive for district heating, desalination and certain process heat applications.
- Meeting of immediate and vital needs of people, such as production of fresh water by using nuclear energy, will likely facilitate the public acceptance.

SMRs having an outstanding future prospects will have their role within the near future energy plans in many countries, it would be reasonable to advise, that developing countries, in particular Islamic countries, establish the means and ways of collaboration for the improvement of SMRs and non-electric applications of nuclear energy in order to achieve socio-economic development. Therefore, collaboration may be implemented within the context of the Culture of Science Initiative of the IAS, and the activities and research projects undertaken by the IAEA in this subject should be endorsed.

REFERENCES*

1. J. KUPITZ, Small and Medium Reactors: Development Status And Application Aspects, Lectures given at the workshop on Nuclear Data and Nuclear Reactors, Trieste, 2000.
2. World Energy Outlook, OECD/IEA, 2003.
3. World Energy Assessment, Energy and Challenge of Sustainability, UNDP, UN Department of Economic and Social Affairs, World Energy Council, 2000, p.31.
4. World Energy Assessment, Energy and Challenge of Sustainability, UNDP, UN Department of Economic and Social Affairs, World Energy Council, 2000, pp. 337-338.
5. Nuclear Energy in a Sustainable Development Perspective, Nuclear Energy Agency, OECD, 2000.
6. Guidance for the Evaluation of Innovative Nuclear Reactors and Fuel Cycles, Report of Phase 1A of INPRO, TECDOC-1362, IAEA, 2003.
7. Market Potential for Non-electric Applications of Nuclear Energy, Technical Report Series no.410, IAEA, 2002.
8. ibid. p.34.
9. ibid p.51.
10. Hydrogen as an Energy Carrier and its Production by Nuclear Power, TECDOC-1085, IAEA, 1999.

* As well as the above many references were cited within the text.

Towards New Energy for Sustainability: The Strategy in Iceland

BRAGI ARNASON
and
THORSTEINN I SIGFUSSON
University of Iceland and Icelandic New Energy

1 INTRODUCTION

The aim of this paper is to give an overview about the new sustainable energy strategy in Iceland.

Iceland, is a country situated just south of the polar circle in the Atlantic Ocean where Eurasian plate and the North American plates meet. At this spot, quite a lot of heat comes to the surface. There is quite an important activity of the so called North Atlantic ridge which in fact surfaces in Iceland. Iceland is expanding by about 2.5cm in both directions each year.

Combined with the fact that the precipitation in Iceland caused by the North Atlantic lows and the altitude of the country make it possible for us to harness hydroelectric electricity and geothermal electricity. Both are quite sustainable and they will be the bases of our discussion.

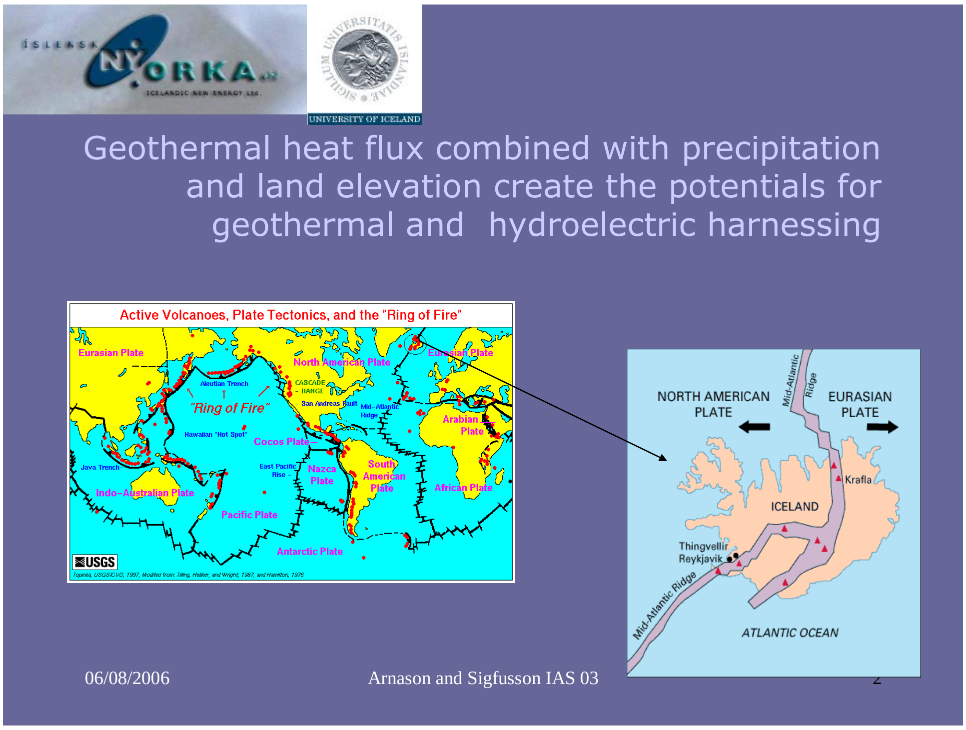


Figure 1. Geothermal thermal heat flux and precipitation as well as land elevation create the potentials for geothermal and hydroelectric harnessing.

2 BACKGROUND

The first settler Ingolfur Arnarsson settled in Reykjavik by the Islamic Calendar in the year 252 after sailing out of Norway. Iceland was then as it is now almost deprived of fossil energy sources. Since, Icelanders continued the sustainable lifestyle until the advent of imported fossil fuels.

In Reykjavik, the first official utilization of geothermal water took place in the municipal cloth-washing pools and can be seen in Figure 2, which is 100 year old photo.

Figure 2. In Reykjavik, the first official utilization of geothermal water took place in the municipal cloth-washing pools.

3 THE ICELAND ENERGY MIX

3.1 Background

The energy usage in Iceland, during most of the 20th century and beyond is represented in Figure 3. In the 1940s, coal played a very important role, oil was emerging and geothermal was harnessed and later also hydroelectric. It may be noted that these two main pillars of the Icelandic energy system were rising through the century; hydroelectric, geothermal, and oil is keeping its status throughout the whole century.

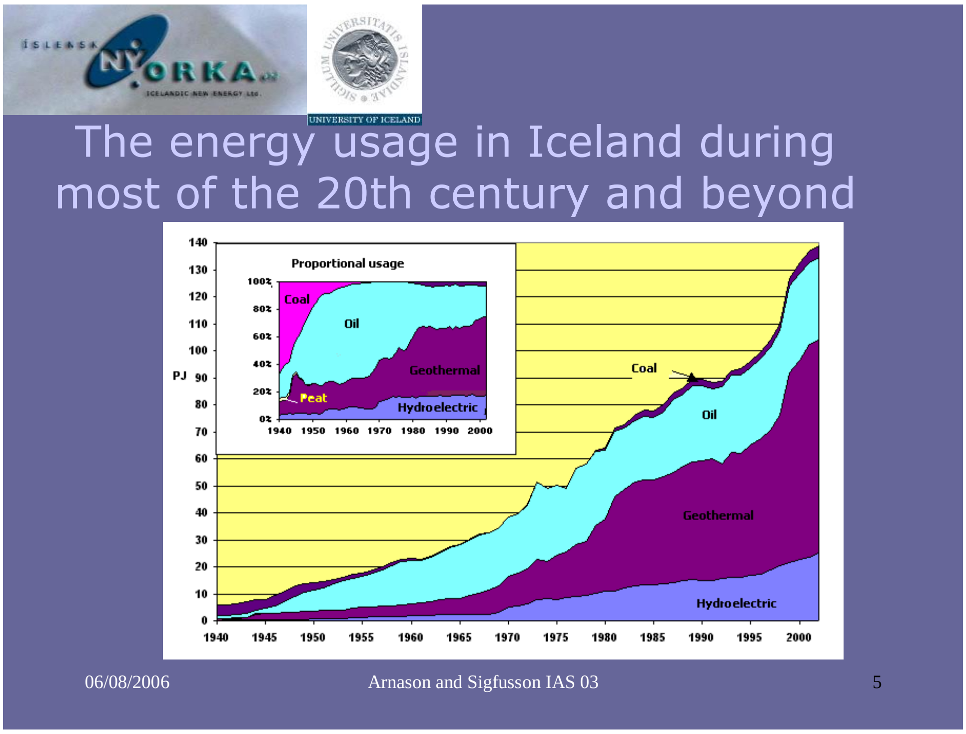


Figure 3. The energy usage in Iceland during most of the 20th century and beyond.

3.2 Energy usage

Figure 4 shows a triangle each side of which represents one form of energy. The top of the triangle is the 100% oil and gas with the red scale going down to zero on the right hand side. The bottom left hand side is coal from zero to 100 % and the bottom scale from the left to right is renewables. If we start the blue line around 1930, you can see how important coal was to our energy at that time. The energy mix then developed away from coal and in the direction of oil, gas and renewables until about 1965 or so. The line then takes a definite turn towards renewables. At present, we are getting quite close to renewables and quite far from the coal. However oil and gas, especially oil, remain an important part of our energy system. Iceland is now about 100 % sustainable as regard space heating and domestic electricity.

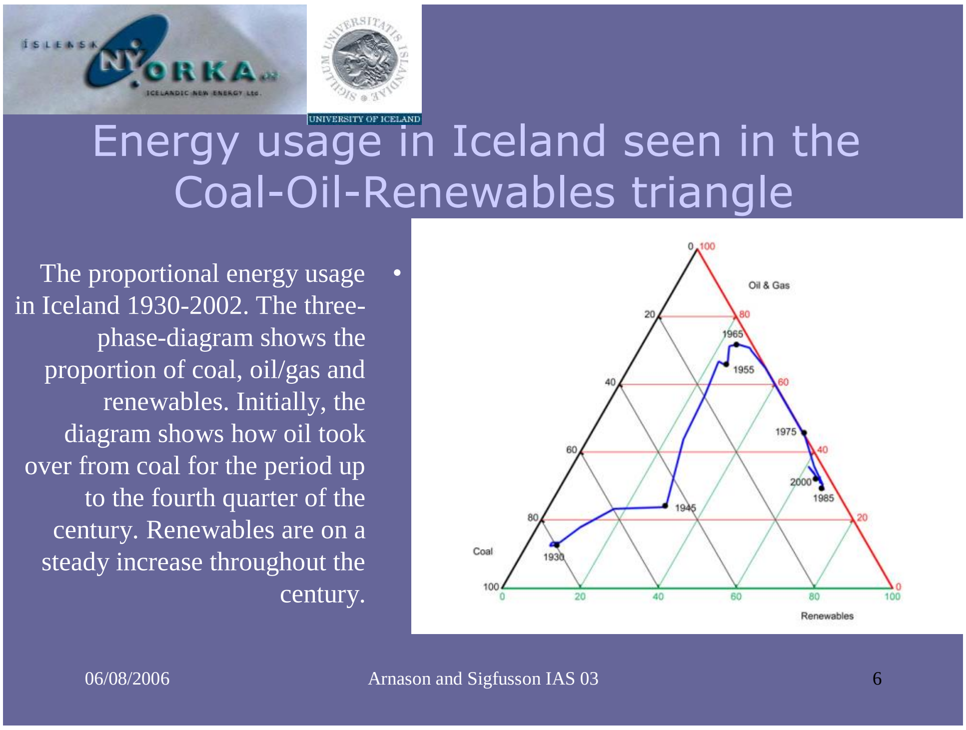


Figure 4. Energy usage in Iceland seen in the Coal-Oil-Renewables triangle.

4 ENERGY HISTORY OF ICELAND

If you look at the energy history of Iceland, starting about 1100 years ago, when the settlement of Iceland was started, the main fuel was wood and peat and that remains the case until the eighteenth century when imports of coal and coke start. Then in the century after that, the import of liquid fossil fuels started and it was at the turn of the last century that hydroelectric energy was started in Iceland. We usually talk about an infrastructure change in Iceland associated with the advent of hydroelectric energy. Around the Second World War, geothermal space heating was started in Iceland and that led to another infrastructure change. That is called the infrastructure change number II. So at the turn of the millennium, we think that we are seeing quite almost a paradigm shift in our energy history and this is hydroelectric and geothermal hydrogen economy.

In Iceland however, the Transport sector, fishing fleet and the industry still emit about 11 tons per capita per year of CO_2 and they off course require oil and gasoline imports.

Greenhouse gas emission in Iceland is about 3 million tons annually. One third of that comes from the transport sector, one third from the fishing sector; and a third from industry. In total, this is about 11 tons per capita per year which is quite higher than in the average OECD country.

This has led to a dilemma. When the Kyoto protocol was signed, Icelandars realized that they had already cleaned up their energy system. Cleaning up after 1990 was rather difficult because we had done a lot of it before. Politically, it caused quite a dilemma and the question was raised of what could be done in Iceland to further enhance the cleaning of the energy.

5 THE H-BACKGROUND

5.1 General

In 1978, hydrogen related research at the University of Iceland was initiated by Professor Bragy Arnason. In 1990, a meeting between the University of Iceland and Hamburg

Electricitaets Werke paved the way finally, in 1997, to the Ministry of Industry and Commerce appointing a committee on "Domestic Fuel Production." This committee proposed negotiations between Icelandic and European Partners. And in 1999 the Icelandic New Energy company was formed and there was a memorandum from the Government of Iceland deciding to aim for a hydrogen energy economy. The Prime minister, the Industry Minister and the Minister of Environment all signed the Intention of the government of Iceland on 27 of October 1998.

The Mission of Icelandic New Energy was "to set up a joint venture company to investigate the potential for eventually replacing the use of fossil fuels in Iceland with "hydrogen based fuels" and thereby create the world's first hydrogen economy."

The Iceland New Energy company was split into almost two equal halves. There was the Icelandic majority 51% owned by an Icelandic Holding Company, VistOrka (Eco Energy), then there was a 49% large minority owned by Shell Hydrogen, Norsk Hydro and Daimler Chrysler. The owners of the Icelandic VistOrka Holding Company were more or less the whole energy players in Iceland; the New Business Venture Fund, Reykjavik Energy, the National Power Company, Sudurnes Regional Heating Corporation, University of Iceland, the Technological Institute of Iceland, Fertilizer Plant, Aflvaki hf, and the Government of Iceland.

5.2 Energy use for the Hydrogen economy

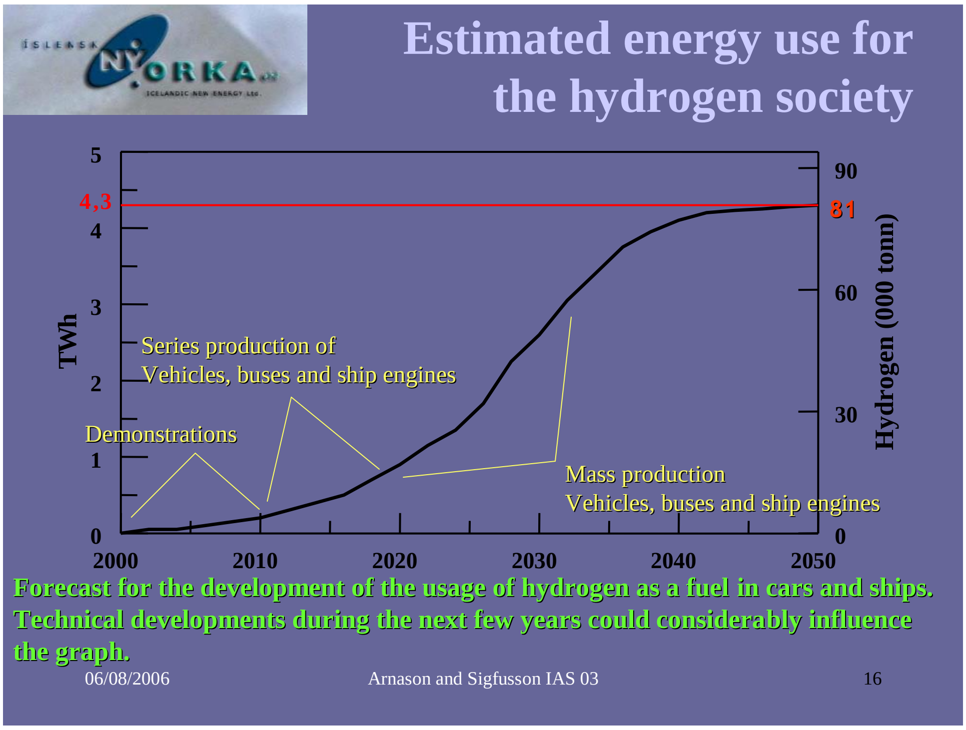


Figure 5. Estimated energy use for the hydrogen society

This new society had off course to plan ahead. We had to think about where to start and how to work in the time to come. From Figure 5, it may be noticed that 4.3 TWh of electricity is needed to create a full scale hydrogen economy as regards to transport and fishing fleet, and 81,000 tonnes of hydrogen is needed. In the next 10 years we would expect serial production of vehicles, buses and ship engines. And now as the road gets deeper we would for the next 10 years also expect mass production of vehicles, buses and ship engines, so you can see that we have been thinking of the 50 year time span for the change of this energy system. In the last century we saw two major infrastructures in one century, so 50 years is probably not too optimistic and hopefully not pessimistic either.

We then started working towards financing a project in Iceland, where we would test fuel cell buses in Reykjavik. The buses would be fuelled with electrolysis based hydrogen. We argued that Iceland has the unique characteristic that you can operate a "hydrogen based fuel project" in a CO2 neutral environment. We have similar standards and transportation system as most other developed countries and therefore the results can easily be adopted elsewhere. We developed the experience in converting from one energy source to another. It was very important that the project makes a big impact.

Three buses in Reykjavik will be 3 buses out of 77 buses. Thus, is almost a real-scale project. The new technology needs to be evaluated under severe weather conditions. The political backdrop was set in that the government of Iceland announced that it was aiming to transform Iceland into a hydrogen society in the near future.

5.3 Other innovative energy projects

Of the first projects of Icelandic New Energy, and the most important, has been the Fuel Cell Bus demonstration project ECTOS (Ecological City Transport System). The second project was the Fuel Cell Passenger Vehicle demonstration programme, and the third a very Icelandic and very special one to us, namely the Fuel Cell Fishing Vessel demonstration. These were the identified priority areas for our work.

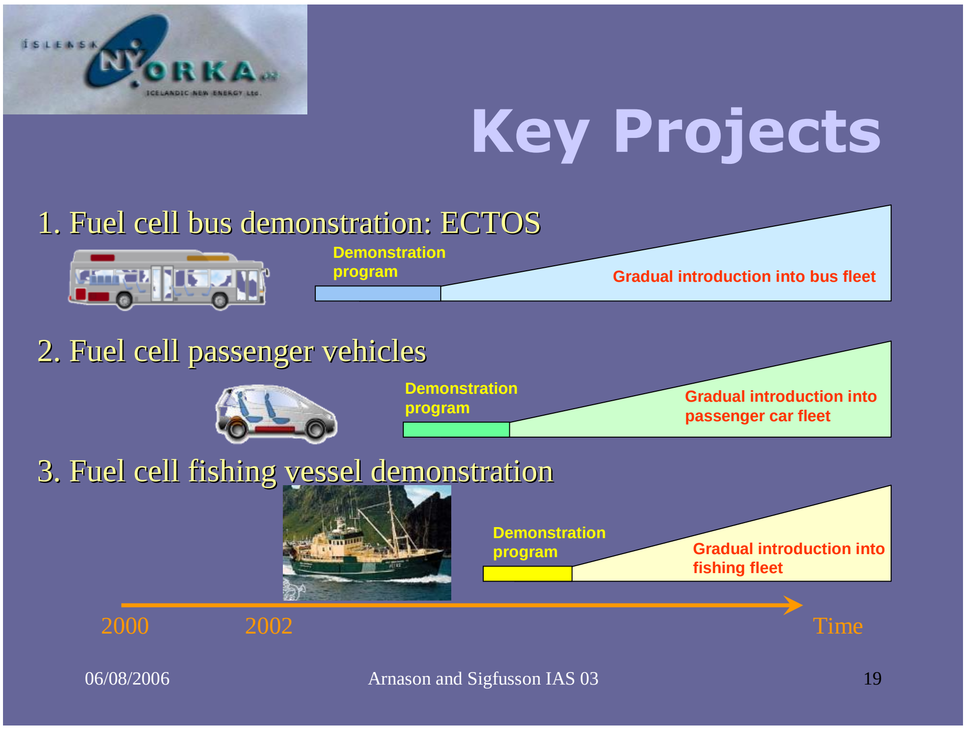


Figure 6.

The ECTOS project was funded by the European Union (EU), which provided about Euro 2.85 million of the whole project cost which was Euro 7 million. The project duration would be about 4 years divided into 2 key phases each spanning two years. The first involves the preparation, establishing infrastructure, maintenance facility, etc, while the second 2-year phase would be the actual demonstration of three Hydrogen buses and commercial infrastructure.

The project partners are a number of leading interests and companies including; Daimler Chrysler, Evo Bus, Norsk Hydro, Shell Hydrogen, the University of Iceland, the Technological Institute of Iceland, Skeljungur Hf which is a Shell off-shoot company in Iceland, the Straeto Municipal Bus Corporation now General Bus Corporation and then the Vinnova Swedish Agency for Innovations Systems and the University of Stuttgart.

5.4 Sharing the experience

In the wake of ECTOS, nine cities in Europe expressed interest to do the same under a project called CUTE (Clean Urban Transport Energy). These cities will all run 3 buses like the ones we have in Iceland; Stockholm, Hamburg, Amsterdam, Stuttgart, Barcelona, Porto, Madrid, Luxemburg and London. So that a total of 30 buses will be run in Europe testing the same sort of basic thesis as well as Australia, which will be adding another 3 buses to Perth's fleet of buses in Western Australia.

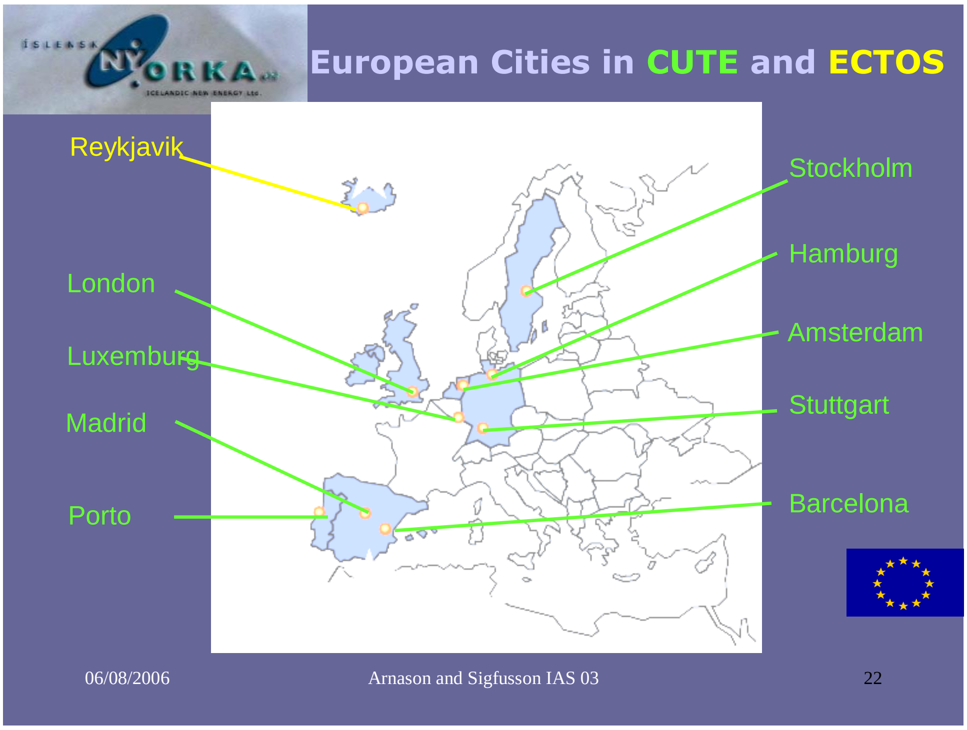


Figure 7.

5.5 ECTOS

ECTOS project infrastructure is about creating and integrating hydrogen into an existing urban setting in Reykjavik. The hydrogen will be produced on site by electrolysis (using renewable electricity to split water into hydrogen and oxygen) and the only supply will be water and electricity. The storage will be done under 440 bar pressure and the distribution on site will be done with gaseous hydrogen directly onto the vehicles.

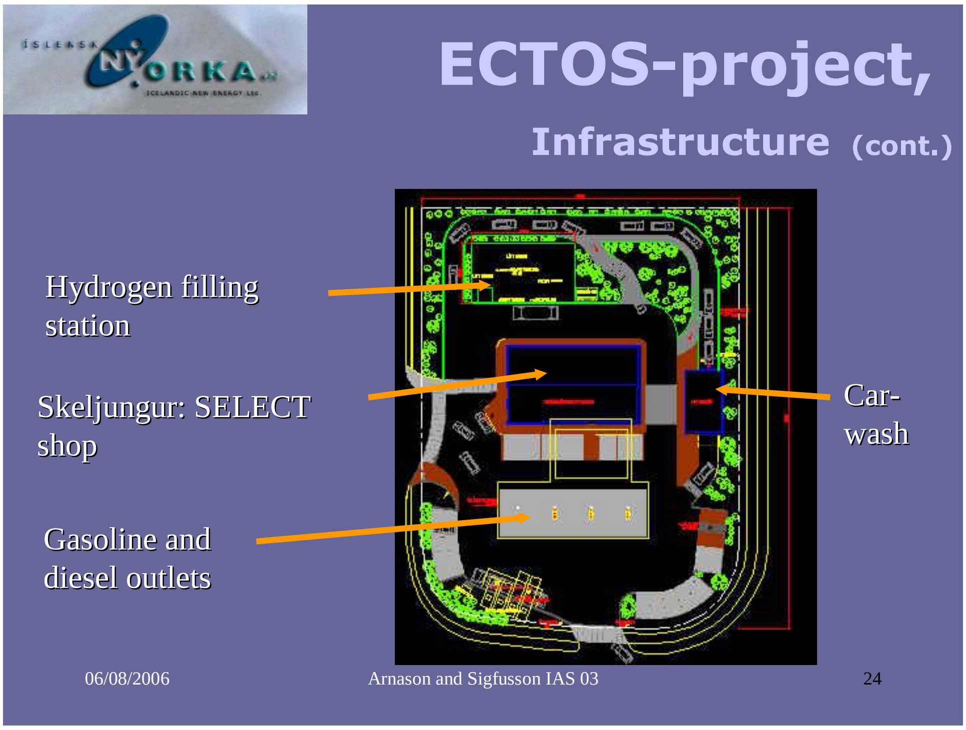


Figure 8.

Figure 8 shows the plan of the fuel station. As mentioned earlier, the station is going to be integrated into a commercial station, where there will also be gasoline and diesel outlets as well a grocery store and car wash. In the left hand corner, there is the hydrogen filling station, which is 22x13 meters or so in area. On the left, one can see the electrons from the network powering the electrolyser. You can see the supply water from the waterworks and the electrosyser will split the water, we in fact leave the oxygen to the surrounding, but we keep the hydrogen compressed together and stored in a 440 bar flasks. Dispenser are there and every morning we would expect the bus coming to the station take about 6 and a half minutes to fill for a day journey in Reykjavik.

The fuel cell buses have a range of about 220 to 250 kilometers, the maximum speed is approximately 80 kilometers an hour, which is quite suitable for a local traffic. One can imagine that the emissions are only water vapor and in a country rather deprived of vegetation we would like to grow some trees and help produce 'rain' for such a purpose.

The bus itself is built as shown in Figure 9. I may be noted that most of the structure is in the top section of the bus, where the Hydrogen Tanks are placed; you have the Fuel Cell Supply Unit, you have the Fuel Cells themselves, you have the Air Conditioning part which in Iceland will probably be only heating, and you then have the Transmission part, you have the Electric Motor and never forget that a bus of this kind is an electric vehicle powered by the energy of hydrogen, through of fuel cell, you then have Auxiliary Components and this makes a bus which there will be 3 buses in Iceland.

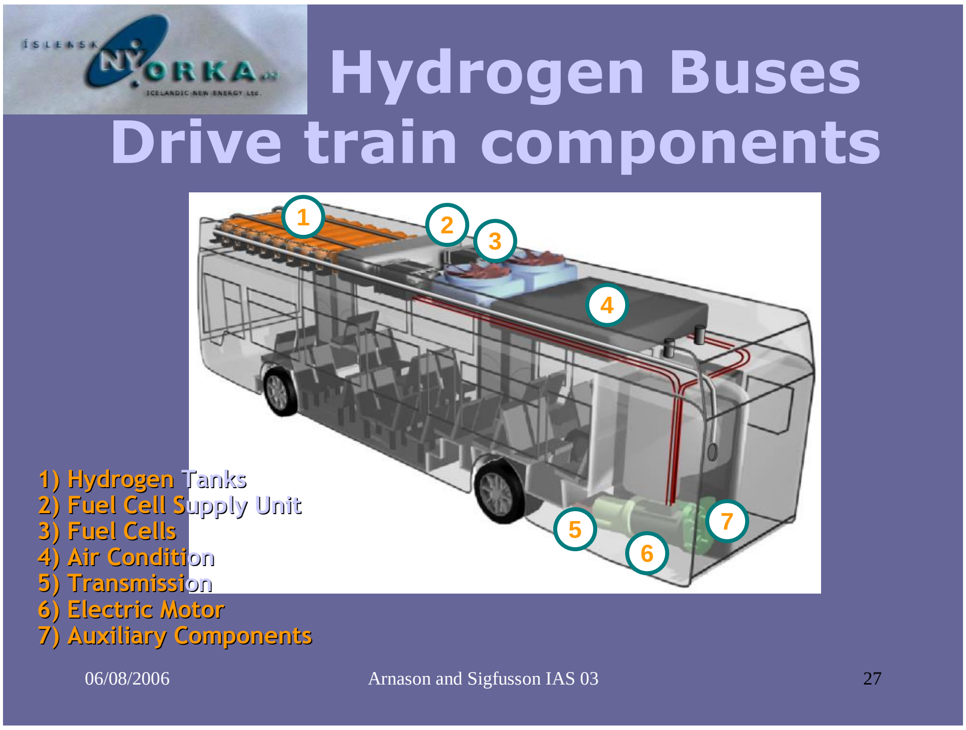


Figure 9.

5.6 The fuelling infrastructure

The fueling infrastructure for the future is the following. The station will, as it is seen here, be very open, and it will be open and the architects were quite conscious about that openness. We inaugurated this station on the 24 of April 2003, there were about 300 guests at the ceremony and about 150 international journalists.

The infrastructure possibilities in Iceland are off course mainly two fold, there is the hydroelectric power base and there is the Geothermal power base, both will be running electrolysis. It is clear to us in Iceland that other countries cannot follow us directly, they need to use other forms of sustainable energy, the most ideal one or 2 most ideal ones would be wind power generation and solar photovoltaics but all of these forms of energies and infrastructure would then lead to possible storing and distribution in a form of, for simple compression as we do in Iceland in on site dispenser, or we could choose a liquid hydrogen way and possibly transport by lorries to a remote dispenser.

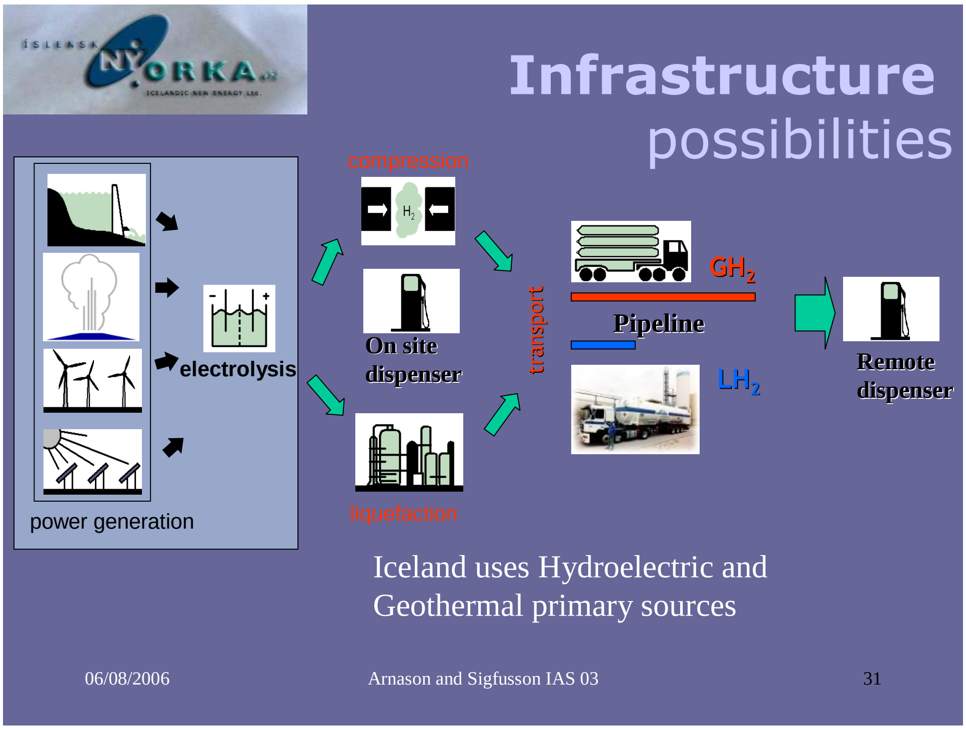


Figure 10.

The infrastructure analysis is quite a big part of the ECTOS project. As the main ring-road in Iceland is about 1500 km long, it would require a minimum of 5 to 7 fuelling stations to make it acceptable for a customer to use hydrogen in the country. We have chosen about 5 locations and investigated the impact of producing to hydrogen at each location and then tried to extrapolate this to the rest of Iceland.

Off course, there is a lot of non-technical facets of ECTOS. There is a socio-environmental and economic issues. There are the methods, the first barriers, the first benefits in the steps for a hydrogen society in Iceland.

And we have produced quite a lot of information and education. Let me point out to you that www.newenergy.is and on the same net www.ectos.is there is quite a lot of information on the projects. We're making interactive educational material focusing on the school generations who will become the future users. And we hope that ECTOS will provide valuable raw material.

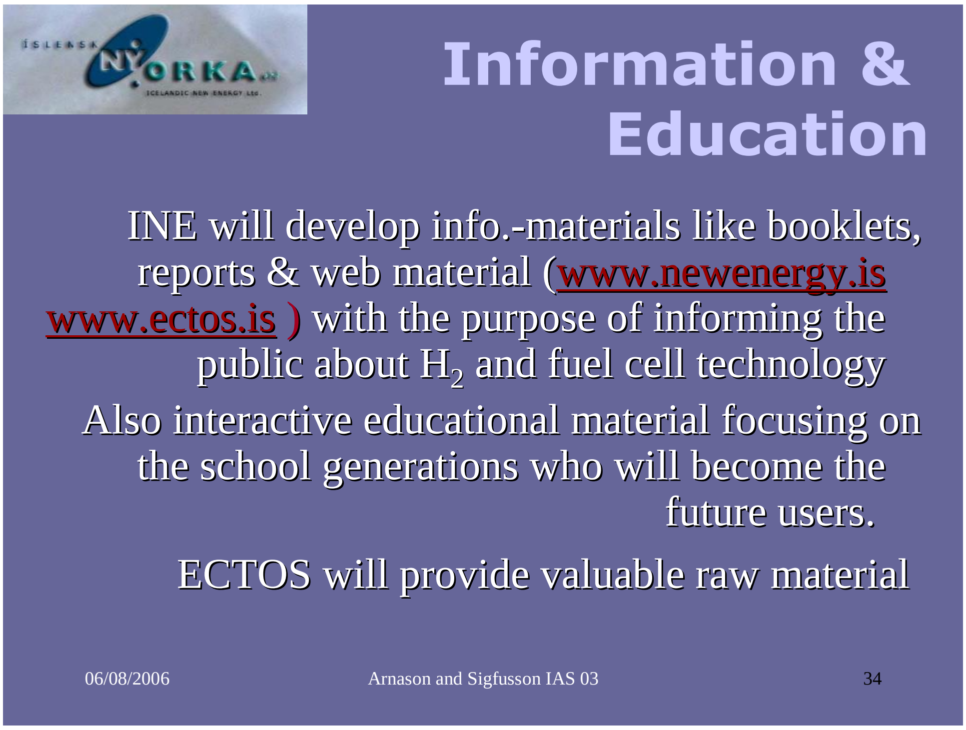


Figure 11.

5.6 Public acceptance

Off course, we needed to see how our work was received in Iceland. So that around the initial phases of the company we had a general survey showing us that about 20% of the respondents, I think that about 1200 people were questioned, have heard about Icelandic New Energy and its projects. But 93% of the respondents claimed to have a positive attitude towards hydrogen as a future fuel and this was very encouraging. Most of the public was though claiming that information was lacking on the energy shift.

The expected results of ECTOS is the basic information on social acceptance, technological performance, real costs, economic feasibility, system organisation, input needed from the political level, - both local and international ones. And off course we would expect more questions.

5.7Fuel-cell passenger vehicles

The next phase in the project is the fuel cell passenger vehicles. This is being discussed with many car producers. And we would like to seek partners for the launch of fleet application of fuel cell passenger vehicles in Iceland.

The final main chapter of our work, which was the idea about the demonstration vessel for naval hydrogen if you like. You have to assume that a 500 Kw engine for a 100 ton fishing vessel, quite typical in Iceland, would have to store sufficient amount of hydrogen for about 4 to 5 day trip. This would mean that the amount of hydrogen needed to be stored for such a fishing vessel could be about 1 ton of hydrogen and it would be very difficult to imagine that this amount of hydrogen is kept in the form of high pressure gas so we would have to think about methods. The methods available would for example be off course the liquid hydrogen, the liquefaction is quit costly and probably not as easy to do right now and the second one would be metal hydride storage, metal hydride is like metallic alloy sponge which absorbs the hydrogen and desorbs the hydrogen, and you can imagine that a massive hydrogen storage of this kind could be placed in the keel of the boat as a ballast. This all being looked into.

5.8 Other main projects

Other main projects going on in Iceland is a market assessment of small fuel cells, examination of the possibility to replace batteries with small PEM fuel cells and hydrogen stored in metal hydride bottles. We have been looking at the export of hydrogen, exporting "CO_2 neutral" hydrogen from Iceland to the European Continent. And again quite a lot of work on economic and social cost of hydrogen infrastructure.

We think that the main challenge facing us in Iceland will be hydrogen storage. We think that we will leave the studies and research in fuel cells themselves to the larger countries to the larger research groups but our consortium has decided that storage is a main focus for the years to come. The possibilities off course are, liquid H_2, gaseous H_2, Metal Hydrides or Chemically bonded or in other hydrogen compounds as artificial fuels. The University of Iceland is focusing on metal hydrides research.

There is a very interesting development in Iceland to combine thermoelectricity and merging that with hydrides. Hydrides need heat and need both input and output to operate.

And making hydrogen by using the heat content of geothermal water is one of the novelties of research in Iceland presently, and it would be interesting to tell the world about these developments in the months or may be years to come.

You see on this picture hydrogen produced from a hot-tap-water. On the left hand side you have a thermoelectric generator which makes, it's only run on tap-water from the house system if you like, municipal system, it goes on to the electrolyser, it split the water into hydrogen and oxygen. And on the right hand side you have a fuel cell which then capture the electrons again and turns the fan.

Figure 12.

6 CONCLUSION

Being independent of fossil fuel imports is a beautiful vision which could be partly realized in Iceland during the next decades, and completed around the middle of the 21st century. Icelandic New Energy and the University of Iceland and their international partners are working to reach the goal of changing the fuel base. Thus, it is not impossible to create a hydrogen society in Iceland.

Sustainable Use of Biomass Energy in Turkey

MUNIR OZTURK*, MEHMET ERGIN**
and
MAHIR KUCUK***

1 ABSTRACT

During the last millenium demographic developments in Turkey have followed an increasing trend. Population has gone up from 12 million in 1923 to 70 million in 2002. The economic growth through heavy industrialization has been based on utilization of energy locked in fossil fuels. Although not so serious, the country is facing some pollution problems today from these sources. If these problems do not force a shift to other energy sources, the finite supply of these sources will push the community for a change in the long run. An alternative in this direction is to use environmental friendly renewable energy sources like solar, biomass, wind, hydro, geothermal, oceanthermal, wave-tidal, and wastes. Out of these, burning firewood for heat is perhaps one of the oldest forms of energy that humans have used throughout history. It has now become biomass or bioconversion, including a feedstock from plant cover, waste wood from wood processing, from recycling/demolition, short rotation coppice, agricultural residues (straw), waste from furniture, pulp and paper industry, organic wastes, animal wastes, muncipal solid waste. The advantages being; it is readily available, reduces the need for fossil fuels as well as foreign dependency, increases domestic employment, adds secondary value to the agricultural crop, biomass crops produce oxygen, and provide bio-diesel. Some disadvantages are; energy comes mainly from plants which must be harvested, land use to grow biomass materials is needed for other purposes, biomass crops result in depletion of soil nutrients, burning plants causes some air pollution. One of the major disadvantages is the loss of forest cover. Forest area of Turkey on the whole is 20,763,247 ha, i.e., 26.7 % of the countries total area. 48 % of this forest is productive (10,027,568 ha), and 52 % (10,735,679 ha) unproductive. Nearly 8.3 million ha of the latter are groves and 1.8 million ha are coppice. On regional basis, 24% is distributed in the Black Sea, 20% in the Mediterranean, 18% in the Aegean, 15% in the Marmara, 11% in inner Anatolia, 8% in East Anatolia, and 4% in the Southeast Anatolia.There are 7297 forest villages with a population of over 2.5 million in Turkey. The number of villages in the vicinity of forests is 11,851 and nearly 5 million inhabitants live here. They depend on the forests to a great extent. The fuelwood from these forests amounts to about 7 million m3 obtained from 11,388 ha of an energy forest area. Although charcoal and coal are used as main fuel, individual heating through traditional use of firewood is common in these areas. Deforestation is thus increasing at a high speed due to usage of trees both for industrial as well as heating purposes. The two patterns of use determine how forest resources are exploited: consumptive use and productive use. The use of wood in Turkey fits the former pattern because people simply forage for their daily needs in local woodlands and forests. As such, there is an urgent need for a sustainable use of these areas. This paper presents the suggestions for combating this situation.

2 INTRODUCTION

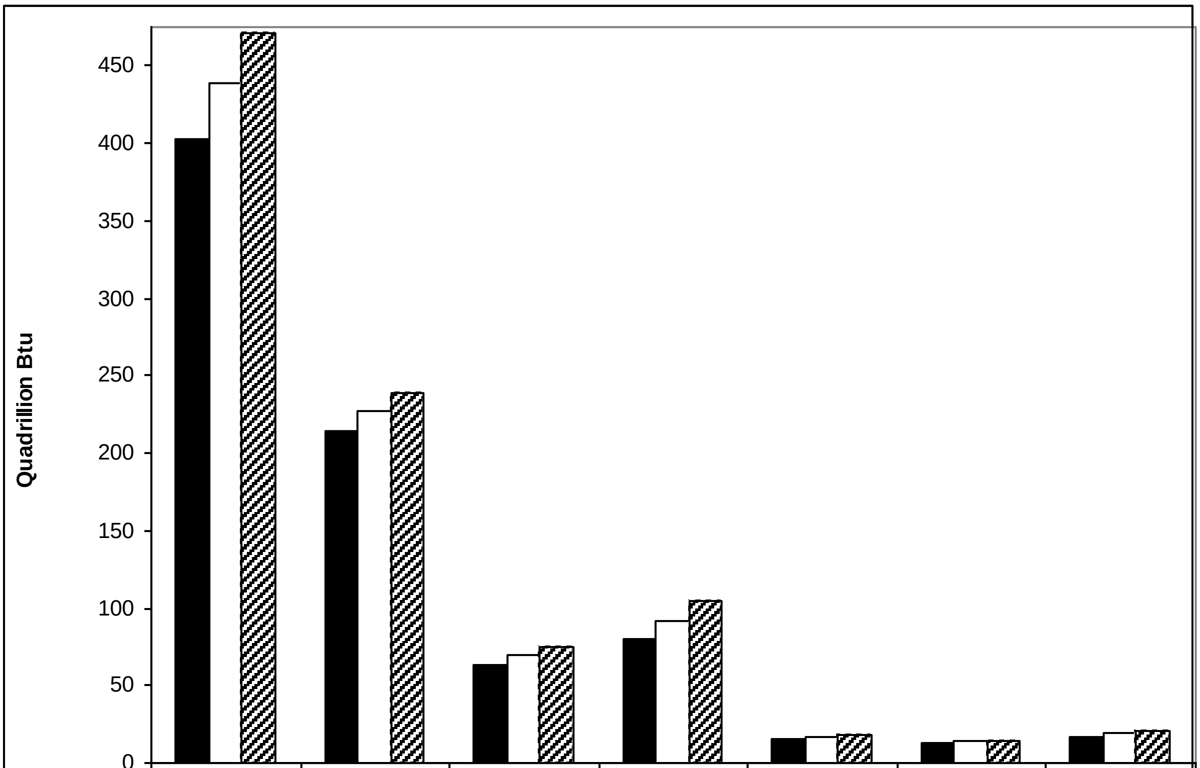
Every form of life requires a constant input of energy.If the flow of energy through organisms or societies ceases, they stop functioning and begin to disintegrate.Some organisms and societies are more energy efficient than others.If societies are to survive, they must continue to use energy. However, they may need to change their pattern of energy consumption as traditional sources become limited (Veziroglu,1996; Enger and Smith, 2000) . The sun provides the energy in every ecosystem which is essential to maintain life.

---

* *Ege University,Centre for Environmental Studies,Izmir,Turkey.*
** *Secretary General Islamic World Academy of Sciences ,Turkey.*
****Deputy Director General, National Parks, Ankara,Turkey.*

The 18th World Energy Congress was the first major global energy event of this century stressing the fact that modern energy services for everyone is a key to sustainable development and peace in the world. The statement “Energy for Tomorrow’s World - Acting Now!” in ” The Challenges of the New Millennium-Energy for People, Energy for Peace,” established the goals of energy accessibility, energy availability and energy acceptability and stressed the importance of sustainable energy development (Anonymous, 2001). It is a fact that there are abundant resources in every region of the world to meet growing global energy demand, but it is essential for all countries to diversify their energy portfolios by keeping all energy options open.

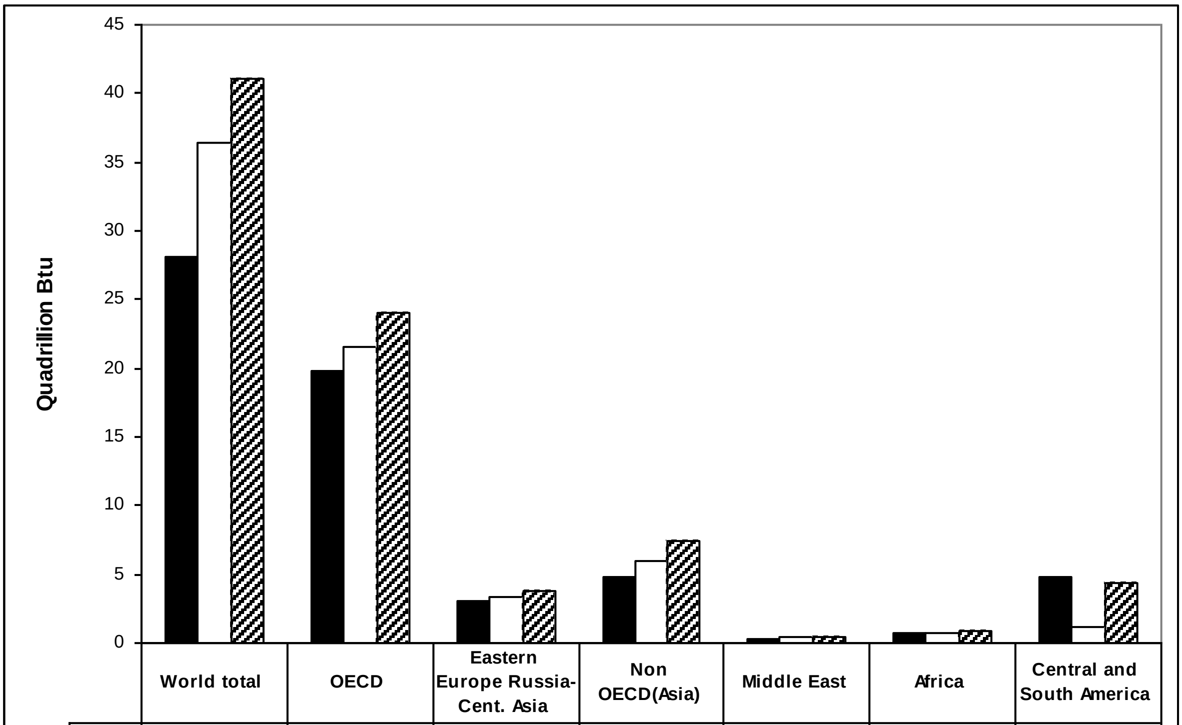
The world proven reserves of petroleum lie around 1,033,2 billion barrels, natural gas 5,141,6 trillion cubic feet and coal 1,087,2 billion tons. Out of this, 26.6 billion barrels, 83 trillion cubic feet and 5.04 billion tons were used in 1998 (Wright and Nebel,2002). Oil production in OPEC countries Saudi Arabia, Kuwait, Libya, Algeria, Iraq, Qatar, UAE, Iran, Indonesia, Nigeria, Gabon, Venezuela lied around 34.8 million barrels per day in the year 2000 and is estimated to go up to 41.7 and 46.2 million barrels in the years 2005 and 2010. The consumption data is presented in (Figures 1and 2).



	World total	OECD	Eastern Europe Russia-Cent. Asia	Non OECD(Asia)	Middle East	Africa	Central and South America
2000	402,6	214,4	63,7	79,4	15,2	12,6	17,2
2005	438,6	227,4	69,4	92,1	16,9	13,60	19,1
2010	471,7	239	74,7	104,2	18,4	14,60	20,8

Figure 1. World energy consumption

The percentage of energy sources used for generating electrical power in the world is 17.7 (nuclear), 14.8 (natural gas), 38.4 (coal), 9.3 (oil), 18.4 (hydro), and 1.4 (wood+refuse+renewables); common renewables being; solar, wind, biomass, energy from waste, geothermal, hydro, wave and tidal, ocean thermal (Wright and Nebel, 2002).



	World total	OECD	Eastern Europe Russia-Cent. Asia	Non OECD(Asia)	Middle East	Africa	Central and South America
■ 2000	28,1	19,8	3,10	4,8	0,3	0,70	4,8
□ 2005	36,4	21,5	3,40	6	0,4	0,80	1,2
▨ 2010	41,1	24	3,8	7,5	0,4	0,9	4,4

Figure 2. World renewable energy consumption.

3 THE ENERGY SECTOR IN TURKEY

The economic growth through heavy industrialization in Turkey has been based on the utilization of energy locked in fossil fuels. Although not so serious, the country has started facing minor pollution problems from these sources. If these problems do not force a shift to other energy sources, the finite supply of these sources will push the country for a change in the long run. An alternative in this direction is to use environmental friendly renewable energy sources like solar, biomass, wind, hydro, geothermal, oceanthermal, wave-tidal, and wastes.

Turkey possesses important geopolitical location bridging Asia to Europe.A major goal of the country is to become the “Eurasia Energy Corridor,” for the transmission of the Central Asian oil and natural gas resources to Europe, thereby serving as one of the most important terminus points for oil and gas exports of the current century. The Baku-Tbilisi-Ceyhan Crude Oil Pipeline and Turkmenistan-Turkey-Europe Natural Gas Pipeline passing through the Caspian Sea are the two important projects in this connection(Anonymous, 2003).

The energy demand of Turkey at home will be doubled between the years 2000-2010, due to high economic development as well as a population increase of over 75 million.The estimated amount of investments for the production facilities by the year 2010 is around $45 billion. The country’s basic strategy is diversification of energy sources to secure fuel supply and to ensure sufficient, reliable and economic energy supplies on time. According to projections, the energy demand which was 72 million earlier, will increase 7% annually, reaching 175 and 314 million TOE[*] in the years 2010 and 2020 respectively. The ratio of domestic production to demand was 40% six years back, and this figure will decrease by 30 and 25% in the years 2010 and 2020. Upto 2010, 63 thermal units with total capacity of 28220 MW, and 158 hydraulic units with the total capacity of 14826 MW will be added to the system. An additional 44150 MW capacity is expected to be added in 2020. Hydro power will decrease from the present 46% to 38% and 27% in 2010 and 2020; but the share of thermal power will

[*] TOE is Tonne of Oil Equivalent (Editors).

increase, with natural gas fired ones leading. The nuclear power will have 3% share in 2010, but will increase to 9% when 8 more units will be added between 2010-2020. The value of lignite fired power plants will decrease down to 15% from the present 27%. Imported coal fired plants will increase their share to 4% in 2010 and to 8% in 2020. Turkey is striving hard to diversify energy resources on country basis. The gas consumption is estimated to reach 52 and 80 BCM by the years 2010 and 2020 respectively. More than half of this consumption will be used for electricity generation.The number of power plants to be installed by the year 2020 is reported as 116 units with a capacity of 43218 MW, out of which 71 will be thermal. For this purpose new and renewable sources will be added to the energy supply cycle thereby protecting the environment and public health in the process of meeting the energy requirements. In addition, research and development in energy efficiency and renewable energy sources will be encouraged. Presently, in order to establish and implement an integrated environmental energy production and consumption policy, a dynamic energy-environment policy has been initiated which guards national interest and at the same time fulfils international commitments.

Total energy production lied around 27059 (Ktoe) (Kilo tonne of oil equivalent), with a general consumption of around 1192 (koe) per capita in 1999 and a total primary energy supply of 76773 (Ktoe). The same year out of a total 29.06 mtoe (Mega tonne of oilequivalent) production, share of renewables and wastes was 6.80 mtoe. The general energy demand data for 2005 shows there is a total need of 1856 (koe) per capita, and 129625 (Ktoe) total primary energy production.

4 BIOMASS

4.1 General

The burning of firewood has become utilizing biomass energy, bioconversion, which is just deriving energy from present day photosynthesis, not a new name but to put pizzazz into an old concept (Nebel and Wright,1998). Early in human history, people began to use different sources of energy to make their lives more comfortable. Because nearly all of their energy requirements were supplied by food, primitive humans were no different from other living beings in their ecosystems. Wood provided a source of fuel for heating and cooking. Eventually this biomass energy was used at a large scale. Biomass is plant matter and includes feedstock from plant cover, trees, grasses, agricultural crops, fuelwood, agricultural residues from harvesting crops (straw), short rotation coppice, crops grown for their energy content, waste from furniture, pulp and paper industry, waste wood from wood processing, from recycling/demolition, muncipal solid waste, animal waste, aquatic plants, algae or other biological material. These traditional, often noncommercial sources of fuel provide more than 14-19 % of the world’s energy today, but are not reported in most statistics about global energy (Owen and Chiras, 1995). In many developing countries, these sources of fuel are a large proportion of the energy available. Biomass provides upto 90% of the total energy demand of these nations (Enger and Smith, 2000).

4.2 Biomass conversion

Biomass is a renewable source of energy which can be used as a solid fuel or converted into liquid or gaseous forms for the production of electric power, heat, or chemicals, or for use in vehicles. It is the process of obtaining energy from the chemical energy stored in biomass. In fact, burning wood is a form of biomass conversion that has been used for thousands of years. Biomass can be burned directly as a source of heat for cooking, burned to produce electicity, converted to alcohol, or used to generate methane. US attains 4% of its energy from biomass and more than 7500 MW of electricity are generated by employing biomass technique (Enger and Smith, 2000). Malaysia has developed an invigorative progrmme of biomass based power generation which includes wastes from palm oil industry and other sources (Ibrahim et al.2002).

4.3 Advantages of Biomas

What makes this fuel attractive is that it is readily available significant renewable and recycle resource. Its use reduces foreign dependency and adds secondary value to agricultural crops. Crops can create habitat thus increasing biodiversity. Diversity of biomass crops include: poplar, cottonwood, euclyptus, grasses, and shrubs. Increasing habitat area decreases systems dependence on pesticides, herbicides, and fertilizers. It is an alternative energy source for developing countries but developing nations use indigenous resources more efficiently. It helps cut down on wastes, use of waste reduces waste in landfills, is often inexpensive. Growing biomass crops produces oxygen and does not add to the global carbon dioxide problem. It reduces air pollution and a decrease in greenhouse gas emissions. It reduces the need for fossil fuels, where employment is a major problem. Labor-intensive fuels could provide work and income for people currently out of work thus increasing domestic employment, opportunities to stimulate rural development. Of the environmental considerations worthy of a mention is the environmentally sound energy option for developing nations that decreases dependency on foreign fossil fuels, and catalyses the liberalisation of energy market.

4.4 Disadvantages of Biomass

Energy comes mainly from plants that must be harvested. This can deplete the soil of nutrientsand in turn compounds the food shortage in developing nations vis-a-vis leading to a loss of biodiversity. Land used to grow biomass is needed for other purposes, byproducts of biomass contain less energy per galon than gasoline. Biomass conversion raises some environmental and economic concerns and countries that use large amounts of biomass for energy are usually those that have food shortages. It is labor intensive, the cost is higher, and storage facilities are required. Biomass from wood is a somewhat dirty fuel, burning plants releases carbon dioxide, particulates and other pollutants. Studies indicate that more than 75 organic compounds are released when wood is burned, 22 of which are hydrocarbons known or suspected to be carcinogens. No reliable studies have however been conducted to determine if wood burning produces them in large enough quantities to be harmful.

4.5 Biomass resources in Turkey

In primary energy consumption data of 1999, the amount of wood used is reported to be 17.74 million tons and wastes 6.53 million tons. As against this annual production of wastes alone amounts to 25 million tons (Anonymous, 2003).

5 FORESTS AND FUELWOOD

Wood is the most widely used form of biomass. In developed countries such as the USA, Norway and Sweden, wood supplies about 10% of the home heating fuel. In the US alone, about 5 million homes rely entirely on wood for heating and another 20 million use wood for some heating. Canada obtains 3% of its total energy from fuelwood (Wright and Nebel 2002). In Africa, women and children may travel 50 km a day in search of fuel wood. Infact, wherever forests are ample relative to the human population, firewood or fuelwood, can be a sustainable energy resource (Ozturk, 2000).

In early civilizations, wood from the forests was the primary fuel and its heavy use eventually lead to shortages. Some of the Asian countries experienced a wood shortage hundreds of years before Europe and USA. In many of these places animal dung replaced wood as a fuel source.The forests of Europe supplied sufficient fuel until the 13th centuary and in USA upto 19th century. At present potentially renewable forests cover about 34% of the earth’s land surface, and in the past 3 decades nearly half of these forests have been destroyed to provide cropland, rangeland, lumber, fuelwood, dam reservoirs,and urban lands. As such, forests, especially tropical forests are disappearing faster than any other terrestrial ecosystem (Ozturk, 2000; Enger and Smith, 2000).

Forests have many vital ecological functions by acting as giant sponges, absorbing, holding, and gradually releasing water that recharges springs, streams, and aquifers. They regulate the flow of water from mountain highlands to croplands and urban areas and help control soil erosion, the severity of flooding, and the amount of sediment washing into rivers, lakes, and artificial reservoirs.

Forests play an important role in the global carbon cycle and act as an important defence against global warming, reomove carbon dioxide from and add oxygen to the air which explains why the world's tropical forests have been called the lungs of the earth.Thus, large-scale deforestation contributes to projected greenhouse warming. Forests provide habitats for a large number of wildlife species than any other land ecosystem, making them the planet's major reservoirs of biological diversity.They also help buffer noise, absorb some air pollutants, and nourish the human spirit by providing solitude and beauty. In 1990, the area of tropical forests cleared annully was 20million ha (Erdem, 2000). Present destruction and degradation of forests is one of the world's most serious environmental and resource problems. The World Bank estimates show that of the 33 countries that are net exporters of tropical timber, only 10 will have any timber left to export during coming years. Deforestation places additional burden on the poor, especially woman, because they must walk long distances to find and carry home bundles of fuelwood. They cannot buy it, for it will take 40 % of a poor family's meager income (Enger and Smith, 2000).

In the developing world, where as many as 2.5 billion people depend on wood for cooking and heating, shortages are becoming widespread. FAO-UN noted that 1.3 billion people are meeting their needs for wood by depleting existing supplies, cutting trees down faster than they could be replenished.Two thirds of these people live in Asia, especially near the Himalayas. Many of the rest live in arid parts of Central Africa and the Andean plateau of South America. By 2005, the number of people who will have problems collecting enough wood to meet their needs will climb to 3 billion unless something is done, and quickly. Depletion of wood creates enormous human suffering and also leads to widespread ecological damage: erosion, desertification, flooding, and habitat destruction (Ozturk et al., 2002).

Two patterns namely; consumptive use and productive use determine how forest resources are exploited. Most fuelwood use in developing countries fits the consumptive pattern. People simply forage for their daily needs in local woodlands and forests. Unfortunately, this kind of use often results in a deforestation that spreads outward from population centres. Hondurans are reported to cut 7 million cubic meters of firewood every year to use in cooking their meals, resulting in a high rate of deforestation.The country is in desperate need of a fuelwood policy that would encourage replanting and the sustainable use of wood in a land that is ecologically ideal for growing trees (Wright and Nebel, 2002).

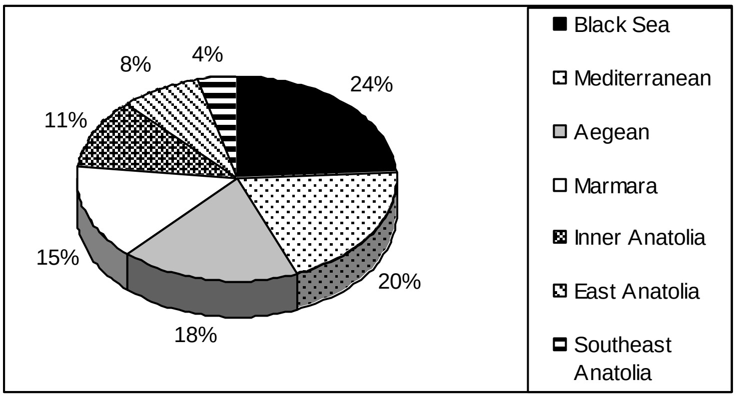


Figure 3. Percentage distribution of forests on regional basis in Turkey.

Forest area of Turkey on the whole is 20,763,247 ha i.e., 26.7 % of the countries total area, out of which 20,744,765 ha is government owned and 18,492 ha is private. 48 % of this forest is productive (10,027,568 ha), and 52 % (10,735,679 ha) unproductive. Nearly 8.3 million ha of the latter are groves and 1.8 million ha are coppice.The distribution on regional basis is given in Figure 3. Major species dominating these forests are: needle leaved species such as pines (5,542,768 ha), fir (463,676 ha), cedar (223,918 ha, and junipers(81,639 ha) bringing the total to 6,563,616 ha. Other needle leaved species like maritime pine amount to (55,435 ha), radial pine (2,429 ha), doglas (345 ha) i.e., a total of

80,75 ha. Broad leaved species like beech (1,062,381 ha), oaks (1,874,340 ha), chestnut (72,400), alder (57,767 ha), hornbeam (63,282 ha), ash (10,221 ha) which comes to a total of around 3,463,952 ha and other broad leaved species include mainly eucaluptus (319,728 ha).

The sum total of these species is 10,027,568 ha (Anonymous, 1999a, 2001 and 2002). The subject of productive energy forest has been introduced in Turkey very recently (Kurmus, 2000; Yazgan et al. 2000). Present estimates show that in the year 2000, 34% of the total consumption was met locally and this is expected to go down to 25 % in the year 2020, meaning that 75 % shall have to be imported. There is thus an urgent need to improve this situation through a creation of energy forests (Saracoglu, 1995; Anonymous, 1999b, 2001).

There are 7297 forest villages with a population of over 2.5 million in Turkey. The number of villages in the vicinity of forests is 11,851 and nearly 5 million inhabitants live here. They too depend on the forests to a great extent. The fuelwood from these forests amounts to about 7 million cubic meters obtained from 11,388 ha of an energy forest area (Anonymous, 1999a). Although charcoal and coal are used as main fuel, individual heating through traditional use of firewood is common in these areas. Deforestation is thus increasing at a high speed due to consumptive usage of trees both for industrial as well as heating purposes. Locals, wood suppliers, furniture industry simply forage in nearby woodlands and forests to bring down their costs. As such, there is an urgent need for a sustainable use of our forests.

6 CONCLUSION

It is important to remember that humans have faced many challenges through the ages but each time found a solution to them. What we we need today is thus a holistic, comprehensive approach to energy, including its social and cultural dimensions. What can be done?

Economic growth, social progress, and environmental protection are the three interlinked pillars of sustainable development. We should identify, synthesize, and publish the key data on the economic, environmental and social aspects of fossil fuels, nuclear power and renewables, which would allow realistic comparisons. Education on the role of energy in sustainable development, capacity building in developing countries, and better communication with the general public, are important factors in this work. If governments, regulators, energy companies, and consumers work together, energy development will serve all people in the world and can be a real catalyst for peace.

An international market for wood should be developed, which would encourage people with land to plant trees as a cash crop. Forests can be planted near villages and managed to produce a sustained yield. Marginal rural land could be used for this purpose as well. When people have to pay for fuelwood, trees become an important resource that can be put under the stewardship of local communities or private landowners, and a sustainable use of forests can result. Then all of the other benefits of goods and services provided by forests are preserved or restored. UN-FTPP can prove helpful in this direction. Fortunately, there has been an encouraging development recently, a report from Europe mentions that market share of sustainable wood is increasing. The report mentions that all timber sold on the Dutch market must come from sustainably managed forests. The actual result was less than 4%. Meanwhile, the new goal for 2005 is 25%. Insufficient supplies, lack of interest from timber merchants, and a lack of clarity in certification are the main reasons for the slow progress of sustainable wood production and procurance. Wood exporters like Sweden, Canada, and Malaysia do not have any certified wood. This creates a problem. However, about 600 companies in different countries have enrolled in the Forest Stewardship Council's certification system. Some 11 million hectares of forest in 27 countries are certified by the Forest Stewardship Council as meeting standards of sustainable management. We need a globally responsible conservation ethic and a new model for conservation science. People are part of ecosystems and as such humans shape ecosystems and are shaped by them.

For a commercial energy access of two billion people in the world who do not have it now, there is a need for political and legal stability at the global and regional levels, otherwise the forest cover on our plane will be depleted more and more. For a sustainable use of our forest cover, we need to apply cleaner combustion technologies with low emissions; identify the linkages between natural gas development and other critical resources, such as potable water, because of gas fuelled desalination plants, which also produce electricity; hydroelectric power seems advantageous in terms of global warming.

We need to promote the safe use of renewables and add renewable technologies in the global energy mix. A regional integration and global trade will accelerate the diffusion of technologies, especially in developing countries, to address the environmental acceptability of energy production, distribution and use. Accelerated technology diffusion and market reform measures will help reduce local and regional loss of the green mantle of our earth.

REFERENCES

1. 1999a: Report of Directorate General of Forests, Ministry of Forests, Ankara, 7-32.
2. 1999b: Energy forests. Ministry of Forests, Ankara.
3. 2001: Our Forests. Ministry of Forests, Ankara, Publ. no.128, pp.15.
4. 2001: Energy for Tomorrow's World - Acting Now. The World Energy Council (WEC), The 18th World Energy Congress, Argentina.
5. 2002: Report of Directorate of Forests, Ministry of Forests, Ankara, pp. 119.
6. 2003: June 5, World Environment Day. Environmental Engineers Newsletter, 3, Ankara.
7. 2001: The 18th World Energy Congress, Ministry of Energy, Argentina.
8. Enger, E.D.; Smith, B.F. (2000): Environmental Science. McGraw Hill, pp.434.
9. Erdem, U. (2000): Cevre Bilimi. Ege University Press, Cevmer 1, pp.498.
10. Ibrahim, H. (2002): Small renewable energy power programme for the promotion of renewable energy power generation. 1st Meeting of ASEM Gren IPPs Network, Bangkok, October.
11. Ozturk, M. (2000): Ecosystems.In: Environmental Science-Sustainable World (Ed. Erdem, U.) Ege University Press, 64-115.
12. Ozturk, M.; Celik, A.; Yarci, C.; Aksoy, A.; Feoli, E. (2002): An overview of plant diversity, land use and degradation in the Mediterranean region of Turkey. Environmental Management and Health, 13, 5, 442-449.
13. Kurmus, A. (2000): Energy limitations and forestry. Journal of Forest Engineers, February, Ankara.
14. Nebel, B. J.; Wright, R.T. (1998): Environmental Science.Prentice Hall, New Jersey,USA, pp.698.
15. Owen, S.O.; Chiras, D. D. (1995): Natural Resource Conservation-Management for a Sustainable Future. Prentice Hall, New Jersey, USA, pp.586.
16. Saracoglu, N. (1995): Possibile contributions of energy forest projects to the Turkish energy potential.Karadeniz Technical University Forest Faculty Publ., 4, 23-25.
17. Veziroglu, N. (1996): Towards a cleaner energy. Ekoloji, 18, 33-36.
18. Wright, R. T.; Nebel, B. J.(2002): Environmental Science. Person Education, New Jersey, USA, pp.681.
19. Yazgan, E. M.; Yilmaz, R.; Yetim,L.; Ozyavuz, M. (2000): Importance and neccessity of establishment of energy forest in South Anatolian Project region. GAP CEVRE Congress, 607-616.

Contemporary Problems and Achievements in Desulphurization of Oil, Gas, Petroleum Products and Waste Waters

A.M.MAZGAROV
Fellow of IAS
All-Russian Research Institute of Hydrocarbon Raw Material, (VNIIUS), Kazan, Tatarstan Republic, Russia

A major part of energy all over the world is produced at present and will be produced in the nearest future on the basis of hydrocarbon feed stock: oil, gas and coal.

Allah endowed generously with oil and gas exactly Islamic countries: Iran, Iraq, Saudi Arabia, Kuwait, Azerbaijan, Tatarstan, Bashkortostan, Turkmenistan, and others. The task of scientists is to develop the most efficient technologies of production, treatment, and rational (without *israf*) use of this gift of Allah to Moslems.

Production and processing volumes of sour, mercaptan-containing oils and gas condensates are increasing steadily all over the world. Sulphur is contained in oils in a form of various compounds (Table 1). During production, transportation, storage and processing of oils and gas condensates "active sulphur" (S^o+H_2S+RSH+COS+CS_2) causes most serious ecological and technological problems.

Hydrogen sulphide and low molecular weight mercaptans are volatile, highly toxic; they have an unpleasant odour and high corrosivity. Maximum permissible concentrations of mercaptans and hydrogen sulphide are shown in Table 2.

Fifteen or twenty years ago mercaptan-containing oils and gas condensates were produced only in Pricaspian Lowlands (Orenburg, Astrakhan, Karachaganak condensates and Tengiz and Zhanazhol oils); in the 90-ies the geography of such oil fields extended significantly. Production of Qatar condensate, Douglas oil in Liverpool Gulf near Great Britain, gas condensate of South Pars field in Iran was started.

Table 1. Sulphur compounds in crude oil

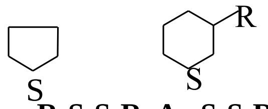
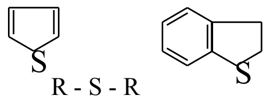
№	Chemical formula	Name	T_{boil}	Notes
1.	**S^0**	Elemental sulphur	**134 ^{0}C (T_{melt})**	Active Sulphur
2.	**H_2S**	Hydrogen sulphide	**- 60.7 ^{0}C**	
3.	**COS**	Carbonyl sulphide	**- 47.5 ^{0}C**	
4.	**RSH**	Mercaptans (thiols)	**6÷500 ^{0}C**	
5.	**CS_2**	Carbon disulphide	**46.3 ^{0}C**	
6.	**R-S-R, Ar-S-R, Ar-S-Ar** 	Sulphides (thioethers)	**35÷600 ^{0}C**	Residual sulphur
7.	**R-S-S-R, Ar-S-S-R**	Disulphides	**109÷600 ^{0}C**	
8.		Thiophenes	**84÷600 ^{0}C**	
9.	R - S(=O) - R	Sulphoxides		
10.	R - S(=O)(=O) - R	Sulphones		

Table 2. Maximum permissible concentrations of mercaptans (MPC)

№	Mercaptans	T $_b$, ^{0}C	$MPC_{W.Z.}$ Mg/m^3	$MPC_{M.S.}$ mg/m^3	Odour threshold mg/m^3
1	CH_3SH Methyl mercaptan	+ 6	0.8	$9 \bullet 10^{-6}$	$2 \bullet 10^{-5}$
2	C_2H_5SH Ethyl mercaptan	+ 36	1.0	$3 \bullet 10^{-5}$	$6 \bullet 10^{-5}$
3	$i – C_3H_7SH$ i-Propyl mercaptan	+ 60	1.5	$1 \bullet 10^{-4}$	$2 \bullet 10^{-4}$
4	H_2S (Hydrogen sulphide)	- 61	10	$8 \bullet 10^{-3}$	$1.2 \bullet 10^{-5}$

Table 3 shows concentrations of total and mercaptan sulphur in oils and gas condensates of some fields.

Table 3. Total and mercaptan sulphur content in different oils and gas condensates

Feedstock	**Total sulphur , wt %**	**Mercaptan sulphur , wt %**	**MeSH, ppm**	**EtSH, ppm**	**MeSH +EtSH, ppm**
Astrakhan condensate	1.38	0.19	340	270	610
Orenburg condensate	1.25	0.84	15	400	415
Karachaganak condensate	0.67	0.16	135	460	595
Tengiz oil	0.58	0.08	150	200	350

Zhanazhol oil	0.47	0.18	42	213	255
Qatar condensate	0.26	0.17	17	313	330
Douglas oil (Great Britain)	0.40	0.13	5	50	55
South Pars condensate (Iran)	0.67	0.15	150	350	500
Yamashi oil (Tatarstan)	3.10	0.14	6	68	74
Markovskii oil (Irkutsk Obl.)	1.00	0.41	35	85	120
Novolabitkii oil (Ul`yanovsk Obl.)	4.58	0.35	25	225	250
Radaevskii oil (Samara.Obl.)	3.05	0.078	10	55	65
Shchelkanovskii oil (Bashkortostan)	4.45	0.054	6	50	56
Noshovskii oil (Perm` Obl.)	3.40	0.067	8	50	58

Among oils with high mercaptan content the oil of Tengiz field takes a special place, because this field is the largest and its oil is transported to Novorossiysk via densely populated regions of Russia. To provide safe storage and transportation of oil it should be treated to 10 ppm of hydrogen sulphide and to 20 ppm of mercaptans C_1-C_2. To treat Tengiz oil for low molecular weight mercaptans and hydrogen sulphide VNIIUS developed and proposed to Chevron oil company, U.S.A., which is an owner of this field since 1993, a process of direct oxidational demercaptanization of oil using a highly efficient phthalocyanine IVKAZ catalyst. Activity and stability of IVKAZ catalyst is 3-4 times higher than those of Merox catalysts (Table 4). This catalyst was tested on Shiraz oil refinery (Iran) instead of a French catalyst of Procatalyst company and it appeared to be 15 times more stable than the French one. If the French catalyst is added every day by 100 grams, our catalyst is added every 15 days by 100 grams.

Table 4. Activity and stability of metalphthalocyanines

№	PcMe	ACTIVITY of oxidation of PrSNa $K_{eff} \cdot 10^4$, s^{-1}	STABILITY of oxidation of PcMe $K_{eff} \cdot 10^5$, s^{-1}	ACTIVITY of oxidation of t-DDM, $K_{eff} \cdot 10^3$, l/mole s
1	Without catalyst	0.22	-	0.05
2	$PcMn(SO_3H)_4$	0.23	8.68	0.09
3	$PcZn(SO_3H)_4$	0.24	7.46	0.10
4	$PcCrCl(SO_3H)_2$	0.24	2.93	0.28
5	$PcFe(SO_3H)_4$	0.34	11.40	0.29
6	$PcNi(SO_3Na)_2$	0.29	1.44	0.30
7	$PcCu(SO_3H)_2$	0.52	0.22	0.68
8	**$PcCo(SO_3Na)_2$**	**5.35**	**9.84**	**2.23**
9	$PcCo(COOH)_8$	25.40	39.40	0.60
10	$PcCo(NO_2)_4(SO_3H)_4$	20.71	7.55	1.35
11	$PcCoNH(oct)CH_2COOH$	45.52	8.42	2.44
12	PcCo sulfamoil	14.00	9.42	2.50
13	$PcCo(SO_2N(PhCH_2)CH_2COOH)_2$	58.03	8.65	3.11
14	$PcCoBr_7(OH)_8$	73.81	2.04	3.36
15	**Merox – 2**	**14.20**	**7.51**	**3.56**
16	$PcCo(OH)_4(SO_3H)_2$	37.52	8.71	3.71
17	**MOSKAZ – 1**	**25.40**	**0.18**	**3.83**
18	**MOSKAZ – 2**	**124.00**	**1.39**	**4.14**
19	**IVKAZ – 2**	**187.00**	**4.54**	**10.11**
20	**IVKAZ**	**65.42**	**2.05**	**16.83**

Fundamental exploration of kinetics and mechanism of mercaptan oxidation allowed to develop scientific and technologic principles of selective demercaptanization of crude oil (the DMC-1 process) [1].

On the basis of pilot test results and technologic conception of VNIIUS, “Bechtel Ing.” company worked out a design of a commercial plant for Tengiz oil demercaptanization, consisting of two process lines of 4 MM tons per year capacity (Figure 1).

The stabilized oil at a temperature of 50-60°C is supplied to tubular turbulent reactor M-1, in which reactions of hydrogen sulphide, mercaptans C_1-C_2 and naphthenic acids with an aqueous solution of sodium hydroxide and IVKAZ catalyst proceed at a high velocity. Then, the oil, mixed with the catalyst complex and the air in M-1, enters the bottom of reactor R-1, in which oxidation of toxic light volatile mercaptides C_1-C_4 to low-toxic heavy-volatile neutral disulphides takes place at a temperature of 50-60°C and a pressure of 10 bar.

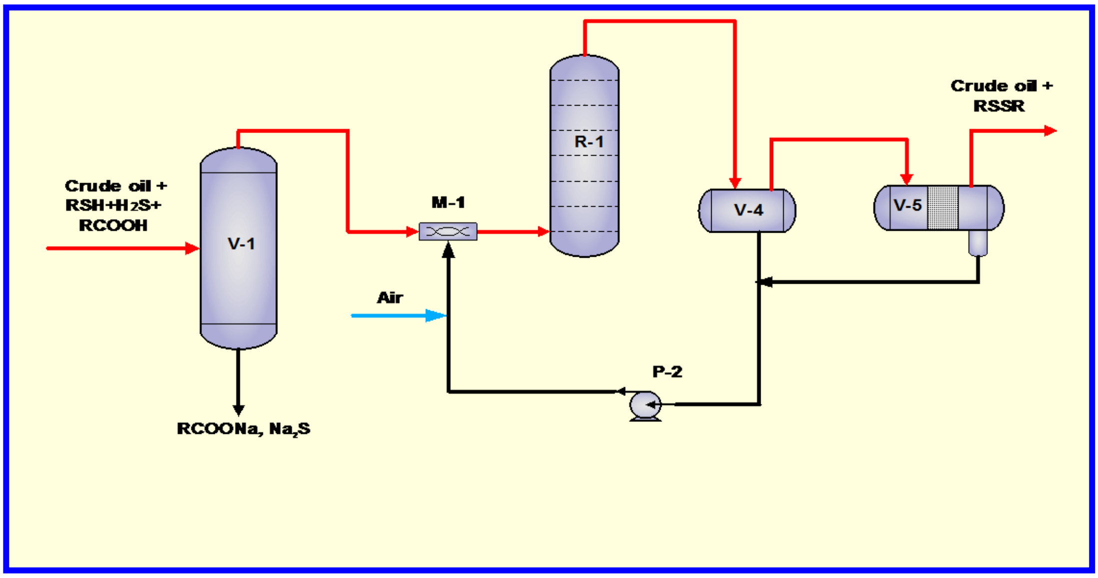


Figure 1. DMC-1 process.

From the top of the column the reaction mixture passes to separator V-4, where the oil settles from the catalyst complex. From the bottom of V-4 the catalyst complex is fed to reactor R-1 with pump P-1. The demercaptanized oil flows from the top of V-4 to coalescer V-5 to be separated from the entrained catalyst complex droplets. From V-5 the oil is sent to storage tanks.

The catalyst complex is a 5-20% aqueous solution of sodium hydroxide and 0.005% IVKAZ catalyst.

The DMC-1 plant was commissioned in March 1995, the DMC-2 plant – in August 1996. Both plants operate very stably. In 2000 the capacity of each plant reached 6 MM t/yr. Methyl- and ethyl mercaptan content after treatment does not exceed 5-10 ppm in a sum. Actual catalyst consumption constitutes less than 0.05 g per ton of treated crude, and sodium hydroxide consumption, calculated on dry substance, amounts to less than 40 g per ton, that is below than during demercaptanization of light hydrocarbon feedstock. The DMC-1 plant provides essentially complete removal of methyl- and ethyl mercaptans, removal of 70% of propyl mercaptans and 40% of butyl mercaptans.

After start-up of the DMC-1 plants the mercaptan odour disappeared on the whole territory of Tengiz gas refinery and its tank farms. It became possible to transport Tengiz oil in tank cars to European countries via the whole territory of Russia without any harm to the environment.

Tengiz demercaptanization plant became the first and the largest in the world practice plant of crude oil demercaptanization. Operation experience of these plants and analysis of operation of some units of the plants allowed developing improved modifications of the process: DMC-1M, DMC-2 and DMC-3.

The DMC-1M process as compared to the DMC-1 process treats not only light oils and gas condensates for hydrogen sulphide and mercaptans C1-C_2, but also heavy oils with high viscosity under field conditions at minimal capital costs. A flow sheet of the process is shown in (Figure 2).

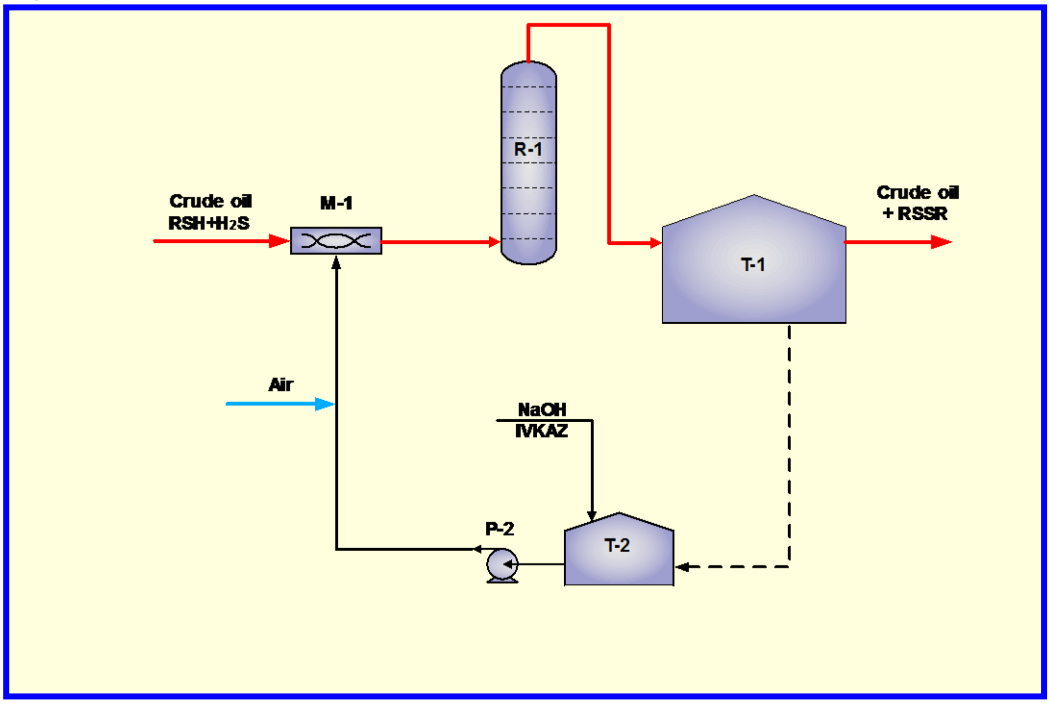


Figure 2. DMC-1 M process.

The treated oil, stoichiometric quantity of air for oxidation of hydrogen sulphide and mercaptans C_1-C_2 and an aqueous-alkaline solution of IVKAZ catalyst in an amount of no more than 5 litre per ton of oil are mixed in tubular mixer M-1 and in orifice mixer-reactor R-1. Reactor R-1 provides intensive mixing of the reagents and selective oxidation of mercaptans C1-C_2 to disulphides and oxidation of hydrogen sulphide to elemental sulphur and sodium thiosulphate at a temperature of 20-50^{o}C and a pressure of 4-5 bar. The elemental sulphur in its turn also oxidizes the mercaptans to disulphides. Emulsion formation promotes mercaptan and hydrogen sulphide oxidation. Due to a small amount of the alkali, mixed with the oil, a potential formation of an emulsion with heavy oils does not present any hazard for transportation, storage, and processing of the oil. Afterwards the reaction proceeds in a pipe and in storage tanks. A major part of the caustic solution settles in tanks and is re-used for preparation of the catalyst complex in tank T-2. Metering pump P-2 provides a continuous supply of the catalyst complex from T-2 to mixer M-1.

A small part of the caustic remains in the oil and acts as a corrosion inhibitor in the refinery pipeline and equipment.

The DMC-1M process was tested on oil fields of J.S. “Tatex” for demercaptanization of heavy oils and also for demercaptanization of Zhanazhol oil (Kazakhstan) and proved to provide deep treatment of the oils for low molecular weight mercaptans C1-C_2 and hydrogen sulphide at minimal consumption of the alkali and catalyst.

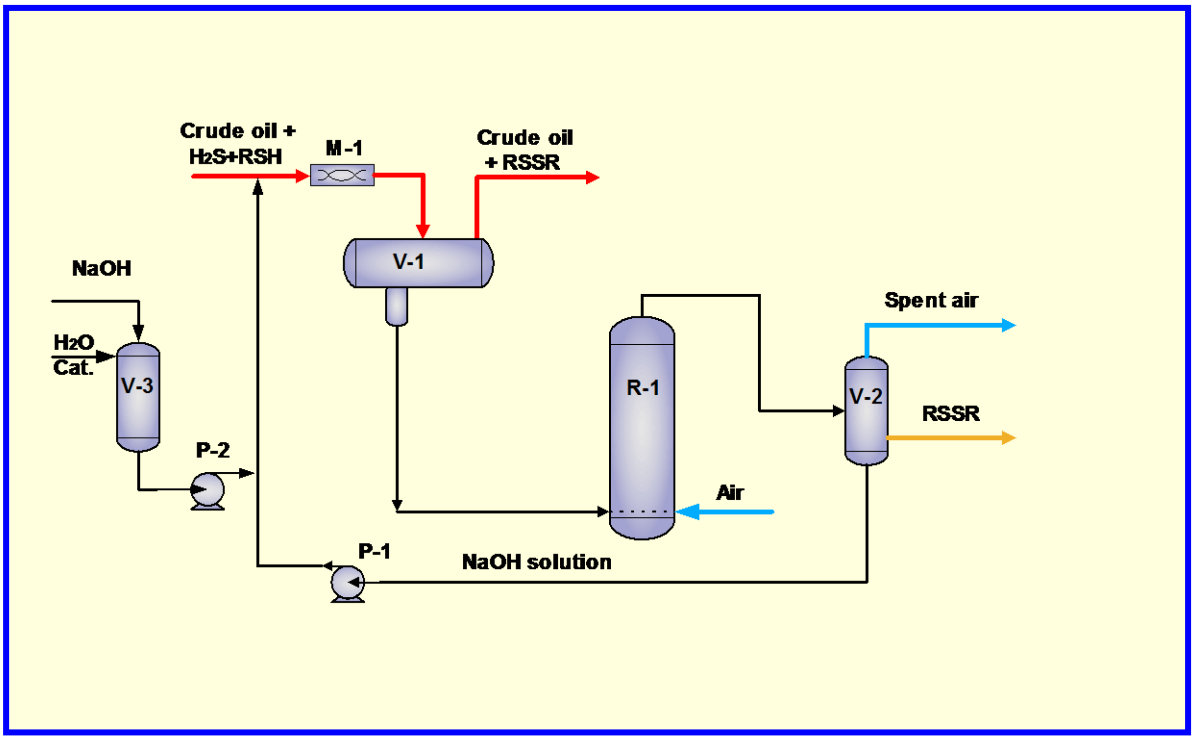


Figure 3. DMC-2 process

The DMC-2 process allows treating oil for hydrogen sulphide and mercaptans C_1-C_2 without a contact of the oil with the air (Figure 3).

The DMC-3 process (Figure 4) provides removal of mercaptans C_1-C_4 and hydrogen sulphide from oils and gas condensates with a high sulphur content. The process is performed in two stages. On the first stage hydrogen sulphide and mercaptans C_1-C_2 are removed from the oil using a 2-10% aqueous solution of caustic. Then the caustic solution is regenerated by oxidation of sodium sulphide and sodium mercaptide with air oxygen over heterogeneous UVKO catalyst following reactions 1 and 2:

$$2RSNa + 0.5O_2 + H_2O \rightarrow RSSR + 2NaOH \quad (1)$$

$$3Na_2S + 4O_2 + H_2O \rightarrow Na_2SO_4 + Na_2S_2O_3 + 2NaOH \quad (2)$$

On the second stage mercaptans C_3 and higher are oxidized with air oxygen to disulphides over IVKAZ catalyst, dissolved in the 2-10% caustic solution.

The stabilized oil at a temperature of 20-50^{o}C is supplied to mixer M-1, in which it is mixed with the circulating caustic solution, and then enters separator V-1 in order to be separated to oil and alkaline phases.

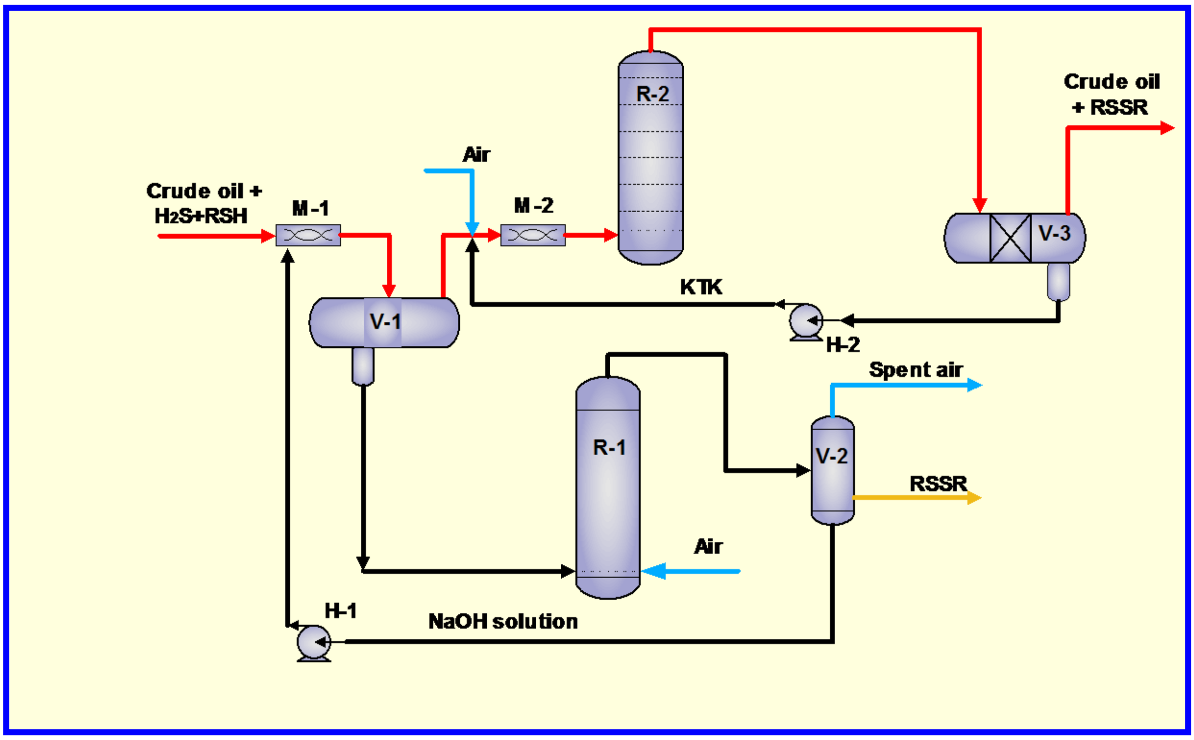


Figure 4. DMC-3 process.

The caustic solution, saturated with the mercaptans and hydrogen sulphide, is mixed with the air and enters regenerator R-1, where it is regenerated at a temperature of 50-60^{o}C and a pressure of 4-5 bar over UVKO catalyst following reactions 1,2.

From the regenerator the reaction mixture enters air separator V-2, in which the air and disulphides are separated from the caustic solution. The caustic solution is returned from the bottom of separator V-2 with pump P-1 to mixer M-1.

The oil, settled from the caustic solution, flows from separator V-1 to the second stage of treatment to mixer M-2 to be mixed with the air and catalyst complex (solution of caustic and homogeneous IVKAZ catalyst). The mixture of oil, catalyst complex, and dissolved air enters reactor R-2, where oxidation of mercaptans C_3 to disulphides takes place at a temperature of 50-60^{o}C and a pressure of 6-12 bar. From the top of reactor R-2 the reaction mixture flows to separator V-3 to be separated to oil and alkaline phases. The oil, containing the dissolved disulphides C_{3+} , is sent to a storage tank and the catalyst complex is fed to mixer M-2 with pump P-2.

The DMC-3 process was commissioned on Orenburg gas refinery in October 2000 for Karachaganak condensate treatment for hydrogen sulphide and mercaptans. The plant capacity is 2 MM t/yr (35000 bbl/day). Mercaptan C_1-C_4 content was 1600 ppm before treatment, and below 30 ppm after treatment.

Existing technologies of NGL treatment for H_2S+RSH+COS+CS_2 are multistage and consist of the stages, shown in Figure 5.

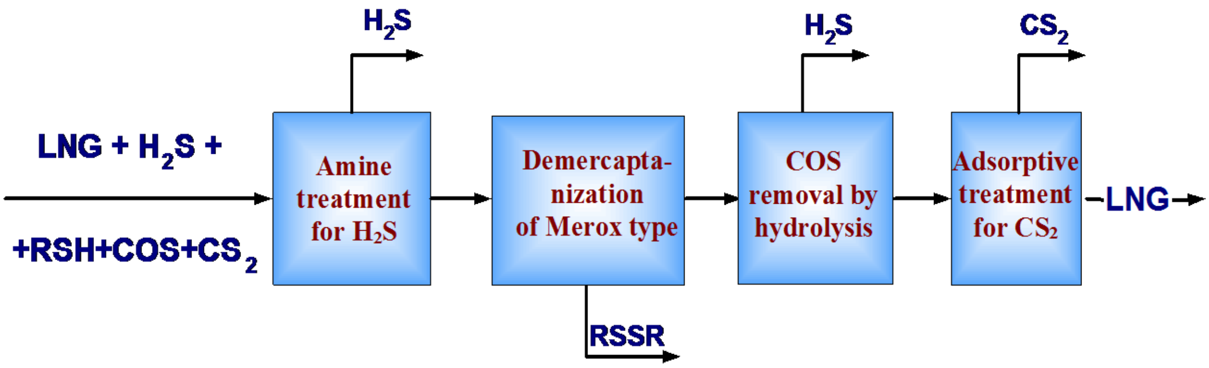


Figure 5. Diagram of LNG treatment for H_2S, RSH, COS and CS_2.

To treat LNG and LPG for sulphur compounds (H_2S+RSH+COS+CS_2) an efficient one-stage alkaline absorption DMD-2M process with oxidational catalytic regeneration of the alkaline solution is developed. The process is based on alcohol-alkaline hydrolysis of COS+CS_2 at a temperature of 50-70°C and absorption of CO_2+H_2S+RSH with an alkali followed by oxidation of mercaptides and xanthogenates to disulphides, of toxic sodium sulphide to non-toxic sodium sulphate and sodium hyposulfite with air oxygen over UVKO-2 catalyst [2].

The process flow sheet is shown in (Figure 6). The hydrocarbon fraction is supplied to the bottom of extractor V-1 at a temperature of 40-50°C and a pressure of 5-20 bar. A 10-20% aqueous-alcohol solution of caustic soda at a temperature of 50-70°C is fed to the top of the extractor with pump P-1. The reactions, that take place in the extractor, are as follows:

$$H_2S + 2\,NaOH \rightarrow Na_2S + 2\,H_2O \qquad (3)$$

$$RSH + NaOH \rightarrow RSNa + H_2O \qquad (4)$$

$$COS + 4\,NaOH \rightarrow Na_2S + Na_2CO_3 + 2\,H_2O \qquad (5)$$

$$CS_2 + 6NaOH \rightarrow 2Na_2S + Na_2CO_3 + H_2O \qquad (6)$$

$$CS_2 + ROH + NaOH \rightarrow NaS-\underset{\underset{S}{\|}}{C}-OR + H_2O \qquad (7)$$

$$-\frac{d[CS_2]}{d\tau} = k[CS_2]\,n_{ROH} \quad ;\ n = 0.1 \div 0.4$$

Then the aqueous-alcohol solution of the caustic flows from the extractor bottom to the regenerator, in which regeneration of the caustic takes place over the catalyst following reactions 1, 2 and 8:

$$2S{=}C\begin{matrix}\diagup OR\\ \diagdown SNa\end{matrix} + 0.5O_2 + H_2O \rightarrow S = \underset{\underset{OR}{|}}{C}-S-S-\underset{\underset{OR}{|}}{C}{=}S + 2NaOH \qquad (8)$$

$$|\,r\,| = k\,[\,S = C\begin{matrix}\diagup OR\\ \diagdown SNa\end{matrix}\,]\,[O_2]\,[kat]$$

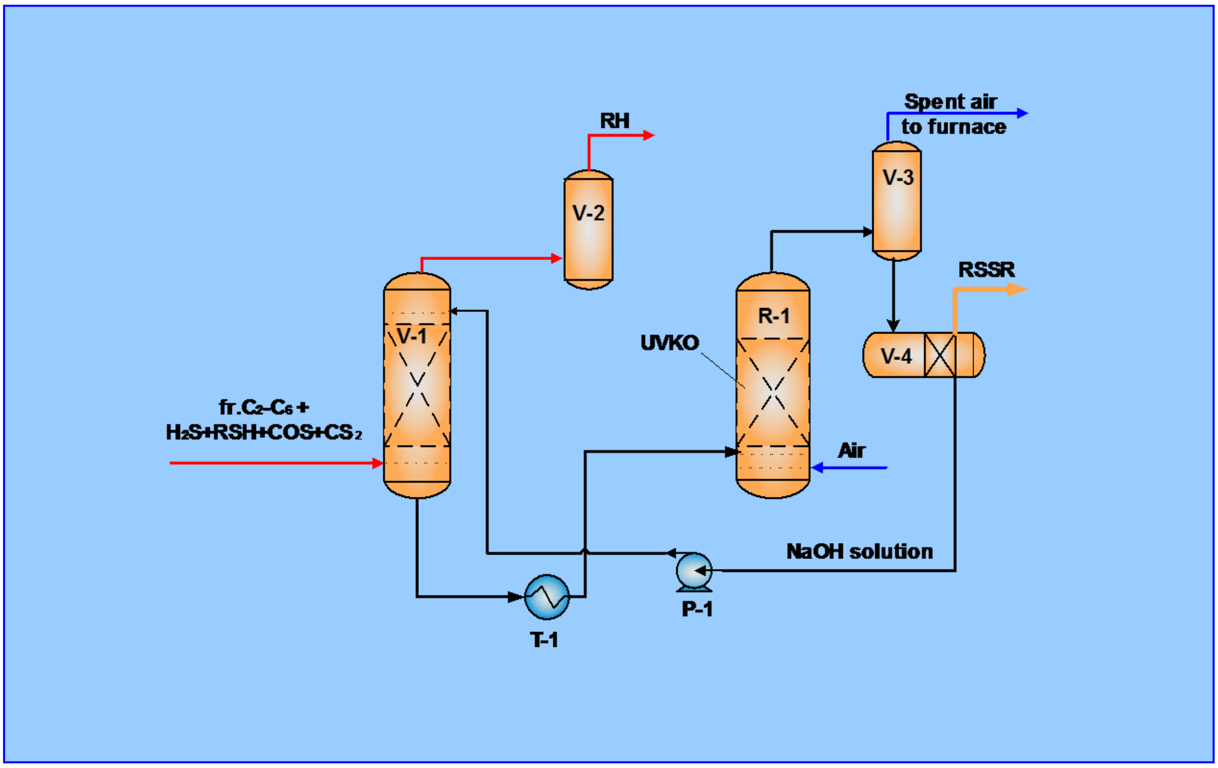


Figure 6. DMD-2M process

The DMD-2M process has been successfully operating on Perm gas refinery for treating NGL since 2000. The plant capacity is 300000 t/yr. A license for this process was sold to Iranian oil company (NIOC).

Heterogeneous UVKO catalysts are carbon-fibre materials produced by the pyrolysis of cellulose fibres in CO_2 atmosphere at a temperature of 800-900°C. A specific surface of such activated materials is from 300 to 600 g/m^2. These materials contain up to 0.3% of metal oxides, and, first of all, ferric oxides (3) Fe_2O_3 and ferrous oxides (2) FeO, that provide high catalytic activity to them in the reaction of sodium sulphide oxidation in the aqueous-alkaline medium. On the basis of this carbon-fiber material new commercial UVKO type catalysts were developed for oxidation of sodium sulphide and mercaptide. A commercial form of this catalyst is manufactured as rolls of carbon-fibre cloth wound together with metal sieve. Depending on a reactor diameter the rolls may be of different sizes.

Oxidation of mercaptans and regeneration of mercaptan-containing alkaline solutions are carried out using UVKO-2 catalyst, which is manufactured by application of cobalt phthalocyanines from aqueous-alkaline solution to UVKO-1. An optimal concentration of cobalt phthalocyanine (IVKAZ) on the surface of UVKO-2 is 0.02-0.05% of the carrier mass.

The DMD-1 process for demercaptanization of aviation kerosene was developed using UVKO-2 catalyst and commissioned on Kuibyshev and Ukhta refineries. The capacities of the processes are 310 000 t/yr and 50 000 t/yr accordingly (Figure 7). The DMD-1 process allows to obtain mercaptan sulphur content after treatment of no more than 5 ppm for gasoline and 10 ppm for kerosene.

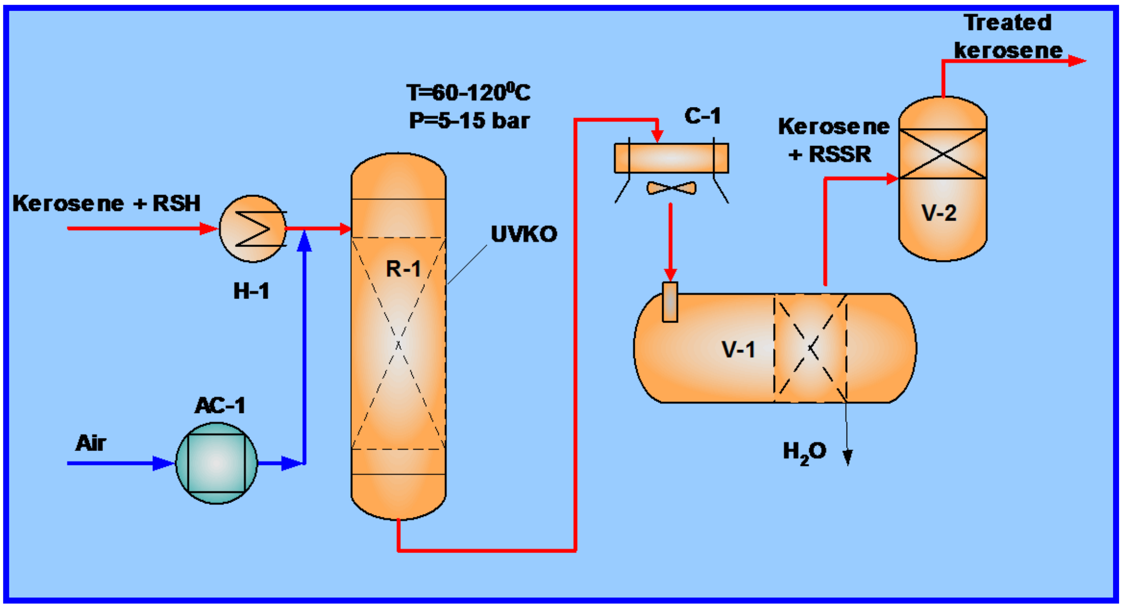


Figure 7. DMD-1 process.

The process consists in mercaptan oxidation with air oxygen to disulphides over heterogeneous UVKO catalyst at a temperature of 60-80^{o}C and a pressure of 5-15 bar.

The DMD-3 process (Figure 8) provides treatment of light and heavy naphtha for mercaptans to 5 ppm. The process is carried out in two stages:

- on the first stage, mercaptans C_1-C_3 are extracted with the catalyst complex and afterwards oxidized in the regenerator and removed in the form of disulphides;
- on the second stage, mercaptans C_{3+} are oxidized to disulphides over heterogeneous UVKO-2 catalyst directly in the naphtha stream.

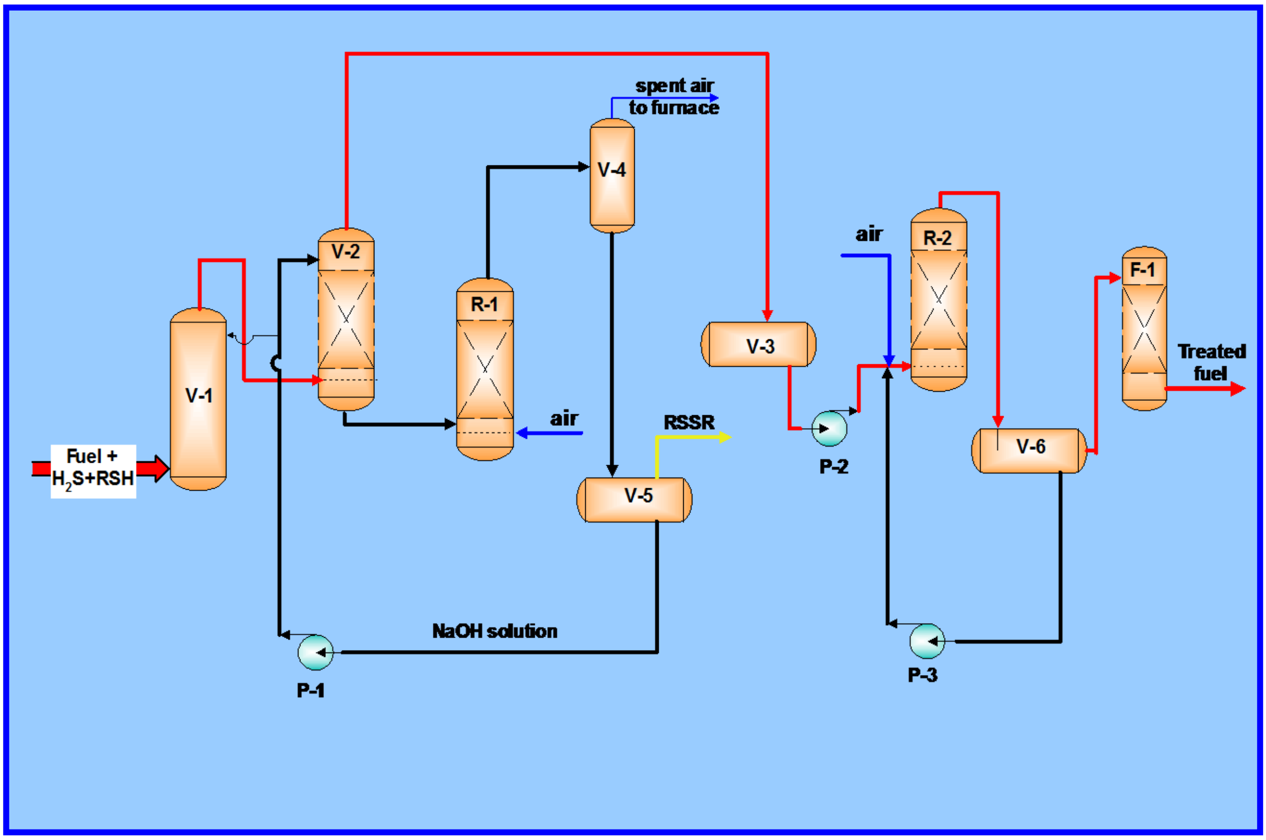


Figure 8. DMD-3 process

A license for the DMD-3 process was bought by NIOC; the process was tested successfully on a pilot plant of RIPI with a capacity of 100 l/hr. At present developed is a design for large commercial plant KHAGR PCC (Iran) for treating propane (500 t/day), butane (500 t/day) and naphtha (426 t/day) on the basis of the DMD-2K and DMD-3 technologies.

Figure 9 shows the DMD-2 Odorant process, which provides simultaneous treatment of naphtha for hydrogen sulphide and mercaptans and production of an odorant (a mixture of natural mercaptans C_2-C_4) for odorization of gases and dimethyl sulphide – a coking inhibitor during ethane pyrolysis and sulphurization reagent for hydrotreating catalysts. The process has been successfully operating on Orenburg gas refinery since 1986 and satisfies all requirements of Russia for the odorant. At present work is being conducted on commissioning this process in Iran; a pilot plant has been tested successfully this July and the first Iranian odorant has been produced on it. Currently Iran pays more than 2.0 MM dollars per year to buy odorants.

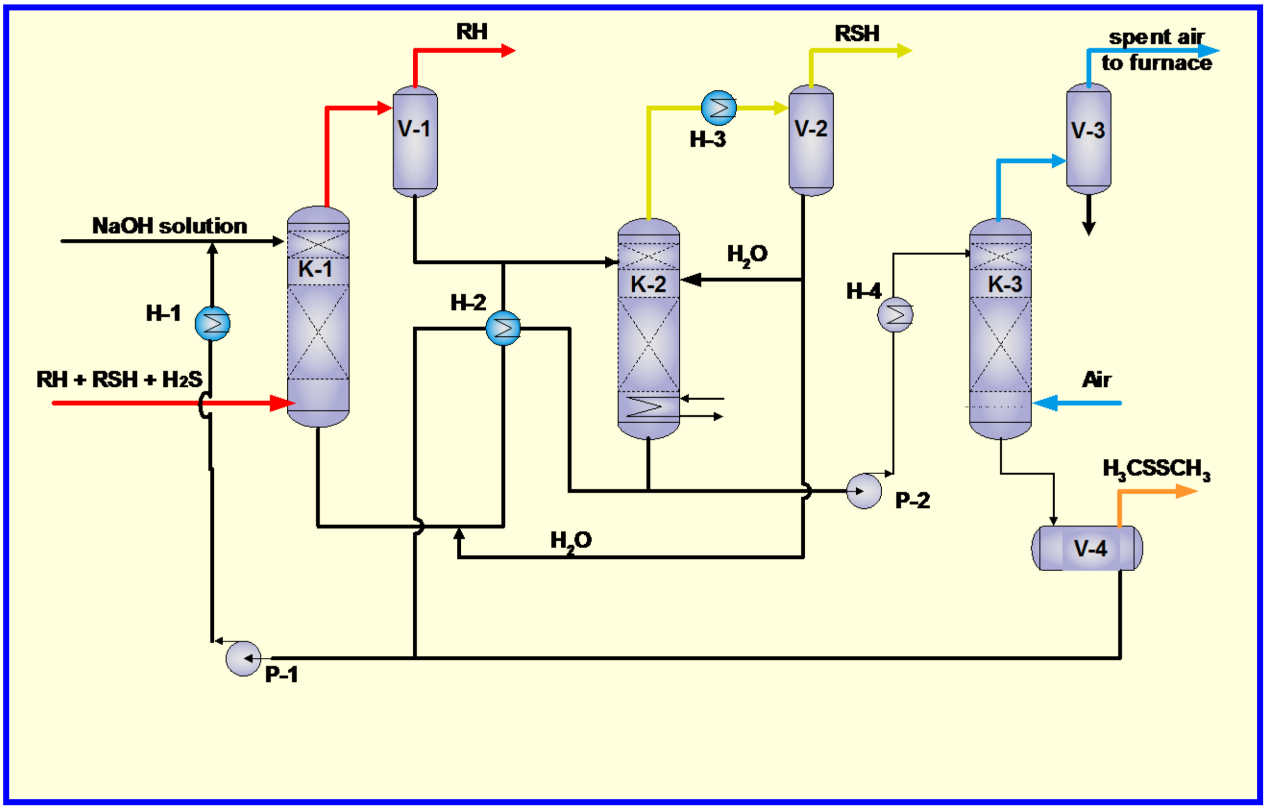


Figure 9. DMD-2 "ODORANT"

(Figure 10) shows the Serox-W process flow sheet.

Waste waters, separated from the oil products and mechanical impurities and heated in heat exchanger H-1 to a temperature of 60-80°C, are sent via filters F-1, F-2 to reactor R-1, charged with UVKO-1 catalyst. Oxidation of sulphide and mercaptide sulphur over the catalyst surface takes place in the reactor at a temperature of 60-80°C and pressure of 4-5 bar with air oxygen, supplied to the bottom of the reactor, following reactions 1 and 2.

The treated waste waters from the top R-1 and the air are sent to air separator V-1, the spent air is sent to a nearest incinerator for calcination and the treated waste waters after cooling in cooler C-1 to a temperature of 50°C are passed to biological treatment facilities. The process provides sulphide and mercaptide sulphur oxidation to 99.5%.

The Serox-W process has been operating on Ryazan refinery since 1990 and on Kuibyshev, Ufa and Yaroslavl refineries since 1996 for treating technologic condensate from catalytic cracking plants. The capacity of the plants is up to 30 m^3/hr, residual sodium sulphide content does not exceed 20 mg/l. The catalyst life time is at least 5 years.

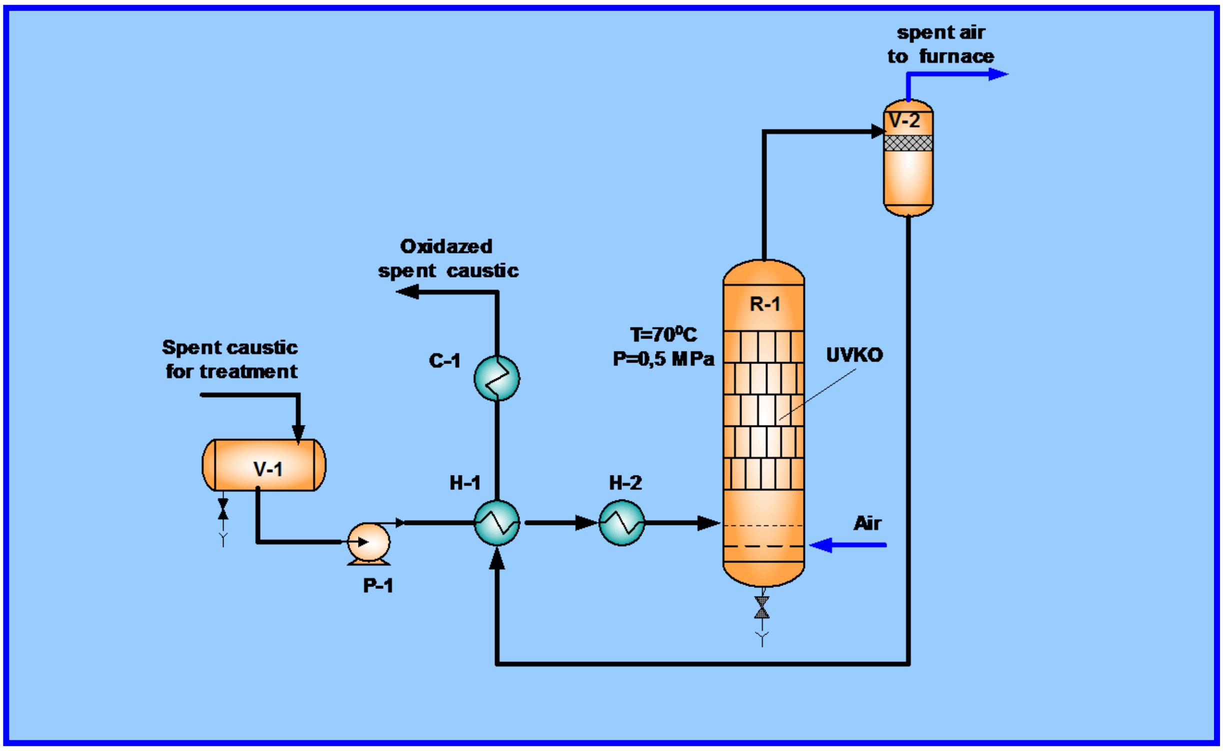


Figure 10. Serox-W process

However the UVKO-1 catalyst like all heterogeneous catalysts appeared to be inapplicable for treating sulphur-alkaline waste waters from plants, producing ethylene by hydrocarbon pyrolysis. The matter is that these waste waters contain significant amounts of olefins, dienes and acetylenic hydrocarbons, which being heated to a temperature above 40^{o}C in an alkaline medium, polymerize quickly and plug the catalyst and the reactor. Therefore, to oxidize sulphur-alkaline waste waters from pyrolysis plants only homogeneous catalysts should be used. Just this was done by us on Burgas petrochemical plant (Bulgaria). Due to high activity of homogeneous Co-Mu phthalocyanine IVKAZ-W catalyst its consumption is very low (0.01 g/l) and, accordingly, the catalyst concentration in the oxidized sulphur-alkaline waste waters is insignificant (at most 10 ppm). Besides, metal phthalocyanine molecules accelerate oxidation reactions of organic and non-organic compounds in biological treating facilities.

IVKAZ-W catalyst allows to oxidize toxic sodium sulphide to 85 % to neutral sodium sulphate under mild conditions (T=80^{0}C, P=3-5 bar).

REFERENCES

1. Mazgarov A.M., Vildanov A.F., et al. "A selective treatment of various oils and gas condensates to remove light mercaptans and hydrogen sulphide", Proceedings of the 15th World Petroleum Congress, 1998, pp.877-881.
2. Mazgarov A.M., Vildanov A.F., et al. "Complex treatment of light naphtha for H_2S, RSH, COS, CS_2 and CH_3SCH_3", XX-th International Symposium on the Organic Chemistry of Sulphur, July 2002, Arizona, USA.

Ecology, Sustainability, and Stewardship

MUNIR OZTURK* ,MEHMET ERGIN**and EREN AKCICEK***

**Ege University ,Centre for Environmental Studies ,Izmir ,Turkey*
***Secretary General Islamic World Academy of Sciences ,Turkey*
****Ege University, Faculty of Medicine ,Izmir, Turkey*

1 ABSTRACT

Ecology and sustainable development immerged long back as main concepts and policies for the stewardship of different communities. They possess a similar goal; the sustenance of desired conditions on biosphere. Ecological management and sustainable development are a prudent path to pursue. However both are as yet dreams, because we see that ecological crisis faced by us in the 21st century is threatening the world, either because people have too much, or too little. The new century is characterized not only by great changes and new opportunities but also by increasing risks. The poverty of the majority of the earth's inhabitants and over consumption by the minority are the major causes of eco disasters. This action is essentially the backlash of modern development. Today's ecological crisis is actually related to the greed, irresponsibility, and lack of interest in ethical values. This is well known historical fact that we the humans, in the course of our material progress, have lost the ethical basis of our philosophy of life, by neglecting the moral and value bases of society. The industrially developed nations have achieved higher standards of living through an unethical use of natural resources of industrializing nations. This has contributed to the lack of a holistic approach to creation and life in them. No one knows for certain the magnitude of natural inheritance cohabiting this planet with us, but the figure is said to lie around 30 million. These have come into being during a period of 3 billion years of evolution.

Natural extinctions are taking place as a part of normal evolutionary process, but the wave of extinction mankind is observing lately is a cumulative result of man's antilife and unplanned activities. Both genetic as well as ecological diversity are nearing extinction. Although objectivity always is getting clouded by emotions still there is a great need today for the conservation of ecodiversity, its sustainable use, and the equitable sharing of the resulting benefits than it was in the past. Ecologists as stewards of nature can at the most contribute to reversing this trend by facilitating the acquisition, dissemination and utilization of ecological knowledge to ensure the sustainability of biosphere and providing a biosocial model to the managers. Many efforts are being spent on the study of inter-relationships of environment and organism. Such assessments are providing logical bases for clear thinking towards life and a greater comprehension of the eternal laws of nature. Countries all over the globe are now trying to include principles that support nature conservation. However, unless these commitments are based on altruism and action, success is impossible. No meaningful result can be envisaged without both a reflection on the ethical implications of our plans of action and a moral urgency for their implementation.

There is a greater need for a new spirit of international cooperation. We shall witness many new challenges to the security and sustainability of our planet if steps are not taken. The fundamental lessons contained in our faith traditions are increasingly coming to the forefront. From biogeographical considerations if area of a habitat decreases by ten to one, annihilation of species diversity in this place will be around 50%. Thus we as humans are actively involved in a "ecocide" which includes "specide" as well and should be accepted as a crime if "genocide" is so. The aim of this paper is to present some principles important for the success of application of ecological approach and stewardship towards our mother earth.

2 INTRODUCTION

Man is both creature and moulder of his environment, which gives him the opportunity for intellectual, moral, social, and spiritual growth. The natural and man-made aspects of man's environment are essential to his well-being. The environment is defined as the sum of all the social, biological and physical or chemical factors which compose the surroundings of man. The biotic and abiotic components of the environment show a hierarchial arrangement among the components and a state of equilibrium existing at each level. Both time and space act as limiting factors on these levels. According to Binark (1995) earliest publications enlightening the interactions between man and environment are 4600 years old, dealing with the impact of climate on human health (Nei Ching) written by Chinese emperor Huang, followed by that of Hippocrates (500 BC) and Ibn-i Sina (980-1037) stressing the importance of environmental quality in human health.

The historical origin of the present day environmental crisis lies in the failure of people to anticipate the long-range consequences of their activities and consequences that have been aggravated by the misuse of modern technology (Dubos, 1976, 1980). Today's thinking is; science discovers, industry applies, man conforms, and individuals, groups, entire races of men are falling into step with science and technology. While science and technology have in the past decades become predominant some people today have started suggesting that humankind should not follow the lead of science and technology. The present view is that scientific technology must be managed with a strong concern for the long-range consequences of human interventions into nature. Thus, for those concerned with encouraging ecologically responsible behaviours towards environment, there is a need for an emphasis on "ecolacy," which stresses the importance of education as a contributing factor both to the development of environmental attitudes and the display of environmental behaviours (Hardin, 1985). An awakening of attitudes towards the quality of our world and preservation of nature has resulted in a broadened ecological approach towards a relationship of humans with their environment. Ecological management, sustainable ecosystems and biological diversity are only a few of the phrases used to characterize this changing view, because of the serious environmental problems we are facing today.

A huge number of pollutants we face outdoors press us to run home however, here we face indoor pollutants. While running from rain we are caught by hail (Ozturk et al., 1993; Ergin and Ozdas, 1993). A report disclosed by WHO points out that annual expenditure for untreated diseases has reached a level of over $400 billion, out of which cancer occupies first level with over $120 billion, followed by cardio-vascular diseases with nearly $100 billion (Bassett et al., 2000). An estimated 200,000 to 570,000 people die every year from health problems caused by air pollution. Even with our abundance of food, some 40,000 people die each day of starvation and disease. Worldwide, polluted water affects the health of a staggering 1.2 billion people and contributes to the death of about 15 million children under age 5 every year. Just 2000 km away from us in the space more than 5 million kg of waste is revolving around us. Industry is producing annually 2 billion kg of pesticides including 70.000 different chemicals resulting in death of one human being per minute due to poisoning in developing countries. Nearly 3 billion of Earth's six billion people do not have access to safe water and two billion people lack proper sanitation. Half of the world's 500 major rivers are seriously polluted and depleted. In many developing countries, rivers downstream of major cities are little cleaner than open sewers. Global water consumption rose sixfold, more than double the rate of population growth. The amount of irrigated land has grown from 10 to nearly 300 million hectares during the last 100 years. Fifty years back there were only 5000 large dams in the world; today, this number is above 35,000. Water shortages increase social inequity. There is a big pressure on the coastal areas due to human migrations. Some 1.2 million barrels of oil are spilled into the Persian Gulf annually. Nearly 70% of the world's major marine fish stocks are overfished or are being fished at their biological limit. Climate change has been linked to the increasing ferocity of natural disasters, with 3 million people lost in the past 3 decades.

Economic losses from natural disasters reached $120 billion in 2 years. The concentration of heat-trapping gases in the atmosphere is higher than at any time in the past 200,000 years. Deforestation contributes 20-25 percent of total carbon emissions into the atmosphere, ranking second only to fossil fuels. In the past decade alone an area of 154 million hectares of the tropical forests has been destroyed. Financial stabilization programs imposed by economic gate-keepers like World Bank and IMF give nations no recourse but to cut expenditures on social and economic projects for the poor in order to meet debt repayments. The debt burden falls hardest on people struggling to make a living from their environments. And in turn the environment becomes degraded as the poor are compelled to take everything they can from it for survival. During the past 50 years, production of synthetic chemicals increased more than 300 times. After a half-century of pesticide overuse, nearly 1000 agricultural pests worldwide are resistant to pesticides. Nearly 400 million tons of hazardous waste is generated every year. Although the average global per capita income is more than 5000 $ a year, better than 50 years back, yet 1.3 billion people still live on less than $1 a day. Nearly half of Earth's 6 billion people live in cities, and 1 billion are exposed to health-threatening air pollution, about 600 million live in shanty towns, while an estimated 100 million are homeless. Each year about 61 million people are added to cities through rural to urban migration, natural increase, and transformation of villages into urban areas Bassett et al. (2000). All these depict our disharmonious and chaotic lifestyles.

As against the traditional cultures which developed under harmony with nature, present day humanity is facing severe threats of environmental deterioration ((Badran, 1993; Babaev, 1996), but they have started interrogating more and more the meaning of "Life." Philosophers say that the secrets which lie hidden and could not be answered by science and technology will be answered through literature, art, and religion. People will show much inclination towards these during 21'st century.

The 20th century was a period operated outwardly, energy dependent and with definitive rules. This century will be the century of ecology, internally operated, knowledge dependent, with a recollection of sacred events, and ecological problems will be understood better (Ozturk, 2001). The crystal ball of the future is clouded, and there is a long shadow in the direction of the" desired future condition." The purpose of this paper is to present an overview of ecology and sustainability that we believe are crucial to the success of an ecosystem approach towards land and resource stewardship. These are necessary for development of human communities and economies.

3 ECOLOGY AND ECOSYSTEMS

3.1 The backdrop

Ecology is accepted as a major concept for the stewardship of human and biological communities and ecosystem concept is related to it in land stewardship and resource conservation. Many if not all ecological processes have thresholds below and above which they become discontinuous, chaotic, and suspended. When an ecological system is changed by human activity, it becomes more fragile and ecosystem collapses. Human activities influence ecological systems in a number of ways. Our ancestors survived because of an innate sense of "oneness" where they helped each other both in times of wealth and in times of poverty (Oelschlaeger, 1991). However, since the time of Palaeolithic humans have altered their environments in substantial ways, sometimes destructive (Dubos, 1980). This type of thinking does not fit into our present day society because it includes ethics, morality, and the relationship with animal communities i.e., the whole dynamic ecosystem. For them everything was holy; home, fields, the land, the trees, animals and the sky. For example, *beech* tree was sacred for Turks in pre-Islamic era, because it was regarded as a gift from heavens by God ULGEN and he presented it to Goddess UMAY. Its 9 branches represent 9 sects of Turks (Ozturk, 2001). Present day researches have shown that a 100 years old beech tree with a canopy of 14.3 m diameter, produces 1.7 kg of oxygen and uses 2.35 kg of carbon dioxide per hour, filters 1 ton of dust per year, spends 400 litres of water on a sunny day and decreases temperature by 5 ^{0}C, reduces wind velocity by 50 % and erosion by 350 times (Cepel, 1994).

Ecosystems are communities of organisms working together with their environments. They can occur from microscopic scales to the scale of the whole biosphere. An ecosystem is a home for all living beings (Ozturk and Secmen, 1999). Such a perspective in ecology means thinking about land—its soils, waters, air, plants, animals, and all their relationships. They are constantly changing over time and open to a constant flow of materials and energy, however the changes are not precisely predictable by science (Botkin, 1990). One of the major aims of ecology today is restoration of degraded habitats, multiple-use of ecosystems, thus a better relationship with the environment (Erdem et al., 1995). To make scientifically sound decisions an integrated understanding of the physical, biological, and human dimensions of ecosystems is needed. The balancing of all three dimensions is the best way to produce what people want while not spoiling the options of future generations needlessly. It means we must blend the needs of people and environment values in such a way that different land covers represent diverse, healthy, productive, and sustainable systems. People are a part of these systems and, as such, humans shape them, and in turn, are shaped by them. The human dimension of ecosystem management must include information about people's traditional and changing perceptions, beliefs, attitudes, behaviours, needs, values, and the past, present and possible future influences of humans on ecosystems. Successful integration of human dimensions into ecological systems is signified when biophysical and social data become indistinguishable.

People as an integral part of ecosystems are dependent on their resources and factors in affecting some of their changes. But we do not have a dominion over ecological systems. Instead, they are very powerful and capable of causing great harm if not treated with respect. Thus a person's attitude and actions toward ecosystems must be respectful. If not, then harm will come which may only be rectified by performance of an appropriate healing ceremony. The management of ecosystems includes the integration of ecological, social, and economic factors at different periods to maintain a diversity of life forms, ecological processes, and human cultures. Traditional approaches to land or resource preservation attempt to either freeze ecological conditions at a desired state—which is not biologically possible—or allow natural forces to run without human interference—which is appropriate in some cases but not always socially or politically acceptable. Traditional approaches to multiple-use land focus on sustaining yields of desired resources. All ecosystems are dynamic. They change over space and time in response to inputs of energy, new species, natural events, and how people treat them (Botkin, 1990).

In general, the larger the ecosystem the more diversity, resilience, and productivity it can sustain. But most ecosystems are now influenced in some way by human activities. Existing ecosystem capabilities determine what is possible in our lifetime. Sustaining desired ecological, economic, and social conditions in ecosystems that are managed for multiple purposes is a big challenge. But it is not an impossible task if, people realize that no single objective can dominate ecosystem management at all geographic scales or even at the same site for all times. Success will depend on having scientifically sound, economically feasible, and socially acceptable strategies for achieving combinations of ecological and social goals.
An obvious challenge we face today is accounting for landscape pattern in space and time. Ecological processes generate patterns, and by studying these patterns we can make useful inferences about the underlying processes; like biotic, abiotic, and disturbances (Urban, 1993).The working hypothesis in ecosystem management is, save the pattern and you will save the process as well. It seems that models will play a crucial role in this direction. Presumably, models will minimize the incidence of "unpleasant surprises" in management, but we must also learn from our mistakes and take corrective action. This actually is a scientific method, and a partnership between different groups. The number of threatened species in nearly all countries, whether developed or undeveloped (WR I. 1993), is but one sign of ecosystems in stress, where the "what?", "how much?" and "how long?" are disturbing questions. Similar forecasts can be applied to such ecosystem amenities as aesthetic appeal, wilderness solitude, critical habitats, sequestering of contaminants, clean air, and other declining levels of ecosystem services. We need to convince the public that it is acceptable for nature to behave differently, and landscapes do not look the same year after year. The role of education in environmental management is great (Badran, 1993; Sheikh, 1993; Ozturk, 1998, 1999).

3.2 Should we restore ecosystems?

Yes, but with humans as a part of it not as unnatural beings. They should not be excluded from their natural surroundings dehumanized landscapes will have no meaning. Ecological communities should serve human needs, but that the needs of other beings must be considered. Excluding humans from nature is an unnatural change that would ultimately destroy ecological communities.

3.3 What do we want to restore?

It can be structural, functional, and holistic (Bonnicksen, 1988a, 1993; Ozturk et al., 2002). Structural goals concentrate on the parts of an ecological community, functional goals concentrate on processes, and holistic goals include both.

3.4 What can we restore?

Select a reference ecosystem (Ozturk, 1995; Feoli et al., 2003) and develop measurable standards, document historical processes and develop restoration practices that mimic the effects of those processes, project the consequences of management to improve restoration practices before intervention, and finally monitor the results of intervention and revise management practices to ensure success.

4 BIODIVERSITY

In response to changing values, emphasizing concern for our environment and for our descendants, new concepts such as sustainability, and biological diversity are affecting everyday decisions (Badran, 1993). Sustainability and biological diversity are increasingly popular buzzwords in environmental management circles most frequently used terms in both popular and scientific discussions. They mean different things to different people and nothing to some people. The variety of life and its many processes in ecosystem determines ecological capabilities. This variety is known by the term biological diversity. It is a valuable characteristic of ecosystems for ecological, economic, educational, and aesthetic reasons. Concerns for biodiversity started out in the 1970's with focus on threatened and endangered species, but has been progressively broadened until all facets of the variety of life on earth have been included (Batanouny and Ghabbour, 1996). Scientists do not know all the ecological roles or potential values of biological diversity. Nor do they understand all the processes that keep ecosystems functioning. It is not likely that they ever will. But complete knowledge is not necessary to understand that retaining the natural parts and processes of biodiversity is important for the future health and productivity of all ecosystems (Leopold, 1981).

Today, there is no part of the earth that escapes at least secondary human impacts, about 47% is dryland, 11% of the earth's land surface is in intensive agricultural use, about 24% is grazed by domestic animals, and about 3% is occupied by urban and industrial developments. The world's forests occupy about 31% of the land. The remaining 31% is occupied by deserts, tundras, rocky barrens or ice or snow (Solbrig, 1993). No one knows for certain the magnitude of natural inheritance cohabiting this planet with us, but the figure is said to lie around 30 million. These have come into being during a period of 3 billion years of evolution. Natural extinctions are taking place as a part of normal evolutionary process, but the wave of extinction mankind is observing lately is a cumulative result of man’s antilife and ad-hoc activities. Both genetic as well as ecological diversity are nearing extinction. Scientists estimate 300,000 plant species, between 4 and 8 million insects, and 50,000 vertebrate species, of which some 10,000 are birds and 4,000 are mammals. One-quarter of earth’s 4,630 mammals and 11% of all bird species are at a risk of extinction. At least 40% of the world’s economy and 80% of the needs of the poor are derived from biological resources. Over the past 25 years, the number of birds migrating between Europe and Africa has declined 1% a year (Erdem et al., 1995). The major global environmental change devastating this biodiversity and ecological processes is fragmentation of habitats(Simberloff, 1988, 1993). In 100 years 30.000 plant species have totally or partially gone extinct and loss of genetic diversity is around 15-20 %. While 3000 hectares per hour of our forests are destroyed a day, after another 50 years 40.000 plant species are expected to become extinct. 80% of tropical forests embodying 1400 plant types with 70 % of raw material for cancer treatment are gone. Today 80 % of the woodlands that originally circled earth’s surface in abundance have been cleared, fragmented or degraded through logging, mining and other large-scale developments threatening 40% of them. Earth’s forests have disappeared faster in this century than in any previous one (Noor, 1993).The underlying forces behind deforestation are poverty, population and economic growth, urbanization, wood exports and expansion of agricultural lands (Ozturk et al., 1996; Ozturk, 1999). Some 300% of the world’s original forests have been converted to agriculture. About 38 % of the world’s cropland has been degraded by poor agricultural practices. Erosion is stripping away topsoil at rates 16-300 times faster than it can be replaced. More than 150,000 square kilometres are turned to desert each year, forcing people to leave their homes in search of food and work. It is a problem that threatens the dry lands that cover 40% of earths land surface. Continuing land degradation jeopardizes the livelihoods of more than one billion people. Dry lands are vulnerable because they recover so slowly from disturbance (Qasem, 1993; Ozturk et al.1996; Babaev, 1996).

With limited water, the land is susceptible to erosion and salinization, caused by over-grazing, over-farming, vegetation clearing, and climate change. New soil forms slowly and salts, once accumulated, tend to remain where they are. The populations of fresh water species has declined by 50%. The Islamic countries are getting a good share from these practices. The habitat loss in Bangladesh is reported to lie around 91%, in Pakistan 76%, Indonesia 48%, Malaysia 41%, and Turkey 21 % not to talk about other desertified Muslim countries in Africa. Nearly 150.000 vascular plants have been reported from the Islamic world, out of which 25.000 are endemics with a ratio varying between 2-50% (Davis et al., 1994). We still have to learn how to accommodate biodiversity in the management of multiple use and agricultural lands. Thus, managing with biodiversity in mind involves much more than simply maintaining native species or ecosystem processes. The challenge is to find the levels of compromise that will accommodate both some retained biodiversity and human needs now and into the future. The details of how this is done will vary enormously across the globe. The circumstances show that it is inevitable that much loss of biodiversity will continue especially in developing countries (West, 1993). From biogeographical considerations if area of a habitat decreases by ten to one annihilation of species diversity will be around 50 %.

5 SUSTAINABILITY

Lately several terms like biodiversity, ecosystem health, ecosystem management, viable populations, conservation biology, restoration ecology, and global change have emerged in the field of applied ecology. One of the most important of these terms is Sustainability. It is an immature notion with different images for each environmental scientist and manager. The term sustainable has multiple definitions each reflecting the cultural complexities of humans and society (Box, 1993). It has a different appeal and significance to people of contrasting cultural backgrounds, sociohistory, and geographic location. Defining sustainability is not simple because it must apply to marry ecological and social situations. One fairly typical, proposed definition is (EMIT, 1993): "The ability to sustain diversity, productivity, resilience to stress, health, renewability, and/or yields of desired values, resource uses, products, or services from an ecosystem while maintaining the integrity of the ecosystem over time". Efforts have been made to clarify the word, sustainability, by the context in which it is used (Norton, 1991; Woodmansee, 1992). But everyone agrees that sustainability is a good thing, and that desirable situations last longer under it. The term is appealing because, despite differences as to how to achieve sustainability, both " green" environmentalists as well as those investing in commodity production favour it, for being a desirable ecological condition, but its reliable context is a requirement for a return on long-term capital investment (Allen and Hoekstra, 1992). Sustainable ecological systems could differ in that the observer recognizes different aspects of the material system as important. Different material systems will suggest different criteria for what is important, but even one material situation can be viewed according to many criteria such that the ecologist recognizes an ecosystem as opposed to a community, population, or landscape. For example, a given tract of land that makes up the material system can be viewed as a spatially defined and ordered place, a landscape; however, that same piece of land may be seen as a physical setting in which a population is growing or declining. Both views can be reconciled with the material system, but in the first case the system is identified as a landscape, while in the second case it is a population and its environment. For clarification we must ask the relevant questions; what is to be sustained, at what level is " whatever" to be sustained, how long is it to be sustained, and for whom? Various attempts have been made to answer these questions (Costanza, 1991; Toman, 1992).

In a multicultural society, ethical considerations of the relationships between man and nature bring purpose and direction to the operational dimensions of ecosystem sustainability (Allen and Hoekstra, 1993). Sustainable land use depends, in part, upon determining the ecological carrying capacity of the land, determining what people want and need from the land, and a political and economic system that matches what people want and need with the land’s ability to produce the desired goods and services. While the potential ecological carrying capacity of the land remains relatively stable, the cultural and social demands on the land are constantly changing, causing the actual carrying capacity to fluctuate widely through time. The concept of sustainable development in rich countries is most often embraced by conservation groups and organizations. At the same time, these rich countries are using a disproportionate amount of the world's resources. Sustainability is a grass roots movement. If we concentrate on education, creativity, application, we can move to a level where social justice is balanced with resource use, where development is truly sustainable. New cultures that develop in the future will be able to reach their potential if we in this generation remember, *equity for today's generation, a better life for our grandkids, leave options open for those who follow us, leave the world better than we found it. The quest for sustainable land use is doomed if we ignore equity and social justice in our sustainability equation.* As educators we have responsibility to make sure our culture is sustainable, we have stewardship of the ecological base for sustaining our culture. There are some misconceptions about sustainability; an overemphasis on the observer side of the duality as opposed to the observed system. It is inappropriate to strive for a completely pristine system without humans and use that as the benchmark for sustainability. As a matter of fact we humans cannot do the impossible; no matter how much we desire because before the impossible appears on the agenda, insurmountable problems will emerge if the intended human manipulation flies in the face of significant material flows.

Sustainability is also a goal towards which we strive. Our biological thinking should be to improve our ability to survive as a species. A domination of the ecosystem and mining its capital will create serious problems. This ecosystem is a depletable asset, not a bottomless pit into which we can dump our existence. Sustainability means that humans are living in symbiosis with the greater whole so as to maintain or increase environmental capital, relative to human welfare.

6 STEWARDSHIP

Ecology and sustainable development have immerged long back as main concepts and policies for the stewardship of different communities. Earth and everything in it has not been created in vain. Whatever lies between Earth and Heavens has not been created for fun. Our universe is like chain of beads beautifully placed in balanced fashion (Sheikh, 1993) acting under the orders of a prescribed law and working under a complete submission to these Laws of their creator. Our creator has created enough for us, but it will not be enough for our "Greed". Traditional societies knew this well, they faced not many problems. It basically stems from the anthropocentric lifestyle we follow i.e., our attitudes and ethics. We achieve great successes but commit big mistakes. More our knowledge of ecology increases more we get astonished at the unity of life and its diversity. From the human perspective we see the ecosystem as having a purpose. That purpose is to support and sustain human welfare as defined by the values and preferences we hold. But, because human life depends on the condition of the ecosystem as a whole, the higher purpose is to sustain the ecosystem such that it is capable of sustaining human life, and not only human life, but quality human life and hope of continued improvement into the future. This purpose lifts us out of the ecosystem, so to speak, into a role of stewardship. Because we have emerged as the species in control but capable of reasoned action and self control, we must accept the responsibility to manage the behaviour of the whole ecosystem by managing ourselves within the system as well as managing and nurturing the system with which we interact. In all healthy biological functioning, things persist and grow because other things are not sustained. Absolute sustainability where nothing is broken down might be possible on the moon, for that is a suitably static place, but here on Earth; a completely sustainable system in every detail cannot, and has never existed on it. So by sustainability we must mean something different from the potential for absolute and complete persistence.

Evidence of evolving land management approaches in urban, agricultural, and wildland environments show that the concept of sustainability and stewardship are becoming accepted at most of the levels (Soule, 1985). But for most, this acceptance has been largely because of an intellectual understanding, and not because the products or processes of sustainable landscape management are inherently preferred. Our cultural ties to the scenic aesthetic run deep, and because of the primacy of aesthetics in environmental perception.

It will not be possible to force our way past ecological balances with the expenditure of material resources. Pumping the ozone to the stratosphere to replace lost ozone there is so far from being an option that anything of that must be laughed out of consideration. Human activity involves highly contrived ecological circumstances, so the pristine natural configuration is irrelevant, it must line up with the natural ecological flows that emerge in anthropogenic settings. Ecosystem management employs a full range of practices from preservation to sustainable production to restore and sustain diverse, healthy, productive ecosystems. For practical development of ecosystem management (Robertson, 1992) we need to:

- Protect the land by restoring and sustaining the integrity of its soils, air, waters, biological diversity, and ecological processes.
- Meet the needs of people who depend on resources of the land for food, fuel, shelter, livelihood, and inspirational experiences.
- Improve the well-being of communities, regions, and nations through efficient and environmentally sensitive production and conservation of natural resources such as wood, water, minerals, energy, forage for domestic animals, and recreation opportunities.
- Seek balance and harmony between people and land with equity between interests, across regions, and through generations, meeting this generations resource needs while maintaining options for future generations to also meet their needs.

7 QUO VADIMUS?

Biocentrism considers the earth or the environment as either the master of society or a deity that should be worshipped. Anthropocentrism considers the earth or the environment as a servant or slave of society that should be exploited to serve human needs. It is foolish to think that people will sacrifice their own welfare on behalf of other species or that they will knowingly modify the environment in a way that jeopardizes human survival. Ecological management and sustainable development are a prudent path to pursue. However both are as yet dreams, because we see that ecological crisis faced by us in the 21st century is threatening the world, either because people have too much, or too little. The new century is characterized not only by great changes and new opportunities but also by increasing risks. The poverty of the majority of the earth's inhabitants and over consumption by the minority are the major causes of eco-disasters. This action is essentially the backlash of modern development. Today's ecological crisis is actually related to the greed, irresponsibility, and lack of interest in ethical values. This is well known historical fact that we the humans, in the course of our material progress, have lost the ethical basis of our philosophy of life, by neglecting the moral and value bases of society. The industrially developed nations have achieved higher standards of living through an unethical use of natural resources of industrializing nations. This has contributed to the lack of a holistic approach to creation and life in them. Although objectivity always is getting clouded by emotions still there is a great need today for the conservation of ecodiversity, its sustainable use, and the equitable sharing of the resulting benefits than it was in the past.

The human population is putting increasing pressures on the health and productivity of lands, waters, air, and resources, jeopardizing their goals. The world economy is in recession, neighbours are fighting with their neighbours, and society itself has changed. Concern for personal wealth has replaced concern for society. God lives on stock exchange markets. The ethic for today still is greed is good, rules are for fools, and he who is rich in the end wins (Ozturk, 2001). New public attitudes about sustainability and land use came and went, each having an effect on the land. We have passed through an era of exploitation in the past, but have now entered in to eras of preservation, reclamation, environmental concern, and lately sustainability. Our goal should be sustainable land use that will support present and future cultures. Sustainable development became a world issue with the awakening of global economic and environmental interdependence. Environmental disasters knew no national borders. Although human life expectancy has increased, infant mortality is decreasing, adult literacy climbing, scientific, and technical innovations are promising, and global food output is increasing faster than population growth. However, the environmental degradation facts cited above override this situation. Sustainable development is proposed as a prudent path to pursue, but it is still a dream. It is in practice or is seriously tested, but is rapidly evolving. Sustainability precisely should not mean a return to some mythical pristine past. In this new ecological arena, the human creature must pay its way in maintaining system structure. This is precisely a cooperative enterprise, for our species does not have the resources to dominate nature for very long. Thus efforts to achieve sustainability are neither a journey back to nature nor dominance over it. In positive terms, it is a new collaboration with nature that will produce something not often seen in the world before.

Many times emotional, but marginal issues, sidetrack ecologists from sustainable land use and social justice. We divide society over environmental issues rather than seek a sustainable future. There should be way to balance conservation with social justice. There is a call to shape the future conditions of landscapes for a full diversity of life, ecological processes, human values, and resource uses. This will mean balancing science with social values, economic feasibility, institutional traditions, and political muscle. All things in themselves are the effects of the interests of independent living beings. Therefore, there is no great plan that we can depend on, because there are countless beings manufacturing effects, human beings, less than human beings, visible beings, invisible beings, big beings, little beings, beings in every plane within the hierarchical planes of manifestation. All beings are thinking and feeling and acting and desiring and creating effects. The summation of all of this chaotic desiring is the cosmos.

We as a civilization find ourselves at a cultural watershed and should seek sustainability and positive solutions associated with conservation of viable populations to maintain adequate levels of biodiversity, in the face of global change. Only through hard-nosed decisions mediated by recognition of our special role is sustainability going to be achieved. Without it ours will come crashing down, like 21 major civilizations before us (Moore, 1973).

People value and desire a broad spectrum of benefits (including survival) from ecosystems (Ozturk, 2000). To make effective decisions, we must have a scientifically sound and integrated understanding of the physical, biological, and human dimensions of ecosystems. The human dimension of ecosystem must include information about people's traditional and changing perceptions, beliefs, attitudes, behaviours, needs, and values, and the past, present and possible future influences of humans on ecosystems. The grasping spirit of materialism says; better means more wealth and more power, inspite of the fact that all religious sects preach love, understanding, and compassion, and attach great importance towards wildlife and the protection of the environment on which every being in this world depends for survival. We regard our survival as an undeniable right; as coinhabitants of this planet, other species too have this right for survival. Human beings as well as non-humans depend upon the environment as the ultimate source of life and well-being. We are convinced of the inestimable value of our respective traditions and of what they can offer to re-establish ecological harmony. The very richness of our diversity lends strength to our shared concern and responsibility for our Planet Earth. Man’s dominion cannot be understood as license to abuse, spoil, squander, or destroy what God has made to manifest his glory. That dominion cannot be anything else than a stewardship in symbiosis with all creatures. Unity, trusteeship and accountability, that is *Tawheed*, *Khalifa* and *Akhirah*, the three central concepts of Islam, are also the pillars of the environmental ethics of Islam (Bassett et al. 2000).

The famous poet Yunus Emre says;
Its stem is gold -Its leaves are silver
And its branches expand -They invoke the name of the Lord.

A lyric from a villager goes like (Binark, 1995);
Do not cut a tree, let a beautiful bird sing from its each branch,
Do not cut it, so that a tired farmer takes a rest underneath its shadow,
Do not cut it, let it serve as a protective angel for our village,
Do not cut it, so that my beautiful country becomes joyous and gay day by day.

Sustainable land use depends on world peace and world trade. Unless sustainable development is linked to basic issues of equity, social justice, and community stability for poor people, sustainable development will fail. Can we relate to sustainable human lifestyles when we are hooked on a consumption society? We can only succeed if we make our own lifestyles sustainable. It means feeding the poor countries which are growing four times faster than rich countries; nearly 4 out of 5 babies are born into poverty; and bridging the gap between the haves and the have nots. The standard of living of poor must be raised if they are to participate in this activity. Sustainable land use means adjusting land use through a combination of ecology, economics, and social justice together. It is linked to cultural demands, because as the cultures change land use also changes. Balancing land capability and cultural demands will be controlled by what we can imagine, creativity, and vision. And all these are enhanced by education. We need to tie science and application together in the simple steps of education and mix scientific credibility with social acceptance or political correctness in Islamic countries (Altamemi, 1993; Badran, 1993; Sheikh, 1993, Ozturk, 1998, 1999). Ecologists as stewards of nature can at the most contribute to reversing this trend by facilitating the acquisition, dissemination and utilization of ecological knowledge to ensure the sustainability of biosphere and providing a biosocial model to the managers.

8 CONCLUSION

Many efforts are being spent on the study of inter-relationships of environment and organism. Such assessments are providing logical bases for clear thinking towards life and a greater comprehension of the eternal laws of nature. Countries all over the globe are now trying to include principles that support nature conservation. However, unless these commitments are based on altruism and action, success is impossible. No meaningful result can be envisaged without both a reflection on the ethical implications of our plans of action and a moral urgency for their implementation. There is a greater need for a new spirit of international cooperation. We shall witness many new challenges to the security and sustainability of our planet if steps are not taken. The fundamental lessons contained in our faith traditions are increasingly coming to the forefront.

We can start with ; by creating citizen juries which are representative, well-informed and formal; work within the scope of natural processes shaping the ecosystem; focus on end result; coordinate strategies for mutual resources; get people involved in decision-making; use information technology (Feoli et al., 2003); integrate management and research to continually improve the scientific basis of ecosystem management; revitalize environmental education; develop, monitor, and evaluate vital signs of ecosystem health; increase role of research; create equity for today’s land stewards. If they do not have a high standard of living there will be no tomorrow; equity for future generations and leave options open for our grandkids, without closing our future uses, so that people today embrace a dream for tomorrow; keep the land productive and learn to live on the interest without depleting the principle; improve what has been given to us and try to leave the world better than we found it. If we do not succeed the polluter and the ecology freak will as today continue as two faces of the same coin.

REFERENCES

1. ALLEN, T.F.H., HOEKSTRA, T.W. (1992) Towards a Unified Ecology. Columbia Univ. Press, N. Y.
2. ALLEN, T.F.H., HOEKSTRA, T.W. (1993) Towards a definition of sustainability. In: Sustainable Ecological Systems (Eds.Covington and DeBano) USDA, GTR RM-247, 98-107.
3. ALTAMEMI, A. (1993) Cooperation between Islamic Countries on Environment and Development. In: Environment and Development in the Islamic World (Eds. F. Daghestani and Saleh Al-Athel), 497-574, IAS Amman- Jordan.
4. BABAEV, A.G. (1996) Problems of Arid Land Development. Moscow University Pres, pp.282.
5. BADRAN, A. (1993) Sustainable development and the changing ecosystems. In: Environment and Development in the Islamic World (Eds.F. Daghestani and Saleh Al-Athel), 81-99, IAS Amman-Jordan.
6. BADRAN, A. (1993): The role of education in the protection of environment: Treatise and Case studies. In: Environment and Development in the Islamic World (Eds. F. Daghestani and Saleh Al-Athel), 433-462, IAS Amman-Jordan.
7. BASSETT, L., BRINKMAN, J.T., PEDERSEN, K.P., (2000) Earth and Faith. UNEP, New York, pp.80.
8. BATANOUNY, K.H., GHABBOUR, S.I. (1996) Arid Lands Biodiversity in North Africa. The Academy of Scientific Research and Technology, pp. 139, Cairo, Egypt.
9. BINARK, I., (1995) Environmental Understanding in Turks. Cevre ve Insan, 6, 23, 40-51.
10. BONNICKSEN, T.M. (1993) Social and political issues in ecological restoration. In: Sustainable Ecological Systems (Eds.Covington and DeBano) USDA,GTR RM-247, 108-114.
11. BONNICKSEN, T.M. (1988a) Restoration Ecology: Philosophy; Goals, and Ethics. The Environmental Professional 10, 1, 25-35.
12. BOTKIN, D. B. (1990) Discordant Harmonies: A New Ecology Press, New York.
13. BOX, T.W. (1993) Sustainable ecological systems, and cultural change. In: Sustainable Ecological Systems (Eds. Covington and DeBano) USDA, GTR RM-247,2-9.
14. COSTANZA, R. (1991) Ecological Economics: The Science and Management of Sustainability. New York, Columbia University Press, 13, pp. 246.
15. CEPEL, N. (1994) Deforestation and loss of functional values. TEMA, 2, pp.21.
16. DAVIS, S.D., HEYWOOD, V.H., HAMILTON, A.C. (1994) Centres of Plant Diversity. Vol.1, WWF and IUCN, Information Pres, Oxford, U.K. pp.352.
17. DUBOS, R. (1980) The Wooing of the Earth. Charles Scribner's Sons, New York.
18. DUBOS, R. (1976) Symbiosis between the earth and humankind. Science 193,459-462.
19. EMIT (1993) Ecosystem Management Implementation Team. Proposed Glossary of Terms. USDA Pacific Northwest.
20. ERDEM,U.,OZTURK,M.,OZDEMİR,F.,SAYAR,A.,KATAGAN,T. (1995) Conservation of ecological diversity in Turkey. OKEANOS'95 Colloquue, Sci. Int., Montpellier-France, 167-171.
21. ERGIN, M., OZDAS, M. (1993) Climate Change, Air and Water Pollution. In: Environment and Development in the Islamic World (Eds. F. Daghestani and Saleh Al-Athel), 187-260, IAS Amman-Jordan.
22. FEOLI, E., GIACOMICH, P., MIGNOZZI, K., OZTURK, M., SCIMONE, M., (2003) Monitoring desertification risk with an index integrating climatic and remotely-sensed data: An example from the coastal area of Turkey. Environ. Management and Health, 14, 1, 10-21.
23. HARDIN, G. (1985) Filters against folly: how to survive despite economists, ecologists and the merely eloquent. Penguin Books, New York.
24. LEOPOLD, A., (1981) A Sand County Almanac and Sketches Here and There. Oxford University Pres, NY, pp.295.
25. MOORE, D., (1973) Educational Communications. Transcript of talk given to The State Superintendent's Educational Conference in Madison, WI, USA.
26. NOOR, S.M. (1993) Sustainable forest management. In: Environment and Development in the Islamic World (Eds. F. Daghestani and Saleh Al-Athel), 283-292, IAS Amman-Jordan.
27. NORTON, B.G. (1991) Ecological Health, and Sustainable Resource Management. Ecological Economics, 102-117.

28. OELSCHLAEGER, M. (1991): The idea of wilderness: From prehistory to the age of ecology. New Haven, CT, Yale University Press.
29. OZTURK, M., GUVENSEN, A., YUCEL, E. (1993) Role of plants in indoor pollution. Air Pollution II. Nat. Symp., Anadolu Univ., Eskisehir, 287-293.
30. OZTURK, M.A. (1995) Recovery and rehabilitation of Mediterranean type ecosystem- A case study from Turkish maquis. In: Evaluating and Monitoring the Health of Large-Scale Ecosystems, NATO-ARW (Eds. D. Rapport et al.), Springer- Verlag, Berlin, pp: 319-332.
31. OZTURK, M., CELIK, A., NURLU, E., ERDEM, U. (1996) Land degradation in relation to urbanisation and industrialisation in the West Anatolian region - Turkey. Land Degradation, pp: 305-317.
32. OZTURK, M., (1998) Essential Concepts on Environmental Education-I (Ed. Z. AYVAZ) CEVKOR, Environmental Foundation Press, 5, Izmir.
33. OZTURK, M. (1999) Essential Concepts on Environmental Education-II (Ed. Z.AYVAZ). CEVKOR, Env. Foundation Press, 6, Izmir.
34. OZTURK, M., SECMEN, O. (1999) Plant Ecology. IVth, Ege Univ. Press, Izmir, 350 pp., Turkey.
35. OZTURK, M. (1999) Urban Ecology and Land Degradation. In: Perspectives in Ecology (INTECOL). Backhuys Publ., NL, 115-120.
36. OZTURK, M. (2000) Ecosystems. In: Environmental Science-Sustainable World (Ed. ERDEM, U.) Ege University Press, 64-115.
37. OZTURK, M. (2001): An Overview of the Environmental Problems in Central Asian Republics and Turkey. Invited Lecture, June, Kayseri University, Faculty of Science and Arts, Turkey.
38. OZTURK,M.,CELIK,A.,YARCI,C.,AKSOY,A.,FEOLI,E. (2002) An overview of plant diversity, land use and degradation in the Mediterranean region of Turkey. Environ. Management & Health, 13, 5,442-449.
39. QASEM, S. (1993) Desertification in the Muslim World. In: Environment and Development in the Islamic World (Eds. F. Daghestani and Saleh Al-Athel), 187-260, IAS Amman-Jordan.
40. ROBERTSON, F.D. (1992) Ecosystem management for the national forests and grasslands. USDA Forest Service, 6, Washington.
41. SHEIKH, K.H. (1993): The role of education in environmental protection. In: Environment and Development in the Islamic World (Eds. F. Daghestani and Saleh Al-Athel), 463-498, IAS Amman-Jordan.
42. SIMBERLOFF, D. (1988): The contribution of population and community biology to conservation science. Annu.Rev.Ecol.Syst.19, 473-511.
43. SIMBERLOFF, D. (1993) How forest fragmentation hurts species and what to do about it. In: Sustainable Ecological Systems (Eds. Covington and DeBano) USDA, GTR RM-247, 85-90.
44. SOLBRIG, O.T. (1993) Biodiversity and global change. Earth Quest, Spring Issue, 16, 1-3.
45. SOULE, M.E. (1985) what is Conservation Biology. Bioscience, 35,727-734.
46. TOMAN, M.A. (1992) the difficulty in defining sustainability. Resources winter, 3-6.
47. URBAN, D.L. (1993) Landscape ecology and ecosystem management. In: Sustainable Ecological Systems (Eds. Covington and DeBano) USDA, GTR RM-247,127-136.
48. WEST, N.E. (1993) Biodiversity and land use. In: Sustainable Ecological Systems (Eds. Covington and DeBano) USDA, GTR RM-247, 21-26.
49. WRI The 1993 information please environmental almanac. Houghton Mifflin Co., pp.656.
50. WOODMANSEE, R.G. (1992): An ecological perspective of new perspectives. USDA Forest Service, pp.51.

Sustainable Forest Management: An Update*

SALLEH MOHD NOR and MICHAEL V. GALANTE
Academy of Sciences Malaysia
and
TropBio Forest Sdn. Bhd. respectively

1 ABSTRACT

Sustainable Forest Management (SFM) has been moving forward ever since the term "Sustainable Development" was first conceptualised at the World Commission on Environment and Development in 1987. Ever progressing, SFM has come full circle; from area control to volume control, selective management, and reduced impact logging, to certification and an entire process of criteria and indicators. New developments in climate change, carbon sequestration, and emission trading have led to the inclusion of the carbon credit system (Clean Development Mechanism (CDM) under the Kyoto Protocol). It seems that the new designated role of our forests (conservation, biodiversity, producer of wood, carbon sequestration and aesthetics), while not a totally new concept, is putting forestry under tremendous pressure to fulfil the various and sometimes conflicting demands of the various stakeholders. A push is necessary if we are to reach these goals within the framework of the Millennium Development Goals (MDGs).

The quality of SFM seems to have diminished over time, or rather, has not met the requirements that are expected by today's standards, as growth and yield, monitoring and prediction techniques seem to have reached a plateau and thus, has not been able to provide the technical support needed for SFM. The future of our forests lies in the understanding of what our resources can achieve with a realistic mindset of what a properly allocated forest encompasses. What seems to be prevalent is how we are learning to designate, allocate, and distribute our forests. The constraint appears to be due to the improper designation and allocation of our forests.

Furthermore, the concept of "we" is also in scrutiny as this term suggests a public point of view. Shifting the responsibility from the public to the private sector would ease the burden of inefficient and unsustainable forest practices, which would push forest management towards a more sustainable, long-term profitable approach. This approach could likely incorporate all sectors (government, private and local) into the utilization scheme for sustainable forest management.

2 INTRODUCTION

In light of the many discussions on the topic of Sustainable Forest Management (SFM), it has become clear that the concept of SFM is extremely fragile, so fragile, that if one were to "utter it no louder than a whisper; it would crumble under the very weight of those words." So describes the fragility of our tropical rainforests, biodiversity, and the concept of sustainable forest management. To measure sustainability is to measure ourselves and our commitment to our future. How important are the values that we must uphold in order to achieve SFM and how much is it really worth, and for whom? These are some of the questions that we have to seek answers to.

Recent concerns on the status of the forest environment have provided a new focus on SFM. Questions of sustainability have emerged to the extent of threats and demands on consumers to

* Paper presented at the 13th Science Conference of the Islamic World Academy of Sciences, Kuching (Sarawak), Malaysia, 29 September - 2 October 2003.

purchase only timbers produced from "sustainably managed forests," and boycotts and/or discrimination against tropical timber loom constantly. Some governments require that timber products can only be used in their projects if the timbers are certified, while more severe measures have been taken elsewhere in Europe (eg. Denmark, the Netherlands and the United Kingdom) where banning tropical timbers had been considered. Such attention, compounded by past summits and, most recently, the World Summit on Sustainable Development (WSSD), has promoted the concept of SFM on a global scale. However, it seems that there is something missing from this equation. This has resulted in a flood of discussions on sustainability and its related issues but practice on the ground still leaves much to be desired.

According to the Food and Agriculture Organization (FAO) of the United Nations, public expenditure on forestry, especially in Africa, has increased substantially in recent years. However, it does not seem to be enough, and the lack of available financial resources suggests that SFM will not be achieved on the continent in the near future (FAO, 2003). What has significantly increased in SFM in recent years has been the trend of increasing socio-economic benefits which the forests bring; decentralizing revenue collection and expenditure; and the transferring of control from the public sector to the private sector.

The sustainability of forestry practices is now being seriously questioned, especially in tropical forestry. According to an International Tropical Timber Organization (ITTO) study, less than one tenth percent of tropical forests are managed on a sustainable basis (Poore, 1989). Due to the endless season of perfect growing temperatures and rainfall, it would seem most *unlikely* that forestry in the topics could ever become unsustainable. Truly, if sustainability is in place, then the issue of depletion and degradation should not arise. Given the market trend and extensive natural resources of the tropical forests, it would seem that SFM would become second nature to all who routinely deal with these systems. However, it has been shown in the past and in some regions that non-sustainability still continues. If proper sustainable forest management of our forests are not taken seriously enough, it may be too late and it could take an immeasurable amount of resources and time to repair.

3 CONCEPT AND REALITY

The principle of Sustainable Forest Management is to integrate social, economic, and environmental factors for the perpetual benefit of current and future generations. As defined by the FAO, SFM is the act of "meeting present needs for forest goods and services, while ensuring their continued availability in the long term" (FAO, 2003, pp. 47). The key idea in this concept is perpetuity. The numbers however, seem to indicate a different story. Table 1 shows that the area of natural forests in the world is declining drastically. Worldwide, the amount of forest area has decreased by 9.4 million hectares per year during the years 1990-2000. There seems to be an increasing trend towards uncontrolled or unsustainable forestry practices worldwide but the trend in the non-tropical areas appears to be encouraging.

Table 1. Annual gross and net changes in forest area (million hectares per year) 1990-2000

Domain	Deforestation	Increase in Forest Area	Net Change in Forest Area
Tropics	-14.2	+1.9	-12.3
Non-Tropics	-0.4	+3.3	+2.9
World	-14.6	+5.2	-9.4

(FAO, 2001)

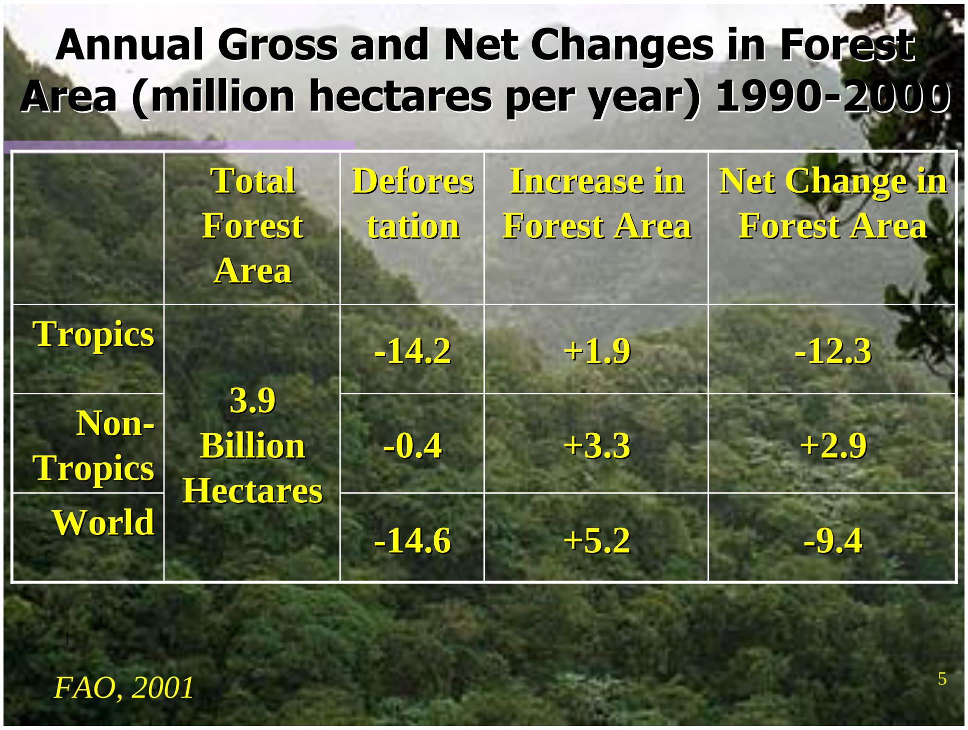


Figure 1. Annual gross and net changes in forest area (million hectares per year) 1990-2000.

Furthermore, deforestation in the 1990s is estimated at 14.6 million hectares per year. The figure represents the balance of annual losses of natural forests (which is estimated at 16.1 million hectares per year or 0.42% per year) minus the area that was replaced through reforestation with forest plantations (1.5 million hectares per year), since plantations are considered as forests (FAO, 2001).

Therefore, as the net global change in forest area during 1990-2000 was estimated as approximately -9.4 million hectares per year, this equals the sum of -14.6 million hectares of deforestation and 5.2 million hectare increase in forest cover in the same period. The global change is approximately -0.22% per year and the estimated net loss of forests for the 1990s as a whole was 94 million hectares, an area larger than the country of Venezuela (FAO, 2001). This is summarised in Table 2.

However, SFM does not only consider the area of forests, but also the production of forest products. Globally, due to the transfer of forests to non-forest lands, production may have increased over time, but this is the essence of sustainability as that production is not sustainable on a longer time frame.

Table 2. Worldwide Changes in Forests-Gains and Losses (million hectares per year) 1990-2000

Domain	Natural Forest					Forest Plantations			Total Forest
	Losses			Gains		Gains			
	Deforestation (to other land use)	Conversion to Forest Plantations	Total Loss	Natural Expansion	Net Change	Conversion from Natural Forest (reforestation)	Affor-estation	Net Change	Net Change
Tropical	-14.2	-1	-15.2	+1	-14.2	+1	+0.9	+1.9	**-12.3**
Non-Tropical	-0.4	-0.5	-0.9	+2.6	+1.7	+0.5	+0.7	+1.2	**+2.9**
World	**-14.6**	**-1.5**	**-16.1**	**+3.6**	**-12.5**	**+1.5**	**+1.6**	**+3.1**	**-9.4**

(FAO, 2001)

4 SUSTAINABLE FOREST MANAGEMENT

Sustainable forest management seems to be more than just "conventional wisdom in practise" which is a misconception. As managers and practitioners alike have repeated the same ideas for such a long time concerning SFM, many managers assume that this misconception is true. However the reality is far from this (CIFOR, 2003). The FAO has concluded a study (FAO, 2001), which reports that the deforestation process in the tropics is dominated by direct conversions of forests to agriculture. What are the economic and social implications of this and what is the impact on SFM? Does it make a difference to the overall income of the local communities? What happens to the surrounding forest areas, and are they considered when decisions and plans are made?

The conversion of natural forests to agriculture or plantations is often the only option to increase the economic well being of the local communities. However, this practice has resulted in mixed land uses and sustainability, depending upon the model of land conversion and the economic and political system present. In Malaysia, under organised land conversion systems, forests have given way to palm oil and rubber plantations which have provided excellent income and employment opportunities. On the other hand, in other parts of the world, uncontrolled forest conversion had resulted in large areas of *Imperata* grassland or alang-alang and the whole system is unsustainable, leading to shifting cultivation practices. SFM encompasses the entire range of variables. Not only is the community factor involved, but also other factors such as biodiversity, natural forests, plantation forests, concession forests, wildlife management, watershed protection and the fostering of goodwill between all parties to enable a broader choice of economic activities. This will lead towards a greater opportunity for all to participate in the management of activities in the area in perpetuity. This is Sustainable Forest Management!

Sustainable Forest Management ideally should include all factors into one scheme, but this is often not possible. An attempt towards this end is the development of Forest Management Units (FMUs). The FMUs are basically long term concessions which allow the private sector, as the

FMU owner or manager, to incorporate and put into practice as many of the elements of SFM as possible. In Malaysia (in particular the state of Sabah) and commencing around 1998, the FMU initiative program started with the State Government giving large "concessions" of generally logged over forest to the private sector to undertake SFM, where the first prerequisite is the development of a Forest Management Plan (FMP), an important factor in SFM. The FMP would have identified areas for different activities, such as harvesting, reforestation, plantation development, community forestry, and conservation. However, financial limitations have not enabled these FMUs to proceed towards SFM, with few exceptions.

Using this concept and deploying it on a national scale takes a great deal of coordination, understanding, and commitment of those involved. However, to fully appreciate the ideology of SFM, one must understand the underlying concept to the entire SFM process: Forest Certification.

5 FOREST CERTIFICATION

Essentially, forest certification is an important recent development in Sustainable Forest Management. Working towards SFM requires an in-depth and stringent set of objectives, rules, and regulations that satisfy the criteria at every level within the SFM framework. The concept of Criteria and Indicators (C&I), which forms part of the certification process, has been adopted to monitor the development of the SFM process and its growth and flexibility has demonstrated a willingness and capacity to adopt SFM on a national scale. However, a proper scientific basis is required for ecosystem health and integrity in general, and soil, water and biodiversity in particular. Thus, they require the continual precautionary approaches; indicators for contributions to climate change mitigation, and SFM for plantations and natural forests as all of these largely remain to be developed on the large scale (Finegan and Campos, 2000).

Criteria and Indicators in general should consider all aspects of institutional requirements such as policy, legislation, economic conditions, incentives, research, education, training, and mechanisms for consultation and participation (ITTO, 1998). However, theory is not the same as what happens in practice.

It was the International Tropical Timber Organization (ITTO) that first began to work on C&I, long before the United Nations Conference on Environment and Development (UNCED) in 1992. C&I has brought forestry closer to reaching the SFM goals. However, according to Finegan and Campos (2000), there have been arguments for more people-centred approaches to SFM. This would emphasize the lack of participation of certain stakeholders in C&I development and the likely benefits of assessing the sustainability of livelihoods.

Forest certification is expanding exponentially as it has become a useful tool to contribute to the achievement of Sustainable Forest Management. In January 2002, the area of certified forest was estimated at 109 million hectares worldwide (ITTO, 2002). According to the ITTO, this is approximately two times higher than it was in the previous year and almost four times higher than it was the year before. Although approximately 3.9 billion hectares of forest is available worldwide (FAO, 2001), only about 3% of the world's forest area is presently certified (ITTO, 2002).

Nevertheless, it must be remembered that certification is driven by a variety of interests. For industry and trade, it is an instrument for environmental marketing; for buyers and consumers, it provides information on the impact of products they purchase; and for forest owners and managers, it is a tool to gain market access or a market advantage.

Within the environmental sector, forest certification can influence how our production forests (harvesting) are managed and controlled and it is a convenient way for governments to control these practices with the end users in mind (Haynes, *et. al.*, 2000). Furthermore, forest certification can stimulate SFM as a means to promote sustainable consumption patterns and a variety of other environmental goals and objectives-as set forth by ministries and governments.

The World Bank (WB)/WWF Alliance target for the world's certified forest area is 200 million hectares by 2005, evenly shared between developed and developing countries. For developed countries, the level has already been attained, while in the latter group, the current area represents only 6.4% of the target. It appears unlikely that this part of the target can be achieved without new approaches. The situation is a cause for concern, in particular since certification was originally introduced as an instrument to promote SFM (ITTO, 2002, pp.10).

As the gap of forest certification becomes narrower between that in developed and developing countries, it seems that views are still not converging. Developing countries seem to be under the impression that it is "another market requirement imposed by importers" which may increase the gap between different schools of thought (ITTO, 2002). This in turn may dampen and even weaken trade ties, which could reduce the chances of Sustainable Forest Management, as market access is critical in SFM. On the other hand, developed countries have been promoting certification as a means of ensuring good and sustainable management.

As certification is quickly becoming the baseline requirement for suppliers and market buyers, it is also quickly becoming a standard methodology towards SFM. As it continues to supply (however smaller but in perpetuity) timber and Non-Wood Forest Products (NWFP), certification seems to increase the value of the products as it provides assurance to the consumer on the product and its quality. Although there are costs involved for the managers and producers, the overall long term benefits seem to outweigh the cost.

Certification promotes the sustainable planning of all forest management operations. This includes the adoption of scientific methodologies and improved conservation techniques, as well as employing proper and adequate forest inventories, management plans and harvesting activities such as Reduced Impact Logging (RIL). This is particularly important as in most tropical countries the quality and implementation of forest management plans have left much to be desired. Therefore, proper monitoring and documentation are necessary for certification and SFM.

Recognizing that many tropical countries are still quite dependent on their natural resource activities (forestry), both as a source of foreign exchange as well as for survival, it is critical that the forest produce is managed in perpetuity. Besides the management of our natural resources, another option that requires discussion is the issue of plantations. These can provide a superior means to supply timber of the overgrown timber industry as well as provide maximum utilisation of the logged over/degraded land - which is in abundance worldwide.

Plantation development is not a new concept; rather it is one which must be enhanced in its delivery as there are still vast quantities of forests which are being harvested without any degree of regeneration taking place. As mass quantities of forests are being exploited and/or converted to agricultural use, forestry has been relegated to the hills, which yields lower quality timber and generates more management problems. As there has been a departure from the concentration on yield management, there has been a shift towards a larger concern for biodiversity, socio-economic issues, environmental protection, etc. If there is such a controversy, which seems to be escalating on a global scale, how can we fix this problem and what timeline can we forecast for its completion?

The substitution by forest plantations may help reduce logging pressure on natural forests in areas which unsustainable harvesting of wood is a major cause of forest degradation and depletion. Forest plantations in New Zealand met 99% of the country's needs for industrial roundwood in the year 1997. This figure can be repeated for countries such as Chile (84%), Brazil (62%) and Zimbabwe (50%) (FAO, 2001).

Seemingly, the only appropriate long term methodology for the forestry industry to adopt is to research the reallocation of our resources into their respective sectors. The term allocation is key in this concept as it represents the different sectors and their individualized specialty. Therefore, if the managers concentrate their efforts into generating a multi-tiered, sectored approach to the allocations of forestry, then the problems of reforestation and maintenance of our biological resources (in abundance) will be better suited to meet the needs of today without compromising the needs of the future.

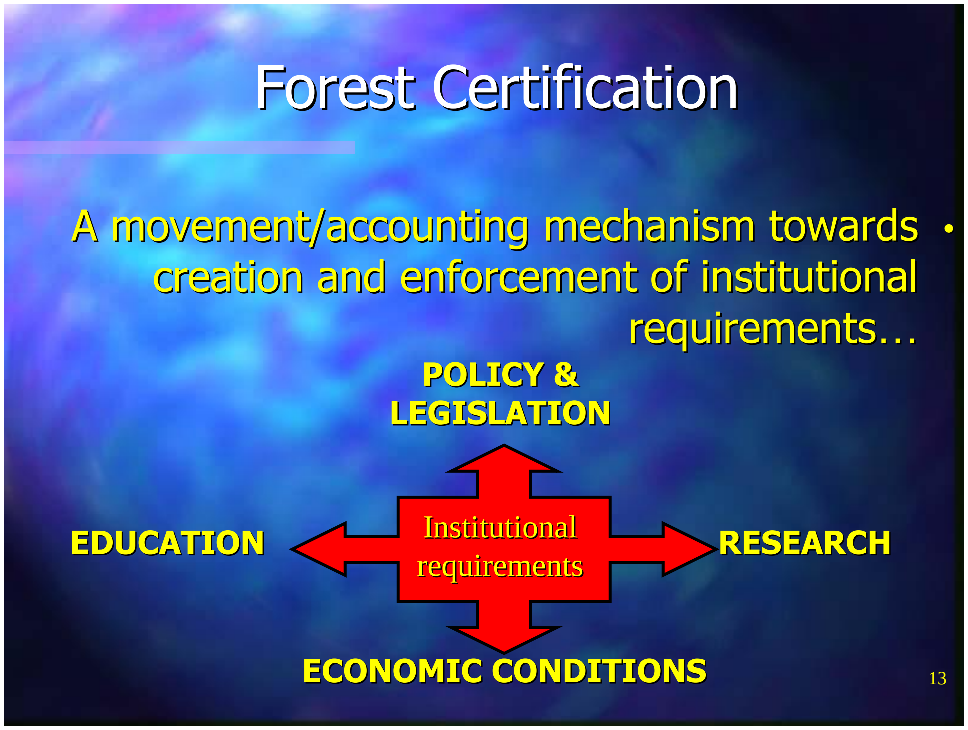


Figure 2. Forest certification.

6 LONG TERM GOALS AND PRIVATE SECTOR INVOLVEMENT

The maintenance of the health, condition, integrity, and vitality of forest ecosystems frequently appears among the C&I for SFM.

What is necessary to achieve this target is the correct allocation of resources, as well as the combined efforts from all stakeholders. Hence, the key to SFM requires the understanding of what our resources can achieve with a realistic mindset of what a properly allocated forest encompasses. What seems to be prevalent is how we are learning to designate, allocate, and distribute our forests. The constraint appears to be due to the improper designation and allocation of our resources. Interdependence is vital to the understanding of this concept. As stated by Finegan and Campos (2000), the public sector point of view is more generally at ease with sustainability assessment as opposed to the private sector which is more stern and focused on the topic. They further state that private individual forest owners and communities have begun to play important roles, including the private sector, where they are increasing their presence in the overall management of our natural resources.

Having stated this, allocation is our key to sustainability. The time has come that in view of the need, concern, and commitment to the management of biodiversity, the remaining unlogged natural forests should be gazetted for conservation, biodiversity, and aesthetics. This is to ensure that future generations will have the natural "old growth" forests to enjoy and for these forests to continue undisturbed to provide the "resources" such as water and biodiversity. Bioprospecting could be promoted as an industry and the presence of undisturbed forests are important if new technologies such as biotechnology, are to be used to "harness" the biodiversity potential of these forests for natural products and pharmaceutical products. "The future of natural forest management would probably give less emphasis to timber production" (Appanah, S. *et. al*, pp.201).

Besides bioprospecting, the full potential of eco-tourism in tropical forests has not been developed. The conservation of virgin old growth tropical forests can open the door to the development of eco-tourism, focussing upon the biodiversity of flora and fauna of the tropical forest ecosystem. Eco-tours can be organized together with the training of local communities as eco-guides. It is suggested that governments develop plans to establish properly run eco-tourism activities to harness that vast potential in the tourism industry.

Logged-over/degraded areas should be utilised as production forests by investing in silviculture activities, especially enrichment planting of fast growing indigenous species. Silviculture treatments may be considered but the result will be slow and the output uncertain. However, enrichment in appropriate areas will ensure higher productivity of known species over a definite time frame. This form of "intensive" natural forest management should be encouraged in logged over forests.

However, if unlogged natural forests are to be for conservation and logged over forests treated with enrichment planting, where would the source of supply for timber be? The answer lies in forest plantations. We have reached a time in the historical development of tropical forestry that a decision must be made that the supply of timber must come from forest plantations which need to be developed immediately. A start must be made, for unless that initial investment is made, tropical forestry is doomed to failure. Forestry in its basic tenet is a business. The growing of trees is also a business, and the private sector is an entity that should be more involved in business than the public sector. As the tropical environment has all the ecological benefits for good tree growth in terms of sunshine, water and sometimes also soil, the conditions are ideal for a commercially attractive forestry plantation business. What is needed is for Governments to provide the initial impetus and incentives for the industry to develop. Once it is developed and going, the cycle will look after itself and sustainability will prevail. The increasing populations and the anticipated increase in demand for wood cellulose will demand the establishment of forest plantations as the only viable alternative. The earlier those tropical countries realise this potential and capture it, the better it is for the future of forestry.

With the development of the Kyoto Protocol and the Clean Development Mechanism (CDM) forest plantations in developing countries, also have the potential to be involved in carbon credit schemes under the CDM. This will also bring much needed financial investments for forestry plantations besides contributing to efforts directed at enhancing the global environment. However, although some projects have taken place in some countries, the potential will come into realisation after the Kyoto Protocol comes into effect.

However, it is recognised that the opportunity cost for use of such lands for forest plantations in the tropics can be high, especially as such crops as rubber and especially oil palm can provide better economic returns. However, these plantations are also aiming at providing cellulose for various panel products such as medium density fibreboard and they could become a major source of fibre in the future with new technological developments. The success of rubberwood in the furniture industry is a well known phenomenon and plans are in place to develop rubber forests using special rubber timber clones. Developed countries should recognise these potentials and promote private sector investments into these multi sector tree crops. Fittingly, the world's population is almost entirely dependant on 30 major food crops, which is but a fraction of the potential plant species that can be exploited for stable food supplies (Saamin and Rahman, 1998).

Historically, forestry has seen a more top-down approach to forest management especially in tropical developing countries where the government and the pubic sector has been the prime player. Understandably, a bottom-up approach where the community or stakeholders play the dominant role may not be the answer. It would seem that close cooperation between the two is necessary for successful implementation of SFM as the stakeholders and beneficiaries of forestry cover all segments of society. As forestry is a business, it would seem natural that some aspects of forestry should be in the hands of the private sector. As the private sector has profitability as its major objective, the long term interests of SFM must be made attractive to the private sector through adequate incentives provided by government. At the same time, the interests of the public and communities living in and around these forests must be protected through adequate legislation. Co-operation between the private sector and the public sector are necessary to ensure that SFM succeeds.

7 THE MILLENNIUM DEVELOPMENT GOALS

At the Millennium Summit in 2000, world leaders instituted the Millennium Development Goals (MDGs), representing a political commitment to translate globally agreed priorities into a better world for everyone. Although these ideas are simple in nature, carrying them out is far from easy. Functioning as a basis for partnership, the MDGs set the terms of globalization, driven not solely by the interests of the strong but rather managed in the interests of the poor (UNDP, 2003). Due to the increasing demand for sustainable leadership and direction, an initiative was taken by the United Nations Development Programme (UNDP) to devise the 8 Development Goals, targeted to be reached by the year 2015. Furthermore, the UNDP utilised its extensive experience to develop integrated development solutions. Under goal number 7, for example, to ensure environmental stability by integrating the principles of sustainable development into country polices and programmes, and reverse the loss of environmental resources; the UNDP and its associated partners (mainly governments and Non-Governmental Organisations (NGOs)) are moving towards identifying concrete policy recommendations and practical measures to respond to the environmental concerns of today’s problems. Sustainable Forest Management is in line with this goal and qualifies as a condition under this programme.

Therefore, the cycle of forest management and its associated problems and constraints have come full circle into the upper echelons of the political debate again after the UNCED or the Rio Summit in 1992, where forestry did manage to play on centre stage. However, the forestry debate and SFM have also moved down to the hands of the public and local communities and also the private sector became also heavily involved. From limitations to harvesting regimes and certification bodies, all sectors have a role to play, and it should be recognised that all parties are essential to the fundamental output of sustainability and SFM.

8 CONCLUSION

For too long, forest management has been “timber-oriented” and has not considered the other non timber and service benefits of forests, all of which are becoming increasingly important. With the development of new technologies and the greater concerns on the environment, forestry has to make a major shift if it is to be relevant and important. It has often been said that forestry has a tremendous potential for economic contribution. With new technologies such as biotechnology in particular, the prospects of bioprospecting for natural products and pharmaceuticals from the natural forest is becoming increasingly apparent. Although environmental stability is a very complex issue, managers and owners of areas and concessions must be reminded of the importance of these key issues that underline the complexity and depth of the issues at stake. Carrying capacity, water, biodiversity, conservation, harvesting, timber production, carbon sequestration, and aesthetic values are still, and forever will be, the key topics on the forestry agenda.

As the international and global interest on tropical forestry is both a challenge and an opportunity, some organisations and sectors view it as a threat, which is exactly why there has not been a better time than now to turn the tide on sustainability and Sustainable Forest Management.

However, this awareness must be translated into commitment. Proper gazettement of our individualistic sectors must be attained for the long term procurement of our resources, and in particular; forestry.

Standards must be set and the monitoring of these practices put into motion. Similar to certification, careful documentation of field operations and management procedures must be noted. Furthermore, while the initiatives stated have a potential useful role to play in Sustainable Forest Management, they can all go amiss if there is a revealed lack of trust between key stakeholders.

To measure SFM is to measure ourselves and our commitment to our future. How important are the values that we must uphold in order to carry out SFM. These are the questions that we should be asking ourselves. SFM has the potential to help us keep track of the changes we have made and the mistakes which we are attempting to correct, however the change in forest values and the facilitation towards adaptive management and expectations must be kept realistic. Working closely with networks of research, monitoring, and forest management will help facilitate progress, but it cannot be a substitute for our own natural tendencies to conserve and protect what we know to be fundamentally correct. Sustainable Forest Management starts with us.

REFERENCES

1. Appanah, S., Krishnapillay, B. and Dahlan, K. (2000). Sustainable Production of Forest Products in the Humid Tropics of Southeast Asia: Latest Developments. In: Krishnapillay, B., Soepadmo, E., Arshad, N.L., Wong, H.H., Appanah, S., Wan Chik, S., Manokaran, N., Hong, L.T. and Khoo, K.C. (eds.) *Forests and Society: The Role of Research Sub-Plenary Sessions Volume 1*, pp.201-210. (XXI IUFRO World Congress: Kuala Lumpur).
2. CIFOR. (2003). CIFOR News Number 32. May 2003. Centre for International Forest Research. www.cifor.cgiar.org
3. FAO. (2001). Global Forest Resources Assessment 2000. Food and Agriculture Association. (FAO: Rome).
4. FAO. (2003). State of the World's Forests 2003. Food and Agriculture Association. (FAO: Rome).
5. Finegan, B. and Campos, J.J. (2000). Criteria and Indicators for the Assessment of Sustainability at the Forest Management Unit Level-A Neotropical Perspective. In: Krishnapillay, B., Soepadmo, E., Arshad, N.L., Wong, H.H., Appanah, S., Wan Chik, S., Manokaran, N., Hong, L.T. and Khoo, K.C. (eds.) *Forests and Society: The Role of Research Sub-Plenary Sessions Volume 1*, pp. 275-287. (XXI IUFRO World Congress: Kuala Lumpur).
6. Haynes, R.W., Stevens, J.A., and Barbour, R.J. (2000). Criteria and Indicator for Sustainable Forest Management at the USA National and Regional Level. In: Krishnapillay, B., Soepadmo, E., Arshad, N.L., Wong, H.H., Appanah, S., Wan Chik, S., Manokaran, N., Hong, L.T. and Khoo, K.C. (eds.) *Forests and Society: The Role of Research Sub-Plenary Sessions Volume 1,* pp. 238-246. (XXI IUFRO World Congress: Kuala Lumpur).
7. ITTO. (1998). Criteria and Indicators for Sustainable Management of Natural Tropical Forests. ITTO Policy Development Series No. 7. International Tropical Timber Organization. (ITTO: Yokohama).
8. ITTO. (2002). Forest Certification: Pending Challenges for Tropical Timber. ITTO Technical Series No. 19. International Tropical Timber Organization. (ITTO: Yokohama)
9. Poore, D. (1989). No Timber without Trees. (Earthscan Publications Ltd.: London).
10. Saamin, S. and Rahman, A. R. (1998). Domestication of Jungle Tree Species for Multipurpose Uses. *The Planter* 74 (871), pp. 561-572.
11. UNDP. (2003). United Nations Development Programme Annual Report 2003: A World of Development Experience. United Nations Development Programme. (UNDP: New York).

Medicine and the Future of Mankind

UĞUR DİLMEN*

1 ABSTRACT

The dawn of the 21st century has been marked by the complete sequencing of a human genetic code. As a result of the sequencing of the human genome, a physical map of the 3 billion base pairs of nuclear DNA has been constructed. Consequently, we can assume that humans have 30000 genes. By comparison, it is only more than the double the number of genes in fruit flies and only about 10000 more than worms. It is interesting to think about how similar we are to lower species. However, it is understandable the genome alone does not hold all the explanations for what it means to be human.

It is predictable that we will continue to focus on the monogenic disorders. However, there will be greater focus on the polygenic disorders and the interactions between genes and the environment.

There are new forces in biomedical research that will enable the discoveries of the future. This includes new research approaches or old approaches to new problems. Among these new areas we can mention comparative genomics, proteomics, and bioinformatics.

Cord blood transplantation seems to be one of the most hopeful treatment modalities of the 21st century.

2 INTRODUCTION

Academicians of this century are fortunate in a time of unparalleled opportunity in basic sciences and health sciences and have many exciting opportunities to contribute to an explosion of information about biological processes and physiological functions, besides the genetic and environmental basis of the diseases.

In addition to basic medicine, other areas of science have opened doors of understanding that are key for advances in all aspects of medicine. Secondly, we have the possibility to translate more of this fundamental information into new diagnostic, therapeutic, and preventive strategies that will enhance health and well-being.

3 IMPORTANT ADVANCES IN DIFFERENT AREAS OF MEDICINE IN THE 20th CENTURY

In infectious diseases, improved public water supplies decreased infant mortality and reduced diarrhoeal disease; antibiotics and vaccines have contributed to the treatment and control of tuberculosis. There have been advances in neonatology in the first 50 years of the last century; incubators, oxygen therapy, cardiorespiratory monitors, and application of X-ray for the diagnosis of some neonatal diseases. Additionally in the last 50 years of the same century, developments included improvement in intravascular access, continuous positive airway pressure, continuous flow mechanical ventilation, discovery, and therapeutic application of surfactant, rediscovery of breast milk and non-invasive imaging.

In the haematology/oncology area, the most eminent improvements are elimination of Rh disease, therapy of childhood malignancies, haematopoietic growth factors, blood product support, clotting factor replacement, and bone marrow transplantation.

The developments in chest diseases were mechanically assisted ventilation, pulmonary function testing, fiberoptic bronchoscopy, discovery of the cystic fibrosis gene and lung and heart-lung transplantation.

---

* Professor of Paediatrics and Neonatology, Department of Neonatology, Dr Z. T. Burak Maternity Hospital, Ankara, Turkey, and Fellow of the IAS.

The advances in nephrology include the administration of steroids for idiopathic nephritic syndrome, end stage renal disease management (haemodialysis, kidney transplantation and end stage renal disease treatment (calcitriol, erythropoietin, etc)).

Gastroenterology also showed important improvements such as; development of oral rehydration solutions, development of technology and application of total parenteral nutritions, development of endoscopy, discovery that Helicobacter pylori causes ulcers and liver transplantation.

Some advances in endocrinology; isolation of thyroxine, discovery of insulin, identification and purification of adrenal steroids, isolation of hypothalamic hormones, elucidation of hormone receptors and purification of growth hormone.

Genetics showed important advances; the first description of Mendelian inheritance and inborn error of metabolism in man. Alkaptonuria (1902), Pauling and Ingram showed sickle cell disease results from change in a single amino acid in a protein (1942). Tijo and Levan approved 46 human chromosomes (1956). The first cloning of disease related genes (1986-1989); and the near completion of human genome sequencing took place (2000).

Immunology was one of the important research areas in the last century. The identification of antibodies in the gammaglobulin fraction of the serum, the discovery of the roles of thymus and other lymphoid organs, and the identification of functions of lymphocyte subpopulations; are manifestations of this. Discovery of surface molecules and secreted factors from cells of the immune system were areas of interest. Allergy was also an eminent research area. Discovery of Ig E by Dr Ishizaka, the discovery of the roles of mast cell and basophile in allergic response, the discovery of the roles of T cell subpopulations in allergy, and the development of treatment strategies to Ig E, IL-4 or IL-5 were important advancements

4 21ST CENTURY CHALLENGES

4.1 General

The dawn of the 21st century has been marked by the complete sequencing of a human genetic code. As a result of the sequencing of the human genome, a physical map of the 3 billion base pairs of nuclear DNA has been constructed. Consequently, we can assume that humans have 30,000 genes. By comparison it is only more than double the number of genes in fruit flies and only about 10,000 more than worms. It is interesting to think about how similar we are to lower species. However, it is understandable that the genome alone does not hold all the explanations for what it means to be human.

It is predictable that we will continue to focus on the monogenic disorders. However, there will be greater focus on the polygenic disorders and the interactions between genes and the environment.

There are new forces in biomedical research that will enable the discoveries of the future. This includes new research approaches or old approaches to new problems. Among these new areas we can mention about comparative genomics, proteomics, bioinformatics, pharmacogenomics and bioethics. These new fields will be accompanied by new technologies in biomedical research including microchip DNA arrays, robotic sequencers, markedly more sophisticated mass spectrophotometry and novel imaging systems.

The improvement in biomedical field generated new treatment facilities in genetic diseases and in the 21st century treatment modalities with genetic materials or cells will be important research areas. One of the most eminent methods in this area is cord blood transplantation.

4.2 Ethical aspects of the therapy with genetic material

“We (God) created Man in the most perfect form.’’

The above verse from the holy *Qur’an* is often used to explain that each human life has its own inherent value and goodness. Humans however also have the capacity for autonomy and self determination and thus have the choice of pursuing a course of action that remains true to their innate pure state or following an immoral path. Whilst genetic research and gene therapy may have positive uses in serving to restore health (and in the process integrity), care must be taken to ensure that other Islamic principles are not violated. An accurate and complete knowledge of one's pedigree is a fundamental human right; only somatic cell lines should therefore be used in transplantation of genetic material since parental integrity is then not compromised and there is no question of hereditary characteristics being influenced.

“Know your genealogy and respect your blood ties.”

The above Islamic principle manifests the fact that children have the right to be born through a valid union (marriage) and to know their parentage fully. Artificial insemination and in vitro fertilisation are therefore licit only if sperm from the woman's spouse is used.

4.3 Stem cell transplantation

Blood stem cells are pluripotent cells and can develop into red blood cells, white blood cells and platelets. Bone marrow transplantation means replacing a transplant patient's diseased or damaged blood stem cells with the donors' stem cells. The three sources of blood stem cells are bone marrow, peripheral (circulating) blood and blood collected from the umbilical cord and placenta after a baby is born.

4.4 Cord blood transplantation

In the 1970s, medical researchers discovered that human umbilical cord blood contained the same kind of stem cells found in bone marrow. Because stem cells from bone marrow had already been used successfully to treat patients with life-threatening blood diseases, such as leukaemia and immune system disorders, researchers believed that they could also use stem cells from cord blood to save patients.

In 1988, doctors transplanted human umbilical cord blood into a 5-year old boy suffering from Fanconi's anaemia. Ten years after the transplant, the boy is alive and seems to be cured of his disease. Based on this and other successful transplants, doctors and medical researchers began to collect, freeze and store cord blood units (CBUs) at cord banks throughout the world.

Finding a donor, for this sort of medical procedure, may be particularly challenging for patients from racial and ethnic minorities. Patients and donors must be fairly closely matched genetically. This degree of match is determined by comparing the tissue type of the patient and donor. Tissue type is inherited, so patients have a better chance of finding a match within their own ethnic group. But because the number of minority donors tends to be low, patients from racial and ethnic minorities have been less successful in finding donors than Caucasian patients.

The collection and storage of cord blood is one way to give patients of all racial and ethnic backgrounds greater access to stem cell transplantation. For that reason, beginning in the early to mid-1990s, medical institutions around the world began making a serious effort to collect and store cord blood units for use in transplantation.

The following eligibility criteria, proposed by transplant doctors;

1. Patients must have one of the following forms of leukaemia or related diseases:

- High-risk acute lymphocytic leukaemia (ALL);
- Acute myelocytic leukaemia (AML)**;**
- Acute undifferentiated leukaemia**;**
- Juvenile myelomonocytic leukaemia;
- Mylelodysplastic syndrome**;**
- Advanced chronic myleocytic leukaemia (that is, with a chronic phase occurring more than a year after diagnosis)**;**
- Chronic myelomonocytic leukaemia**;**
- Paroxysmal nocturnal hemoglobinuria; and
- Advanced lymphoma**.**
-

2. Or, patients must have one of the following forms of anaemia or related diseases:

- "High risk" severe aplastic anaemia**;**
- Fanconi's anaemia**;**
- Inborn errors of metabolism (e.g., Hurler syndrome, Maroteux-Lamy syndrome, adrenoleukodystrophy, metachromatic leukodystrophy, globoid cell leukodystrophy, mannosidosis, fucosidosis)**;**
- Immunodeficiency states (e.g., Wiskott-Aldrich syndrome, SCID, Chediak-Higashi Syndrome, leukocyte adhesion deficiency, X-linked lymphoproliferative disease)**;**
- Familial erythrophagocytic lymphohistiocytosis (FEL)**;**
- Blackfan-Diamond syndrome**;**
- Infantile osteopetrosis**;**
- Kostmann's syndrome**;**
- Congenital amegakaryocytic thrombocytopenia**;** and
- Others**.**

3. The donated cord blood must contain more than 1 x 10^7 nucleated cells per kilogram of the recipient's body weight and must be matched at 4 of the 6 HLA-A, B, and DRB1 antigens. In other words, there must be an adequate number of stem cells for engraftment in the donor base on the donor's weight, and there must be at least a 4/6 HLA match between the CBU and patient.

4. The patient's liver, kidney, heart and lung function should be adequate

Stem cell transplantation in myocardial infarction and Parkinson disease resulted in some hopeful consequences. Recently lots of animal researches are continuing in different areas.

We may assume that the number of diseases in this list will increase in the next decade. Consequently, the mankind has an opportunity to see less genetic disorders than before, however to see much more complication of the new treatment modalities.

REFERENCES*

1. Bloom FE: Science as a way of life: Perplexities of a physician scientist. Science 300:1680, 2003.
2. Pirisi A: Can a supercomputer help doctors manage patients? Lancet 362:452, 2003.
3. Gray JAM: Post-modern medicine Lancet 354, 1550, 1999.
4. Bucley RH: American Paediatric Society Presidential Address 2000: Reflections on the20th and 21st centuries Pediatr Res 51:119, 2002.
5. Morrison I, Smith R: The future of medicine. Br Med J 309:1099, 1994.
6. Mc Cloy R, Stone R: Virtual reality in surgery. Br Med J 323:912, 2002.
7. Pescovitz OH: Society for Paediatric Research Presidential Address 2002: Paediatric Research in the Era of genomics Pediatr Res 51: 782, 2002.
8. Schuldiner M, Yanuka O, Itskovitz-Eldor J, Melton DA, Benvenisty N. Effects of eighth growth factors on the differentiation of cells derived from human embryonic stem cells. Proc Natl Acad Sci USA 97:11307, 2000.
9. Rosenthal N: Prometheus's vulture and the stem cell promise. N Engl J Med 349:267, 2003.
10. Reya T, Morrison SJ, Clarke MF, Weissman IL. Stem cells, cancer, and cancer stem cells. Nature 414:105, 2002.
11. Weissman IL. Stem cells: units of development, units of regeneration, and units in evolution. Cell 100:157, 2000.
12. Kim JH, Auerbach JM, Rodriguez-Gomez JA, et al. Dopamine neurons derived from embryonic stem cells function in an animal model of Parkinson's disease. Nature 418:50, 2002.
13. Austin TW, Lagasse E. Hepatic regeneration from haematopoietic stem cells. Mech Dev 120:131, 2003.
14. Gatrad AR, Sheikh A. Medical Ethics and Islam. Arch Dis Child 84:72, 2001.

* As listed by the author.

A Proposal on the Establishment of an International Islamic Centre for Life Sciences and Biotechnology in Malaysia

ABDUL LATIF IBRAHIM*

1 ABSTRACT

The purpose of the paper is to inform and to seek the consideration decision-makers in Malaysia on a proposal to establish an International Islamic Centre of Life Sciences and Biotechnology dedicated to advance research and education covering fundamental and applied areas in life sciences and biotechnology with the aim of making Malaysia as the seat of learning and research of the Muslim World.

2 INTRODUCTION

2.1 Dr Mahathir Mohammed the Prime Minister of Malaysia in his speech at the Congress on Towards Reviving the Golden Age of Islam organized by IKIM stated – quote :

- If at one time Islam could create an outstanding civilization, can Islam today once again create another civilization just as outstanding? Those who are rational are confident that this is not an impossible task. Its achievement is surely not easy. It will definitely take time. But then no targets can be met if no attempt is made to reach it. Everything begins with the first step. The first step that needs to be taken is to determine our target, which is to define what is meant by success and prosperity; and
- Every Muslim is surely keen in reviving the golden age of Islam. The problem lies in how we can achieve this objective. It is certain that if we continue our present practices, and if we do not strive towards that direction, chance that we will be left far behind.

2.2. The first step in reviving the glory of the golden age of Islam is to mobilize Muslim scholars, scientists, researchers and students and provide them with an infrastructure and facilities that promote them to advance research and education in life sciences and biotechnology. The infrastructure will be in the form of a centre which will act as centre of excellence to foster cooperation among Muslim scholars and scientists by organizing research and education programs that can lead to important discoveries and inventions. It is proposed that a centre for life sciences and biotechnology be established as both are the science and technology of the 21st century. The centre can be located in Malaysia.

3 WHY LIFE SCIENCES AND BIOTECHNOLOGY AND IN MALAYSIA

3.1 Life sciences and biotechnology are widely recognized as the next wave of the knowledge economy. The knowledge base of life sciences and biotechnology are creating new application in health care, agriculture and food production, environmental protection as well as new scientific discoveries. The expansion of the knowledge base is accompanied by transformation scientific discovery and innovation into practical use and products. This will bring about new wealth creation, regenerating old industries and offering new jobs to sustain the knowledge based economies. It is essential that the Muslim communities developed skills and capabilities in harnessing the potential of life sciences

*Fellow of the Islamic World Academy of Sciences from Malaysia.

and biotechnology for food and water security, better health care and wealth creation. This can be achieved through the collaborative efforts of the international life sciences and biotechnology community by creating mechanisms that can bring them together. Life sciences and biotechnology will be the science and technology that will promote the scientific and technological advancement of the Muslim community.

3.2 Malaysia is embarking an ambitious program to harness the potential of biotechnology for social and economic development. The establishment of the National Biodiversity and Biotechnology Council reflects the firm commitment of the Government to develop biotechnology. A national biotechnology policy which will provide the necessary guidance and direction is being drafted. A number of universities and research institutions are involved in advanced research and development in life sciences and biotechnology. Under the 8th Malaysia Plan the government will establish 3 National Biotechnology Institutes in the area of Genomics and Molecular Biology, Agro-Biotechnology and Nutraceutical and Pharmaceutical Biotechnology. The 3 institutes together with a Business Development Directorate will form Malaysia's BioValley. The co-location of Malaysia's BioValley in the Multi-Media Supercorridor (MSC) will see the convergence of biotechnology and information technology which is very unique to Malaysia. MSC will provide the advance critical information and communication technologies to support information discovering, modelling and remote partnership essential for advancing life sciences and biotechnology within Malaysia and among the Muslim countries. Therefore Malaysia would be an ideal Muslim country for the location of the centre. Malaysia has all the critical success factors for the development of life sciences and biotechnology for the Muslim Ummah.

4 THE PROPOSAL

4.1 In 1986, the standing Committee of Scientific Technological Cooperation (COMSTECH) of the Organization of Islamic Conference (OIC) established the Islamic Academy of Sciences (IAS) with its headquarters in Amman, Jordan. One of the objectives of IAS is to serve as consultative organization of the Muslim Ummah and Institutions of member states of the OIC on matters related to science and technology. One of the major activities of IAS is to act as a forum where members meet yearly in a conference to discuss specific areas of sciences and technology and to publish the proceeding of the conference. The IAS also publishes a scientific journal on the activities of member countries. Although these efforts are commendable, they are not sufficient to revive the past glory of Muslim science and technology advancement. What is needed is an organization and infrastructure that offer world class experts and students access to advanced research facilities and equipment to conduct leading edge research and that the research outcome are essential towards industrial competitiveness of Muslim countries. This can be achieved through provisions of fellowship, scholarships, research attachment, and research grant that are competitive and attractive. To facilitate the creation of the advanced research and education program, the establishment of an International Islamic Centre of Life Sciences and Biotechnology is proposed. The centre will make use of infrastructure and facilities that are available in universities and research organizations in Malaysia. The International Islamic Centre for Life Sciences and Biotechnology will be the coordinating centre to advance research and education for the benefit of Malaysia, the Muslim Ummah and mankind.

4.2The centre will be a virtual institution and will be established through a consortium of both public and private universities and research institutions in Malaysia with strong interest in the life sciences and biotechnology. To facilitate and enhance its activities, the centre will establish and foster networking with local and international academic and research institutions especially from the Muslim countries. It is proposed that a secretariat will be established at the International Islamic University Malaysia (IIUM) which will be responsible to coordinate and spearhead the formation of the centre. IIUM has the experienced to attract and manage international Muslim students and Muslim scholars from Muslim countries and Muslim communities in developed countries. It is also worth mentioning that IIUM has keen interest in life sciences and biotechnology. Moreover, IIUM top management has given its consent, in principle, for the establishment of the centre at IIUM as part and parcel of making IIUM as a leading international centre of educational excellence which seeks to restore the leading and progressive role of the Muslim Ummah in all branches of knowledge.

5 ELEMENTS OF THE INTERNATIONAL ISLAMIC CENTRE OF LIFE SCIENCES AND BIOTECHNOLOGY

1. *Vision*

Malaysia as the centre of excellence for research and education in life sciences and biotechnology for the Muslim Ummah.

II. *Mission*

a) To mobilize the talent of Muslim scholars, scientists and students to advance research in life sciences and biotechnology for the benefit of Malaysia, the Muslim community and mankind; and

b) To facilitate the creation of an International Islamic Centre of Life Sciences and Biotechnology in Malaysia which can act as the hub for research and education of the Muslim Ummah.

III. *Objectives*

a) To serve as the International Islamic Centre for Life Sciences and Biotechnology where Muslim scientists and students can participate in Malaysia research development and education program.

b) To provide access to advanced research facilities and equipment for world class Muslim scientists to conduct research that is critical to the Muslim World and essential to mankind.

c) To stimulate fundamental and applied research that can lead to discoveries and inventions, and international recognition of Muslim scientists' contributions.

d) To train Muslim scientists and students in areas of life sciences and biotechnology that is critical to the advancement of the Muslim Ummah and mankind.

e) To act as a forum for exchange of ideas among international Islamic scientific community, policy makers, industrialists and international organizations through periodic conferences, seminars, workshops and short training courses.

IV. Goals

a) To enhance quality of life of the Muslim Ummah through food and water security and protection of health and environment.

b) To attain international recognition in life sciences and biotechnology for Muslim scientists and scholars, and Malaysia as the host nation.

c) To ensure that both Malaysia and Muslim scientists acquire the expertise and capability in developing and acquiring innovative scientific knowledge and critical technologies.

d) To build collaborative relationship among Muslim scientists.

6 ACTIVITIES

The centre will focus on 3 main activities:

a) *Research*

The centre will facilitate multi-disciplinary research program in life sciences and biotechnology with emphasis in agro-biotechnology, nutraceutical and pharmaceutical biotechnology and molecular biology. The objective of the research program is to stimulate leading edge fundamental and applied research that promotes the participation of the industry. The research activities will be developed on existing strength and facilities that are available in Malaysia.

b) *Education*

The centre will provide opportunities for scholarly development in life sciences and biotechnology for the Muslim Ummah. The centre will promote and facilitate post-graduate and post doctoral research program on scientific problems related to life sciences and biotechnology.

c) *Services*

The centre will provide facilities for use in research in life science and biotechnology through the consortium of universities and research institutions. The centre will promote outstanding Muslim scientists in research programs that will benefit Malaysia and the world scientific community.

7 BENEFITS TO MALAYSIA AND THE MUSLIM UMMAH

a) Accelerate the development of biotechnology in Malaysia through the participation of world renowned scientists and entrepreneurs.
b) Attain international recognitions for excellence in research and education in life sciences and biotechnology.
c) Assist Muslim countries acquire capabilities in harnessing the potential of biotechnology to improve the quality of life.

d) Provide opportunities for Malaysia and the international Muslim community to pursue graduate and post-doctoral training in life sciences and biotechnology under the supervision of outstanding Muslim scientists and scholars.

e) Increase cooperation and communications between Malaysian scientists through consortium program of the centre
f) Develop networking among Muslim countries in life sciences and biotechnology.
g) Generate sufficient highly skilled workforce and a conducive environment and that will be an incentive to attract biotechnology and life sciences companies in Malaysia.

8 CONCLUSION

8.1 The proposed International Islamic Centre of Life Science and Biotechnology represents a new initiative for Malaysia's programme in life sciences and biotechnology. Malaysia can take a pro-active approach in the harnessing the potential for biotechnology by utilizing the expertise that are available among the Muslim Ummah and taking advantage of existing strength and opportunities of biotechnology in Malaysia. The result of this initiative will be the creation of forward looking educational and research programme, accelerated development of research and monitory skills, broadening research and learning environment and enhanced educational quality. Such an initiative will not only benefit Malaysia but also the Muslim Ummah.

8.2 Malaysia has many of the critical success factors that will facilitate the establishment of the centre and this include:

i) Strong support by government on biotechnology through the National Biodiversity and Biotechnology Council chaired by the Deputy Prime Minister of Malaysia;
ii) A good infrastructure for research and education including BioValley Malaysia and Multimedia Supercorridor(MSC)
iii) Malaysia standing in the Muslim Word.

8.3This initiative will accelerate the development of biotechnology and life sciences through:

i) Training of human resources
ii) Stimulate local and foreign investment
iii) Secure Intellectual property rights
iv) Improve infrastructure
v) Remain competitive, regionally and globally
vi) International recognition
vii) Stimulate economic activity, growth and improve and enrich Malaysian quality of life in terms of health, the environment, and social and economic development.

8.4. The initiative will also assist in the progress of biotechnology and life sciences in the Muslim world through

i) The centre will act as the seat of learning and education for international Islamic community in biotechnology and life sciences;
ii) To provide opportunities for international Muslim scientists and students to participate in research leading to discovery and invention that can benefit mankind;
iii) To act as forum for interaction among Muslim scientists and between Muslim scientists and world scientific community to improve the quality of through life sciences and biotechnology; and
iv) To place the Muslim scientists in the forefront of science and technology.

Harnessing Science and Technology for Development in the K-Economy: A Sketch

OMAR ABDUL RAHMAN*
Executive Chairman
Kumpulan Modal Perdana
Kuala Lumpur, Malaysia

ABSTARCAT

This presentation deals with the policy and management aspects of science and technology for development.

"S&T is not useful until it is useful" meaning until it contributes positively to the socio-political, cultural and economic development of communities or nations.

Harnessing S&T for development therefore requires a whole spectrum of policy, institutions, human resource, and management processes in place.

The presentation will elaborate on the human resource pyramid for scientific development, the science advisory process, the strategies for technology acquisition and for bridging the commercialization gap and the various other components of the technology management processes.

Understanding the complete spectrum of technology management is especially important in the context of the k-economy which requires intensification of the knowledge content in both traditional as well as new economic activities and in governance.

The presentation will finally touch on the elements of a national innovation system as a means of harnessing technology for development in the k-economy.

**Formerly Science Advisor to the Prime Minister of Malaysia; Founder and Immediate Post President, Academy of Sciences Malaysia; Founding Fellow, Islamic World Academy of Sciences; Professor Veterinary Medicine.*

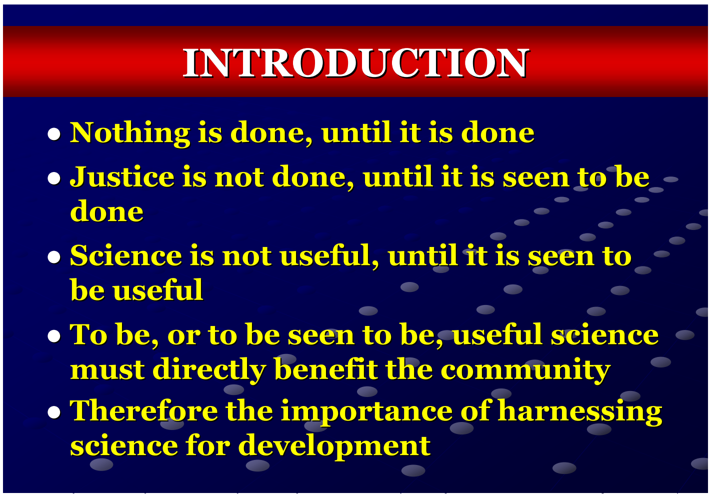


Figure 1. The backdrop.

Figure 2. Twin perspectives of science.

Figure 3. Knowledge-driven economy.

Figure 4. Characteristics of K-economy.

Figure 5. Effects of the K-economy.

Figure 6. Forces driving the K-economy.

Figure 7. Achieving the K-economy.

Figure 8. Imperatives for the Islamic world.

Figure 9. Technology management best practice.

Figure 10. Technology management best practice.

Figure 11. Technology management best practice.

Figure 12. Technology management best practice.

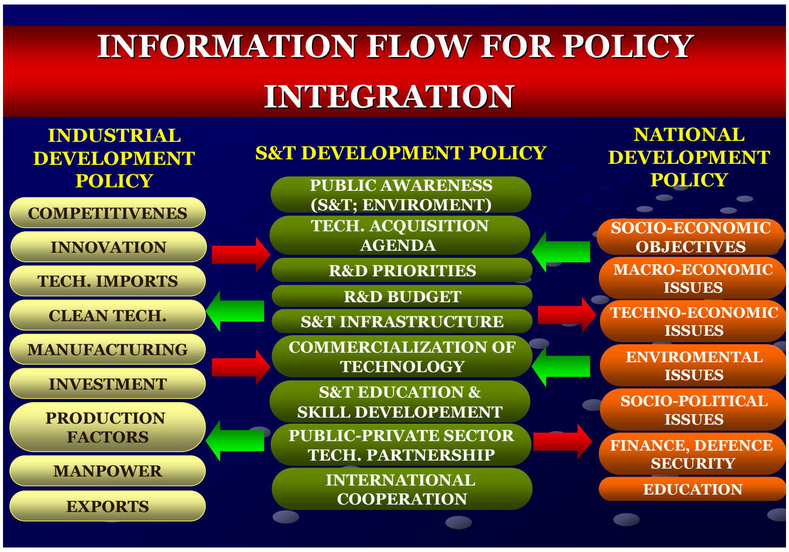


Figure 13. Information flow for policy integration.

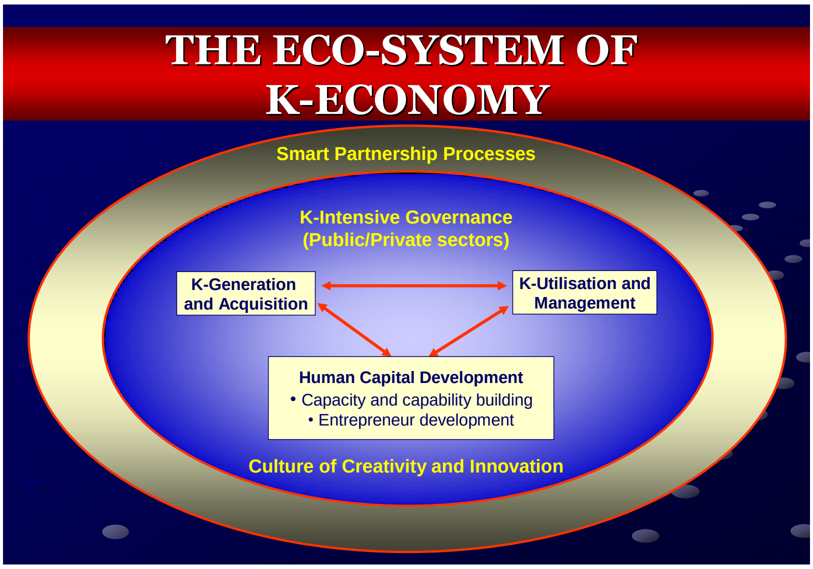


Figure 14. The ecosystem of the K-economy.

Figure 15. S&T human resources pyramid.

Figure 16. Ecosystem for K-utilisation.

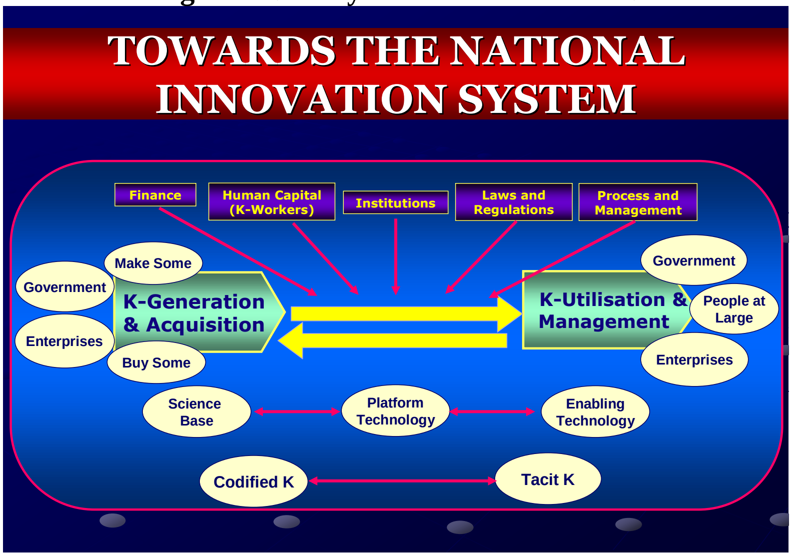


Figure 17. Towards the national innovation system.

Figure 18. Smart partnership.

Figure 19. The Malaysia model.

Figure 20. Conclusions.

State of Science and Technology in the Arab Region: A Sketch

ADNAN BADRAN*
President, Philadelphia University
Jordan

BACKGROUND

The Arab world comprises 20 states and spans from Mauritania on the Atlantic coast in the West to the Arabian Sea in the East. The Arab states include some of the world's poorest (Somalia) and richest (Qatar).

A look at some of the internationally accepted S&T indicators for the Arab world and some individual Arab states may reveal a number of interesting facets. R&D expenditure of the Arab region is probably amongst the lowest at 0.2% of the global R&D expenditure, for example.

Military expenditure in the Arab world is probably is amongst the highest, compared to GDP, in the world.

The following tables and figures carefully compiled from various UN and other sources are self explanatory. They probably reflect the indifference that Arab countries show towards scientific and technological activities as not being a priority area or as a means to realizing socioeconomic development.

The aim of the presentation is thus to bring such important issues to the attention of decision-makers in Arab and Organization of Islamic Conference (OIC) countries.

* 2005, Jordan's Prime Minister, and Fellow of the Islamic world Academy of Sciences.

Table 1. GDP per capita in selected Arab states (US$)

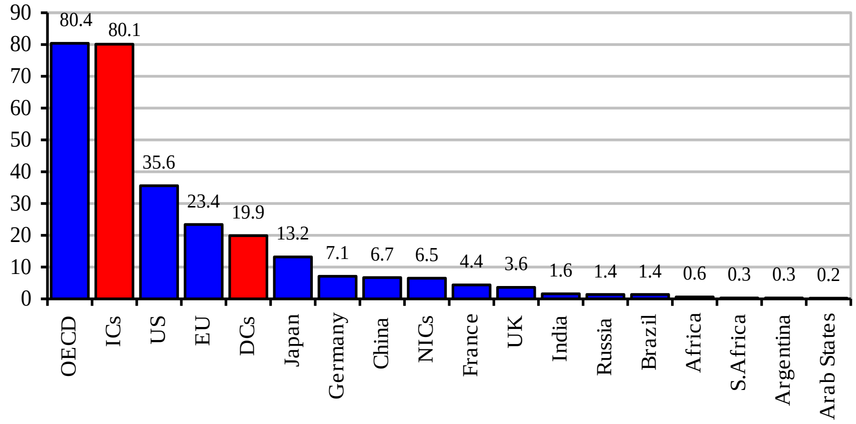
COUNTRY	1995	2002
Mauritania	463	334
Sudan	245	443
Yemen	332	508
Djibouti	858	819
Syria	1163	1180
Morocco	1252	1250
Egypt	1053	1286
Algeria	1456	1661
Jordan	1568	1744
Tunisia	2015	2367
Libya	6340	3292
Lebanon	3178	4552
Oman	6477	7933
Saudi Arabia	7577	8053
Bahrain	10120	11374
Kuwait	14118	14597
United Arab Emirates	17755	20509
Qatar	16642	29948
Average	**2144**	**2430**

Source: *Unified Arab Economic Report (2003).*

Table 2. Registered patents in the USA originating from selected Arab states and other countries

Country	1995	1996	1997	1998-1999	Total
Bahrain	0	0	1	0	1
Egypt	7	6	2	7	22
Jordan	0	2	5	4	11
Kuwait	2	3	2	12	22
Oman	0	0	0	2	2
Saudi Arabia	11	12	14	30	67
Syria	0	0	0	1	1
United Arab Emirates	2	1	2	3	8
China	91	78	103	201	473
S.Korea	1265	1603	2027	5089	9984
Israel	489	591	653	1343	3076

Source: *United States Patent and Trademark Office: www.uspto.gov*



Source: *UNESCO Global Investment in R&D Today (2003).*

Figure 1. R&D expenditure of the Arab region, other regions and selected countries as a share of global expenditure %, 2000.

Table 3. Defence expenditure in the Arab region, Developing and Least Developed countries, 1996

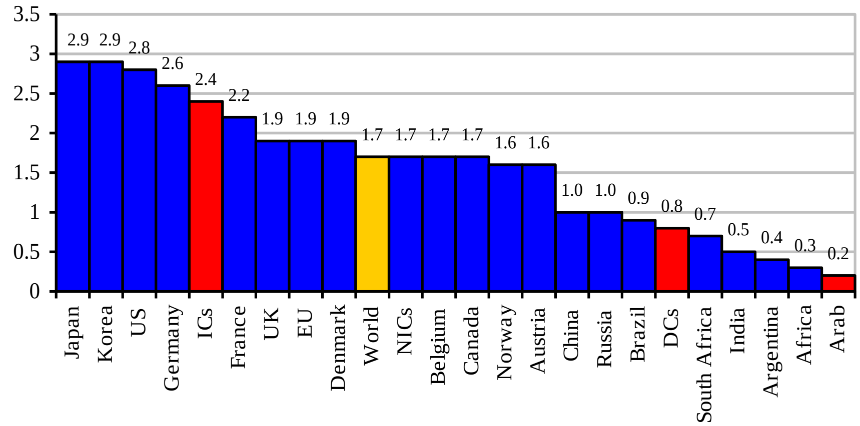
Country	per capita (US $)	As % of GDP	Total US$ million
Arab States	151	7.1	37 433
World	137	2.9	781 093
Least Developed countries	10	2.5	5
Developing countries	39	3.7	171 934

Source*: Atta. R. (ed.) (2003): Strategy for the Development of Science & Technology in Arab OIC Countries; and UNDP Human Development Report, 2003.*

Table 4. Military expenditure in selected Arab states, 2001

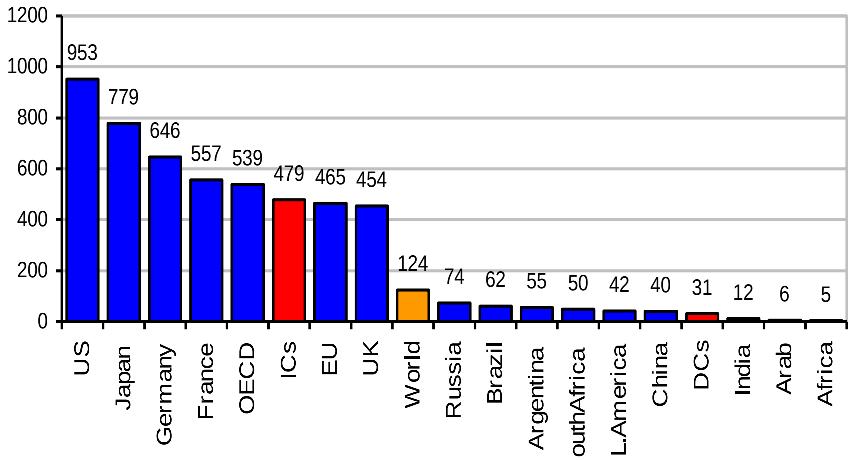
Country	**As % of GDP**
United Arab Emirates	2.5
Kuwait	11.3
Bahrain	4.1
Saudi Arabia	11.3
Oman	12.2
Lebanon	5.5
Tunisia	1.6
Jordan	8.6
Algeria	3.5
Egypt	2.6
Morocco	4.1
Syria	6.2
Djibouti	4.4
Yemen	6.1
Sudan	3.0
Mauritania	2.1

Source*: UNDP Human Development Report, 2003.*



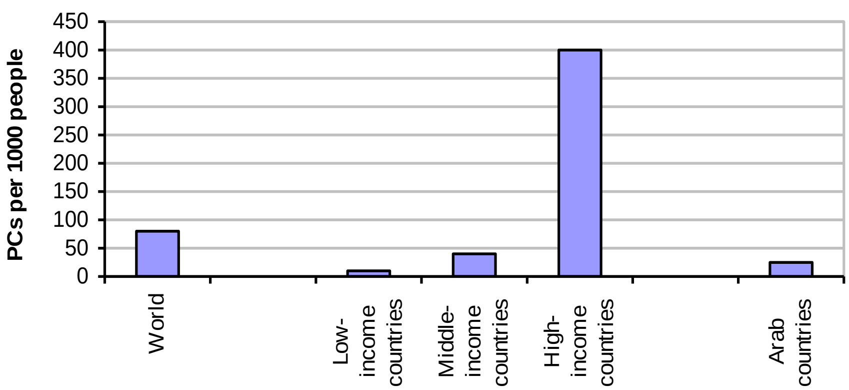
***Source**: UNESCO (2003): Global Investment in R&D Today.*

Figure 2. R & D expenditure in the Arab region, other regions and selected countries as a share of GDP, 2000.



ICS: Industrialized countries;
NICs: Newly Industrialized countries;
DCs: Developing countries.
***Source**: UNESCO (2003): Global Investment in R&D Today.*

Figure 3. R&D expenditure per capita (US$) in the Arab region, other regions and selected countries,



2000.

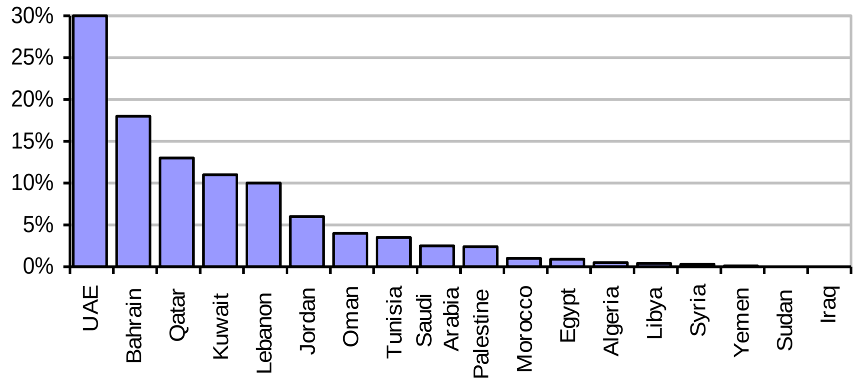
***Source**: World Bank (2002) World Development Indicators; UNDP (2003) Arab Human Development Report.*

Figure 4. Personal computers in the Arab region and other groups of countries, 2001.

Table 5. The digital gap in selected Arab states compared to other countries

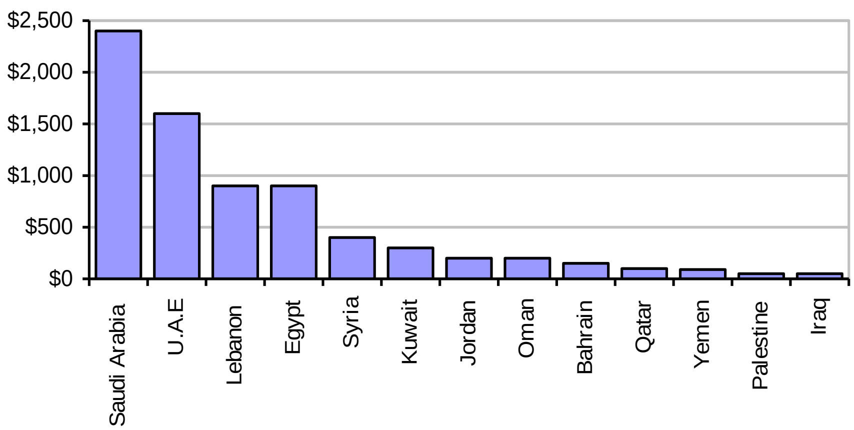
Country	**Score**	**Position in Networked Readiness Index**
USA	5.50	1
Switzerland	5.06	7
France	4.60	19
Malaysia	4.19	25
Tunisia	3.67	40
Jordan	3.53	46
Turkey	3.32	56
Morocco	3.19	64
Egypt	3.13	65
Nigeria	2.92	79
Algeria	2.75	87

Source: *Dutta, S. Lanvin, B. and Paua, F(eds) (2003): Global Information Technology Report 2002,2003; Readiness for Networked World.*



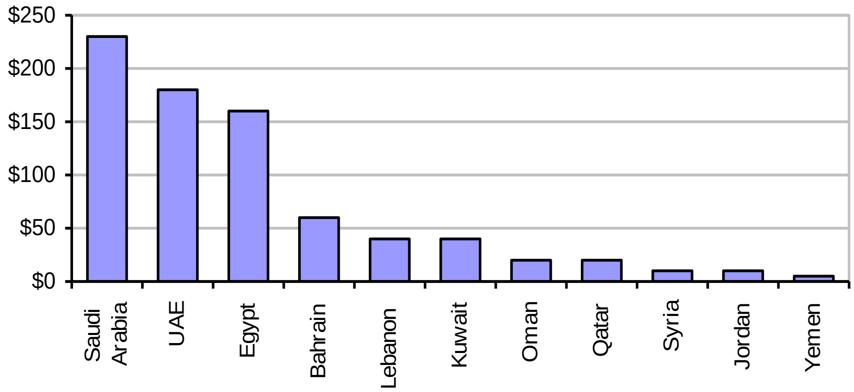
Source*: World Bank (2002) World Development Indicators; UNDP (2003) Arab Human Development Report.*

Figure 5. Internet penetration in selected Arab states, 2001.



Source*: Middle East Economic Digest (MEED), 1999.*

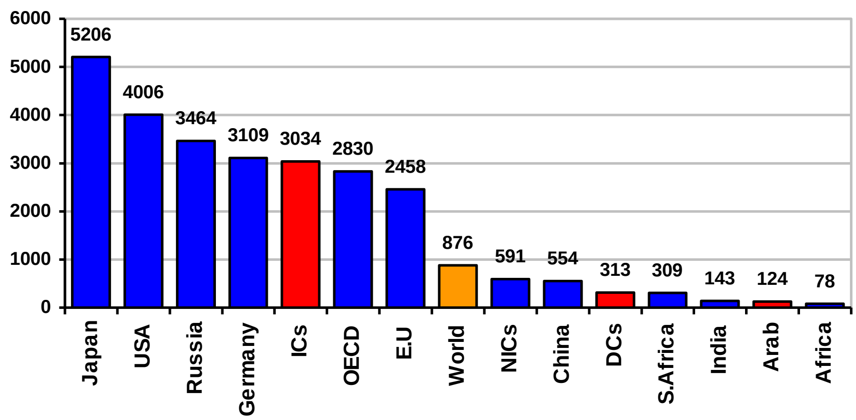
Figure 6. Value of contracts involving transfer of ICT, selected Arab states, 1992-1998 (per capita).



***Source**: Middle East Economic Digest (MEED) 1999.*

Figure 7. Value of consultancy contracts in selected Arab states, 1992-1998 (per capita).

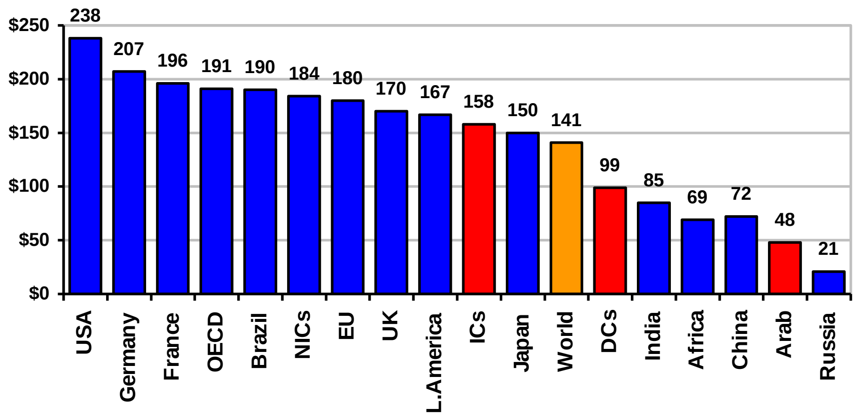
ICs: Industrialized countries;
NICs: Newly industrialized countries;



DCs: Developing countries.

***Source:** UNESCO (2003) Global Investment in R&D Today.*

Figure 8. Researchers in the Arab region and other selected regions and countries, 2000 (per million population).



ICs: Industrialized countries;
NICs: Newly industrialized countries;
DCs: Developing countries.

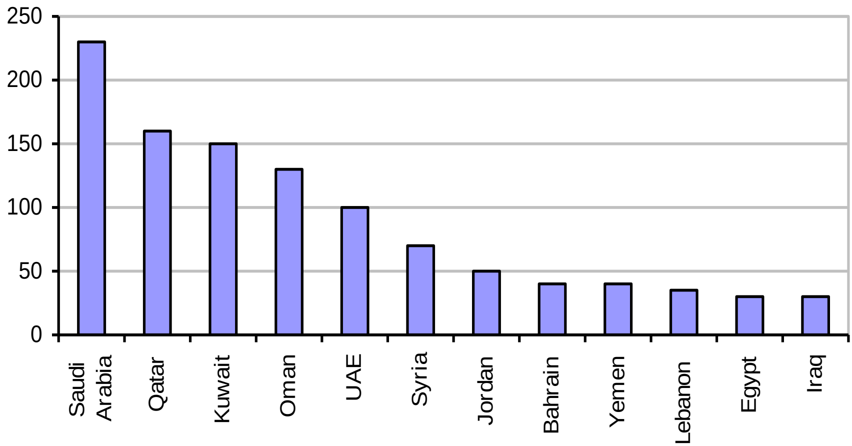
Source: *UNESCO Institute for Statistics (estimates), 2003*.

Figure 9. R&D expenditure per researcher in the Arab region and selected other regions and countries, 2000.

Table 6. Distribution of FTE (full-time equivalent) researchers in ESCWA Arab states, 1998.

	Public sector			University			Private sector			
State	**PhD**	**MSc**	**Total**	**PhD**	**MSc**	**Total**	**PhD**	**MSc**	**Total**	**Total**
Bahrain	5	22	27	29	30	59	0	0	0	86
Egypt	4708	3366	8074	1627	757	2384	114	172	286	10744
Iraq	189	540	729	366	296	662	0	0	0	1391
Jordan	86	129	215	98	42	140	15	31	46	401
Kuwait	117	217	334	81	2	83	8	15	23	440
Lebanon	28	65	93	65	47	112	0	0	0	205
Oman	17	39	56	19	7	26	0	0	0	82
Qatar	2	2	4	18	12	30	0	0	0	34
Saudi Arabia	84	224	308	363	175	538	0	0	0	846
Syria	95	115	210	109	37	146	0	0	0	356
United Arab Emirates	12	44	56	26	25	51	0	0	0	107
Yemen	115	89	204	44	22	66	0	0	0	270

Source: *ESCWA (1999) Science and Technology Policies in the 21st Century.*



Source*: Qasem, S (1998): Development of Science and Technology Indicators.*

Figure 10. R&D expenditure per researcher in selected Arab states, 1998.

Table 7. Researchers in the Arab region by sector of activity, 1998

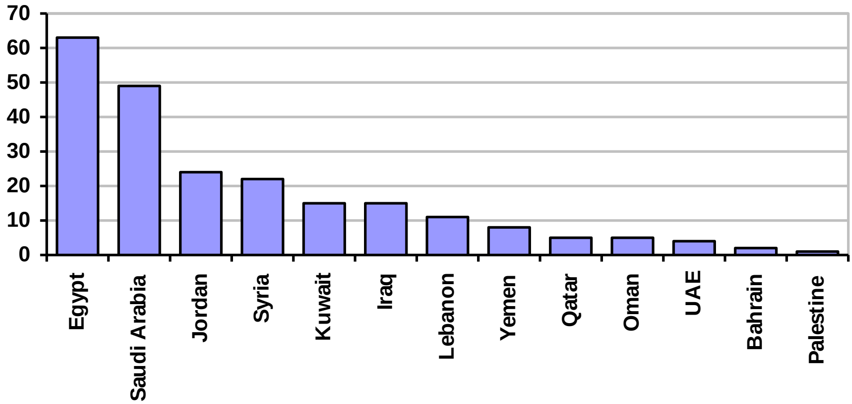
Agriculture	44.2%
Health and food	13.3%
Social and economics	10%
Industry	8.5%
Basic science	8%
Engineering	6.3%
Energy	5%
Petrochemicals	2.8%
R&D management	1.9%
Total	100%

Source*: Qasem, S (1998): Development of Science and Technology Indicators.*

Table 8. Number of R&D units by economic sector in the Arab region, 1996

Sector	Government	University	Private	Total	% Of Total
Agriculture	97	19	1	117	36.3
Health	43	16	0	59	18.3
Industry	34	2	16	52	16.1
Energy	27	1	0	28	8.7
Basic science	12	8	0	20	6.2
Social science	13	7	0	20	6.2
Petrochemicals	11	2	0	13	4.1
Engineering	6	7	0	13	4.1
Total	243	62	17	322	100
%Distribution	75.4	19.3	5.3	-	100

Source: *Qasem, S (1998): Development of Science and Technology Indicators.*



Source: *ESCWA: Science and Technology Policies in the 21st Century.*

Figure 11. Number of R&D units in selected Arab states, 1998.

Table 9. Expenditure on education in selected Arab states, 1996-2001

Country/Region	Expenditure as %of GDP	As % of total expenditure
Saudi Arabia	9.3	22.8
Yemen	7.0	-
Tunisia	6.7	19.9
Egypt	5.2	14.7
Morocco	5.2	20.9
Algeria	5.1	16.4
Jordan	5.1	24.2
Kuwait	4.7	14.0
Mauritania	4.5	19.1
Oman	4.5	9.1
Bahrain	3.7	12.0
Syria	3.5	13.6
Djibouti	3.4	-
Lebanon	1.9	8.2
United Arab Emirates	1.8	16.4
Sudan	0.9	-

Source: *UNESCO (1999) Statistical yearbook 1999. Arab Fund for Economic and Social Development (2002), Unified Arab Economic Report.*

Table 10. Student enrolment in higher education in Arab states, 2000

Country/ Region	Males	Females	Total
Libya	51.7	50.6	51.2
Lebanon	35.2	38.2	36.7
Qatar	13.7	46.2	27.7
Jordan	26.8	30.6	28.6
Bahrain	19.6	31.1	25.2
Palestine	29.2	17.9	24.0
Saudi Arabia	19.6	25.4	22.4
Egypt	27.1	17.8	39.0
Kuwait	13.0	30.0	21.1
Tunisia	19.6	19.0	19.3
Syria	17.6	12.6	6.1
Algeria	15.8	11.0	15.0
Iraq	17.5	9.5	13.6
United Arab Emirates	4.9	20.7	12.1
Yemen	16.7	4.6	10.8
Morocco	10.6	8.0	9.3
Oman	8.8	7.1	8.0
Sudan	7.1	6.6	6.9
Mauritania	6.6	1.3	5.6
Somalia	3.6	1.1	2.3
Djibouti	0.4	0.3	0.4

Source: *Unified Arab Economic Report: Database (2003).*

Science Education to Bridge Cultures

BEATRICE DESCAMPS-LATSCHA[1, 2], PIERRE LENA [2 3]
and
YVES QUERE [2, 3]
[1] *Institut National de la Santé et de la Recherche Médicale,* [2] *La main à la pâte, Montrouge, and* [3] *Académie des Sciences, Paris*

1 INTRODUCTION

The necessity of science and of its first cousin, technology, as a prerequisite for development, is a well established fact that we do not want to elaborate on it here, except to recall the following strict proviso: if this science and this technology are imposed on societies, without a minimum of respect for the local customs and social, religious, moral or simply customary principles that these are founded on, there is a great danger that the graft will not take and that instead of the smooth development anticipated, economic stagnation ensues, accompanied by social regression generated by migrations of populations, chaotic urbanization and the feeling of frustration. It is a good example of a problem all the more complex in that there is no ready-made solution and that it requires at one and the same time our imagination, our intelligence and our listening capacity, virtues which do not necessarily go hand-in-hand.

In fact development of cultures entails an absolute prerequisite the intellectual and moral development of Man, and here Science may play a definite role. Indeed, science is tirelessly educating us, certainly addressing our knowledge and intelligence, but also both our personal and social behavior – shaping our outlook on the world and even our character or our public spiritedness. And this instruction shows itself to be as essential for an industrially mature nation as in what we call habitually a "developing" country, in their standard of living or the tools they have at their disposal.

On the open-ended list of our training, an education in science is both a place to listen to the old questions which men have always asked about the world around them, and a permanent rewording of these questions, as well as a powerful tool to change it, possibly even to control it.

In an attempt to take up the challenge on science education to bridge cultures, we herein propose a three step reflection guided by the concepts of: i) Science education as an "overture to universal virtues"[1]; ii) Science education at an early age as a contribution to children's humanity[2]; and, iii) Health education as a novel challenge for the primary school[3].

2 SCIENCE EDUCATION: AN *OVERTURE* TO UNIVERSAL VIRTUES

If we first leaf through the large volume of virtues[1] that science education represents for all and in particular for those who are not destined for science, we may select three virtues among the many others that may act as bridges across cultures.

---

[1] Yves Quéré. *The virtues of a scientific education*, Nuclear instruments and Methods in Physics research B 164-165, 2000, 23-26 ; *Science and Society*, Japan Society for the Promotion of Science Millennium Forum, Tokyo, 2000 ; ibid, in : "*La science institutrice*", Éditions Odile Jacob, Paris 2001; ibid, *The role of Academies in Capacity Building*, IAP workshop, *Capacity building for Academies in Latin America and the Caribbean Region*. Rio de Janeiro, 2002.

[2] Pierre Léna, *La main à la pâte. A renovation of science teaching in France and partner countries*, Science & mathematics Education for the XXIst century, Bibliotheca Alexandrina, Egypt, June 21-23, 2003.

[3] Working group of the *La main à la pâte* team, coordinated by Béatrice Descamps-Latscha.

Table 1. Brief history of “*La main à la pâte*” in France

- 1995 - Less than 5 % of French *maternelle* schools (age 3 to 5) and *elementary* (age 6 to 11) practice any natural science.
- 1996 - Georges Charpak, the *Académie des sciences* and the *Ministère de l’éducation nationale* begin a small scale experimentation of *La main à la pâte* (**344 classes**).
- 1998 - Publication by the *Académie des sciences* of the **reference TEN PRINCIPLES** as a simple guide for teachers.
- 2000 - The experimentation has expanded as a grass-root movement and rallied over **5 000 classes**, with the *Académie*, public & private support.
- 2000_ - After a *La main à la pâte* Assessment Report, a new official Plan for quality teaching in all schools , Grades 3-4-5 (**200 000 classes**).
- 2001 - New Report : in schools, more science (10-15%), better science, more *in service* teachers training (2% => 7 %).
- 2002 - **New official Curriculum** inspired by ***La main à la pâte* .**
- 2003 - Public debate : **KNOWLEDGE <-> SCIENTIFIC ATTITUDE**

2.1 The spirit of research

By unveiling some of the great fundamental laws that govern nature, Science teaches us the immensity of what we do not know or do not yet know. It is these not-yets which generate the spirit of research, and thus the endeavour for undertaking it and therefore the ability to progress. Those for whom a scientific education has imbued the sentiment that there is a "blank page" open in front of them will undoubtedly have more respect for facts than for ideas, for ideas rather than certainties. They will certainly be inclined to think with rigor and honesty and resist the more-or-less and the preconceived. Without a doubt, if this education has had elements of a multidisciplinary approach, they will be attentive of the many different approaches we have to the world, trained to recognize when they are complementary and the mind will be tuned to subtlety. In this way science is indubitably a space which, although not the only one, is a privileged theatre for the imagination and liberty.

2.2 The gift of imagination

“Science kills the imagination” we sometimes hear, the idea being that science teaches us the limited area of what is, blocking our escapes towards the unknown, whereas art would open the doors to what could be, beyond our mental horizon, thus appearing as an antidote to science.

Nothing could be more erroneous. By unveiling some of the great fundamental laws that govern nature, science teaches us the immensity of what we do not know, or do not yet know. It is these not yet which generate the spirit of research, and thus the endeavour for undertaking and therefore the ability to progress. Science is built upon our questions about nature, which themselves open the door to our hypotheses, and thus stimulate our imagination.

Contrary to what was believed at the end of the 19th century, new knowledge does not bring us closer to a kind of "end" of research but, in fact, opens new fields of from of this particular point of view, research - in a kind of endless arborescence unknown - creates research and helps us to discover continuously the existence of new terra incognita, giving stimulus to our enterprise and to our will of going further.

2.3 The spirit of freedom

Science being par excellence a space for liberty, it constitutes a kind of humus for the spirit of freedom. How could societies develop, in the long term, with men held back by prohibitions or curbs on their thought, on their liberty to circulate, or publish? Science, its history and practice, teaches us liberty: that of a postgraduate who starts on his subject and soon frees himself from the orders of his supervisor; or that of an engineer who invents a new process, often well beyond, or in contradiction with, established ideas and his manager's directives.

Either lodged in the depths of human conscience, or expressed through visible institutions charged with preserving it (learned societies, academies, ethical committees, and so on), the spirit of freedom establishes these two virtues of mankind, creativity and dignity, two ingredients undoubtedly crucial for the culture of societies which will escape to the deadly hold of dictatorships of all kinds.

3 SCIENCE EDUCATION AT AN EARLY AGE: A CONTRIBUTION TO CHILDREN'S HUMANITY

It is indeed because these "virtues" which the example of the sciences is supposed to inculcate us with, are universally necessary for humanity that the French Academy of Sciences has supported, from the outset, the experiment in renovation of science teaching in France in the form of the "*La main à la pâte* programme" launched in 1995 by Georges Charpak[4], joined shortly afterwards by Pierre Léna and Yves Quéré. In order to realize this objective, the Academicians have also the support of a team of around 20 full time persons (The *Lamap team*[5]) and of a *Committee of partners* which is intended to give ideas and financial support to the action of the Académie.

This second part will briefly review the "*La main à la pâte* programme as it has been developed since 1995 in France (Table 1) and other countries (Figure 1), and as recently revisited by one of us[6].

The general idea of *La main à la pâte* is to cause children to participate in the discovery of natural objects and phenomena, to bring them into contact with the latter in their reality, outside of virtual reconstructions, directly through observation and experimentation (Table 2) and to stimulate their imagination, to broaden their mind and improve their command of the language, all but a few among the answers to the general question (Table 3): Why science in schools? On the teachers' side the main aim of "*La main à la pâte*" is to bridge the teacher/science gap and to contribute to their training. A number of distinct resources (Table 4) including an Internet website (Table 5) are now offered to them and guided by the golden rule to train them as children will be taught. Given the success of this French site (which received the award of the best site of the year) an international portal has also been ordered to *La main à la pâte* through the Académie des Sciences for ICSU and IAP scientists[7] (Table 6).

As a more general comment, it is unusual that an Academy, which is assumed to represent the highest level of scientific research and achievement within a country, should concern itself with the dissemination of science at the "lowest" level and show its hand in an area of pedagogical activity in

---

[4] "*La main à la pâte", Les sciences à l'école primaire* (présenté par Georges Charpak) has been translated in many languages including Arab (by Leila Benhassur, Chihab editions, 1996).

[5] Website http://www.inrp.fr/lamap

[6] Pierre Léna, *La main à la pâte. A renovation of science teaching in France and partner countries*, Science & mathematics Education for the XXIst century, Bibliotheca Alexandrina, Egypt, June 21-23, 2003.

[7] marc.jamous@inrp.fr

which it has no recognized competence. The concern of Academies for primary education is not a long-standing tradition. For them the existence of a rift between science and society is a relatively recent fact, and the conviction that the re-establishment of the confidence of adults should begin with a pertinent and enjoyable contact of children with a science close to their daily life, is also recent. Many scientists have now understood that a number of virtues which science should help us to acquire are probably more important for the child's future life than knowledge itself: these include the respect for real facts and the modesty which that should teach us; the intellectual rigour and faculty of reasoning; the perception of what can (and what cannot) be explained by science; the refusal of ready-to-wear thinking, of all kinds of preconceived ideas and of all forms of sectarianism; and, last but not least, the contribution of a scientific training to the improvement of spoken and written expression.

As depicted in Figure 1, the widespread development of *La main à la pâte* or *Hands on* well illustrates how science education at an early age could serve as a bridge across cultures throughout the world.

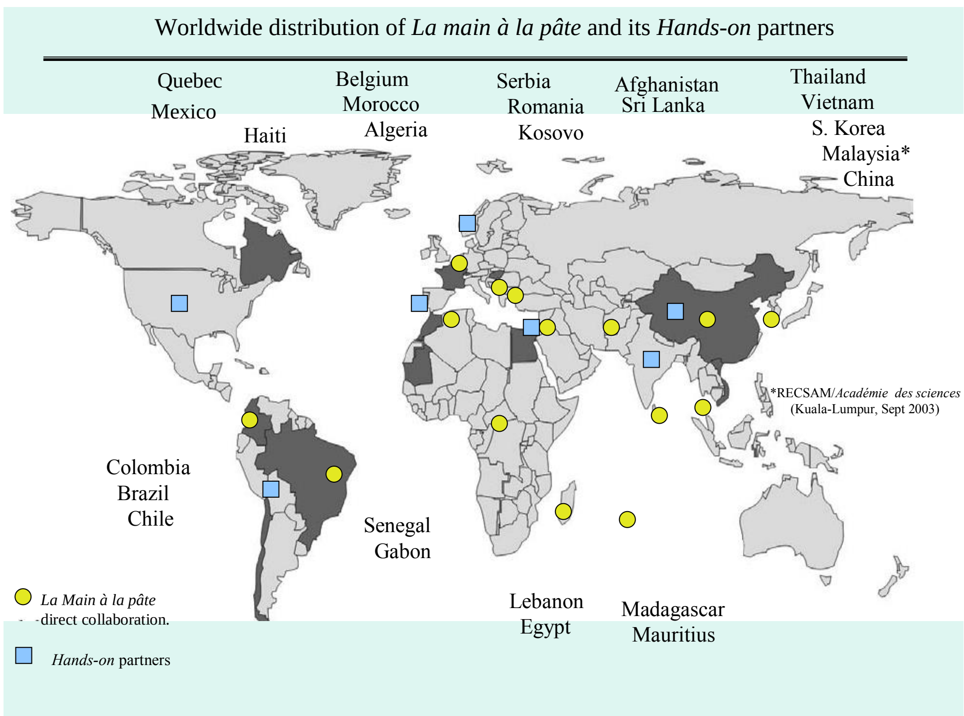


Figure 1. Worldwide distribution of *La main à la pâte* and its *Hands-on* partners.

Table 2. The *La main à la pâte* sequence

- Ask a question on a phenomenon
- Formulate hypothesis
- Argumentation* guided by the teacher
- Experimentation (or observation) *
- Dialectics reasoning <-> experimenting
- Oral & written expression*
- New experimentation
- Search for documents*
- * Collaborative work

Table 3. Why science in schools?

- To develop science and technology *(self-interest ?)*
- To improve work force capabilities *(economy,development)*
- For better share of knowledge *(justice)*
- For better contribution to solve world problems *(wisdom)*
- More rationality : fight against sectarism *(philosophy)*
- More universality : science transcends particularities *(peace?)*
- To foster the sense of beauty and value of knowledge
- *To contribute to children's humanity*

Table 4. Resources to help the teachers make science understanding & teaching possible

- An elaborate web site *(see below)*
- Connecting science to language
- Local intervention of renown scientists
- Annual Prizes at the *Académie des sciences*
- Companionship to schools (students, scientists..)
- Equipment of schools in material kits (6 M€)
- Pilot centers (currently 13 over France)
- Role of media in amplification of good practices : radio
- A « *Book of examples* » (0,5 million copies in 2003)

Table 5. www.inrp.fr/lamap

Table 6. An international portal (ICSU/CCBS & IAP)

(contracted to *Académie des sciences*, France)

For scientists, ICSU & IAP members, policy makers

- A worldwide panorama of various science teaching programs
- Examples of best quality practices ;
- Proceedings of international teaching science conferences ;
- Selection of research articles in the field ;
- Access to the science curricula in various countries ;
- Selection of relevant websites ;
- Report on the capacity building activities and resources from ICSU and IAP members ;
- A Forum for teachers.

CONTACT : marc.jamous@inrp.fr

Table 7. Health education at *La main à la pâte*

	Objectives	Teaching modules
Prevention	Accidental risks Infectious risks Environmental risks Malnutrition/obesity	Security rules Hygiene and vaccination Sun exposure* Balanced alimentation
Protection	Ill-treating Addictions (drugs, alcohol) Violence	Inviolability of the body Dangers of abuse Avoidance of exclusion
Sensitization	Handicap Ethics (identity/ difference)	Absence of frontier between the "normal and pathological" Respect, Tolerance Solidarity

*** *Vivre avec le soleil* : a novel project of** *La main à la pâte* **(David Wilgenbus)**

4 HEALTH EDUCATION: A NOVEL CHALLENGE FOR THE PRIMARY SCHOOL

Evidence has accumulated that health education is not the "apanage" (exclusive right) of physicians, of nurses or other health professionals and that it has to be integrated in science education. Indeed, both health teaching content (how our body functions, how diseases appear and propagate and how we can prevent them...) and methodology (to observe, to propose hypotheses, to verify them, to deduce a behaviour and to evaluate its results…) are scientific.

It is needless to mention that health problems strikingly differ between southern and northern parts of the world (malnutrition *vs.* obesity) and that their prevention is strongly dependent on cultural aspects and environmental conditions. In developing countries part of disease prevention already relies on health education of children (Health promoting schools, *Child to child* program, through World Health Organization and UNESCO, respectively) who thus become both actors and messengers of prevention for themselves, for other children, for their family and their community. In industrialized countries, health education is also an important task for the ministry of health and that of education, given the fact that it could largely contribute to the prevention of risks, the protection against aggressions and addictions, and the sensitization towards disease or handicap as an instigation of solidarity, respect and tolerance towards the "other." The *La main à la pâte* team has recently set up a working group endowed to propose teaching modules within these objectives of health education and which could be developed without harm at an early age (Table 7). Among these, the solar exposure risk as part of the project "*Vivre avec le soleil"*[8] is presently under development. As already achieved by *La main à la pâte* through the so-called "*Eratosthène model*" (measurement of Earth's radius) joining children from several parts of the world, this "*Vivre avec le*

[8] Proposed by David Wilgenbus (Member of the *La Main à la pâte* team) in collaboration with Pierre Césarini (Association Sécurité Solaire).

soleil" project might be an accurate challenge for science education as a bridge across cultures all over the world.

5 CONCLUSION

Those for whom the practice of research has imbued both the sentiment that there are blank pages open in front of them and the necessity of rigorous thinking, should undoubtedly have more respect for facts than for ideas and more respect for ideas than for certainties. They should be inclined to think with honesty and resist the *more-or-less,* the *preconceived,* and also the *ready-to-wear* (including sectarian and superstitious) types of behaviour. Without a doubt, if this practice has included elements of the multidisciplinary harmonics of our environment (physical and social), they will be attentive to the many different - possibly complementary approaches we have to the world, and their minds will be tuned to subtlety. Here, science education is indubitably providing a space, a privileged theatre, for imagination, creativity, open-mindedness, and thus for a harmonious development of our societies and their cultures.

Science, Technology, and Mathematics Education for Sustainable Human Development

JOHN WEBB*
Professor of Chemistry
Division of Science and Engineering
Murdoch University
Western Australia 6150
Australia

1 INTRODUCTION

The third millennium brings us into a world that is changing rapidly technologically. Yet it is a world where social injustices persist and indeed intensify. The challenge of achieving just and sustainable human development for the peoples of our world is indeed considerable. One essential aspect of this technological world is the need for communities and nations to be empowered through science, technology, and mathematics. Education in these areas of science, technology, and mathematics is not the only component of progress towards sustainable human development, but it is an essential and necessary part. Without such education, knowledge, and training, communities face a future of dependency, if not exploitation. Moreover, being comparatively (but not entirely) independent of political bias, education in science, technology, and mathematics offers an opportunity for local, regional, and global cooperation towards a sustainable future.

However, at the present time, education in science, technology, and mathematics is in a critical condition. International measures of achievement reveal disturbing trends in many countries at the same time as more and more national governments and ministries of education are looking towards science and technology education to improve the conditions of their communities. This widespread concern has been expressed strongly in recent global forums, beginning with the World Conference on Science, held in Budapest, Hungary in 1999, organized by the United Nations specialized agency UNESCO (United Nations Educational, Scientific and Cultural Organization) together with the International Council for Science (ICSU). An international conference of science and mathematics educators, held in Goa, India in 2001, echoed these concerns.

This paper, presented within the Round Table Discussion regarding *Science and the Future of the Islamic World and Humanity*, argues that it is time to address these issues by grasping the opportunity to support science, technology, and mathematics education through innovative initiatives and sustained investment.

2 MEETINGS IN TRIESTE, ALEXANDRIA AND PENANG

2.1 Trieste

The discourse and debate on science, the Islamic world, and humanity has engaged the scientific and intellectual community over recent times. In March 2003, representatives of thirteen of the Academies of Science in countries with predominantly Muslim populations gathered at the

* Science and Education consultant, UNESCO Paris, 2002-2003, Email: <j.webb@murdoch.edu.au> . Since 2004, Educational Attaché at the Australian Embassy in Delhi, India.

International Centre for Theoretical Physics (ICTP) in Trieste in northern Italy [1]. Trieste was an ideal location, for the several institutions based in Trieste have played a significant role in the promotion of science and technology capacity building in the developing world and in the advancement of South-South cooperation through the fostering of scientific networks.

The Trieste agenda included a workshop to debate ways of strengthening science capacity in the countries represented, followed by a one day symposium on the theme of Science, Religion and Values. The Workshop was sponsored by the InterAcademy Panel on International Issues (IAP, with membership from a large number of Academies around the world) with support from the Third World Academy of Science (TWAS), which, like IAP, is also based at ICTP in Trieste, the Islamic Educational, Scientific and Cultural Organisation (ISESCO), the National Academies of the USA and UNESCO [2-5]. These meetings attracted considerable international attention, with the leading science magazine and journal, Nature, devoting an editorial to the workshop and symposium as well as providing a substantial report on the proceedings [6].

At the Trieste meeting, papers presented by Prof. Adnan Badran and Prof Atta ur-Rahman, both Fellows of the Islamic World Academy of Sciences, served to highlight the difficulties and challenges facing science and science education in the Islamic world. They drew attention particularly to the low investment in science R&D: estimated at less than 0.2%, in marked contrast to that in many European countries as noted later in this paper [7]. This low level of investment has also been highlighted in the first Arab Human Development Report published by the United Nations Development Program in 2002 [8].

The Arab Human Development Report further noted that Internet use is also very low, estimated at 0.6%. Flowing from this low investment level, the science output is similarly very low. The 57 countries of the Organisation of the Islamic Community (OIC), accounting for a population of more than 1.3 billion in a world of 6 billion account for only about 2% of the world's science citations and only about 1% of mainstream journal articles. Other statistics reinforce this analysis, with approx 226 scientists/engineers per million population, in stark contrast to the approx 7000/million population in a country like Japan.

Prof. Atta-ur-Rahman noted further that the 57 countries had only 550 universities, many at a low standard. He contrasted this with the over 1000 universities in Japan. To put the funding in an international perspective, he noted that the science and technology budgets of all these 550 universities together amount to only half of that of the National University of Singapore. The GDP statistics are equally sobering. The total GDP of 57 Islamic countries is less than half that of Germany and less than a quarter that of Japan.

Although the OIC countries account for about 70% of the world's energy resources, it is increasingly clear that, in this new millennium, global economies are moving from resource-based to knowledge-based economies. This new driving force for economic and socio-economic development requires sustained investments in quality education, particularly higher education, as well as mobilizing the links between science and industry. The paper noted that Malaysia is a nation that has made the transition from agriculture (resource-based) to a knowledge-based economy. As with Korea and Taiwan, the economy had transformed from one, where in 1960, over 50% of GDP came from the agriculture sector to one, in 2000, when agriculture accounted for only 5-10% while over 50% of GDP came from engineered goods, electronics, and the like.

It is relevant to note here that the Dubai Declaration for the promotion of science and technology in the South also expressed its concern at this situation, urging Member States of the Group of 77 to 'raise the level of funding on science and technology research and development to at least 2.5% of the GNP by the year 2010' [9].

Against the background of this analysis, the participants at the Trieste Workshop committed themselves to, *inter alia*,

provide critical and constructive contributions to the development of national human resources in primary, secondary and higher education, and in public understanding of science [2].

2.2 Alexandria

Several months later, in June 2003, the recently opened Bibliotheca Alexandrina in Alexandria, Egypt hosted an international conference on Science and Mathematics Education for the 21st Century. The Director of the Library and the Librarian of Alexandria, Dr Ismail Serageldin, has a strong and compelling vision for the Library to be a centre for debate and discussion on important issues facing the world and, in particular, the region of the Middle East and Mediterranean. Science and mathematics education is clearly identified as such an issue, since it is a major factor in the socio-economic development both of nations and of the citizens within them [10].

2.3 Penang

Malaysia hosted, in April 2003, the World Conference on Science and Technology Education in Penang, the Regional Centre for Education in Science and Mathematics (RECSAM) established by the Southeast Asian Ministers of Education Organization (SEAMEO) joined with various international and national partners to host the World Conference on Science and Technology Education [11]. The Minister of Education of Malaysia, Tan Sri Dato'Seri Musa Bin Mohamad provided a warm message of welcome, noting that

The new millennium has witnessed the globalization of many areas of human endeavours, predominantly in science and technology. This phenomenon has brought about significant challenges in the development, future direction and goals of educational efforts in science and technology, especially in the least developed and developing countries.

The Minister welcomed the occasion of the conference and the discussions that it would stimulate. The opening Keynote address, prepared by the author together with Mr. Walter Erdelen, the Assistant Director-General for Science in UNESCO, explored the status and challenges facing science and technology education from the perspective of UNESCO. The current global concern for education in science, technology, and mathematics, both formally in educational institutions as well as informally in the general community, provides an excellent and urgent opportunity for UNESCO to establish its role as a leader in this area. UNESCO has valuable programs, projects and partnerships for science in schools (basic and secondary education) and universities (higher education) as well as technical and vocational education that can be developed cooperatively with strong partners. UNESCO, furthermore, is committed to support activities promoting science awareness and science communication within the broader community.

3 THE AUSTRALIAN CONNECTION

3.1 General

From the geographic, cultural and trade perspective of Perth, Western Australia, it is easy and indeed natural to look to Asia. Kuching and Perth are on the same time zone. For Perth, the nearest large city is Jakarta, Indonesia, not Sydney, Australia, and much professional and trade activity is within the ambit of Asia, particularly South-east Asia. As a fortunate victim of this geography, much of my professional work has been linked to Asia, through UNESCO science networks and through research on the genetic disease of Thalassemia that occurs widely in tropical Asia.

Diverse projects and networks supporting the development of education, research, and training in universities have linked Australian science more closely with that in Asia. As a chemist, the regional Federation of Asian Chemical Societies (FACS) has been a major pathway for colleagues around the region to meet and to work together to strengthen the chemical sciences in Asia [12]. One of the leading professional societies in the emergence of the Federation from those early meetings was the national chemical society of Malaysia, Institut Kimia Malaysia, a particularly strong society in its professional activities. The IKM remains at the centre of regional cooperation in the chemical sciences.

3.2 Iraq

For the FACS, Asia is a very broad region: in early discussions to establish the federation, in the mid-1970s, one of our partner societies was the Iraqi Chemists Union. As a member of FACS delegations, my visits to Baghdad to develop this cooperation involved seminars, lectures and discussions at the University of Baghdad as well as visiting one of the oldest centres of learning in the world, the Mustansuriyah.

Recent initiatives to assist in the rehabilitation of university science facilities at Iraqi universities and particularly to assist staff and students to continue their science in cooperation with colleagues around the world are particularly welcome. The Internet site, SciDev.net [13], supported by the two premier science journals, Nature and Science, with other partners, provides a continuing account of the situation of science and education in Iraq. As we know, science is an international endeavour, perhaps the most international of human endeavours: cooperation comes more easily than in many other aspects of human interactions.

4 SESAME PROJECT, JORDAN

The SESAME project, based in Jordan, is a current example of using science for regional peaceful cooperation [14]. The project name comes from ‘Synchrotron-light for Experimental Science and Applications in the Middle East’ and is based around the 2.5GeV synchrotron developed from the gift from Germany of the 0.8 GeV BESSY 1 storage ring and injector system. The model for SESAME is the world-famous CERN laboratory created after World War II to facilitate cooperation between scientists working in opposing sides of the Cold War. SESAME promises to become a world-class laboratory, financed and ‘owned’ by the governments of the Middle East region, providing facilities for basic and applied research as well as training of skilled engineers and technicians. Further, as the President of the SESAME Council, Professor Herwig Schopper (formerly Head of CERN) commented, SESAME will foster ‘better mutual understanding and tolerance between people from different traditions, political systems and creeds, thus becoming an excellent tool for peace building – a tool which the region now needs more than ever.’ Construction of the large laboratory facility is underway following the ground-breaking ceremony in January 2003 when HM King Abdullah II of Jordan laid the corner stone for the SESAME building.

5 CHEMISTRY’S DEBT TO THE ISLAMIC ALCHEMISTS

For a chemist, that visit to Mustansuriyah in Baghdad reinforced the awareness of the considerable debts owed to Islamic scientists, whose contributions are only too often overlooked in the historical accounts of the development of contemporary science. In chemistry, our laboratories still contain objects and technologies that were developed by our Islamic predecessors. Chemistry owes a significant debt to our alchemical ancestors such as Jabir, known as Geber in the West.

The writings attributed to Jabir, together with much other evidence, confirm that alchemy was a major contributor and force in the development of science. This contribution has been often overlooked in light of the astrological aspects of alchemy and the fact that alchemy was destined inevitably to be frustrated by its search for the 'philosophers' stone' that could change base metals such as lead into that precious metal, gold. The status of alchemy has been summarized as follows [15]:

Arabic alchemy was alive and flourishing by the end of the eighth century and ...Arabic alchemists made substantial, voluminous and influential literary contributions up to the 14th century'...

They invented many laboratory utensils and improved many others, such as the crucible, alembic, and the retort. They also advanced such chemical techniques and operations as distillation, filtration, straining, calcination, crystallization, and the preparation of chemical elements and compounds. In addition they improved the manufacture of ceramics, soaps, and perfumes.

Because of their belief in the continuance of matter, alchemists contributed significantly to the objectivity of experimentation, to the use of weights and balances, and to the concept of proportional unification of metals.

More recently, in 2002, UNESCO published Volume IV in its multi-volume series entitled "The Different Aspects of Islamic Culture." Volume IV is devoted to Science and Technology in Islam and has an extended coverage from the years of the Islamic Commonwealth through to the continuation of science and technology in the Ottoman Empire, India, and Iran [16].

This topic of Islamic contributions to science was actively discussed at the meetings in Trieste in 2003. Many references were made to the Islamic Renaissance Era (125-645/ 730 – 1250) referred to above, when science flourished. To quote from the paper presented by Dato' Dr Samsudin Tugiman, Executive Director of the Akademi Sains Malaysia (the Academy of Sciences of Malaysia), and Annuar Razak:

Muslim scientists during this era were supported by the pro-active nature of society which emphasized the exchange of ideas and knowledge freely and globally. During this period, the Islamic Commonwealth cut across colours, creeds, and geographical boundaries. Islamic society was tolerant to other religions and receptive to their universal ideas.

Muslim leaders at that time had initiated and supported a culture of knowledge seeking and sharing between the civilizations where caravans laden with manuscripts and botanical specimens plied from Bokhara to the Tigris, from Egypt to Andalusia and Embassies were sent to Constantinople and to India for the sole purpose of obtaining books and teachers.

6 SCIENCE EDUCATION

6.1 Background

Concern for science and mathematics education has been rising to the top of priorities for sustainable socio-economic development over recent years. The World Conference on Science made science education its major 'call to arms:' the future of science depends on reinvigoration of science education around the world!

6.2 International assessments: TIMSS, PISA, SITES

This ambition is the more striking and challenging when viewed together with the concern about poor performance of students in science and mathematics as measured by international studies of school science learning. The 1995 survey known as TIMSS, Trends in Mathematics and Science Study, was a cross national study of science achievement in different countries that investigated factors underlying student achievements. The study looked at many key aspects of science education: science curricula, educational policies, organization of schools, teacher training and support, student backgrounds, attitudes and beliefs, teaching practices and beliefs. The results caused considerable debate and controversy. The first TIMSS assessed the science learning of more than half a million students in 45 countries. In Australia, for example, the study involved were 11,500 students aged about 9, 14,000 students aged about 13 and 3200 students in their final year of high school (year 12). The second TIMSS, in 1999, referred to as TIMSS-R was less ambitious, focusing on 8^{th} grade students in 38 countries. Details are available on the web site of the National Centre for Educational Statistics (USA) [17].

Following on from TIMSS, in 2000 the Organisation for Economic Cooperation and Development (OECD), carried out the Program for International Student Assessment (PISA) to assess the abilities of 250,000 students (15 years old) in OECD countries to apply knowledge and skills in reading mathematics and science: that is, scientific literacy, mathematical literacy and reading literacy. A second such exercise was carried out in 2003 on mathematics, reading, science, and problem solving knowledge and skills. The PISA Plus project repeated the PISA 2000 assessment in a further 10 countries including Indonesia, Albania, Peru and Thailand. A future PISA exercise in 2006 will include 'information literacy' in its scope of student skills assessment. Details are available on the Web site [18].

One final international study is worthy of mention. The Second Information Technology Education Study (SITES) will report on innovative pedagogical practices using information and communication technologies as well as assess students and their teachers for their skills and competencies for the information society [19].

6.3 Primary (elementary) school science and mathematics education

Following the initiatives of Nobel Laureate Professor Leon Lederman in Chicago, USA in the early 1990s, a worldwide movement has grown up around the approach of '*hands-on*' teaching of science and mathematics, also known through its French equivalent, '*la main à la pate*', under the leadership of another Nobel Laureate, Professor Georges Charpak . Discovery-based primary school science and mathematics education programs have now been instituted in many countries, for example, China, Egypt and many countries in Africa, South east Asia and Africa [20] and are discussed in detail elsewhere in this paper.

The concern for science and mathematics education is not restricted to the scientific community. It is shared increasingly by political leaders in diverse countries and regions. Three instances will serve to emphasize this point: Europe, the Australian State (province) of Western Australia and the newly independent nation of Timor Leste.

6.4 Science education in Europe

The situation in Europe [21] was expressed by the European Union in a recent meeting of the European Council in Brussels, 5-6 May 2003. The context developed from the Lisbon European Summit held in Lisbon in 2000 when the Heads of State committed themselves to

Transform Europe into the most competitive and dynamic knowledge-based economic region in the world by 2010.

An ambitious goal indeed! Two years later, in Barcelona in 2002, the Summit called for a substantial increase in the proportion of Gross Domestic Product (GDP) devoted to research and innovation: this was to rise from the current 1.9% to approach 3 % by 2010. Specific goals included the following:

..the total number of graduates in mathematics science and technology in the European Union should increase by at least 15% by 2010 while at the same time the level of gender imbalance should decrease (Relatively fewer woman than men chose to pursue degrees in mathematics, science and technology and even fewer women choose careers in research).

This requires a massive increase in the number of science professionals, including those at the PhD level. Estimates for the number of additional researchers needed by 2010 are substantial, varying from 430,000 to 550,000. At the same time, surveys (Eurobarometer: Europeans, Science and Technology) reported that young people lack interest in pursuing scientific studies and careers. Yet Europe needs more scientists not less.

..by 2010, at least 85% of 22 year olds in the European Union should have completed upper secondary education (successful participation in the knowledge-based society requires the basic building blocks offered by a secondary education).

..by 2010, the European Union average level of participation in Lifelong Learning should be at least 12.5% of the adult working age population (25-64 age group) (in a knowledge society individuals must update and complement their knowledge, competencies and skills throughout life to maximize their personal development and to maintain and improve their position in the labour market).

Thus, overall: *Investment in education is one with long term returns and indirect as well as direct benefits, and most governments consider it to impact positively on several key political challenges such as social cohesion, international competition and sustainable growth*.

6.5 Science education in Western Australia

This European snapshot highlights many aspects of the current situation that is encountered, although in different ways, by all national and provincial governments. In my own State or province of Western Australia, the present Government has actively engaged with these issues [22]. The Premier, Dr Geoff Gallop (a graduate and former member of the academic staff at my University) is also the Minister for Science, quite an innovation for an Australian government at regional or national level. The newly established WA Science Council has moved to stimulate and support science education-based initiatives. Several initiatives can be mentioned:

A scheme to lower the cost to a student of doing a science degree with a teacher education career in mind.

Kids Science State: a vision for the sustainable future of science education, supplying resources to assist primary school teachers to better deliver science and technology experiences in their classrooms;

The means to achieve this include a travelling Science Roadshow developed and run by the established interactive science centre SciTech, a new expanded professional development program for teachers, Do It Yourself Science Kits for schools as well as online science activities for teachers, children, and parents. Funding is provided by the State Government in partnership with private industry (RioTinto, a major resources company).

The scope is broad and specifically includes students and their families. As the program manager stated: *We really want to get scientific literacy right out into the community. We are in the age of science and technology. How can you make informed decisions about things like genetically modified foods or new crops if you don't have some very basic understanding of scientific principles.*

Most recently, the Science Council recommended multi-million dollar funding for expanding a student mentoring program to cover all four universities in WA. In this program, already well established at Murdoch University as the STAR peer tutoring program, university students work with high school students to assist them with their science and math studies [23]. This approach has also been extended to assist students learning a second language, such as Japanese or Indonesian. In such a mentoring program (and there are many around the world) everyone seems to benefit in different but valuable ways: the high school students, the university students, and the teachers.

6.6 Science education: Support for teachers

These initiatives recognize the need to support teachers with professional development in the area of science and mathematics. One of the generalizations well supported by diverse research findings is that good science teachers have distinct characteristics [24]:

- They know their subject matter deeply;
- They know how students learn science;
- They know their students well; and
- They understand the influence of cultural, developmental, gender and other contextual factors.

We need more of these and we need to support them effectively.

This need has been addressed in other ways in other countries, for example, *La main à la pate*, or , *Hands-on science* science education programs referred to above.

The US National Science Teachers Association (NSTA) recognizes this central point in supporting science teachers in a variety of programs. As an illustration, in a recent email Newsletter, NSTA announced the release of Mixing It Up, 'a lively collection of teacher-tested ways to blend science with math, language, arts and more [25]. Each article, from NSTA's elementary school member journal, Science and Children - is categorized by grade level and by the National Science Education standards it addresses. NSTA also announced a survey asking teachers about the use of volunteers, such as scientists, engineers or others with science backgrounds, in the classroom. This has been a highly successful aspect of the *La Main à la pate* program in France over several years.

6.7 Science Education in Timor Leste

For these reasons, UNESCO has recently launched a major mentoring program for Timor Leste (East Timor) as the first step in a science education project for this newly independent nation, based on the STAR peer tutoring program mentioned above but adapted and modified for relevance to the context of Timor Leste. Funding for the Timor project has been provided by the Government of Japan, with the project being administered by the UNESCO office in Jakarta, Indonesia [26].

Other components of the project include the development of locally-oriented interactive science-exhibits, visits of such exhibits to rural villages, support for schools and support for the staff of the Ministry of Education. Partners include the National Science and Technology Centre in Canberra, Australia [27], which has developed such pedagogic and entertaining materials, using them in a travelling program through the dispersed island nations of the Pacific. A small interactive exhibition of *Science on the Move* material was held in Dili, Timor at the time of the visit by UNESCO's Director-General, Mr Matsuura in July 2003.

Timor became the newest and 189th member of UNESCO at a ceremony during the General Conference of UNESCO in late 2003.

6.8 Information and Communication Technology (ICT)

The use of contemporary information and communication technology (ICT) to support initiatives in science education has already been noted above. There are many valuable initiatives in communities throughout the world. Following the International Conference on IT based Capacity Building in Science, held in Okinawa, Japan in January 2003, the participants issued the Okinawa Statement, wherein science and maths education is a central concern:

The potential application of ICT is expected for capacity building in science, starting from education in primary school through higher education up to the training of scientists and engineers but the effective use of ICT varies depending upon the stage of education and the available infrastructure of a given society.

Today's so-called 'digital divide' is not only drawn between the rich and the poor but also between those educated and not-educated; thus education in ICT and its accessibility and availability have the inherent potential to narrow the imbalance due to the gap in income and infrastructure of the society.

And, further, the statement wisely notes….

To increase the effectiveness of science and mathematics education, the aspiration of motivation by inquiry-based, hands-on, and minds-on learning be considered essential. Technology in classrooms may enhance practice for science and mathematics education, but it should be introduced in accordance with the development of students so that learning is not simply replaced by skill of using, but is stimulated to enhance individual's creative potential.

And, for higher education and capacity building in science, higher education institutions should take the initiative in *applying ICT to create new content of education, to enlarge access to information, to foster scientific research and to share scientific knowledge and information.*

ICTs are having impacts in many challenging and perhaps surprising situations. In the June 22, 2001 issue of the magazine ASIAWEEK (sadly discontinued in the economic downturn of late 2001) the magazine could note that only 6% of people on the planet had ever accessed the Internet and half the people in developing countries have never used the telephone. Yet it could refer to several imaginative examples of ICT use, two of which were based in Malaysia, one of which was in the State of Sarawak:

- The mobile phone services for rural Bangladeshis;
- The Internet facilities in southern India (near Chennai) supporting fishermen and rural families with crop price and weather information, established through the M.S. Swaminathan Research Foundation;
- The SMASY project in Malaysia (Smart Masarakyat or, Smart Community) to bring IT to rural poor;

- The e-Bario project to bring IT services and access to the Kelabit community in the isolated town of Bario in the highlands of Sarawak.

More recently, the ‘hole-in-the-wall’ experiment in India [29], where a screen and keypad were provided in the wall of an office building on a street in a poor area: the computer firm was on the other side of the wall, supporting the computer. No sound, no notices were provided yet within a very short time, the street youth were exploring this new feature of their environment and within only a few days, they had discovered and were surfing the Internet. This ‘experiment’ was presented at the Alexandria Conference in 2003 when an agreement was reached with the computer company to establish several of these kiosks in Egypt. It was a salutary lesson on the ability of young minds to explore and learn in the face of new technology.

6.9 Science Education: Quality

At the same time as celebrating these initiatives, it is important to emphasize that sustained advancement in the quality and impact of science education must develop through research-based strategies that identify best practices and the opportunities and constraints on their being used successfully elsewhere. The community of science educators is warming to this approach: we need to know how ideas about science develop, how science is taught and how it is learnt and how choices about science careers are made. Clearly, many of the details in the answers to these questions can have cultural, local aspects. What works in Kuching may not work in Chicago or Paris. We have much to learn from each other. As mentioned above, we do know already that support for science teachers is one of the best investments that can improve the learning outcomes of science education. What kind of support works in Western Australia rather than Senegal or Argentina will depend on the cultural context in which the schools, teachers, and pupils are based.

7 CHALLENGE ISSUED BY THE UNITED NATIONS SECRETARY-GENERAL, KOFI ANNAN

This commitment to reform and reinvigoration of science education, broadly considered, is particularly important, and appropriate at this difficult time in history. Kofi Annan, Secretary General of the United Nations, has recently written to address the successes of science but also the distorted distribution of science initiatives between the developed and the developing world [30]. He calls for scientists to work together to bring the benefits of science to all and, particularly, to work together for peace. In this he refers to the contributions of the Pugwash Movement (Nobel Peace Prize 1995) [31] during the Cold War and other initiatives linking lab-to-lab in supporting nuclear disarmament, noting that:

The idea of two worlds of science is anathema to the scientific spirit. It will require the commitment of scientists and scientific institutions throughout the world to change the portrait to bring the benefits of science to all.

But no bridge that science might build across the gaps between rich and poor is strong enough to withstand the force of violence and war. If science is to reach its full potential and draw on the great minds from every country, we must do more to end and prevent conflict.

Peacemaking and peacebuilding should never be the exclusive preserve of diplomats and politicians.

8 ACKNOWLEDGEMENTS

The author acknowledges the encouragement of, and stimulating discussions with, many friends and colleagues at the Conferences in Kuching, Alexandria, and Trieste, as well as with colleagues in the Science and the Education Sectors of UNESCO.

REFERENCES

1. http://www.ictp.trieste.it/
2. http://www.ictp.trieste.it/~twas/ and TWAS Newsletter, Vol.15, No. 2 (2003).
3. http://www.interacademycouncil.net/
4. http://www.nas.edu/
5. http://www.unesco.org/ and http://www.isesco.org.ma/indexeng.html
6. Nature magazine, March 13, 2003 issue: editorial and report.
7. Atta-ur-Rahman, Bringing Science back to the Muslim World. TWAS Newsletter Vol. 15, pp11-17 (2003).
8. Arab Human Development Report 2003, United Nations Development Program: http://www.undp.org/rbas/ahdr/english2003.html
9. http://www.g77.org/sshlcst/Dubai-Declaration-Scientists.htm.
10. http://www.bibalex.org/smeconference/main.htm
11. http://www.seameo.org/centers/recsam.htm
12. http://www.facs-as.org/
13. http://www.scidev.net/index.cfm
14. http://www.sesame.org.jo/index.aspx
15. The Genius of Arab Civilization. Source of Renaissance, J.R. Hayes (ed.) Phaidon Press Ltd., Oxford, UK [ISBN 0 7148 18828] (1978).
16. The Different Aspects of Islamic Culture. Volume IV. Science and Technology in Islam, A.Y. al-Hassan (ed.), UNESCO Publishing, Paris France [ISBN 3 103830 3] (2001).
17. http://nces.ed.gov/timss/
18. http://www.pisa.oecd.org.
19. http://www.SITESM2.org
20. http://www.inrp.fr/lamap/.
21. http://europa.eu.int/comm/barcelona_council/index_en.html.
22. http://www.sciencecouncil.dpc.wa.gov.au/.
23. http://about.murdoch.edu.au/star/navpage.html.
24. http://www.acer.edu.au/.
25. NSTA Newsletter, August 26, 2003: www.nsta.org.
26. http://www.unesco.or.id/index1024.php.
27. http://www.questacon.edu.au/index_flash.asp.
28. http://www.ocean.itb.ac.id/papers/OKINAWA%20STATEMENT.pdf.
29. http://www.greenstar.org/butterflies/Hole-in-the-Wall.htm for interview with Dr Sugata Mitra.
30. K.Annan, Science for All Nations, Science Vol.303, p.925, 13 February 2004; A Challenge to the World's Scientists, Science Vol. 299, p.1485, 7 March 2003.
31. http://www.pugwash.org/.

Science for the Future of the Islamic World and Humanity

AHMAD S. ISLAM
and
FARHAN KHAN
Molecular Cell & Developmental Biology,
University of Texas T, Austin, USA

1 ABSTRACT

This paper discusses the urgent need to thoroughly overhaul the curricula at the primary, secondary as well as at university levels. Such a measure would build up the basic backbone of science students and equip them with modern concepts and theories imperative to carrying out quality research in both basic and applied fields. The paper also brings into sharp focus the fundamental flaws in the examination system of developing countries, which lay emphasis on memorization rather than on comprehension. It advocates the adoption of a semester system in place of annual in order to encourage originality and independent thinking – the two qualities that bring out creativity in a scientist with unlimited potentiality. Finally, the authors advocate the formation of a high powered committee, headed by the visionary politician and the architect of the modern state of Malaysia, Dr Mahathir to formulate educational and science policies and suggest means for making best use of S&T towards sound development of the "Ummah," both academically, economically and save it from being browbeaten by superpowers.

2 INTRODUCTION

The theme of the present conference is a logical follow-up of the one held in Islamabad last year (2002) on "Nurturing a Culture of Science in the Islamic World." Various speakers spoke at length about Muslims' outstanding contribution to various disciplines of science for over 400 years between the seventh and twelfth centuries. Their discoveries laid the foundation of various disciplines of modern science, namely; chemistry, physics, mathematics, astronomy, biological science, engineering, and medicine. In this article the dismal scenario of S&T as it exists today in the majority of the Islamic countries is discussed with recommendations that may lead to the revival of the academic environment of the golden age of Muslim scientists.

3 THE VOLTE-FACE OF SCIENCE IN THE ISLAMIC CIVILISATION

3.1 The turning point

The zeal and enthusiasm that inspired the Muslim scientists to promote and develop science declined gradually following the conquest of Baghdad by Holagu Khan in the thirteenth century. It was a catastrophe not only for Muslims but also for the whole world. The invaders not only destroyed Baghdad, a city of one million people, but also its famous library, one of the largest in the then world. The fall of Baghdad signified the end of the unified Islamic Empire.

This sensational revelation has been described in the 8th volume of a French publication series called, "When the World spoke Arabic"(1999). Most of Holagu Khan's henchmen became Muslims. When they re-established educational institutions, they only allowed schools, where the syllabus consisted of "Din-e-ilm." They thought it would be much easier to rule the country, if the syllabus was confined to religious education only. They were afraid of intellectuals. That is how the religious leaders got the upper hand. Reasoning and observations, which formed the quintessence of earlier studies and scientific investigations, were abandoned.

On the other hand, scientists from the Western World took a cue from the famous Muslim scientists of the medieval age and made rapid advancements in various fields of science. Strong reasoning and meticulous observations formed the basis of their investigation.

3.2 Current state of affairs

A literature survey of the prestigious journals such as *Science, Nature, and Proceedings of National Academy of Sciences* will reveal that hardly there is any contribution from the Muslim World scientists. On the other hand, besides those by scientists of the developed world, the articles authored by scientists from China, India, Japan, Korea, Singapore and Taiwan etc feature in these journals. Worthy of mention in this connection is that due to lack of articles in various disciplines of science, the Islamic Academy of Science decided in 1998 to confine its publication only to the Medical Science; and as such the original name of its Journal was changed from *J. Islamic Academy of Sciences."* to "***Medical J** Islamic Academy of Sciences.*"*

3.3 Muslim scientists in the USA and Europe

Interestingly, when Muslim scientists move to laboratories in the Western world, some of them do wonders. The Egypt-born, Caltech Professor, Dr Ahmed Zewail won the Nobel Prize in 1999 for demonstrating how atoms in a molecule move during a chemical reaction in a matter of a millionth of a billionth of a second called femto (10^{-15}) second.

A year earlier in 1998, the USA-born Molecular Medicine Professor at UT Medical University, Houston, Dr Ferid Murad, (whose father migrated from Albania) shared the Nobel Prize with two other scientists in the field of medicine for their discovery that nitric oxide (NO) - a short-lived gas within the human system acts as a signalling molecule in the body.

3.4 Why is science backward in the Islamic world?

An in-depth study into the continuous backwardness of the Islamic world in the field of science will reveal that the major reasons for this uncomfortable situation are as follows:

3.4.1 Replacement of English with local languages to teach science

Many of the Islamic countries, namely, Pakistan, Bangladesh became independent after the Second World War. Out of a false sense of national pride, some of these countries; Pakistan and Bangladesh, replaced English with their respective native language, even on science subjects such as physics, chemistry, mathematics, biology etc.. The outcome of such a drastic change was disastrous. The science books published in local languages were far inferior to their counterparts in English, both in the quality of illustrations and subject matter.

3.4.2 No steps taken to bring out quality science books in local languages

If the government in such countries was extra careful in compelling the publishers to bring out locally printed books as good as those by foreign publishers, such an intellectual debacle would not have happened. Let us take one example, that of a geography textbook written by

* The main reason for relaunching the Journal of the Islamic World Academy of Sciences as a specialized Medical Journal was due to the fact that the majority of articles coming in were medical articles. The IAS has plans to launch other science journals to address other disciplines in the future (M. R. Zou'bi).

Dudley Stamp. Vernacular textbooks published to replace the above textbook were of poorer quality, thereby standing in the way of students from attaining basic concepts in various sections of geography. More often than not, students were obliged to memorize lessons without understanding the theme and the substance underlying the text. The effect was compounded when the students trained under this system became teachers and began to impart lessons in which they themselves did not have sufficient knowledge.

4 THE WAY FORWARD

4.1 Introduction of English from the elementary level

Whether we like it or not, English is the international language and for the progress of S&T, introduction of English from the elementary level is vital. Reasonable efficiency in English will enable the students, if they so wish, to go abroad for advanced studies in various fields of science, technology, medicine and engineering. However, attainment of efficiency in English does NOT on any account mean undermining local languages. The traditional courses in local languages such as Islamic/religious studies, those pertaining to the history and heritage of the concerned Islamic country should continue to receive equal importance.

Introduction of English at the second grade will have two main advantages: (a) It will open a gateway to higher learning and research both at home and abroad, enabling the high school and graduate students to grapple with different courses which are all in English at the higher level; (b) exposing the general public to the world of science and technology through popular science journals which are mostly in English.

4.2 Transition of the local language into English

Transition from the local language into English needs to be gradual without disrupting the system all at once. If the changeover takes place, two grades at a time beginning from the second grade, then it will take only five years for the transition, namely, by then in all classes teaching of science subjects will be through the medium of English. It may be mentioned here that the US government has recently made a liberal grant of $100 million to Pakistan for implementation of their educational reform program. This financial assistance to Pakistan will doubtless strengthen the educational projects in that country.

4.3 Cramming vs. originality

Cramming is an easy way out for a student to handle the material that he does not understand. Often the British are blamed for the present defective educational system that encourages cramming and at the end of school years produces clerks and not intellectuals. This is by no means true. Till 1939, there used to be no prescribed courses for English and local languages except for 30%. In other words, questions only for 30% of a paper were asked from prescribed text books and the remaining 70%, comprising grammar, essay and précis writing, translation and grammar were set from books not prescribed in the syllabus. This made the students voracious readers. They would read a wide range of books in order to pass out their examinations. This practice made them proficient in English and helped them develop originality.

On the other hand, from 1940 onwards, the curriculum took a 180 degree turn. Out of 200 marks for English, only 30% of the questions were set from unselected books and literature and the rest i.e., 70% from prescribed books. Gradually students lost their ability to express their thoughts and ideas in their own words. Instead they started cramming, sometimes without understanding. Obviously then, the modified curriculum started off on the wrong foot and it killed the spirit of originality of the students of the Indian subcontinent. This practice is still continuing.

Still there is time for these Islamic countries to go back to the pre-1940 system in which originality is encouraged. In addition, the semester system should be introduced forthwith. The combined effects of the two: (a) a switchover from the local language to English from elementary level and (b) from annual to semester system will create a congenial environment for the growth of science and technology in the Islamic countries.

4.4 Restructuring teachers' certification program

With the rapid advancement of knowledge accompanied by information technology explosion, there is an urgent need for fresh recruits of teachers to learn modern teaching methods. In-house training in these innovative methods needs to be arranged for the teachers who are already in service. Gradually the whole teaching staff, irrespective of their length of service, would undergo training in the new teaching methods. Such a well-trained posse of teachers will produce the right kind of students, capable of demonstrating their originality in answering questions.

Gone are the days when after graduation in science or arts stream, one would become a teacher without undergoing the certification courses. Now, in developed countries, a teacher interne needs to pass a series of compulsory instructional courses after his/her graduation. It is only after successful completion of the prescribed courses do they obtain teacher certification, entitling them to teach in a school. They decide what level of school they would teach before joining a particular stream of certification program.

4.5 Responsibility of instructors

They will bring home to the students that memorization without understanding is no knowledge and it amounts to regurgitating the information on the examination day. Furthermore, some of the teachers' training courses can be integrated into higher degree programs for those, who would opt for teaching profession. One of the techniques that is advocated currently to promote original thinking, is to reward top students with extra points and penalize those who memorize by deducting their marks. This method has been found effective in forcing students to stop cramming.

4.6 Overhauling of Secondary and Higher secondary education system

It is human nature to cling to the old system and oppose innovations. However, if there is something good in a new system, we should adopt it; and if necessary to modify it to suit the country's need. The annual system might have served well in the past but now it cannot cope with the galloping progress of multifaceted science subjects. At one time it was estimated that every ten years, knowledge was doubled but now it takes place every alternate year. By the time an article is published in a journal, it becomes outdated with more exciting findings, sometimes replacing/modifying the older notion. Then there is Internet that brings to the forefront the most recent knowledge. It is, therefore, high time that the annual system is replaced by semester system.

4.7 System reform

4.7.1 Annual vs. semester system

As against the annual system where a student needs to remember whatever courses are taught over the span of full one year, the semester system usually runs for 14 weeks. The teaching is done for 12 weeks and the last two weeks are reserved for holding tests and preparation of test results. In other words, the semester system does not overburden a student compared to the annual system, where the pressure of work is built up all through the year. A student needs to store in his memory a huge body of information, making it difficult for him to do well in the test. More often than not, the annual system encourages a student to depend on his luck. He chooses a few questions. He does well if he finds the same questions which he had chosen for the particular test.

4.7.2 Essay type vs. multiple choice type questions

Essay type questions are now considered out of date as they only test a student over a small range of concepts as opposed to the widely accepted multiple choice type which covers the entire syllabus. Furthermore, the latter type has a built-in mechanism that ensures that only those students, whose preparations are thorough, score the highest. The implementation of the multiple choice system will also eliminate cheating in the examination as no two multiple choice tests have the same form. It will help evaluation of answer papers through computer-aided programme, leaving no room for foul play. It will eliminate all human errors or unfair grading and ensure completion of results of a test within a short period of time.

4.8 Upgrading the curriculum

The books that are currently used are outdated because continuously new knowledge, based on new findings and information, is being added. Furthermore, innovative techniques to present the material should replace old methods. The material need to be presented in a straight forward and an interesting way without making the subject matter more complicated. The teaching would gain momentum and will become popular among students, if the lessons are backed by matching videos and CDs. The lecture theme and its elaboration should be such that it must inspire the students to think for themselves and develop problem solving skills and strategies that are essential to pursue research and more advanced education. Application of modern teaching methods and techniques will hasten the learning process. There is no way of looking back; it is high time to give up the old system and use modern appliances and more proven techniques in order that the students passing out from Islamic countries can compete with their counterparts in all disciplines of science and technology

5 THE INTERNATIONAL SCENE: SOME EXAMPLES

5.1How the recruitment of university staff members is different in a developed country vis-à-vis developing countries?

Let us describe the chain of events that takes place in a developed country in the recruitment of a junior staff member and compare it with those that occur in a similar situation in a developing country. Last year an assistant professor was to be appointed in the Department of Molecular, Cellular and Developmental Biology, University of Texas at Austin. Among many applicants, only four were short-listed. On the basis of seminar lecture presentation, only one Bangladeshi, a post-doctoral fellow in Berkeley, was selected. After the selection, the scholar was asked about the amount of lab space, and the new equipment he would require to set up his lab. After some negotiation, he was given three rooms and about $60,000 to remodel his laboratory with new equipment. Adequate recurring expenditure was also given to him for running his lab for research purpose. In contrast, a newly appointed teacher in a university of a developing country is to share a room with a junior colleague but neither is he given lab space nor any money to do independent research. He applies for funds and gets a small amount from the Ministry of S&T, or any other government source, if he is lucky. He gets frustrated, joins a political party in order to advance his cause for promotion, instead of competing for a higher post through research.

In order to harness science and technology for the benefit of the Islamic world, young PhDs should get all the facility as their counterparts in a developed country. Such a step is crucial. They should be given adequate grants, so that they can continue their research and channel their research work on problems related to the development of their respective country. They should get funds to buy essential equipment and reagents to run their labs and at the same time be made accountable for their research work and scholarly conduct. Active politics must not be allowed to enter the portals of research institutions, where utmost dedication is *sine qua non* to achieve significant results both in basic and applied science subjects.

5.2 India's progress in science and technology

Of relevance in this connection is India's plan, adopted over 22 years ago to build up excellent laboratories in all disciplines of science and technology including those in biotechnology. The senior author had the opportunity to visit a molecular biology lab in Hyderabad, India. There he met one well known Indian scientist, specializing in biotechnology of reptiles. When the author asked him about his previous experience, he said that prior to his joining the institute; he had worked in the Department of Genetics, Edinburgh University for 14 years. He continued to say, "Why should I not come back to my own country when I found the facilities in the UK and India are the same? Difference of salary does not matter because here I have the satisfaction of serving my country and on a problem directly related to the benefit of India." If Muslim countries build up state of the art laboratories, backed up by ancillary facilities, then the majority of their scientists, now working in different parts of the world would come back. After all, none wants to leave the country for good, unless he is forced to do so in order to further his research interest and career.

5.3 Pakistan's move to create centres of excellence in the country by inviting eminent expatriate scientists

Some Islamic countries have already taken innovative steps to establish centres of excellence in their countries. For instance, the Higher Education Commission of Pakistan has recently launched a "Strategic Vision and Planning program."[6]. Under this program, expatriates of outstanding calibre will be recruited in various fields of science and technology. Comparable salary and laboratory facility will be their inducement. They will be hired on an assurance that they would be given adequate funds to set up excellent research facilities. The world famous institutes like HEJ, located in Karachi University Campus is a sure proof that such promises, to be given to eminent expatriate Pakistani scientists at the time of their appointment, will be honoured. The same architect, Professor Atta-ur-Rahman, whose vision and dedication made it possible to the creation and running of the above institute is now the Minister of Education of that country and the above ambitious plan would surely materialize under his dynamic leadership.

6 ROADMAP FOR ACTION

6.1 Can Nobel Laureates help?

Bureaucrats in developing countries fail to see things beyond their limited knowledge and capacity and hence the necessity to get the guidance of the two Nobel Laureates, Ferid Murad and Ahmed Zewail in reforming the entire educational system in the Muslim world. The voice of Nobel Laureates will have more influence than that of any within the individual scientific community in a Muslim country. From that point of view, IAS deserves all our admiration because it took that momentous move by arranging the keynote address by Nobel Laureate Prof. Ferid Murad at the inaugural session of the Kuching Conference. It was the right step in the right direction. It will be a good idea to invite the other Nobel Laureate, Professor Ahmed Zewail to any of the IAS Annual Conferences to be held within the next couple of years.

Without further loss of time, IAS and COMSTECH may jointly make a move in requesting OIC to approach the above two outstanding Muslim scientists to design a Master Plan with the help of experienced scientists from within and outside Islamic countries. Non-

Muslim scientists who are sympathetic to our cause may also be invited for this purpose. Given the authority, the two world class scientists would be able to give solid pieces of advice on the restructuring of S&T policies and recommend activities for implementation of those policies. They would be able to suggest remedial measures to set wrong things right in the educational system, prevailing in the Islamic world. The implementation of their suggestions will have a profound impact on the development of economies of Muslim countries.

All out efforts must be channelled to excite the young and active scientists' mind in Muslim countries about science. It is through such programmes, that young minds and youth will be inspired to do scientific research. The recent effort made by Nobel Laureate Ahmed Zewail deserve special mention in this connection. He has recently launched an innovative program in his native country, Egypt. Ahmed Zewail wants young people of his country of origin (Egypt) to be excited especially in fundamental science as much as their counterparts in the United States." He visited high schools such as the one in Alexandria that already bears his name and to which he donated a portion of his Nobel Prize money. IAS may approach both NL Zewail and Ferid Murad to undertake a world tour and lecture in selected schools to inspire the young minds. In fact, their lectures can be video-taped and distributed throughout the length and breadth of the Islamic countries to carry their extremely valuable message.

6.2 Help from Dr Mahathir

For over 22 years, during the period when Dr Mahathir Mohamad was the Prime Minister of Malaysia, he tried to convince the "Ummah" both within and outside his country, of the importance of S&T in their respective country's economic development. In his recent speech in the School of Oriental and African Studies, London, he reiterated his stand that in order for the Muslims to march forward, they must redefine the meaning of "Ilm." The speeches of this great statesman have been published by the author himself (Mahathir, 2002). Policy makers of the Islamic world should critically study this great leader's speeches. Once they understand its implications, it would be easier for them to implement the policies laid down there, in order to reap the benefit of science and technology for the economic emancipation of their respective country.

6.3 A dialogue between religious scholars and policy makers in science and technology

It is high time that a meaningful dialogue between religious scholars and policy makers in science and technology be held under the auspices of OIC to interpret the meaning of "Iqra." Once and for all, it should be decided that "I'lm" denotes NOT "Din-e-ilm" alone, but it encompass the entire sphere of knowledge, irrespective of whether it is religious study or pure or applied science, medicine, engineering, astronomy or technology. In the medieval ages, some of the pioneer Muslim scientists, who were world famous for their outstanding contributions to science, were deeply religious in their outlook and memorized the whole *Qur'an,* before they had started their scientific career.

7 CONCLUSION

Now is the right time for the "Ummah" to present a united front in bringing out reform in our education system. We have all the components to undertake this gigantic task: (a) the willingness of the majority of Islamic countries to utilize S&T to confront our adversaries who are bent upon controlling our freedom, culture and tradition; (b) the service of the great visionary, Dr Mahathir to head any team set up for this purpose; (c) the possibility of engaging the two Muslim Noble Laureates to the realization of our undertaking.

Losing this golden opportunity will put us back perhaps permanently. The intellectual damage caused by the Mongols has already lasted 800 years. We do not want to wait any longer because that will mean losing our identity gradually. If we still remain inactive and do not reap the benefits that S&T can offer us, we would be relegated to the status, where our voice will be quashed by superpowers. We would turn into their silent partners without having our say in matters of vital importance to the preservation of our sovereignty and culture.

REFERENCES

1. Ahmed Zewail: http://www.nobel.se/chemistry/laureates/1999/
2. Bernhard Elsner (1999), L'age d'or de l;Islam (Lorsque le monde parlait Aarabe): When the World Spoke Arabic (12 x 26). Documentary series by Philippe Calderon and Mahmoud Houssein.
3. Ferid Murad: http://www.nobel.se/medicine/laureates/1998/murad-cv.html
4. Islam A. S. and Khalid W. Islam, Nurturing a Culture of Science in the Islamic World. 12th Annual Conference of Islamic Academy of Sciences held in Islamabad, Pakistan.
5. Mahathir Mohamad (2002) "Globalization and the New Realities: Selected Speeches of Dr Mahathir Mohamad, Prime Minister …" Ist edition.

*6. ECN: FYI: Job Opportunities: Pakistan Needs Highly Qualified Faculty (http://www.mail-archive.com/ecn@smartsmtp.super.net.pk/msg00085.html)
(The goal of this program is to hire 300 foreign faculty members each year for the next 5 years to fill the vast gap of qualified research academics and PhD supervisors in the higher education sector in Pakistan.)

Ground-Rules for Gainful Interaction between Science and (Revealed) Religion for the Future of Humanity

M.M. QURASHI
and
S.M. JAFAR
Pakistan Academy of Sciences, Islamabad
House 4-A, St. 14, F-8/3, Islamabad

1 ABSTRACT

The use of S&T has always progressed according to the needs of mankind, but this progress has been particularly rapid in last 200 years. Some typical benefits are exploration of marine resources, air travel, conquest of space, computers and internet, agricultural and industrial production, health and pharmaceutical products, energy, nuclear power and renewable energy. Misuses of these beneficial advances have arisen largely because of poor adjustment of human ethics to these fast growing facilities. These misuses are enumerated and the horrors of biological and nuclear misuse are under-scored. A possible remedy through positive interaction with ethics and religion is suggested, with special reference to potential threats from the above as well as electronic media.

2 INTRODUCTION

The last fifty years have seen not only a tremendous increase in the variety of manifestations of industrial production, but have also shown how humanity has become more “animal” and less “human,” with the increasing emphasis on science and technology. Mankind has been endowed to use the natural resources of the Earth and the forces of the universe for beneficial purposes of diverse nature, from the earliest times. These include, among others, the collection of food, storage, and preparation of meals, defence against natural enemies, such as wild beasts and other harmful creatures, as well as making use of natural shelters and man-made dwellings for living. Science provides man with these and other material facilities, while the spiritual side of man yearns for fulfilment through aspirations towards the divine.

In order to balance itself between the often opposing forces of materialism and spiritualism (see Figure 1), mankind stands in need of a model that can be understood and followed[1]. The basic guidance is provided in the revealed religious books of God. These scriptures are a source of social and moral guidance, and draw a great deal of strength from references to God’s creations existing in various forms in the universe, including scientific phenomena.

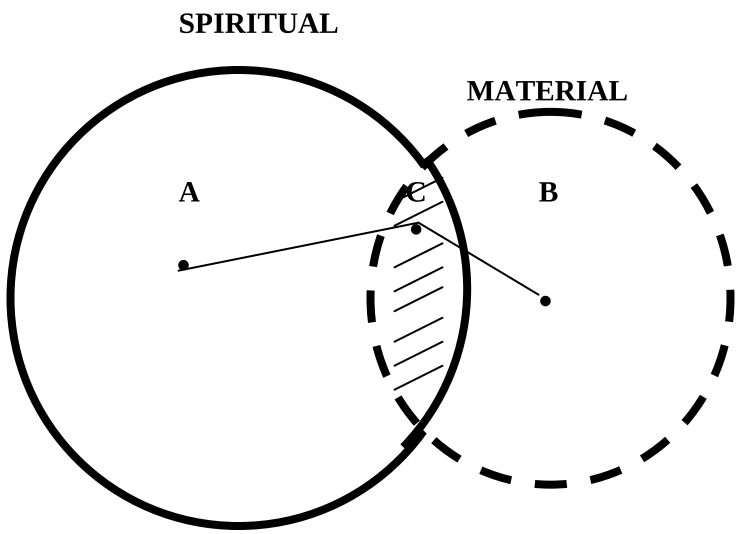


Figure 1. Spiritual and social sciences (A); Material and natural sciences (B); and Man (C).

3 PROGRESS AND BENEFITS OF SCIENCE AND TECHNOLOGY

3.1 General

The state-of-art of the use of science and technology, over the centuries of human existence, progressed according to the needs of the particular era of human civilization. However, the period of the late 19^{th} and 20^{th} century, plus the recent years of 21^{st} century have witnessed phenomenal and even mind-boggling growth and progress in science and technology. Some of the mile-stones in the progress of science and technology over this short period of about 200 years are mentioned below.

3.2 Exploration of marine resources

Special techniques have been used for extensive survey of biological and mineral resources in the deep sea and the continental shelf. Drilling for oil-resources below the sea-bed has been achieved successfully. Tunnel-construction under the sea-bed has now made it possible to travel between the continents by rail and road, not to mention Nuclear-powered submarines.

3.3 Air travel and conquest of space

Jumbo-jets, travelling long distances with high sub-sonic, and even supersonic speeds, have drastically reduced travel-time between distant continents across vast oceans, and over high mountain peaks, so that “breakfast in Pakistan, lunch in London and tea in the USA” is a commonplace, using shortcuts by flying over the North Pole. Special aircraft and helicopters have been used for landing and take-off in difficult mountainous terrain.

Man has been able to land on the moon. Inter-planetary travel has already made it possible to probe some other planets of the solar system, including Mars and Jupiter. Man has established space-stations from where he shuttles back and forth to earth. Satellites have been positioned around the earth for weather-forecasting and issuing warnings about cyclones and floods. Other satellites have been placed in space, for survey of earth-resources, monitoring spread of diseases in forests and crops, and movements of wild life.

3.4 Use of computers and the Internet

Progressive development of high-speed computers has made it possible to store, process and analyse data within seconds, which would have taken days, months and even years to process through the manual processes: design of aircraft and rockets would not have been possible without these. Transmission of messages, data and even voice-mail cheaply through the Internet has now made it possible to transact business, access information, provide educational and recreational programmes across the world, making distance-education, e-commerce and video-telephony a reality.

3.5 Advances in agricultural and industrial sector

New biological techniques were developed during the 19^{th} and 20^{th} centuries. Production of agricultural and livestock resources has increased manifold through the application of many such techniques, notably genetic engineering, irradiation, tissue culture and cloning. Embryo-transfer in livestock and hybrid poultry production have brought about revolutionary changes in structure of the meat, milk and poultry industry, with manifold increases in production.

3.6 Energy and renewable energy sector

Energy is the basic need of mankind from the earliest period of its existence. Use of fossil fuels in the recent period of about a century has ushered in revolutionary changes in the socio-economic and industrial life of mankind. The position of Islamic countries in the changing international socio-political scenario is reviewed here briefly.

Islamic countries have been endowed by *Allah* with vast resources of fossil fuels, but it is an irony of fate that the exploration, drilling, production and refining operations of these resources have been performed by the developed nations because of lack of S&T capability in the Islamic countries, and so the vested interests of technologically advanced Western countries led to adoption of exploitative practices, whereby crude petroleum was purchased at extremely cheap prices whereas they supplied industrial goods and defence equipment at unjustifiably high prices. Only after 1970 did the Islamic countries take some corrective measures and used the OPEC to make decisions regarding cutting down of production of crude petroleum for correcting the supply and demand position to secure better prices in the international market.

In addition to the conventional sources of energy, an additional source of energy in the modern era is the nuclear energy. Gigantic nuclear power plants have been built in the fossil-fuel deficient Western countries and a few developing countries. These plants, although planned originally for beneficial purpose, are plagued by international politics of the UN members and although the IAEA has been created to bring nuclear facilities under its safeguard, it has not been able to make it fool proof.

A more recent addition to the energy resources is that of renewable energy resources, including solar energy, wind power and hydrogen from water, which are freely available in nature, but the technology for harnessing these is expensive and mostly still in the research and development stage. However, these offer great promise for the future of humanity, being pollution free and “cost free.” Islamic countries, especially those deficient in energy resources, should pool their R&D efforts for making use of this free gift of nature.

3.7 Advances in the health and pharmaceutical sectors

Use of antibiotics and immunological techniques, mostly developed during the 19^{th} and 20^{th} centuries, have contributed significantly to the control and eradication of deadly diseases, such as smallpox, tuberculosis, malaria, polio, and numerous other parasitic diseases. Advanced surgical techniques have been developed during the last fifty years for repair and replacement of defective and damaged human organs, such as kidney, limbs, bones, heart, eye cornea and lens, brain tumour, endocrine glands. Cloning techniques have lately been developed for "manufacturing" body-parts from stem cells. Use of nuclear medicine, radiation, and diagnostic techniques have helped in curing cancer and malignant diseases in the early stages.

4 EXAMPLES OF MISUSE OF MODERN SCIENCE & TECHNOLOGY

4.1 General

The above-mentioned benefits have been achieved, for the welfare of mankind, through the peaceful exploitation of the resources of the Earth and the universe, as ordained by God. However, the greed of man, misuse of power, intrigues and sinister motives have gradually changed the face of the Earth into a veritable "hell." Science and technology have been misused mostly for self-agrandization by developed nations, at the expense of poor ones, and then for the destruction of human life, wasteful exploitation of natural resources and environment, on a scale unprecedented in human history. Typical examples are given below.

4.2 Energy resources

Excessive burning of fossil-fuels for industry and transport by developed nations has caused serious damage to the Ozone layer, resulting in global warming, climate change and consequent risk of flooding of coastal cities and harbours. Activities causing environmental degradation have seriously disturbed the ecological balance of the planet Earth, with consequential phenomena of acid rain, soil erosion, and desertification.

'Energy resources' is the area of greatest misuse and a source of continuing conflict between nations. Control and monopoly of oil and gas reservoirs has been the root-cause of wars and large-scale destruction in the modern era and its continuation into the present-day world, Islamic countries and other developing nations being mere "spectators" in this intriguing game. Even the Security Council, the "Policeman" of the UN is a mere show-boy of the Super Powers.

4.3 Nuclear power

The peaceful and beneficial use of nuclear power has been diverted by the "evil-inspired" man for making highly destructive nuclear weapons. Threat of atomic war and resultant "sleepless nights" and indeed years of cold war has kept humanity from enjoying the fruits of S&T endowed by the Beneficent God. Non-Proliferation Treaty (NPT), and Comprehensive Nuclear Test Ban Treaty (CTBT) and all sorts of treaties and conventions devised by the UN and regional organizations have failed to provide fool-proof security and peace to humanity. The destruction of Hiroshima and Nagasaki cities by two atom-bombs dropped in World War II is perhaps the worst example of human selfishness and barbarism. The entire human population, along with the animal and plant population of the immediate area has been wiped out. The tragic misery does not end with the affected generation. Its after-effects are continuing, in and around that area, and will continue to perpetuate for generations, producing maimed and crippled individuals.

4.4 Missile technology

Once developed for placing weather and communication satellites in orbit, this continues to be misused for developing weapons of mass destruction (WMD). Inter-Continental Ballistic Missiles (ICBM) loaded with nuclear war-heads are ready to be fired with a push-button!

4.5 Effects of electronic and Internet services

Revolutionary advancements in electronics and Internet services are the latest and the most "influential" media in the 21st century, which provide numerous beneficial services to humanity, including distant education, e-commerce, news telecasting, recreation, documentaries, weather reports, advertising, accessing information from web-sites, storage and processing of data with "supersonic" speed. However, this is also the area of human activity which has been, and continues to be exploited the most for propagation of unethical, and quite often camouflaged motives of countries, especially the developed countries and their Multinational Corporations (MNCs) who possess the most advanced electronic services.

They are also used for subversion, sabotage, ethnic genocide, creating war-hysteria and corrosion of moral values. At the individual level it is being misused extensively, especially by the youth, for perverted indulgence in sex, pornography, drugs and violence-inciting video films and CDs.

5 DEHUMANIZATION DUE TO TECHNOLOGY AND INDUSTRIALIZATION

5.1 General

Man was created as vicegerent of God and steward of all the resources of the universe. Science and technology are the tools which he has been using for the achievement of his goals, but in the modern industrial era, man has degraded himself to the level of a mere "cog" in the mechanistic world (of the modern era), forgetting the basic purpose of his mission. His current status may be compared to that of a "robot." The fast pace of life in the present industrial age has broken the most sacred institution of humanity, the family unit. Old parents, who were symbols of respect, love and cohesion in our societies, are now a "burden" on the new-generation couple; they are dumped in "old-age homes," where they pass the last days of their life in semi-isolation, cut off from their family.

5.2 Gender equality

The catchy slogans of "equality of gender" and "freedom and equal rights" of women have solved none of women's problems; rather they have been trapped in a more disadvantaged and exploitative situation than before! The much publicized laws against "sexual harassment" have proved to be ineffective and toothless, whereas the work-place atmosphere continues to be plagued with all sorts of abuses, inflicted on the "weaker sex" by the "sex-hungry" male.

Nudity and sex-appeal are used in almost all advertisements, even when the product advertised is exclusively for men's use, such as a razor for shaving the beard. Woman is the "front window" show-piece in the reception office and as "secretary" to the business executive. Woman of the modern industrialized world sits on the "pinnacle" of her glamorous position, ready to be "used, misused and abused" by the so-called "civilized" society.

5.3 Influence of IT

Electronic and computer advancements have made it possible to perform labour-intensive jobs, in minutes and seconds, which previously required months and years to accomplish. This most important gift of science and technology to human society should thus provide spare time for humanistic, altruistic, and educational pursuits, and above all his obligations to his Benefactor and Creator by way of prayers, remembrance (Zikr), and service to his fellow men; but does it?

5.4 The dehumanised man

Unfortunately, the dehumanised man in this mechanistic industrial era has abandoned this primary mission conveyed to mankind through His Prophets. All revealed religions conceive of humanity as a universal brotherhood endowed with the mission of practicing and conveying to his fellow men the message of the Creator of the universe for social and moral guidance of their conduct in accordance with the code of ethics for a gainful and harmonious life in this world and in the Hereafter.

6 EVOLUTION OF SOME GROUND-RULES FOR GAINFUL INTERACTION BETWEEN SCIENCE AND RELIGION

6.1 General

The revealed religious scriptures are sources of social and moral guidance, but at the same time they draw a great deal of strength from references to God's creations existing in various forms in the world around us. Repeatedly, we are called to look around us, to observe, to ponder over the works of God and to reflect on the history of nations. Of course, everything in the universe is there for man to make use of. The proviso is that man should use these in accordance with the guiding rules given by God and His Prophets, who foretell a world Hereafter.

So, it is incumbent on mankind to study and use the things of this world, primarily as a means to the 'harvest of the Hereafter' and not as an end in itself. Such a symbiosis was highly productive in the golden prime of Islam, which produced over one hundred men of towering stature in science. This clearly implies a state of harmony between our spiritual aspirations and the study and use of nature, as also between the two sources of knowledge, viz. reason and revelation[2(a)]. It is a fact that these two sources are sometimes difficult to reconcile or harmonize, as appears from history of the relationship between the Sciences and Religion, wherein we apparently have considerable diversity of views. By definition, there are certain domains that are specific to religion and certain others which are specific to sciences. However, there are regions where there is considerable overlapping and interaction (Figure 2).

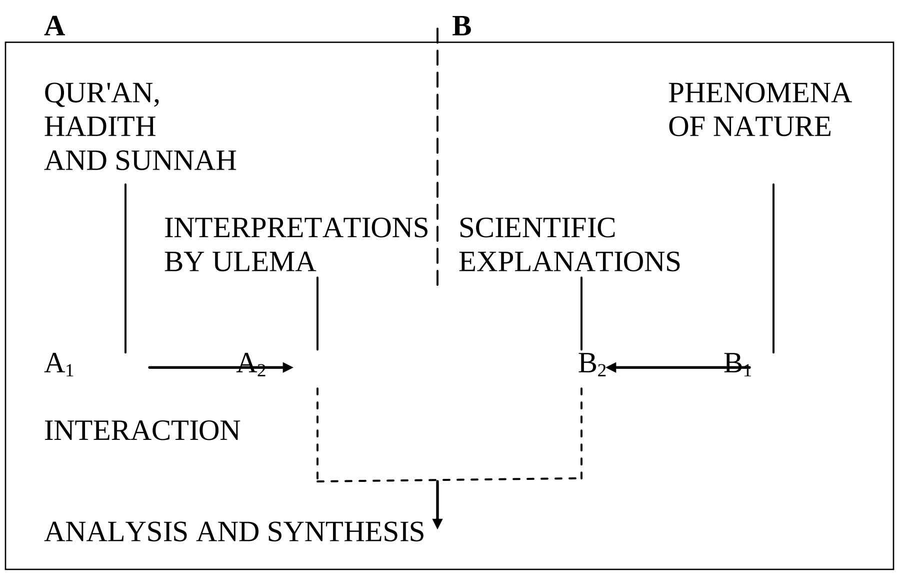


Figure 2. Interaction between science and religion.

It is in this region of overlapping that serious difficulties can and often do arise[3]. These demand revision of some of the processes or premises in one or both of these views.

The significant interactions occur between A_2 and B_2, i.e., between interpretations of *Ulama* and the scientific explanations. In general, three main alternative situations can arise viz:

(a) Conclusions $A_2 \equiv$ Conclusions B_2
(b) Conclusions $A_2 \sim$ Conclusions B_2
(c) Conclusions $A_2 \neq$ Conclusions B_2

The majority of cases fall in situations (a) and (b), but the few that come under category (c) need a great deal of serious attention for their resolution.

The solution to the problems will probably emerge gradually, by taking the basic statements of the revealed scriptures to be as fundamentally and literally ‘correct’ as are the observed phenomena of nature[2(a)], and channelling further research with a view to looking for the missing or mislaid bits of information that would tie things together and thus make an overall coherent picture. This is of utmost importance to mankind today. What is needed are studies appropriately developing scientific and religions viewpoints, in order to establish the dimensions and parameters of a truly appropriate religio-scientific methodology. These efforts should ultimately result in a stable and practical relationship between reason and revelation, leading to the release of tremendous intellectual energy. The role of proper utilization of these sources should help to resolve the conflicts, contradictions, and scientific infertility that largely exists within the religious scholars and the scientists.

6.2 Proposed principles for coordination of science and Islamic Thought

(a) Basis

God, created mankind, and also arranged to send them His guidance through His chosen people, the Prophets. They invited mankind to follow the righteous path and abstain from evil deeds, in order to gain the pleasure of Allah and obtain entry into paradise on the day of judgement. The Holy *Qur’an* is the last revealed scripture of God, and the Universe is also the creation of God. This implies a state of harmony[2(a)] between the phenomena & laws of nature and the verses (*Ayaat*) of Holy *Qur’an*, and in consequence there is no conflict between the two. In fact, “a distinction must be drawn between scientific theory and duly controlled observed fact ……… an observed fact, checked by experimentation is *not* liable to modification”.[2(b)] The *Ahadith*, in general, provide amplification of some of the Qur’anic *Ayaat* in the context of social and natural sciences. Accordingly we can develop the following framework:

(b) Some draft ground-rules

(1) The elaboration and explanation of the versus (*Ayaat*) of the Holy *Qur’an* should *not* be in contradiction with the known phenomena and established laws of nature.

(2) The explanation of authentic Traditions (*Ahadith*) of the Prophet (S.A.W.) in respect of the laws of nature should not negate the universally accepted empirical observations (الله دبت لاي نل دجت ةنسل).

(3) For understanding the Holy *Qur’an* and authentic *Ahadith*, the human intellect and reasoning should be appropriately used.

(4) Scientific phenomena are definite, but hypotheses and theories are continuously in a state of updating and revision. As a consequence of this state of affairs in respect of scientific knowledge, it is not necessary to force a harmonization of the interpretation of the *Qur'an* (and *Hadith*) with each (current) stage of scientific knowledge and advancement*; rather we should re-examine the scientific theories and the interpretation of *Hadith*.

(5) Harmonization of *Qur'an*, *Hadith* and Science should not be extended to the sphere of the unity of God, Prophethood, and Hereafter. It should, in the first instance, be confined to the laws of nature and the observed or observable phenomena of nature.

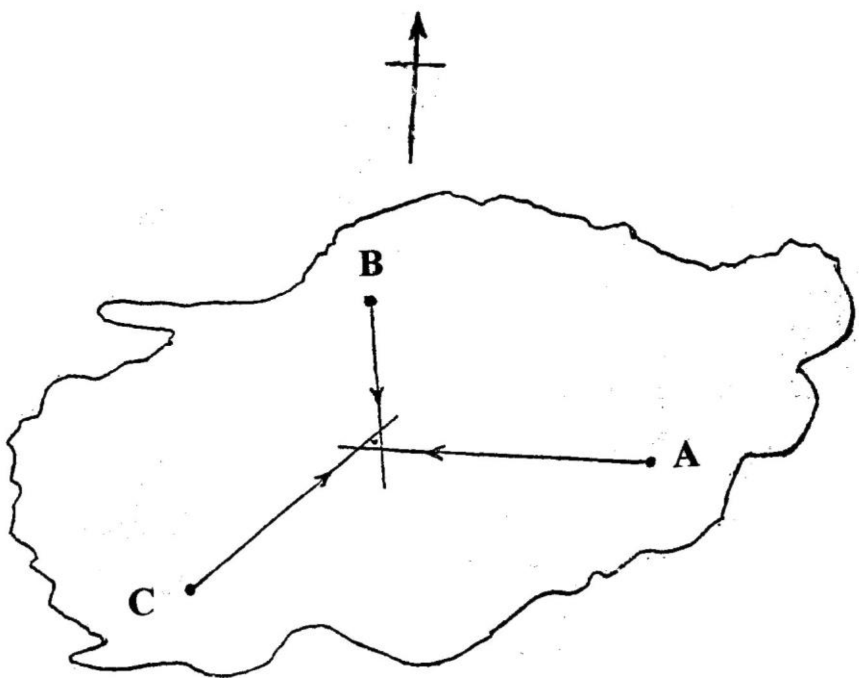


Figure 3. Precise location of object with three bearings.

(c) The methodology

A typical application of this integrative approach is to be found in the principle behind the location of a place in air navigation or plane-table surveying[(4)], as depicted diagrammatically in the sketch of (Figure 3). In the case of air observation, the directional bearings of the target object from three known location A, B & C are plotted on a map (Figure 3) and the point of intersection of the three would give the position of the object being observed or located. In actual practice, due to small measuring errors, the three lines will enclose a small triangle known as the "triangle of error," the middle of which can be taken as the most likely position, as located.

*Neglect of this factor has caused the error into which some recent commentators inadvertently fell; M. Bucaille clearly states[2(c)] that "modern scientific knowledge therefore allows us to understand certain verses of the *Qur'an* which, until now it has been impossible to interpret.[2(c)]

7 TOWARDS THE COMPLETE REALITY

7.1 General

In order to apply this sort of approach for obtaining the "complete reality," we need to combine the information (see Figure 4) from the three types of knowledge characterized above, namely:

1. Knowledge of the physical universe, as specified by observation & experiment and, of course, extended by scientific theories;
2. The Qur'anic knowledge, i.e., the commandments of *Allah* and His statements about the universe and the operation of its constituents;
3. The Islamic view of social sciences and philosophy, which is made up of the *Ahadith** of *Rasulullah* (Prophet Mohammad) (S.A.W.) and the Islamic worldly knowledge of economics, sociology, etc.

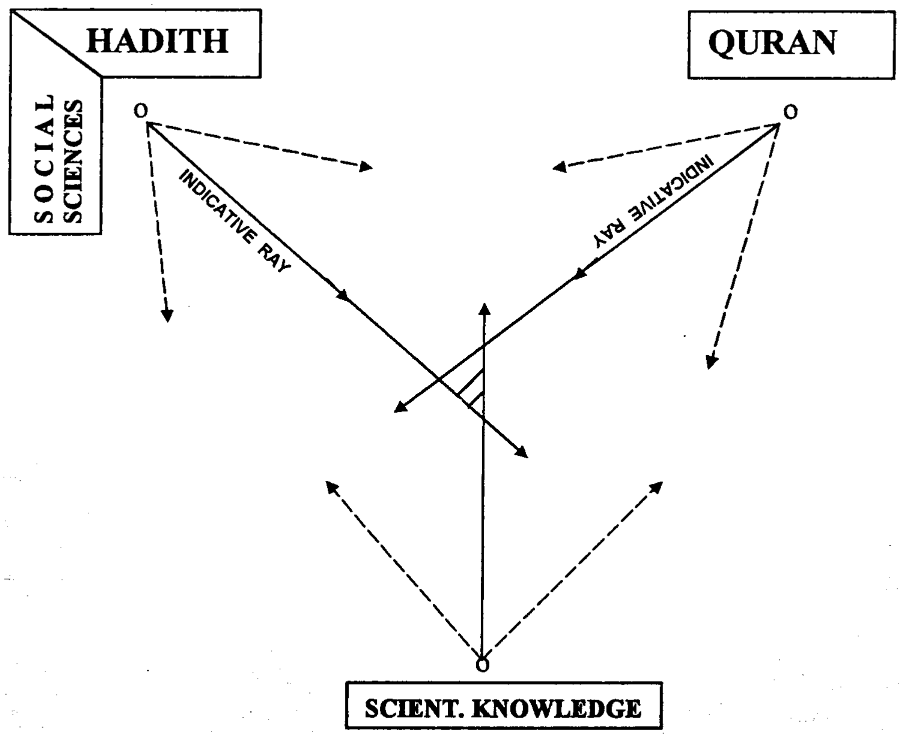


Figure 4. Combination of information from three sources to define the phenomenon precisely.

The above process may then be represented diagrammatically in the sketch of (Figure 4), in which the three composite elements or rays from these to the phenomenon being examined are shown, forming the small shaded triangle of error near the middle of the sketch.

(*) The *Ahadith* explain and amplify the application of the *Qur'an* to our lives in this physical universe and give us the Islamic view of social sciences, combining the Prophetic commentary with our limited knowledge of the social behaviour of man. This is indicated by showing the amalgam of Hadith and Social Sciences at one corner in (Figure 4).

By using all three rays, one is thus able to fix or delineate the precise position (or the complete reality) with a fair degree of certainty or precision. On the other hand, if as often happens one uses only two out of the three rays (or sources of knowledge), then the intersection of the two would lead to a large margin of uncertainty, even for a small error in the directions of the two rays, each of which may be subject, individually, to large errors.

7.2 Discussion of an example from *Surah Luqman*[5]:

Ayah 34 of *Surah Luqman* states: “Lo! Allah! With Him is knowledge of the Hour. He sends down the rain, and knows that which is in the wombs. No soul knows what it will earn tomorrow, and no soul knows in what land it will die. Lo! Allah is knower, Aware.” (See M. Pickthall).

A careful examination of the contents of this *Ayah* reveals that here there are five elements mentioned by *Allah*, namely,

1. With Him is knowledge of the Hour (The Day of Judgement).
2. He sends down the rain, and knows that which is in the wombs.
3. No soul knows what it will earn tomorrow, and no soul knows in what land it will die.

These fall into two categories of two and three elements respectively:

(a) Those which are stated to be exclusively in the knowledge of *Allah*, and mankind has *not* been given knowledge of these, namely elements (iv) & (v), as indicated by the definite word “no”;

(b) Those elements where *Allah* has not withheld (or denied) knowledge thereof from mankind. These latter are elements No: (i), (ii) & (iii), of which (ii) and (iii) are entirely scientific phenomena.

It will be seen that modern science, with the aid of satellites orbiting the earth, is now in a position to forecast the weather with a fair degree of certainty (upto 80% or more in many cases). Also, with the aid of ultrasound and other instruments, man is now able to ascertain the sex of the foetus with high degree of precision (may be 90%), as well as some hereditary defects, *before* the birth of the foetus. This accuracy is likely to increase with further advancement of science. So, when considering the *Hadith* that purports to say that man has not been given knowledge of five things, one must interpret it (the *Hadith*) to refer to complete knowledge of items (ii) & (iii) above.

The above example, as well as a number of other Qur’anic *Ayaat*, provide a basis for further development of appropriate religio-scientific methodology for such interpretations.

8 CONCLUSION

The revealed religions do not deny science but emphasize its benign use with an eye on the life in the Hereafter. There is again a need for this type of symbiosis today. Accordingly, half a dozen ground-rules are outlined for a gainful interaction between science and religion. Positive action for bringing about and developing harmonious relationship between religion and science is needed in the socio-economic situation of the modern era if mankind is to progress in peace. Towards this end, it is necessary to make a coordinated analysis of Qur’anic *Ayaat* containing references to science and technology, using the knowledge of modern science as well as relevant *Ahadith*.

REFERENCES

1. M.M. Qurashi, “Basic Concepts of Physics in the perspective of Qur’an,” Islamic Studies, 1989, 28(1), 55-75.
2. M. Bucaille, “The Bible, The Qur’an and Science,” Translated from the French, published by Seghers, 75725, Paris, 1977, reprinted by Anjuman Itahad ul Muslimin, Karachi 1979, (a) pp. viii & ix, (b) pp. 121-23, (c) pp. 157, 163, 251.
3. M.M. Qurashi, “Thoughts on Inter-Relation between Islam and the Sciences,” M.A.A.S. J. Isl. Sci., 1988, Vol. 4(2), pp. 43-49.
4. M.M. Qurashi, “Coordination of Islamic Thought with Modern Scientific Studies, etc.”, Pak. Jour. of Hist. & Phil. Sci., Vol. 2(1), 1996.
5. Al Qur’an, Surah Luqman, last ayat.

Future Science needs a More Comprehensive Framework

MEHDI GOLSHANI*
Sharif University of Technology
and
Institute for Humanities and Cultural Studies
Tehran, Iran

1 ABSTRACT

Contemporary science has brought enormous benefits to mankind - in nearly all aspects of life. But, science and its technological offspring have also led to weapons of mass destruction, environmental degradation, technological disasters ,etc.- things that threaten the very existence of human beings on the globe.

There are many factors which are responsible for the unpleasant effects of science. In my humble view, the main reason for the destructive effects of modern science is that the basic paradigm underlying the contemporary science is flawed. The scientific community has lost its mission, which in the Islamic worldview is the search for truth and the service to humanity. Thus, science has mostly benefited the wealthy and the powerful.

The received worldview has contributed to the physical and spiritual ills of humanity in several ways. It has confined the realm of valid knowledge to the sensible realm, it has weakened moral concerns in scientists and technologists, it has caused fragmentation of human knowledge with the consequent lost of a unitary view of reality, and it has overshadowed humanity's concern for ultimate questions.

With its present trends, science cannot promise a happy future for mankind. To change the prospect, future science has to be framed within a more comprehensive matrix that can accommodate all aspects of human experience. Some of the most important steps to be taken are the following:

1) There has to be a revival of moral concern in scientists and technologists through supplementing science education by ethical education;
2) To handle mankind's meta-scientific questions, science must yield relevance to humanities (religion, philosophy, etc.). This, in turn, necessitates the introduction of humanities in the science and technology curricula; and
3) There has to be vigorous discussions and debates on the use of scientific knowledge. This necessitates interdisciplinary work which includes physical as well as social sciences and humanities. These are supposed to deal with different issues of human societies, including ethical , social and environmental problems.

In the Islamic world, the best way to realize these goals is to revive the Islamic worldview in the academic arena. The God-centered Islamic worldview, which is rooted in the Islamic revelation, takes a holistic view of nature and has a long range concern for humanity. Thus, it can lead to a more promising science in the future.

* Prof. of Physics at Sharif University of Technology (Tehran, Iran), Fellow of the Islamic World Academy of Sciences; and Director, Institute for Humanities and Cultural Studies, Tehran, Iran.

2 INTRODUCTION

The world in which we live today is very different from the medieval times and the difference can be attributed to science and its technological offspring. The advances made during the last two hundred years in the physical and biological sciences, have expanded our understanding of the world in an unprecedented manner. Similarly, the advances in the practical applications of science have given us an enormous control over the forces of nature and human minds. But the developments brought about by science and technology has been both beneficial and detrimental to mankind. For example, scientific and technological knowledge has increased physical comforts, life expectancy and the standards of living beyond any expectation of our ancestors. On the other hand, science and technology have been used for the destruction of our fellow human beings and the pollution of our environment, and a large number of scientists have been working in military research establishments producing means of mass destruction, and unfortunately the scientific community has played a passive role in this regard. **Freeman Dyson** has put the matter elegantly:

> *"The failure of science to produce benefits for the poor in recent decades is due to two factors working combination: the pure scientists have become detached from the mundane needs of humanity, and the applied scientists have become more attached to immediate profitability."* (1)

The rapid progress of science during the nineteenth century, led to the expectation that science alone can handle all problems of human concern. Thus, in the early decades of the twentieth century many scholars and politicians prophesized that science would solve all problems of humankind and would promote human happiness. **Jawaharlal Nehru,** the first prime minister of independent India, echoes the view of these people:

> "*It is science alone that can solve the problems of hunger and poverty, of insanitation and illiteracy, of superstition and deadening custom and tradition, of vast resources running to waste, of a rich country inhabited by starving people…. Who indeed could afford to ignore science today? At every turn we seek its aid….The future belongs to science and to those who make friends with science.*(2)

But as early as 1924, **Bertrand Russell** expressed scepticism about science being a total blessing for mankind:

> *Mr. Haldane's Daedalus has set forth an attractive picture of the future as it may become through the use of scientific discoveries to promote human happiness. Much as I should like to agree with his forecast, a long experience of statesmen and government has made me somewhat sceptical. I am compelled to fear that science will be used to promote the power of dominant groups, rather than to make men happy.*(3)

In **Russell**'s view, the bad effects of science are rooted in the fact that science by itself cannot control human passions:

> *Science has not given men more self-control, more kindliness, or more power of discounting their passions in deciding upon a course of action. It has given communities more power to indulge their collective passions, but, by making society more organic, it has diminished the part played by private passions. Men's collective passions are mainly evil; far the strongest of them are hatred and rivalry directed*

towards other groups. Therefore at present all that gives men power to indulge their collective passions is bad. That is why science threatens to cause the destruction of our civilization. [(4)]

Now, science can affect human life at two different levels:

1) At the practical level, it can solve human problems both at the individual and the societal levels;
2) At the theoretical level, it can enrich man's imaginative conception of the world;
3) During the Middle Ages and in the early days of modern science, the pursuit of science was for the sake of contemplating God's handiwork, rather than securing material benefit for humankind. **Heisenberg** expresses Kepler's view of science eloquently:

For Kepler , science is not at all a means of producing material benefits for man, or of making possible a technology for better living in our imperfect world, and opening up the paths of progress. Quite the contrary – science is a means of elevating the mind, a way of finding peace of solace in the contemplation of the eternal perfection of the creation. [(5)]

At the practical level too, those scientists were conscious of the consequences of their work.

3 WHY HAS CONTEMPORARY SCIENCE FAILED ITS PROMISE?

In my humble view, all of the unpleasant consequences of current science are rooted in the dominance of a worldview among contemporary scientists that has the following characteristics: rejects any knowledge which is not rooted in sense data; neglects ethical issues in the scientific enterprise; controls and manipulates nature and human societies; neglects a holistic view of reality; and ignores humanity's ultimate concerns. Here we illuminate these points briefly:

(i) Restriction to the sensible realm

Modern science confines itself to the material real, and confers reality only to those things that can be rooted in sense data. Empirical verification is the court of ultimate appeal. In the words of **Bertrand Russell**:

Whatever knowledge is attainable, it must be attained by scientific methods; and what science cannot discover, mankind cannot know.[(6)]

Therefore, spiritual realities are considered either as unreal or reducible to physics. This has led to the negligence of God and the spiritual dimension of humankind and the separate development of science and culture.

All this is contrary to the Qura'nic outlook according to which our knowledge about the world is not restricted to the sense data, and there are many realities in the world to which we do not have any access:

سبحان الذي خلق الازواج كلّها ممّا تنبت الارض و من انفسهم و ممّا لا يعلمون (يس/٣٦)

Glory be to Him Who created pairs of things, of what the earth grows, of their own kind and of what they do not know. (36: 36)

With the tools of modern science we can investigate physical phenomena, but we cannot comprehend universe's underlying unity. The embedding of science within a more comprehensive framework, adds wisdom to science and leads to seeing the unity behind the diversity.

(ii) Value-neutrality of science

It is commonly held in the scientific circles that science and ethics are two independent spheres of human concern. Thus, ‘normative statements’ cannot be derived from ‘factual statements’. This had led to the idea of value-neutrality of science which has been very effective in marginalizing ethical considerations and has led to the spread of moral relativism in modern societies and has weakened the ethical concerns in the scientific enterprise.

Scientific work is not done in a human vacuum. Values outside science creep into the scientific practice at the human level. In fact, all scientific works involve some value judgments and these could be effective in the choice of theories or in the applications of science. As **Popper** put it:

> *“The fact that science cannot make any pronouncement about ethical principles has been misinterpreted as indicating that there are no such principles, while in fact the search for truth presupposes ethics.”* [7]

There are other reasons for the marginalization of moral values in the scientific enterprise. For example, some of the current theories of science, such as Darwin’s theory of evolution, have undermined the belief in an objective moral order. In fact, they credit moral values with only a utilitarian role. As **V. E. Frankl** elegantly put it:

> *“Values and meanings are nothing but defence mechanisms and reaction formations.”* [8]

Excessive specialization, too, has isolated science from other areas of human concern. As **Toulmin** put it:

> “*It was the development of specialization and professionalization that was responsible for excluding ethical issues from the foundations of science.*[9]

We believe that science and ethics merge at the metaphysical level. Thus a theistic metaphysics, like the Islamic worldview, integrates science with ethics. This leads to accountability and responsibility of the scientist at all stages of his/her life.

In the Qura’nic outlook, one should combine the acquisition of knowledge with the acquisition of moral values:

هو الذي بعث في الاميين رسولاً منهم يتلوا عليهم آياته و يزكيّهم و يعلّمهم الكتاب و الحكمة
و ان كانوا من قبل لفي ضلال مبين (الجمعه/٢)

He is the One Who dispatched a messenger from the unlettered among themselves, to recite His verses to them and to purify them and teach them the Book and wisdom, even though previously they were in obvious error (62: 2).

(iii) Acquisition of power

Where as the old science was looking for reading the book of nature as the God's handiwork, the dominant tendency in modern era has been to advance knowledge for the enhancement of the political and economic power and to look upon nature as a commodity to be exploited. **Schumacher** has put the matter elegantly:

> *The old science – 'Wisdom,' or 'science for understanding' – was primarily directed 'towards the sovereign good,' i.e. the True, the Good and the Beautiful, the knowledge of which would bring both happiness and salvation. The new science was directed mainly towards material power, a tendency that has meanwhile developed to such lengths that the enhancement of political and economic power is now generally taken as the first purpose of, and main justification for, expenditure on scientific work. The old science looked upon nature as God's handiwork and man's mother; the new science tends to look upon it as an adversary to be conquered or a quarry to be exploited. The greatest and most influential difference, however, relates to the attitude of science to man. The 'science for understanding' saw man as made in the image of God, the crowning glory of creation, and hence 'in charge' of the world, because noblesse oblige. The 'science for manipulation,' inevitably, sees man as nothing but an accidental product of evolution, a higher animal, a social animal, and an object for study by the same methods by which other phenomena of this world were to be studied – 'objectively.'* [10]

The misuse of science and its technological offspring during the last century brought many curses for humanity and damaged the environment. This created serious discontent among some of the noted scientists of our era. In his letter to Einstein in 1954, **Max Born** complained about the evils of modern science:

> *"I read in the paper recently that you are supposed to have said: 'If I were born a second time, I would become not a physicist, but an artisan`. These words were a great comfort to me, for similar thoughts are growing around in my mind, in view of the evil which our once so beautiful science has brought upon the world."* [11]

This was said at a time, when the scale of the misuse of science was negligible with respect to what we are witnessing today.

In our era there are two main considerations for the promotion of science and technology: 'seeking science for the sake of science' and 'seeking science for material goals and power.' The present industrial West has fallen into the trap of "technopoly" – to use Neil Postman's terminology – and it has become a paradigm that whatever can be done must be done. Furthermore, with the emergence of big science, the goals of scientific and technological research are increasingly set by industry or governments whose objective is not truth but knowledge and power. It is forgotten that science and technology are supposed to secure humanity's welfare and so their goal must be the good of humanity. This may require some constraints on certain areas of knowledge.

In the Islamic outlook, the sciences of nature should be keys to our cognition of the signs of God in the universe and for solving the individual and societal problems, without interrupting the cosmic order.

(iv) Fragmentation of human knowledge

One of the characteristics of scientists during the middle ages was their holistic view of nature. They considered all fields of knowledge as branches of the same tree, and tried to have a unitary view of nature. Today, due to excessive specialization, there is fragmentation of knowledge both across disciplines and within disciplines. Thus, e.g., people in sub-disciplines of a field of inquiry, like physics, are foreign to each other's vocabulary at the advanced level. This leads to a lack of integral vision of the individual scientists and leads to a society of individuals, each seeking his/her personal interest.

Another problem is that a scientist's worldview is shaped by the assumptions and methods of his/her specialty. Then, e.g., one who is working in biological science is tempted to assume that genes account for all of human conduct. Furthermore, being concerned only with one's specialty prevents one from paying attention to those elements which relate one's discipline to a larger whole.

Thus, fragmentation has deprived us from a holistic view of nature .Some of the eminent scientists and philosophers of our time have complained about the narrowness of the contemporary scientists' vision of reality. In the words of **Heisenberg**:

> *Today, the scientist's pride is love of detail, the discovery, and systematizing of the smallest revelations of nature within a narrowly circumscribed field. This is naturally accompanied by a higher esteem for the craftsman in a special subject, the virtuoso, at the expense of an appreciation of the value of interrelations on a large scale. During this period one can hardly speak of a unified scientific view of nature, at least not as far as content is concerned. The world of the individual scientist is the narrow section of nature to which he devotes his life's work.* [(12)]

Another byproduct of this fragmentation is that physical and natural sciences are more or less indifferent to what goes on in humanities. But if science is to be practiced by humankind and is to be used to solve humanity's problems, how could physical and biological sciences be divorced from humanities?

(v) Ultimate Questions

Because of the limitation of its scope, modern science cannot answer many questions of human concern-questions like 'What are we doing here?' , 'What is the purpose of life?'-and it is silent about the meaning and purpose of human life and about morality. In the revealing words of **Erwin Schroedinger**:

> *The scientific picture of the real world around me is very deficient. It gives a lot of factual information, puts all our experience in a magnificently consistent order, but it is ghastly silent about all and sundry that is really near to our heart that really matters to us. It cannot tell us a word about red and blue, bitter and sweet, physical pain and physical delight; it knows nothing of beautiful and ugly, good or bad, God and eternity. Science sometimes pretends to answer questions in these domains, but the answers are very often so silly that we are not inclined to take them seriously.* [(13)]

The current scientists' worldview not only leaves all ultimate questions of human concern unanswered, it even denies the validity of such questions. Thus, the meaning of life has lost its significance, and human beings, under the overwhelming forces of technology, are demanding more and more material welfare, at the expense of their spiritual dimension.

4 FUTURE SCIENCE

As we mentioned, science and technology have enabled humankind to control its physico-chemical and genetic environment, bringing about many blessings as well as curses to humanity. In fact, humankind is presently confronted by environmental pollution and degradation, mismanagement of natural resources, and enormous means of mass destruction. As we move into the future, the effects of science upon humanity increases at a rapid pace, and the question arises as to whether science should be allowed to develop freely without restrictions. Thus, there is an urgent need to eliminate the causes of curses that could be brought about by science and technology. We believe that this could be achieved, if the following steps are taken:

(1) As we saw, the development of science and technology for its own sake and without concern about its impact on society and environment has generated a real threat to the human race. There has to be a revival of moral concern in the scientific enterprise. This is especially true for our age that advances in molecular biology and genetic engineering has produced an unprecedented increase in human power over living beings, and without a moral compass anything can happen. As **Anthony Giddens** put it:

"Not just the external impact, but also the logic of unfettered scientific and technological development will have to be confronted if serious and irreversible harm is to be avoided. The humanizing of technology is likely to involve the increasing introduction of moral issues into the now largely 'instrumental` relation between human beings and the created environment." (14)

and in the eloquent and insightful words of **Freeman Dyson**:

"If technology continues along its present course, ignoring the needs of the poor and showering benefits upon the rich, the poor sooner or later rebel against the tyranny of technology and turn to irrational and violent remedies.... The widening gap between technology and human needs can only be filled by ethics…. Ethics can be a force more powerful than politics and economics. The free market will not by itself produce technology friendly to the poor. Only a technology positively guided by ethics can do it." (15)

Since the days of Hippocrates, nearly 2500 years ago, there has been a code of ethical conduct for physicians. In our age that the fate of humanity lies in the hands of scientists, there is a need for an ethical code of conduct for all scientists, and there should be ethical committers for examining the long term effects of proposed scientific projects. Unfortunately, a noticeable part of the scientific community has submitted itself to the demands of politicians and military establishments, without taking any responsibility for its acts. There has to be a serious re-examination of the role scientists are playing in developing the war industry, and scientists' involvement in arms' research projects should be stopped, and there should be vigorous discussions and debates on the uses of scientific knowledge. This necessitates interdisciplinary work which includes physical and biological sciences as well as social sciences and humanities. These are supposed to deal with different issues of human societies, including ethical, social, and environmental ones.

The inclusive worldview that accommodates future science should integrate science and ethics. This necessitates that scientists' training be accompanied by ethical education, in order to give them accountability and responsibility at all stages of life. This could be most effectively done in a religious context, where religion can provide justification and interpretation of moral values and can mobilize people for the preservation of the environment. As **E. F. Schumacher** put it:

"… it is impossible for any civilization to survive without a faith in meanings and values transcending the utilitarianism of comfort and survival – in other words, without a religious faith." [16]

It is religion that offers a coherent understanding of life, humankind and cosmos.

(2) In the Middle Ages science used to be primarily a tool in mankind's search for truth, and it was meant to serve humanity at the practical level. Contemporary science has lost a large proportion of these goals. Today, scientific enterprise is funded mostly by governments, and in the industrially advanced countries it is mostly subordinated to immediate practical goals. Thus those fields of knowledge are primarily supported that have utilitarian ends and lead to the enhancement of the political and economic power. This commercialization of science has devalued it and has led to the dehumanization of the world. The goal of science has to be elevated to serve humanity's higher inspirations. Only if science is subordinated to wisdom, it can bring happiness and salvation for humankind.

(3) As we noticed, contemporary science deals with the physical aspects of our world and ignores supra-sensible realities. Its fundamental paradigm is to explain all natural phenomena in physico-chemical terms. Thus, there is no room for God in the natural order, and science addresses only the material needs of humankind and is sought for the control of nature and fellow humans. This has resulted in contemporary science presenting a limited view of reality, and has made science and its products as demonic tools for deviating humanity from its God-assigned role. The solution lies in changing the direction and goal of science and technology and in seeking a unifying framework which accommodates all levels of reality and all aspects of human life. **George Ellis** has put the matter elegantly:

"The underlying order of the universe is broader than described by the understanding of physics alone, and relates to the full depth of human experience, in particular providing a foundation for morality and meaning." [17]

To differentiate between the broader outlook and the regular scientific one, Ellis uses cosmology (with small c) to refer to the technical subject of physical cosmology and uses Cosmology (with capital c) to cover issues such as values, purpose, religion, ultimate questions, etc.

In the Islamic worldview, reality has both material and non-material dimensions. Thus, future science must recognize both aspects of reality and their interaction. Only under the guidance of such a worldview, human beings can live in harmony with nature and with their fellow beings, and can have a more comprehensive view of reality.

(4) As **Bertrand Russell** had predicted (in 1923), most of the benefits of science has reached the wealthy and powerful, and scientific knowledge has not eliminated poverty. Thus, **Nehru**'s dream of science solving the problem of hunger and poverty was not realized during the twentieth century. In fact, science and technology have failed to act as social equalizers, narrowing the gap between rich and poor, and to improve the quality of human life to an acceptable level. Future science should compensate for this uneven distribution of the blessings of science. Thus, science should become a shared asset for all people and should aim at the welfare of all mankind, rather than being means of domination over nature and fellow beings.

(5) As we saw, fragmentation of scientific disciplines has deprived us from a unitary view of reality. Of course, one should not halt the progress of science by neglecting specialization, as

it is neither feasible nor commendable. But, one must not forget the necessity of embedding one's specialty in a wider frame of reference. Otherwise, one will lose a unitary view of reality and the meaning of one's own existence.

Thus, we need an integration that preserves the unique features of each discipline, but, at the same time, shows how different disciplines can be integrated with other disciplines and how can all of them be related to a larger whole. One needs to consider the significance and status of various disciplines within the context of human person and the cosmos at large, and to arrange them into a hierarchy of levels according to their complexity – starting from physics and ending with humanities. This means that physics gives the most detailed information about the material world, and as we go up the scale, we reach humanities that describe human behaviour.

Another important point is that scientific knowledge is not the only kind of valid knowledge, because there are areas of human concern about which science cannot say anything. Thus, e.g., science cannot say anything about moral values, about art works and about the supernatural. Furthermore, science can't deal with the ultimate questions of humanity- Why are we here? What are we doing here? etc. – and can't justify, by itself, its very foundations. To handle these insistent deeper issues, science must yield relevance to humanities (religion, philosophy, etc.).In the words of **Peter Medawar** (the Nobel laureate in medicine):

"It is not to science, therefore, but to metaphysics, imaginative literature or religion that we must turn for answers to questions having to do with first and last things." (18)

It is the neglect of these meta-scientific questions that has dehumanized science. The appeal to magic, astrology, and mysticism in the West is a good testimony to the failure of science to satisfy humanity's deepest needs.

Thus, there has to be a re-evaluation of the present educational system in order to instill some sense of breadth in students and to inform them about the interrelatedness of various disciplines. This could be done by adding sufficient number of humanity courses to the science and engineering curricula and to have across disciplinary collaborations and discussions. This kind of effort has started at some of the major universities of the West (like MIT, Stanford, Cambridge, Oxford, etc), but Islamic countries are well behind in this respect.

5 CONCLUSION

We mentioned that modern science has significantly advanced our knowledge of the physical world and has produced both blessings and curses for mankind. But the weight of the curses appears to threat humanity's future. We also echoed the opinion that the main cause of curses is the current worldview that underlies modern science.

The received worldview has confined humanity to the material plain, has weakened humanity's sense of moral order, has taken the breadth from scientists' general outlook, and has put the science at the service of the powerful and the wealthy to exploit the nature and human beings. We believe that all of these curses could be prevented if the received worldview is enlarged to an inclusive one that embraces all needs of humanity - the material needs as well as the spiritual ones - and relates human life to the rest of the universe. One such inclusive framework is the Islamic worldview – a God-centred worldview – which is rooted in the Islamic revelation, takes a holistic view of nature, admits a hierarchical structure for reality and has a long range concern for humanity. According to this worldview, humanity is part of a wider cosmic order and is supposed to harmonize all of its activities, including the scientific and technological ones, with this cosmic order. Unless this fundamental change takes place in the mentality of the scientists of our generation, future science would lead to more destructive results than we have witnessed so far, and there would be no hope for the future of humanity.

REFERENCES*

1. F. Dyson, "Can Science Be Ethical?" *Christian Ethics Today*, Vol. **3**, No. 5, Dec. 1997.
2. Jawaherlal Nehru, *Proceedings of the National Institute of Science*, **27** (1960), P. 564.
3. Bertrand Russell, *ICARUS or The Future of Science* (London: Kegan Paul, Trench, Tubner & Co., LTD., 1924), P. 1.
4. Ibid., PP. 62-63.
5. W, Heisenberg, *The Physicists Conception of Nature*, trans. From German, A. J. Pomerans, (Westport, Conn.: Green Wood Press Pub., 1970), P. 84.
6. B. Russell, *Religion and Science* (New York: Oxford Univ. Press, 1970), P. 243.
7. K. R. Popper, "Natural Selection and the Emergence of Mind," in *Evolutionary Epistemology, Rationality and the Sociology of Knowledge*, ed. Gerard Radnitzky & William W. Bartley, III (La Sall, Ill.: Open Court, 1987), P. 141.
8. Quoted in E. F. Schumacher, *A Guide for the Perplexed* (London: Jonathan Cape, 1977), P. 14.
9. Quoted in M. Artigas, *The Mind of the Universe* (Philadelphia: Templeton Foundation Press, 2000), P. 258.
10. E. F. Schumacher, *op.cit*, P. 14
11. Quoted in A. P. French, *Einstein: A Centenary Volume* (London: Heinmann Educational Books, 1974), P. 277.
12. H. Heisenberg , *Philosophical Problems of Quantum Physics* (Woodbridge, Conn.: Ox Bow Press, 1979), P. 80.
13. K. Wilber, ed., *Quantum Questions* (Shambhala: New Science Library, 1984), P. 81.
14. Giddens, A. *The Consequences of Modernity* (Stanford University Press, 1990), P. 170.
15. Freeman Dyson, *op.cit*,
16. E. F. Schumacher, *op.cit*, P. 129.
17. George Ellis, *Before the Beginning* (London: Boyars/Bowerdean, 1993), P. 125.
18. P. Medawar, *The Limits of Science* (Oxford: OUP, 1984). P. 60

* As cited by the author.

The Science and Technology Scene in the State of Sarawak, Malaysia[1]

JAMES D MAMIT[2]

1 ABSTRACT

Sarawak is the largest state in Malaysia, covering an area of 124,449 km^2 (Figure 1), and has a population of approximately 2.1 million. It is the least populated Malaysian state with a population density of 16.9 persons per km^2. It is thus apparent that the establishment of educational infrastructure and facilities requires careful planning so as not to deprive citizens of their right to education.

S&T development in Sarawak is governed by the formal education system provided by both the federal and state governments. The learning of S&T related subjects begins when children at the age of six attend the first year of the primary-level schooling. The teaching-learning process uses interactive IT through which students indulge in hands-on learning. As the students proceed to secondary-level schooling, S&T subjects are taught for those in the science stream. In national universities, about 80% of majors are in the S&T fields.

R&D in S&T fields is the pursuit of the government and national universities in Sarawak. R&D institutions of the government are tentacles of government departments which receive little funding. Consequently, R&D activities are ad-hoc and not quite well organized. Thus, the government should avail more funding to R&D. In universities, R&D activities are better organized and focused.

High-tech industries are taking roots in Sarawak. In the Sama Jaya Free Industrial Zone, 14 high-tech foreign and local companies are operating, producing products ranging from multi-layer ceramic chips to semi-conductor fabricated wafers. What is left for the state to vigorously pursue immediately is biotechnology.

2 INTRODUCTION

Under Article 74 and the Ninth Schedule of the Federal Constitution of Malaysia, science and technology (S&T) education comes under the jurisdiction of the Federal Government.[3] But, in keeping with the concept of federalism, states in Malaysia have the prerogative to take up science and technology education as well as research and development (R&D) in areas of S&T.

In Sarawak, the state government has developed a number of innovative programmes to complement the formal education system of the federal government so that S&T education is being pursued with vigour and greater interest by the people of the state. Moreover, the state government prides itself on basing development policies on S&T approaches.

The objective of this paper is to highlight the current situation of S&T in Sarawak, detailing S&T education at all levels, R&D and high technology pursuits.

---

[1] Paper presented at the Thirteenth Science Conference of the Islamic Academy of Sciences (IAS), 29 September – 2 October 2003, Hilton Hotel, Kuching, Sarawak, Malaysia.

[2] Science and Technology Panel, the Islamic Council of Sarawak, Malaysia.

[3] Federal Constitution as at 25 June 1990. International Law Book Services, Kuala Lumpur, Malaysia.

Figure 1. The state of Sarawak, Malaysia.

3 SCIENCE AND TECHNOLOGY EDUCATION

3.1 The new education strategy in Malaysia

A market-sensitive education system is evolving in Malaysia. Schools and universities are taking up the challenge of globalization by changing not only the content of curriculum and programmes, but more importantly the delivery systems. Information technology (IT) is enhancing the teaching and learning in schools and universities.

The structural transformations of Malaysia's economy is placing society at the threshold of a fundamental shift; first into an information-based society and then to a knowledge-based society. Thus, the government has primed our education structures to enable the building of well educated, highly skilled and strongly motivated professionals. The nation's human capital is its most important economic and development resource. Thus, Malaysia is embarking on an educational journey that will deliver the promises made to establish itself as a fully industrialized country by the year 2020.

The government is facilitating change and seeking innovative approaches to expand the education base. Strategies for growth and development of education are a significant departure from the government-propelled initiatives of previous years. A Malaysian Inc approach in education is making it possible for the private sector to meet the needs for tertiary education by offering degree, diploma and certificate level courses (Figure 2).

The government has set the stage for a major revolutionary change in its education system. Since 1995, it has successfully enacted six legislations to position Malaysia as a regional education hub. With such legal framework, the education system is indeed set for a quantum leap, which can thus make sweeping changes to our institutes of learning, enabling them to offer a wide range of courses, different options and approaches to learning, better management, new teaching methods and an overall increase in productivity and standards.

To take full advantage of the opportunities offered by an increasingly borderless world, foreign universities are encouraged to set up offshore branches in Malaysia. At the same time, the private sector is given the mandate to establish private schools and universities. This dynamic relationship between the government, the private sector and strategic foreign academic partners is propelling the nation toward realizing its goal of becoming a developed country by the year 2020. Central to the new education strategy is the learning of S&T at all educational levels.

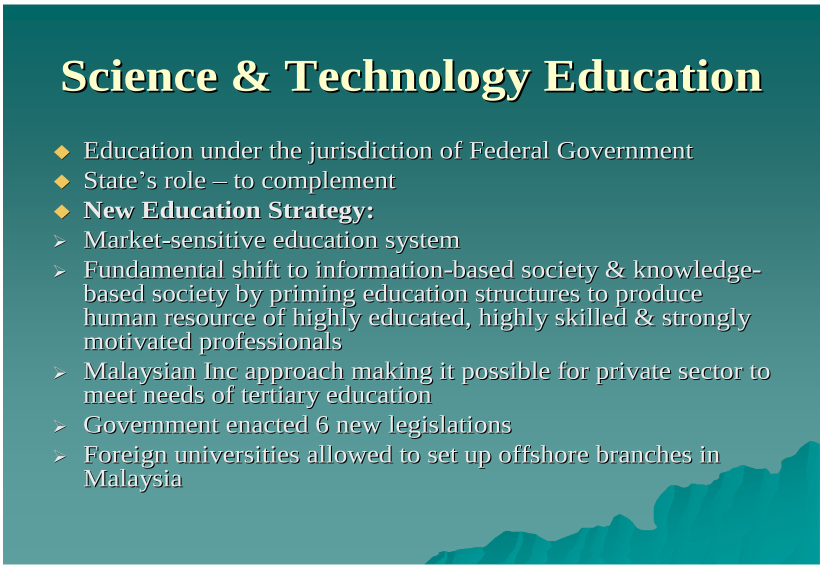


Figure 2. Highlights of the education policy of Malaysia.

3.2 S&T education at the primary level

Primary schooling begins at six years of age and is completed over a period of six years. Sensitive to the multi-ethnic nature of the population, the government sets up two categories of schools, namely, the "national" and the "national-type" schools. At the primary level, the emphasis is on acquiring strong reading and writing skills, as well as building a strong foundation in basic sciences and mathematics.

Even in primary level education, S&T has been swept along by the powerful currents of the IT revolution. The government has responded by implementing wide-ranging reforms to give primary schools the skills and competence to ride the crest of the IT wave, thus giving school children an early and better start to acquire knowledge of S&T.

In primary schools in Sarawak, the education system is putting interactive IT as the core of teaching-learning and management process. Starting from 2003 school year, the teaching-learning process uses the English language for the subjects of science and mathematics for Year One pupils. This process is made easier with the employment of interactive IT. The pupils themselves who are required to handle computers are exposing themselves at an early age to technology.

Currently, there are 1,255 primary schools scattered throughout Sarawak with a total number of pupils being approximately 450,000, and there are 3,741 primary-school science teachers.[4] While the schools in urban and semi-urban areas are well equipped with IT facilities, some of the schools in rural areas are still ill equipped due to unavailability of basic amenities, such as electricity and telephone lines. Most of these schools are located in the interior of Sarawak. In this situation, the state government is complementing the task of the federal government by installing solar-energy cells in schools for generating electricity to power computers and satellite telephones, thus reducing the digital divide between rural schools and urban schools (Figure 3).

---

[4] Education Department, Sarawak (2003).

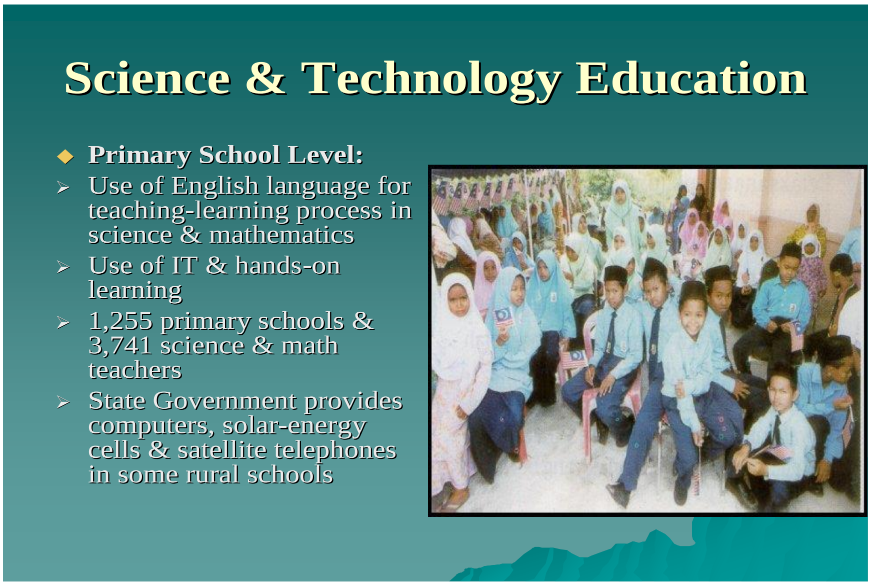


Figure 3. S&T education at the primary level.

3.3S&T education at secondary level

Secondary schooling offers a comprehensive education programme in Malaysia. The curriculum includes a wide range of subjects from the arts and sciences to vocational and technical subjects that provide a practical bias and hands-on approach to learning.

In preparation for the Lower Secondary School Assessment Examination (PMR) at year three, the learning of basic sciences and mathematics is integrated into single subjects respectively. As in primary schools, the learning of these subjects is interactive IT based, thus making the students well exposed to technology. Starting with the 2003 school year, the teaching-learning process for the subjects of science and mathematics employ the English language for year one secondary-school students.

Following the outcomes of the PMR, students move into more specialized fields of study at the upper secondary school level, based on choice and aptitude. At upper secondary level, students are streamed into the arts and sciences categories. The sciences category students take up specialized S&T subjects mainly in science and mathematics, such as biology, chemistry, physics and a few specialized mathematics subjects. At year five, the students are re-evaluated through the Malaysian Certificate of Education (SPM).

At upper secondary schooling, the government has also established a number of technical and vocational schools to provide technically-biased academic education with hands-on approach to learning. Most of the subjects in these schools are in areas of S&T for pre-employment skills.

After the SPM assessment at year five, students who have obtained satisfactory results may proceed to year six to prepare themselves for the Malaysian Higher School Certificate (STPM) examination at year seven. Streaming of students into the arts and sciences categories still applies here. The STPM programme qualifies students for entry into the national universities, colleges and teacher-training institutions.

In Sarawak, there are 151 secondary schools, seven vocational schools and one junior science college, with a total student population of approximately 175,000, and there are 2,032 science teachers altogether.[5]

[5] Education Department, Sarawak (2003).

3.4 S&T education at tertiary level

As education becomes increasingly international in character, Malaysian universities are becoming more contemporary in outlook. Each university has developed its own competitive strengths, positioning itself as a centre of selective excellence, because educational programmes are shaped by forces operating in the marketplace. Courses and programmes are demand driven and sensitive to changes in the global environment.

It is recognized that a country's ability to master technology, to manage complex systems and to innovate will increasingly mark the difference between nations that succeed and those whose futile efforts lie in trying to cope with the future, armed only with obsolete skills. Malaysia's university education system, therefore, addresses the challenges presented by globalization.

All universities in Malaysia offer courses related to S&T from levels of bachelor to doctorate degrees. In fact, in all universities about 80% of majors are associated with the S&T fields. Today, our universities cater for about 40% of those within the tertiary education age group.[6]

In Sarawak, there are three national universities, namely; Universiti Malaysia Sarawak (UNIMAS), Universiti Teknologi Mara (UiTM) and Universiti Putra Malaysaia (UPM) Branch Campus. There are 28 private colleges and universities operating in the state and among these are two universities from Australia that have set up their offshore campuses. Both Australian universities are offering courses in the fields of S&T. Presently, the total student enrollment in these universities and colleges is approximately 15,000.

4 RESEARCH AND DEVELOPMENT

R&D in the fields of S&T in Sarawak is predominantly the pursuit of the government and universities. There are five government institutions that conduct active R&D mainly in the fields of agriculture and crop protection, fisheries, food production, forestry and biodiversity conservation, and rubber products. These R&D institutions are the tentacles of government departments which often receive relatively smaller budgets than other non-R&D divisions of the departments. Hence, R&D activities are mostly ad-hoc and not well organized (Figure 4).

The state government could benefit from R&D if more funding is made available so as to enable R&D activities to be well planned and structured. In this way, R&D activities would yield discoveries and tenable results. The government could then take steps to commercialize the discoveries.

Among the universities and colleges in Sarawak, only the national universities are involved in R&D. Unlike R&D activities in government institutions, they are better organized and more focused on their agenda.

Presently R&D budget in Malaysia is about 0.4% of its GDP, while developed countries spend up to 3% of their GDP on R&D.[7] Malaysia could benefit by allocating a larger share of its GDP to R&D expenditure, with the government playing a more dominant role in this venture. The government needs to support a workforce that is technologically creative and innovative, if the country is to be the international hub of the K-economy. R&D is a crucial element in the mosaic of policy measures that needs to be put in place.

[6] Ministry of Education, Malaysia (2003).
[7] http://www.mier.org.my

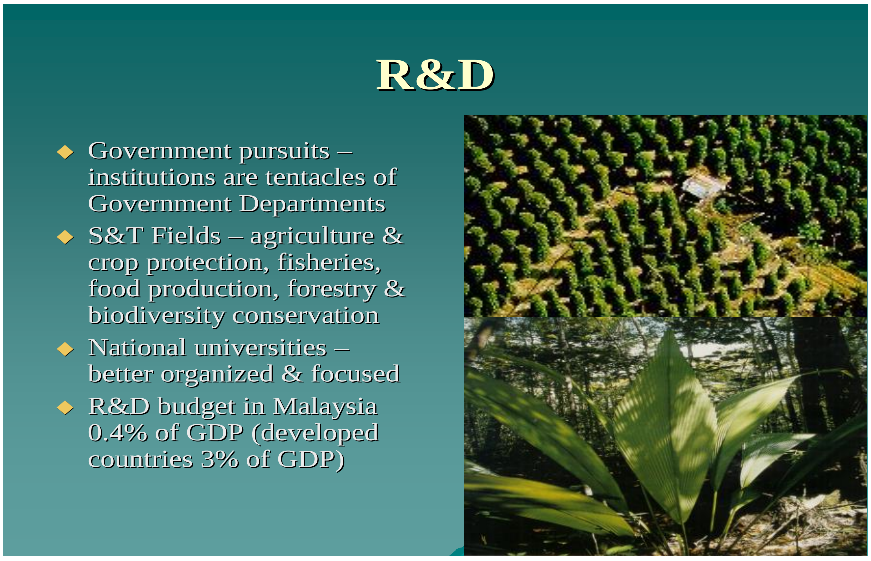


Figure 4. R&D activities in Sarawak.

5 HIGH-TECH INDUSTRY

Sarawak has embarked on an ambitious plan to attract high-tech industry. The government has established a free-trade industrial zone for this purpose, where foreign companies can operate without the hassle of much bureaucracy. The necessary clearances for export and import of goods are processed in one-stop centre.

Today, there are 14 companies of electronic and IT capabilities, foreign and locally owned, operate in the Sama Jaya Free Industrial Zone in Kuching. These companies manufacture products that include thin-film magnetic disks, multi-layer printed circuit boards, multi-layer ceramic chips, semi-conductor fabricated wafers, capacitor elements, telecommunication products and accessories, telephones and accessories, intermediate frequency transformers, and conductive pastes for electronic components.

The success of the government's efforts to attract high-tech foreign companies is due to, partly, the availability of an educated and trainable work force in the state. Not far from the Sama Jaya Industrial Zone is the government's technical training centre, where short-term technical courses are offered to those who desire to work as technicians in those high-tech companies.

In spite of the initiatives by the state government to establish high-tech industry, the notable absence of biotechnology is somewhat bewildering. The state is endowed with a wealth of high diversity of biological resources deserving to be utilized for useful products produced by biotechnological means. Even though the government has established the Sarawak Biodiversity Centre (SBC), its role and functions are only confined to the enforcement of regulations pertaining to unauthorized collections of biological resources and unauthorized research on biodiversity. A re-examination of the beneficial role of the SBC is deemed necessary to prevent it from becoming a non-performing organization and to create its leadership role in spearheading biotechnology in Sarawak.

6 CONCLUSION

S&T development in Sarawak is governed by the formal education system provided by both the federal and state governments. The learning of S&T related subjects begins when children at the age of six. The teaching-learning process uses interactive IT in which students are required to engage in hands-on learning. As the students proceed to secondary-level schooling, S&T subjects are taught to those in the science stream. In national universities, about 80% of majors are in the S&T fields.

R&D in S&T fields is the pursuits of the government and national universities in Sarawak. R&D institutions of the government are tentacles of government departments which receive little funding. Consequently, R&D activities are ad-hoc and not quite well organized. Thus, the government should avail more funding on R&D. In universities, R&D activities are better organized and focused.

High-tech industries are taking roots in Sarawak. In the Sama Jaya Free Industrial Zone, 14 high-tech foreign and local companies are operating, producing products ranging from multi-layer ceramic chips to semi-conductor fabricated wafers. What is left for the state to vigorously pursue immediately is biotechnology.

Nobel Laureates’ interaction with Young Hopefuls: A Unique Annual Event at Lindau, Germany

N. M. BUTT[1]
PINSTECH, PO Nilore, Islamabad, PAKISTAN
Fax: 0092-51-9290275, e-mail:nmbutt36@yahoo.com

1 ABSTRACT

A group of eight Pakistani talented graduate students/young scholars (aged between 20 and 30) participated in the 53rd Nobel Laureates’ Meeting at Lindau for a period of one week from 30 June – 04 July 2003.

The subject of the meeting this year was Medicine/Physiology. The eight Pakistani students were selected out of 45 top candidates nominated by 15 Institutions in Pakistan, through a selection board of eight eminent scientists of Pakistan. The selection was on severe standards of merit. Twelve Nobel Laureates lectured to a total of 550 participants from about 30 countries. They also had several informal and face-to-face discussions with the students. This unique occasion is provided annually to graduate students and young researchers the world over to cultivate dialogue and understanding among the nations of the world and to sustain the progress of knowledge by inspiring the young to adopt careers of research through inspiration and motivation as a result of their informal interaction with the Nobel Laureates. The Lindau Conference provides a unique scientific event throughout the world in collecting so many Nobel Laureates at one place for a period of one week. The first such meeting held in Lindau was on 11 June 1951 at the interest and support of Count Lennart Bernadotte, where some scientists from Europe met. This first meeting was attended by seven Nobel Laureates and some 400 physicians from Germany and the neighbouring countries. For over 50 years such meetings are a regular annual happening in the beautiful city of Lindau located in the south of Germany on Lake Constance.

As a result of this participation, the members of the Pakistani group were greatly motivated to carry on research as some of them were offered places by the Nobel Laureates to do research with them. They also developed useful cooperative and friendly contacts with their contemporaries from USA, Germany, UK etc. for mutual academic benefit in years to come. This event is indeed a very unique and useful forum for drawing benefits in developing human resource in science and technology and motivating the youth of the countries across the world. The participation is indeed more useful for developing and OIC countries to draw benefits from this unique event in the world. This is an occasion where the best of one country meet the best of other countries. Some details of the participation of the Pakistani group are presented in this paper.

2 THE EVENT!

For over 50 years, an annual conference is being held in Lindau, Germany; whereby several hundred students/young scholars meet usually about 20 Nobel Laureates for one week of lectures and informal discussions. The purpose is to sustain world knowledge by inspiring and motivating the young students to adopt careers of research. Each year a subject is chosen from among the three subjects; Physics, Chemistry and Medicine/Physiology.

Students between the ages of 20-30 are selected from various countries across the world take part annually in this conference.

[1] Fellow of the Islamic World Academy of Sciences. Since January 2006; Chairman, Pakistan Science Foundation (Editors).

The 2003 Conference was held in Lindau from June 30 – July 4 2003 on the subject of Medicine/Physiology. About 550 students from about 30 countries participated in this activity; about 200 German students, 30 American students, 30 Austrians, 20 British, 20 Indians, and 20 Japanese students etc. were among the participants.

Twelve Nobel Laureates in the field of Medicine/Physiology and Molecular Biology participated. The Nobel Laureates were L. Cooper (1978); E.H. Fischer (1992); W. Arber (1978); R.A. Marcus (1992); C. Nusslein-Volhard (1995); B. Sakmann (1991); E. Neher (1991); T.N. Wiesel (1981); R. Huber (1988); H.O. Smith (1978); G. Blobel (1999) and H. Michel (1988).

The main programme consisted of a general inaugural session held on 30 June in which the premier of Bavaria Province also participated.

Figure 1. Some Nobel Laureates (blue ribbons) sitting in front row.

The technical programme of the week consisted of two "panel" sessions, one each by six Nobel Laureates, of their views on the topics of "Future of Medicine" and "Basic discovery to clinical practice" (Figure 1 & Figure 2(a &b)).

Figure 2 a. Panel 1: Nobel Laureates (six from right).

Figure 2b. Pakistani students listening to panel discussions.

The other technical programme consisted of subject lectures by the Nobel Laureates in their fields of specialization. All the participants in the conference, i.e. 550 students and some senior scientists invited to attend the conference attended these programmes. The two afternoons consisted of programmes for students only and the senior scientists were not permitted. These consisted of “students – Nobel Laureates” face to face “scientific discussions.”

Figure 3a. Nobel Laureate Prof. L. Cooper with Pakistani students.

Every Nobel Laureate had a separate desk in a separate room/partition and answered questions of students in 1 ½ hour session. Any student could attend any session of any of the Nobel Laureates and could discuss matters openly and informally. This was a great opportunity for young minds to be inspired and motivated and to satisfy their enthusiasm and curiosity to interact at this level (Figure 3 (a,b & c)).

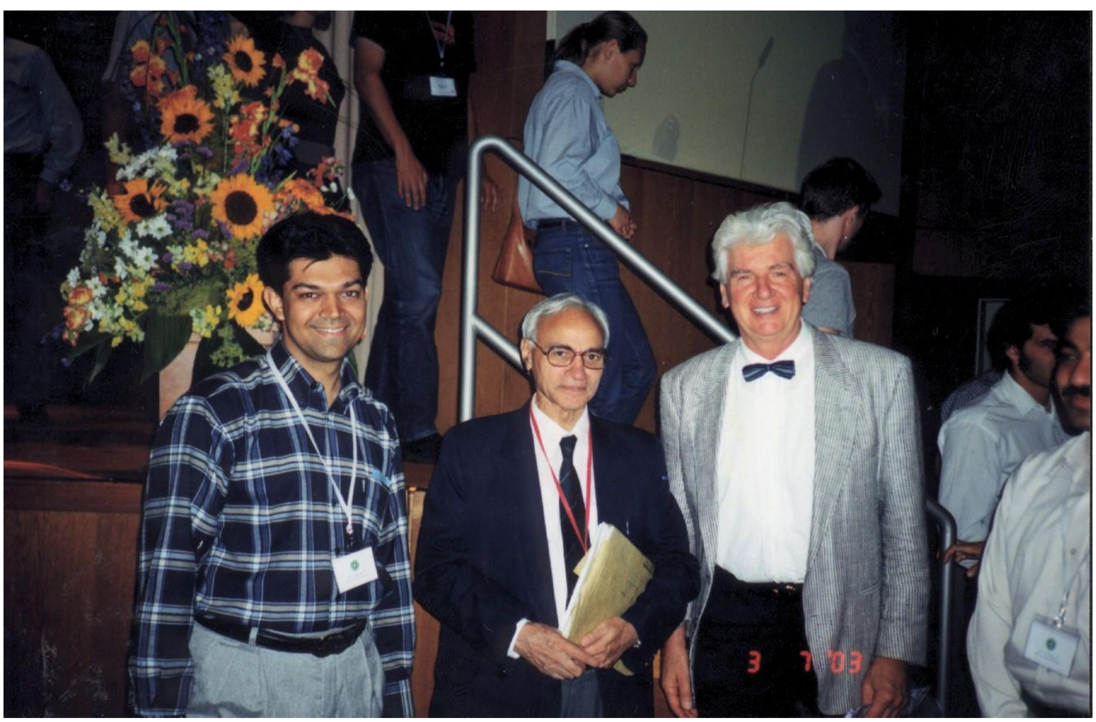


Figure 3b. Nobel Laureate Prof. G. Blobel and Pakistani students.

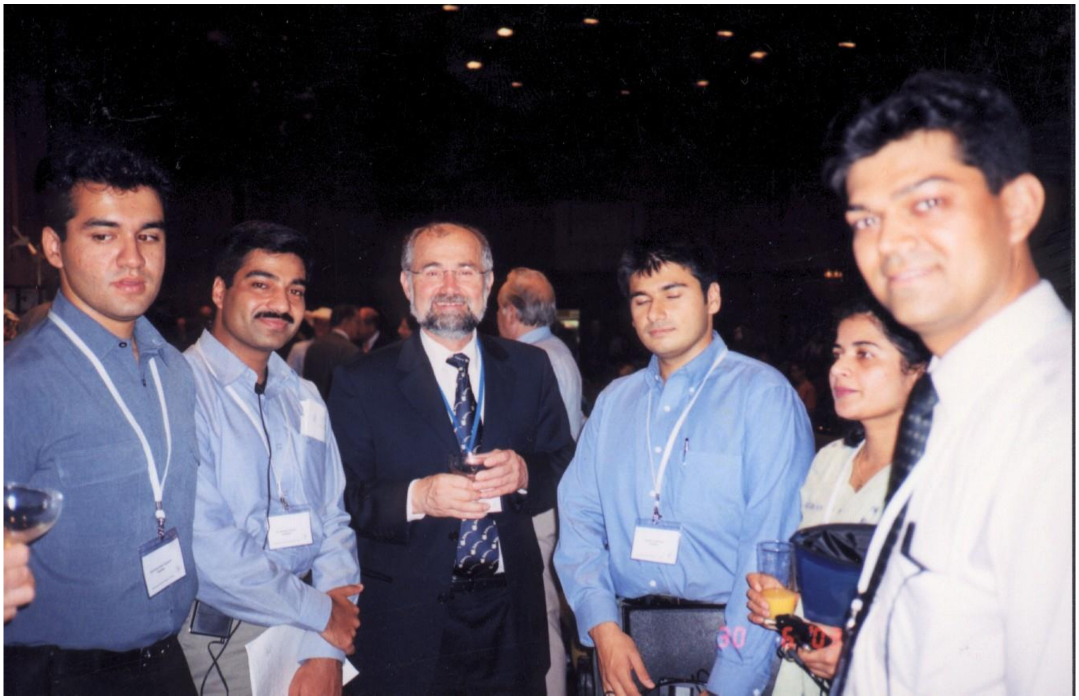


Figure 3c. Nobel Laureate Prof. E. Neher with Pakistani students.

Figure 4. President Countess Sonja Bernadotte making farewell speech in Mainau Castle.

The conference ended with brief speeches by the President, of the Committee of Nobel Laureates Meetings in Lindau, Sonja Bernadette, a Nobel Laureate representative and a student representative (Figure 4).

The week long programme, while on the one hand provided an informal forum of creating friendship of various cultures of the world, provided chances of scientific cooperation between individuals – a cooperation which helps in the development of world knowledge as well as creates long living human bonds of friendship. Also this forum provided the chance to Nobel Laureates to pick up best young minds and offer them chances to do research in their laboratories and contribute to the success of their own research programmes by such young researchers either as PhD students or as young post-docs. Further, this forum provided ample time for interaction among young minds with their contemporaries from different countries. It planted the seeds of personal friendships as well as collaboration and mutual interaction among them. Such friendships run for several years and cause cooperative research in the years ahead. Pakistani students made frequent discussions with their contemporaries from various countries (Figure 5(a &b)).

Figure 5a. Pakistani student, Miss Aisha Mohyuddin (red dress, end of table) in discussion with students from the USA.

Figure 5b. Pakistani delegation attending reception hosted by US delegation.

3 PAKISTAN'S PARTICIPATION

3.1 Background

In an international conference in Hungary in which Dr. N.M. Butt participated, he met with a well known German Professor of Nuclear Medicine, Professor L.E. Feinendegen. During the week long conference friendship developed between the two. The presence of Prof. S. M. Qaim, a very well known nuclear chemist of Pakistani origin and is settled in Germany, who knew Prof. Feinendegen, strengthened this friendship.

Professor Feinendegen, a very cooperative man of "world-sharing attitude of knowledge" informed Dr. Butt about the Lindau Annual Conferences and told him that Pakistan was not taking part in this useful annual event.

He suggested that if he could take the responsibility, of selecting 10 talented Pakistani students/young scholars between the ages 20-30 years, they could participate in these unique conferences. The fact that Professor Atta-ur-Rahman, the Minister for Science and Technology in Pakistan at the time, was making an effort to strengthen science in the country encouraged him to accept this responsibility. On returning home, Dr Butt received a letter from Prof. Feinendegen appointing him as "Representative in Pakistan" of the "Committee of Nobel Laureates Meetings in Lindau" of which Countess Sonja Bernadotta is the President, and Professor Feinendegen is the Vice President.

Although the participation costs $2500 per participant to a US participant, with $500 being the conference fee, the offer of Prof. Feinendegen for the group of 10 Pakistani students was free of cost. Only air travel was required. To further the process, Dr N.M. Butt made efforts to raise the funds needed for the air-travel of the 10 students and made a proposal to his parent agency, the Pakistan Atomic Energy Commission (PAEC). Dr Khalil Ahmad Qureshi, the PAEC Member (Fuels), encouraged this scheme and supported the proposal and provided Rupees 600,000 for travel. The PAEC Member (Physical Sciences) Dr Masud Ahmed recommended the case to the Chairman PAEC; Mr Parvez Butt.The Pakistan Atomic Energy Commission was kind to approve another grant of Rupees 600,000. Dr Atta-ur-Rahman (Chairman HEC) and Dr Suhail Naqvi (Member HRD, HEC) very much supported this project on behalf of the Higher Education

Commission (HEC) and agreed to extend financial support. The HEC further took a very supporting step of approving funds for this scheme for a period of 5 years.

3.2 Selection of talented students

With the financial support of PAEC and HEC, Dr N. M. Butt designed and executed a scheme of careful selection of talented students on “strict merit.” The first participation of Pakistani students was planned for the year 2003 in the Lindau conference to be held from June 30 – 4 July 4 2003, on the subject of Medicine/Physiology. Dr Butt approached the heads of 15 Medical and Molecular Biology institutions in Pakistan and requested the nomination of the “Three-Best” candidates from any one institution. He tried on an individual basis as well to get the best possible candidates to compete in this process. Forty five candidates applied from 15 such institutions from all over Pakistan. Dr. Butt formed a committee of five very eminent scientists as the Selection/Executive Committee to manage this scheme. This committee short-listed 19 candidates on the merit of the CVs received (Figure 6).

Figure 6. Selection Board members with 18 short listed candidates.

The committee decided to personally interview each candidate to select the best 10 students. The committee co-opted four specialist professors related to Medicine and Physiology/Molecular Biology during the interviews of the candidates (Figure 7(a & b)).

Figure 7 a. Members of the Selection Board.

Figure 7b. Candidate being interviewed by the members of the Selection Board.

For each candidate interviewed, based on the average marks of eight members of the Board, a merit list was prepared the same day and signed by each member of the board. The top eight candidates were selected for participation in the Lindau Meeting. Of these were four girls and four boys. The names of the candidates were; (1) Dr Aisha Mohyuddin (KRL, Islamabad), (2) Dr Abida Raza (NIBGE, Faisalabad), (3) Miss Somaira Majeed (NIBGE, Faisalabad), (4) Mr Hammad Nasir Qureshi (KEMC, Lahore), (5) Dr Naveed Janjua (Agha Khan Medical College, Karachi), (6) Miss Saman Zafar (RMC, Rawalpindi), (7) Mr Nadim Syed Jafri (Sind Medical

College Karachi) and (8) Dr Saeed Mehmood Khan (Agha Khan Medical College, Karachi). This was a highly meritable selection of eight very talented students from Pakistan (Figure 8).

Figure 8. Finally selected 8 students with Mr Parvez Butt (Chairman PAEC).

To further brighten their vision, an orientation camp was arranged in Islamabad extended over 3 days before the Lindau Conference. In this orientation, about 20 eminent scientists including subject specialists, Members of Selection Committee as well as prominent heads of scientific organizations like Chairman HEC, Prof. Atta-ur-Rahman (Figure 9a) and Chairman PAEC, Mr Parvez Butt (Figure 9b) addressed the group of eight finally selected students in a very informal manner over all the three days of the orientation camp, together with Dr Sahukat Hameed Khan (Figure 9c) and Dr N. M. Butt (Figure 9d).

Figure 9a. Prof. Atta-ur-Rahman (Chairman HEC) at informal discussions with 8 selected students during orientation camp.

Figure 9b. Mr Parvez Butt (Chairman PAEC) at informal discussions with 8 selected students during orientation camp.

Figure 9c. Dr Shaukat Hameed Khan, member Selection Committee, addressing the 8 selected students at the orientation camp.

Figure 9d. Dr N. M. Butt, Member Selection Committee and Representative in Pakistan, Nobel Laureates Meeting in Lindau, addressing the students at the orientation camp.

3.3 Cooperation of the German Embassy in Islamabad.

Apart from the sincere help of the Lindau Committee through the efforts of Professor Feinendegen, the German Embassy in Islamabad cooperated and provided help through issuing "Gratis Visas" to the selected students.

H.E. the Ambassador of Germany in Islamabad, Mr Cristoph Brummer was very kind to host a reception at his residence in honour of these students to which the Selection Committee was also invited. The Ambassador provided a very lively and informal atmosphere of discussions (Figure 10 & Figure 11).

Figure 10. Students and Members of the Selection Committee at the reception hosted by the German Ambassador Mr Cristoph Brommer at his residence.

Figure 11. Cultural Attache of the German Embassy in Islamabad, Mr Fabian Richter addressing the students at orientation camp.

3.4 Participation in Lindau Conference 30 June – 4 July 2003

3.4.1 Getting there

The group of eight selectees was led by Dr N. M. Butt as "Caretaker" to participate in the conference. The group travelled by Air from Islamabad to Frankfurt and by train onwards from Frankfurt to Lindau.

The group arrived in Lindau on 28 June, a day before the start of the conference. The group attended the Inaugural Session on the first day of the conference, i.e. 30 June.

3.4.2 Successful activities during the conference

The group members took keen interest in the scientific discussions with a large number of contemporary participants as well as with the Noble Laureates. They asked frequent and intelligent questions to the lecturers and made very relevant discussions and over the period of the conference created a very appreciative impression among the participants. They found no hesitation in equally intellectual discussions with the best of the participants from the advanced countries like USA, Germany, UK, etc.

3.4.3 Praiseworthy performance of the Pakistani group

Pakistani students made very good intellectual impressions on some of the Nobel Laureates during the lectures and informal discussions. One of the Nobel Laureates, Prof. Hamilton Smith became very friendly with the group and even spent an exclusive lunch time with the full group. He made offers to two of our medical students to work in his laboratory for a period of one year or so Figure 12.

Figure 12. Nobel Laureate Prof. Hamilton Smith and his wife at lunch with the Pakistani students.

3.4.4 Pakistan gets prominence

Professor Feinendegen, the Vice-President arranged a special one hour meeting of the Pakistani Group with the President Countess Sonja Bernadotte for discussions and presentation of Pakistani gifts (a painting and books on Pakistan) (Figure 13a &16b).

Figure 13a. A Pakistani painting being presented to the President Countess Sonja Bernadotte during her exclusive meeting with Pakistani students.

Figure 13b. A book on Pakistan being presented to Vice-President Prof. L. Feinendegen during meeting with Pakistani students.

Another matter of prominence for the Pakistani group was the half hour interview arranged with the publisher of an American journal; "The Journal for Minority Medical Students" in the US. The interview of the Pakistani students with photos was conducted by the publisher Mr Bill Bower and will be published in this American Journal.

3.4.5 Group's second week in Germany

Professor Feinendegen had proposed to Dr Butt that after one week after the Lindau conference, it would be useful for the Pakistani students to visit a couple of hospitals in Germany to appreciate the research level of medical institutions in the country. The group travelled by train from Lindau to Munich on 6 July, and visited Rechte Izar, a big hospital, on 8 July.

Prof. Wester conducted the visit, particularly the section on Nuclear Medicine (Figure 14(a & b)).

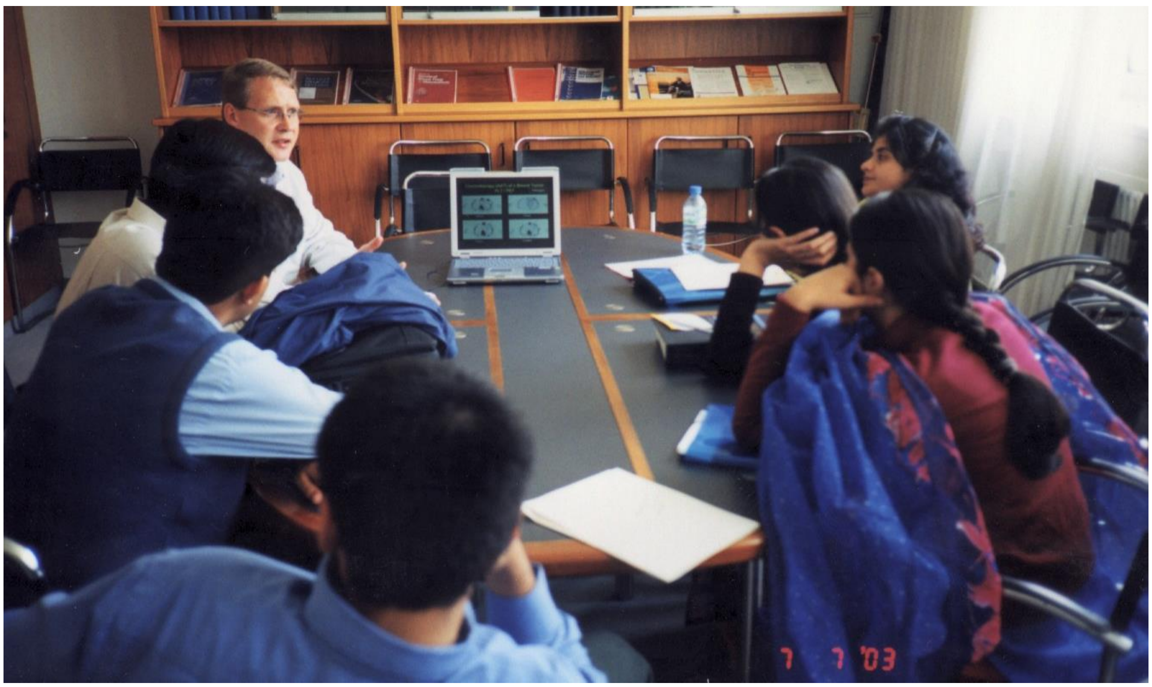


Figure 14a. Dr Wester, Dept. of Nuclear Medicine, Isar Clinic, (famous Hospital in Munich) addressing the Pakistani students.

Figure 14b. Dr Wester, Dept. of Nuclear Medicine, Isar Clinic (Munich) with Pakistani students.

Not missing the occasion while in Munich, the group visited Germany's best Science Museum located in the city. The visit to the Science Museum was indeed very informative (Figure 15).

Figure 15. Pakistani students at the famous "Deutsches Museum," Munich.

The group then travelled to Juelich and arrived there in the evening of 8 July and visited the famous Research Centre, Forschungszentum Juelich on 9 July through the kind arrangements of Prof. S. M. Qaim, a respected researcher (of Pakistani origin and settled in Germany) at the Institute of Nuclear Chemistry. Juelich Research Centre is one of the very famous multi disciplinary centres in Germany. The students visited the Institute of Nuclear Chemistry directed by Prof. H. H. Coenen with Prof. Qaim where radio-isotopes are extensively used for medical purposes (Figure 19).

Figure 16. Pakistani students with Prof. S. M. Qaim and his colleagues during visit to the Inst. Of Nuclear Chemistry, Forschungszentrum Juelich.

The radio isotopes are produced in the nuclear accelerators called Cyclotrons available in the institute. Some members of the group also visited the Institute of Nuclear Medicine directed by Prof. Hans Herzog while others visited the Institute of Genetic Engineering.

Dr Butt found time to discuss the latest research on Materials Science using Neutron Scattering with one of the researchers at the Institute of Materials Research. The visit to Juelich was full of discussions by the students and was appreciated by Prof. Herzog and Prof. Coenen. The group made a high level intellectual impression in Juelich. This was reflected by the e-mails from Prof. Herzog and Prof. Coenen sent to Dr Butt after his return to Islamabad. Both the Professors offered places for any student of the group who would like to do research in the areas which are being pursued.

4 CONCLUSIONS

The first participation of Pakistan in the Lindau Conference has been a very fruitful and successful event for our talented youth. The Lindau Conference will deal with the subject of Physics in June 2004 and Chemistry in June 2005 before again starting the next cycle with Medicine/Physiology in 2006 again.

The cooperation of HEC and PAEC in this unique Human Resource Development international activity will go a long way in building strong science and technology in Pakistan. The support of Mr Parvez Butt, the Chairman PAEC and of Professor Atta-ur-Rahman, Minister of Science and Technology and Chairman of HEC, will bring dividends to the initiative of Dr Butt and his dedicated efforts, along with his Selection Committee of Eminent Scientists; Dr Masud Ahmed (Member, PAEC), Dr Suhail H. Naqvi (Member, HEC), Dr Abdullah Sadiq (Rector, PIEAS) and Dr Shaukat Hameed Khan (DG, SPS). This cooperative venture of PAEC and HEC is a source of great strength to the development of science and technology in Pakistan.

The sincere help of the president of the Lindau Committee, Countess Sonja Bernadotte, and that of the Vice-President, Professor Feinendegen, without whose support there would have been no Pakistani participation in this unique event; must be acknowledged. One must also remember the kind help extended by H.E. the Ambassador of Germany in Pakistan, Cristoph Brummer in this program.

The future is bright for this programme with the approval of funds for the next 5 years by the Pakistan Higher Education Commission.

Nematodes:
A Limiting Factor in Agricultural Productivity*

MOHAMMAD SHAMIM JAIRAJPURI*
Section of Nematology, Department of Zoology,
Aligarh Muslim University
Aligarth 202002, India

1 ABSTRACT

This paper reiterates that the plant parasitic nematodes rank among the most important and serious pests of agricultural crops throughout the world. Nematology or plant nematology is the discipline which deals with this group of nematodes. The knowledge of nematodes may be very ancient, but it was the animal and human parasites that were known since antiquity rather than the plant parasites. The main reasons for this delay being the very small to microscopic sizes of phytonematodes which require a magnifying device to become visible. These little worms occur in a wide variety of sizes and shapes and in enormous numbers. Their study gained importance and momentum only in the 1950s and 1960s. The most important plant-parasitic nematodes are root-knot nematodes (*Meloidogyne* spp.) which are prevalent in warmer countries and cyst-forming nematodes (*Heterodera/Globodera* spp.) found largely in colder climates of the world. In addition, there are innumerable other species of phytophagous nematodes that attack our agricultural, horticultural crops, ornamental and other plants such as forest trees, grasslands, etc. If these pests are not properly and carefully dealt with immense losses would occur with disastrous consequences for the farmers as well as for the country.

2 INTRODUCTION

The human population no doubt is rising and in third world countries the rise is at an alarming rate. The modern scientific knowledge has made available improved medical facilities that has lead to a sharp increase in human longevity. All this has greatly enhanced demand for food. Fortunately, lot of improvements have taken place simultaneously in the field of agriculture as well. Not only that the crop productivity has increased with the help of improved and high yielding crop varieties but in the recent years GM crops have also been introduced though their utility may be highly controversial, as of now. The greatest threat to crop productivity and plant health comes from the pests of crops which may be insects, nematodes, fungi, bacteria, viruses, etc. Unfortunately, the nematodes are least known but incidentally the most dangerous of all these. They are often referred to as enemy in hiding or the unseen enemy. Many call them as 'king of pests' and perhaps rightly so. It is unfortunate that our agriculturalists and farmers are by and large ignorant about them and even if they know, their knowledge is very poor. Further the methods to combat or in other words control them are very difficult and without much success.

The nematodes are a unique group of rather primitive invertebrate animals in a number of ways. They occur abundantly in all possible and conceivable types of habitats, e.g., water, (both freshwater and marine), soil and as pests and parasites of plants and animals. In many ways they are like insects e.g., in diversity, distribution and in causing pathogenesis and diseases in man and animals, both vertebrates and invertebrates, as also in all types of plants, such as grasslands, forest-trees, vegetables, ornamentals, and all crops including horticultural crops. The nematodes indeed are most widespread

* Professor of Zoology; and Fellow of the Islamic World Academy of Sciences from India.

animals occurring in the deepest oceans, freezing polar seas, hot-water springs, arid deserts, alpine lakes, mountain tops and frozen Antarctica, all representing very hostile climates of the world. Surprisingly the nematodes are not only present but quite abundantly in all these ecosystems. This is indeed a tribute to their adaptability. In not so unfriendly habitats such as in agricultural soils and those which are more moderate and salubrious, their presence is obviously in far greater numbers and diversity.

An attempt has been made here to give some introductory and preliminary information about the diversity and universality of nematodes as also to highlight their importance to mankind, particularly from the point of view of agriculture. This being the main reason for choosing the topic for presentation here. The nematodes are essentially soil–inhabiting but quite a vast majority of the species are herbivorous and obtains their food by feeding on plant roots, sometimes they may also feed on their stem and other above-ground parts such as leaves and inflorescence. In the process they may cause damage to these parts which could be very extensive resulting into crop failures and severe economic loss to the farmers. There are mainly three groups of nematodes in the soil that are generally found associated with plants, namely Tylenchida, Dorylaimida and Mononchida. While the first group contains nearly all species that are plant parasites, the second one has only some plant-parasitic species, the others may be free-living or predatory. The Mononchida are exclusively predatory. The predatory species of Dorylaimida and Mononchida are very beneficial as they can kill plant-parasitic nematode species and are thus of great value in our biological control programmes. In my nearly a dozen books and nearly 400 research papers on these three groups of nematodes which were published during the last four decades (1963-2003), I have explored almost all fundamental and applied aspects of agricultural Nematology. Consequently, the School of Nematology at Aligarh Muslim University has made a distinct mark and is well-known throughout the world for its excellence.

The other reason of my choosing this topic on plant nematodes is the fact that throughout the Muslim world, the awareness about these important pests of crops, which are often referred to as king of pests, is largely non-existent. In a few countries such as Iran, Turkey, Egypt, Pakistan, etc., efforts have been made to develop Nematology but these have not attained the status and stature that was expected. It would not be out of place to mention that even the United Kingdom needed two of us to develop expertise in their top institutions of the Commonwealth Agricultural Bureau's, International Institute of Parasitology, U.K. There is thus an urgent need to develop expertise in Nematology in the Islamic Countries so that their agricultural base could be further strengthened and widened. India would be of great help in this matter as it has many experienced nematologists and reputed institutions.

3 NEMATODE DIVERSITY

The basic pattern of body organization may be very similar in all nematodes, but these tiny primitive creatures are structurally very diverse and have in many respects, amazing ways of life. Foremost among these is their numerical superiority, which surpasses all imaginations. A single acre of soil from an arable land is said to contain as many as 3,000,000,000 nematodes while those from sandy beach nearly half as much. A single grain of wheat parasitized by the well-known wheat-gall nematode, *Anguina tritici* may contain up to 100,000 of its juveniles. Those who may be familiar with techniques for their extraction from soils would indeed know that in a single sample it is not unusual to find 10-15 genera of nematodes with as many or more species of different kinds and characteristics. Rarely these numbers could be astounding, for example, in one soil sample, weighing not more than 1 kg from a locality in Malnad tracts of Karnataka we had ourselves recorded (unpubl.) over 60 genera of nematodes. This alone speaks volumes about the tremendous diversity of this group as also their wide distribution. Leaving aside perhaps protozoan, no other animal group, insects included, is so numerous and widespread. The claim of some nematologists that nearly 90% of all metazoans in the world are nematodes, something about which entomologists would rather be skeptical, is indeed closer to truth than exaggeration (Jairajpuri, 2002).

4 NEMATODE NUMBERS

Apart from their numerical superiority the species numbers of nematodes are also unbelievably very high, close on heels to that of insects. The latter, as is commonly known, make up nearly 80% or over 800,000 known species out of a total of over one million species of all groups of animals. The remaining 20% or about 200,000 animal species also include species of nematodes that are known so far. These numbers around 20,000 species or a mere 10% of biodiversity excluding insects, but only about 2% of total animal biodiversity. These figures are for all types of nematodes described so far, i.e., free-living, predatory saprophytic, parasitic, etc. But the fact remains that full potential of species numbers, like their numerical superiority, has neither been properly understood nor fully appreciated by biologists largely due to lack of experience and expertise on nematodes. The number of known nematode species at the moment is literally a 'chicken-feed' as compared to those of insects. It is, however, true that only a very minute fraction of nematode species, that actually exist in this world, have been collected, inventorised and described.

5 NEMATOLOGY DISCIPLINES

Though nematology gained attention and recognition only in 20th century, our knowledge of a few species of nematodes of medical importance dates back to Papyrus Ebers (circa 1500 BC). The intestinal roundworm (*Ascaris lumbricoides),* filarid (*Wucheraria bancrofti*) and the Guinea worm called the serpent of Moses (*Dracunculus medinensis*) were already known to ancient man. Avicenna (circa 1000 AD) prescribed a treatment for pinworms (*Enterobius vermicularis*) which is used even today. But spectacular progress made in nematology during the last few decades and interest now being taken in the study of nematodes is not really due to species that attack man or animals. Their study is still traditionally and perhaps rightly so, a part of Helminthology, which pertains to larger discipline, called Parasitology. The trend in nematology has been to restrict study only to free-living, aquatic and soil-inhabiting nematodes which may also parasitize plants. The approach is more systematic, biological and agriculture-oriented. Sometimes in order to avoid confusion this branch of study has also been called Phytonematology but then it pertains only to plant parasitic nematodes and thereby excluding other related and equally important groups. There is a third category as well that of insect nematology exclusively devoted to nematode parasites of insects. Insect nematologists join hands sometimes with parasitologists but most of the times with nematologists, rarely they may also keep their separate identity. Importance of this group of nematologists has shot up in recent years because of the valuable role that insect-parasitic nematodes may play in biological control programmes for insect pests of crops. A lot of work is being done in many parts of world on potential of species of *Steinernema* and *Heterorhabditis* so as to use them as biopesticides against insects.

In India work on plant and soil nematodes started almost simultaneously in North at Aligarh and in South at Hyderabad. But the centre at Aligarh showed exponential growth, both in quality and quantity. The students of the Aligarh Muslim University in Agricultural Nematology later on went to many other centres where they either headed or played key roles in the development of Nematology. A few went abroad to U.K. and U.S.A. to occupy key positions. Though the study of structural biology and biological diversity remained their strong points,the work of repute was also carried out in the area of biology, behaviour, reproduction, predation, biological control, etc. The nematologists who are already well recognized for their work in this field are Siddiqi, Jairajpuri, Khan, Baqri, Ahmad, Tahseen, and others. A total of some 1000 new species, 150 new genera of nematodes, and some 1000 research papers and over two dozen outstanding books have been written. The books of international repute are on Tylenchida by Siddiqi (1986,2000), Dorylaimida by Jairajpuri & Ahmad (1992), Mononchida by Jairajpuri & Khan (1982), Nematode Taxonomy by Jairajpuri & Rahaman (2001), Nematode Structure by Jairajpuri (2002), Nematode Diversity by Jairajpuri (2002), Nematode Pest Identification by Jairajpuri (1989), Nematode Bio-control by Jairajpuri et al. (1990), etc.

6 NEMATODES IN AGRICULTURE

6.1 Background

The nematodes differ ecologically as also structurally. The ecological differentiations are largely due to habitat requirements, but the structural variabilities are primarily due to differences in the feeding habits. In a way the two types of differences are interrelated. The modifications are basically in the structure of mouth cavity and the anterior region of alimentary canal though the reproductive organs may also get involved. As a consequence of the above we have nematodes living in all kinds of conceivable biotopes and these may be free-living, microphagous, saprophagous or saprobionts, carnivorous, herbivorous or plant parasites and predaceous. It is the plant parasitic nematodes that are of concern to us in the present write-up. Despite their ecological or structural variability the nematodes do not differ very widely from one other. The nematodes that have developed ability to feed on plants have their stoma or mouth cavities exceedingly narrow and needle-like. This provides them the possibility of penetrating the plant cells, hydrolyzing their contents and then sucking them as food. This causes damage to the plants and ultimately the destruction of crops (Anon., 1986; Hague & Bridge, 1980). In some instances these nematodes in association with bacteria, fungi and viruses may cause much more damage then they are capable of inflicting alone.

The plant parasitic nematodes occur all over the world attacking all types of crops and plants causing extensive damage which ranges from about 10% to rarely 90% averaging about 12.3% (Sasser, 1989). Though the number of phytoparasitic species worldwide may be numerous but some more commonly occurring and also more pathogenic ones are mentioned below (Walia & Bajaj, 2003). Brief mention of their characteristic and damage inflicting capabilities are also mentioned:

Root-knot nematodes: *Meloidogyne* spp.
Cyst nematodes: *Globodera* spp. *Heterodera* spp.
Rice root nematodes: *Hirschmaniella* spp.
Citrus nematodes: *Tylenchulus* spp.
Stem nematodes: *Ditylenchus* spp.
Gall seed nematodes: *Anguina* spp.
Burrowing nematodes: *Radopholus* spp.
Lesion nematodes: *Pratylenchus* spp.
Reniform nematodes: *Rotylenchulus* spp.
Dagger nematodes/pin nematodes/stubby root nematodes *Xiphinema*/*Longidorus*/*Trichodorus* spp.

6.2 Root-knot nematodes, *Meloidogyne* spp.

The nematodes are whitish, pyriform that are lodged inside the root galls. More than 80 species belonging to genus *Meloidogyne* have been recorded. The nematodes are polyphagous and some of its important hosts are tomato, brinjal, cucurbits, potato, fruits such as papaya, grapes, peaches, tea, coffee, cotton, jute, tobacco, and many more. The parasites cause reduced plant growth, yellowing of foliage, wilting, smaller fruits and loss of yield due to galling of varying sizes on the roots. The species prefer warm climates and occur in tropical and subtropical countries of the world.

6.3 Cyst nematodes, *Globodera/ Heterodera* spp.

They are highly economically important nematodes that are very host specific. They produce cysts which are rounded in *Globodera* and lemon- shaped in *Heterodera*. The cysts remain in the soil and may contain a large number of eggs (400-500). The temperature and moisture helps the juveniles to emerge from the cysts. The host plants show poor growth and chlorosis is also quite evident. The favoured hosts for these nematodes are potato, sugarbeet, oat, wheat, barley, rye, soyabean, etc. The species are generally found in colder or temperate regions of the world.

6.4 Rice root nematodes, *Hirschmaniella* spp:

The nematodes are widespread and associated with rice all over the world. They are provided with a well developed stylet and basal knobs. They are both ecto- and endoparasitic and migratory in habit. They burrow inside the roots which later turn brown due to necrosis and damage to cortical cells. The physiological functioning of roots degrades with the result that the rice plants show poor growth, reduced number of ear-heads and resultant reduction in grain yield.

6.5 Citrus nematodes, *Tylenchulus* spp:

These are generally parasites on orange tree roots. Mature females are semi-endoparasitic with saccate bodies that are bent at vulval region. The hosts of nematodes are all types of citrus, grapes, olives, etc. The effect of nematodes is on the growth of trees, yellowing of their leaves and twigs, delayed fruit production, lesser yield and inferior quality of fruits. The distribution of the parasite is worldwide.

6.6 Stem nematodes, *Ditylenchus* spp:

Both the females and males are vermiform. They have a variety of hosts such as onions, bulbs of ornamentals, e.g., narcissus, tulips, hyacinths, alfalfa, clover, maize, rye, beans strawberries, potatoes, mushrooms, etc. Distribution is all over Europe, Canada, USA, Russia, Swelling or gall-like growths appear, stunting, malformation and death of plants may be the result. Two important species, *D. dipsaci* and *D. angustus* are of great economic importance, the first one is associated with many species of plants, mainly ornamentals, while the latter has an affinity for rice plants causing ‘Ufra’ disease.

6.7 Gall seed nematodes, *Anguina* spp:

These are endoparasites of seeds, stems and leaves of cereals, grasses and other plants. It is widespread in wheat growing regions, Europe, Asia, USA, Australia, New Zealand, India, and the Middle East. Galls bear second stage juveniles which are quiescent. Under moist conditions they emerge and feed on seedlings due to which wheat plants undergo stunting, wrinkling and twisting. The leaves get reduced and irregular earheads, gall or cockle formation takes place. Loss is both quantitative and qualitative. Seed cleaning is the most effective control measure. An important species of this genus is *A. tritici* which not only causes gall formation but in association with a species of bacteria, *Clavibacter tritici* causes yellow ear rot or ‘tundu’ disease.

6.8 Burrowing nematodes, *Radopholus* spp:

They are associated with banana and are migratory endoparasites causing root rot. Other hosts are pepper, tea, coffee, maize, sugarcane, coconut, vegetables and sometimes citrus. Cavities are formed which coalesce and result into characteristic brown lesions. Yellow disease or ‘yellows’ in black pepper results in falling leaves stunted growth, and lowered production.

6.9 Lesion nematodes, *Pratylenchus* spp:

These are vermiform nematodes causing wounds on the roots which are ideal places for bacteria and fungi to flourish causing root lesions. The trees get stunted, chlorosis sets in leading sometimes to the death of plants. It has coffee, tea, tobacco, citrus pinapples, grapes, maize, sugarcane, etc. as hosts.

6.10 Reniform nematodes, *Rotylenchulus* spp:

The mature females are bean-shaped but the males are vermiform. It has a large variety of hosts such as fruits, pulses, vegetables, cotton, coffee, etc. The nematodes live as sedentary semi-endoparasites causing damage to feeder roots thereby resulting into yellowing and wilting of the plants.

6.11 Dagger nematodes/pin nematodes/stubby root nematodes, *Xiphinema*/ *Longidorus*/ *Trichodorus* spp:

Xiphinema spp. are migratory ectoparasities characterized by their long spears with flanges at the base. They can also transmit viruses and attack woody plants causing damage to their roots. *Longidorus* spp. are also virus vectors possessing a long stylet and causing damage to root tips that results in the decline of plant growth. The *Trichodorus* spp. that are commonly called as stubby nematodes are provided with a stylet which is solid needle-like. These can also act as vectors of tobacco rattle virus. They are associated as root ectoparasites of tomato, maize, onion, sugarcane, etc. The host roots become stubby due to the absence of fine feeder roots, hence the name.

7 ENVIRONMENTAL MANAGEMENT OF NEMATODES

The significance of nematodes as serious pests of crops and limiting factors in agricultural productivity dawned upon mankind rather late. When the world awakened to face challenges of economic rehabilitation after the Second World War, increasing agricultural productivity was an important consideration. Extensive mono-culturing had led to considerable depletion in crop yields due to a steep rise in population levels of all kinds of pests, the nematodes being the foremost. This naturally called for the adoption of control measures on a large scale. Taking clue from the sister disciplines of Entomology and Plant Pathology similar methods like cultural, physical, regulatory, chemical control, etc. were employed. Some of these proved useful in certain situations, others cumbersome and often too expensive to merit consideration for application on a large scale. Although cultural control methods appeared promising in some instances, the co-operation from the farmers considered extremely essential in such situations was not really forth-coming. Chemical control has its merits but the cost of nematicides, difficulties in their availability, their highly toxic effects in the soil and on underground water and also on the plants has led to either banning or restricting the use of these chemicals because of the environmental hazards. Only in some very special situations their use could be permitted. Quite often they leave residual effects in the soil as also in the plants that can threaten human health as also that of livestock upon consumption.

The limitations or failures of the conventional methods have stepped up, in the recent years, the search for alternative methods of control. This has brought to light two rather very exciting and promising possibilities-the cropping systems and the biological control both of which are environment friendly. These strategies aim at the suppression of nematode populations to manageable limits. It is imperative that in order to successfully apply either of the two methods, an in-depth knowledge of the pest, its host plants and also of the environment inhabited by both has to be obtained. At present it may appear to be rather theoretical but such programmes have been successfully applied in the area of Entomology for insect pests and there being thus no reason why these should not succeed for the nematodes. Though the latter are more persistent and also soil- inhabiting hence rather difficult to tackle. In certain situations trap-cropping, early maturing varieties as also enemy plants have also been successfully used. The well-known case is that of marigold (*Tagetes* spp.) being used for apple replant problem due to nematodes.

Nematodes, like all other organisms, have many limiting agents-parasites, predators, enemy plants, etc., which help in keeping a natural check on their population levels. When nematodes assume the status of pests, it is essentially the result of a steep unchecked rise in their population indicating the failure of the antagonistic organisms to counteract this rise. The remedy, therefore, lies in introducing them artificially into an ecosystem as a parasite, predator, or some other agent for keeping a check on the nematode species or by taking measures to enhance the existing population levels of someo of these antagonistic organisms.

8 CONCLUSION

The plant-parasitic nematodes are serious pests on a large number of crops of agricultural importance the world over. Unfortunately, our knowledge about these pests is rather scanty and very little attention is being paid to control these pests which cause on an average about 12% yield losses. In extreme cases, the losses could be very high resulting into total crop failures. Use of chemicals called nematicides provides some relief from these parasites but the toxic effects of these compounds does more harm than good to the plant health. As a result most of these chemicals were ultimately banned. Cropping systems, biological control methods and IPM may ultimately turn out to be a better strategy against these parasites. There is thus a real need on a worldwide basis to study these nematodes, their disease causing mechanisms to develop control strategies for enhanced crop productivity.

REFERENCES*

1. Anon (1986). Plant-parasitic nematodes of Bananas, Citrus, Coffee,Grapes and Tobacco. Publ. Union Carbide, U.S.A., 71 pp.
2. Hague, N. G. M., and Bridge, J. (1980). Nematodes, the unseen enemy, U.K., 17 pp.
3. Jairajpuri, M.S. (1989). Nematode Pest Identification. Publ. Zool. Deptt., AMU; 357 pp.
4. Jairajpuri, M.S. (2002). Nematode Structure: With special reference to plant parasitic, soil-inhabiting nematodes of the Orders Dorylaimida, Mononchida & Tylenchida. Impressions Quality Printers, Hyderabad: 213pp.
5. Jairajpuri, M.S. (2002). Nematode Diversity. Silverline Printers, Hyderabad: 500pp.
6. Jairajpuri, M.S. (2002). Nematode diversity with special reference to surface structures. Presidential address, Zool, Ent. & Fish, 89th Indian Science Congress, 2001-2002 at Lucknow. 32 pp.
7. Jairajpuri, M.S. and Ahmad, W. (1992). Dorylaimida: *Free-living Predaceous and Plant-parasitic Nematodes.* Publs. E.J.Brill, Leiden. The Netherlands and Oxford & IBH Publ. Co. Pvt. Ltd. New Delhi; 458pp.
8. Jairajpuri, M.S. and Khan, W.U. (1982) Predatory Nematodes (Mononchida). Associated Publication Company, New Delhi, India; 131pp.
9. Jairajpuri, M.S., Rahman, P.F. (2001). Nematode Taxonomy: *Concepts and recent trends.* Impressions Quality Printers, Hyderabad: 235 pp.
10. Jairajpuri, M.S., Alam, M. M. and Ahmad, I. (1990). Nematode Biocontrol: *Aspects & Prospects.* CBS Publ. Delhi; 152 pp.
11. Sasser, J.N. (1989). Plant Parasitic Nematodes: The Farmers Hidden Enemy. A Cooperative Publ. of Dept. of Plant Pathology and the Consortium for International Crop Protection, Printed at NCSU, Raleigh, U.S.A., 115 pp.
12. Siddiqi, M.R. (1986) Tylenchida, Parasites of Plants and Insects. Commonwealth Agricultural Bureaux, Farnham Royal, Slough, UK, ix + 645 pp.
13. Siddiqi, M.R. (1986) Tylenchida, Parasites of Plants and Insects, 2ND Edition. CAB International Wallingford Oxon OX10 8DE UK, 833 pp.
14. Walia, R. K. and Bajaj, H. K. (2003). Text book on Introductory Plant Nematology, ICAR Publ. 227 pp.

* As listed by the author.

Table 1. Worldwide annual yield losses due to damage by plant parasitic nematodes

Life sustaining crops	(%)Loss	Economically important crops	(%)Loss
Banana	19.7	Cacao	10.5
Barley	6.3	Citrus	14.2
Cassava	8.4	Coffee	15.0
Chickpea	13.7	Cotton	10.7
Coconut	17.1	Cowpea	15.1
Corn/ maize	10.2	Egg plant	16.9
Field bean	10.9	Forages	8.2
Millets	11.8	Grape	12.5
Oat	4.2	Guava	10.8
Peanut	12.0	Melons	13.8
Pigeonpea	13.2	Miscellaneous	17.3
Potato	12.2	Okra	20.4
Rice	10.0	Ornamentals	11.1
Rye	3.3	Papaya	15.1
Sorghum	6.9	Pepper	12.2
Soybean	10.6	Pineapple	14.9
Sugarbeet	10.9	Tea	8.2
Sugarcane	15.3	Tobacco	14.7
Sweet potato	10.2	Tomato	20.6
Wheat	7.0	Yam	17.7
AVERAGE	**10.7**	**AVERAGE**	**14.0**

Overall average 12.3%
cf. Sasser (1989).

Conference Committees

Advisory Science Committee

Prof. A S Majali FIAS (Chairman)
Prof. M D Shami FIAS
Prof. Mehmet Ergin FIAS
Prof. A S Islam FIAS
Prof. Munir Ozturk FIAS
Dr James Dawos Mamit
Mr Misnu Bin Haji Taha
Eng. Moneef R Zou'bi DG-IAS

IAS Organising Committee

Eng. Moneef R Zou'bi DG-IAS
Ms Lina Jalal, IAS
Ms Taghreed Saqr, IAS
Ms Hind Bilbeissi, IAS

Advisory Panel

YAB Chief Minister of Sarawak (Chairman), Datuk Amar Tan Sri Hj. Bujang Nor, Tan Sri Hamid Bugo, Senator Datu Taha, Datu Dr. Hatta, Prof. Datuk Dr Yusuf Hadi, Prof. Dr Abdul Rahman Deen, YB Dr. James Dawos Mamit, Dr Hirman Ritom, Dr Starlin Hardin, Commissioner of Police, Datu Putit Matzen, Datin Ailene and Dr Paul Chia.

Local Committee

Datu Putit Matzen (Chairman), Dr James Dawos Mamit, Mr Misnu bin Haji Taha (Rapporteur), and Abg. Mohamad Shibli bin Abg. Nailie.

Chairpersons of Conference Sessions

Session 1:	Prof. Abdel Salam Majali FIAS	(Jordan).
Session 2:	Prof. Yusuf Hadi	(Malaysia).
Session 3:	Prof. Mehmet Ergin FIAS	(Turkey).
Session 4:	Dr James Dawos Mamit	(Malaysia).
Session 5:	Prof. Zohra Ben Lakhdar FIAS	(Tunisia).
Session 6:	Prof. Hashim M El-Hadi FIAS	(Sudan).
Session 7:	Hon. Haji Awang Mohamad Asfia Awang Nasar	(Malaysia).
Session 8:	Prof. Jane Cardosa	(Malaysia).

List of Conference Participants

1. Dr Fatimah Abang, Institute of Biodiversity & Environmental, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

2. Prof. Abdul Rashid Abdullah, Deputy Vice-Chancellor, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail ara@cans.unimas.my

3. Mr Fadlullah Bin Abdullah, Tabung Baitulmal Sarawak, Lot 154-155, Bangunan Zakat & Fitrah, Jln Haji Taha, 93400 Kuching, Sarawak, Malaysia.

4. Dr Omar Abdullah, Faculty of Engineering, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

5. Ms Siti Hajar Bt Abd Rahman, Jabatan Perikhidmatan Awam, Bahagian Pencen, Tingkat 3, Bangunan Sultan Iskandar, Jalan Simpang Tiga, 93300 Kuching, Sarawak, Malaysia. E-mail hajar@jpa.gov.my

6. Haji Aini Bin Haji Abdul Hamid, Majlis Amanah Rakyat, Pejabat Mara Negeri Sarawak, Peti Surat 1352, 93728 Kuching, Sarawak, Malaysia. E-mail ainia@mara.gov.my

7. Mr Norraha Abdul Rahim, Assistant Director, Sarawak Museum Department, Jalan Tun Abang Haji Openg, 93566 Kuching, Sarawak, Malaysia.

8. Tan Sri Datuk Prof. Omar Abdul Rahman (FIAS), Executive Chairman, Kumpulan Modal Perdana Sdn BHD, Lot 13.1, 13th Floor, Menara Lien Hoe, No8, Resort, 47410 Petaling Jaya, Selangor, Malaysia. E-mail tsomar@modalperdana.com

9. Abg. Zainudin Abg. Abdul Rahman, Perbadanan Stadium Negeri Sarawak, Peti Surat 2918, 93756 Kuching, Sarawak, Malaysia.

10. Dr Fasihuddin B. Ahmad, Lecturer, FRST, UNIMAS, FSTS, University Malaysia Sarawak, 94300, Kota Samarahan, Sarawak, Malaysia. E-mail bfasih@frst.unimas.my

11. Prof. Ishfaq Ahmad (FIAS), Special Advisor to the Prime Minister of Pakistan, Government of Pakistan, Chief Executive Secretariat II, PO Box 3008, Islamabad, Pakistan. E-mail ishahmad@comsats.net.pk

12. Mr Morshidi Bin Ahmad, Kementerian Alam Sekitar dan Kesihatan Awam, Tingkat 2, Bangunan MASJA, Petra Jaya, 93050 Kuching, Sarawak, Malaysia.

13. Dr Nazeer Ahmad, Chief Engineer, Dr A Q Khan Research Laboratories, PO Box 502, Rawalpindi, Pakistan. E-mail drnazeerahmad@yahoo.com

14. Mrs Sarina Bt Ahmad, UNIMAS, Faculty of Resource Science & Technology, 94300 Kota Samarahan, Sarawak, Malaysia.

15. Mr Zulkifli B. Ahmat, UNIMAS, Faculty Sciences Computer & Technology, 94300 Kota Samarahan, Sarawak, Malaysia.

16. Ms Agatha Alfred, FRST, UNIMAS, University Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail agatha@yahoo.com

17. Prof. Aishah Mohd Ali, Kuching, Sarawak, Malaysia.

18. Mr Michael Dawi Alli, Deputy Resident, Administration Sarikei Division, Pejabat Residen, 96100 Sarikei, Sarawak, Malaysia. E-mail michadal@sarawaknet.gov.my

19. Prof. M Shamsher Ali (FIAS), Vice-Chancellor, South East University, 24 Kamal Ataturk Avenue, Banani, Dhaka 1213, Bangladesh. E-mail msali@seu.ac.bd

20. Puan Suraya Binti Haji Mohamad Ali, Executive Officer, Sarawak Timber Industry Development Corporation, Wisma Sumber Alam, Petra Jaya, Peti Surat 194, 93702 Kuching, Sarawak, Malaysia. E-mail pusaka@po.jaring.my

21. Prof. Madya Yusoff Ali, Selangor, Sarawak, Malaysia.

22. Mr Mohd Salleh Alli, Sarawak, Malaysia.

23. Mr Haji Loling Othman Bin Haji Alwi, Pejabat Mufti Negeri Sarawak, Tingkat 6, Bangunan Mahkamah Syariah, (Anjung Kanan) Jalan Satok, 93400 Kuching, Sarawak, Malaysia. E-mail lolingoa@sarawaknet.gov.my

24. Mr Saifulbahry Bin Alwie, Unit Perancangan & Pembangunan, Pejabat Residen, Bahagian Kapit, 96800 Kapit Sarawak, Malaysia.

25. Mr Drahman Bin Haji Amit, Pejabat Daerah Kuching, Jalan Barrack, 93000 Kuching, Sarawak, Malaysia.

26. Mr Masbah Hj Ariffin, Kuching, Sarawak, Malaysia.

27. Prof. Muhammad Asghar (FIAS), Institute of Sciences Nucleaires, 53-avenue des Martyrs, 38026 Grenoble Cedex France. E-mail masgharfr@yahoo.fr

28. Prof. Ahmed Abdullah Azad (FIAS), Director of Research, University of Cape Town, Faculty of Health Sciences, Anzio Road, Observatory, Cape Town 7925, South Africa. E-mail aazad@curie.uct.ac.za

29. Ybhg Datu Abd Rashid Hj Abd Aziz, Tabung Baitulmal Sarawak, Lot 154-155, JLN HAJI, Taha, 93050 Kuching, Sarawak, Malaysia.

30. Prof. Adnan Badran (FIAS), President, Philadelphia University, PO Box 1, Philadelphia University 19392, Jordan. E-mail abadran@philadelphia.edu.jo

31. Mrs Maha Badran, c/o Philadelphia University, PO Box 1, Philadelphia University 19392, Jordan. E-mail abadran@philadelphia.edu.jo

32. Mr Mohd Nazari Abu Bakar, Sarawak, Malaysia.

33. Puan K. Girija A/P K. Balakrishna, Deputy Director, Radio Television Malaysia, Jalan P. Ramlee, 93614 Kuching, Sarawak, Malaysia.

34. Dr Nabil Bessaih, Associate Professor, UNIMAS, Faculty of Engineering, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail bessaih@feng.unimas.my

35. Ms Rahmah Biak, Environmental Control Officer, Natural Resources and Environment Board, 18-20th Floors, Menara Pelita, Petra Jaya, 93050 Kuching, Sarawak, Malaysia. E-mail rahmahbbt@yahoo.com

36. Ms Hind Bilbeissi, Programme Officer, Islamic Academy of Sciences, PO Box 830036, Amman, 11183, Jordan. E-mail bilbeissi@hotmail.com

37. Mr Radin Blayong, Kuching, Sarawak, Malaysia.

38. Dr Othman Bojo, Lecturer, University Malaysia Sarawak, Pusat Pemajuan Pelajar, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

39. Ms Rashidah Haji Bolhassan, Chief Executive Officer, Pustaka Negeri Sarawak, Jalan Pustaka off Jalan Stadium, 93050 Petra Jaya, Kuching, Sarawak, Malaysia. E-mail rashidahb@sarawaknet.gov.my

40. Prof. Naci Bor (FIAS), Editor-in-Chief, IAS Journal, Mithatpasa Caddesi, No. 66/5, Ankara, Turkey. E-mail nacibor@bir.net.tr

41. Abang Bustan Bin Abg. Borhan, Kuching, Sarawak, Malaysia.

42. Mr Mansor Bin Hj. Borhan, Administrative Officer, Pejabat Daerah Kecil, 94650 Kabong, Sarawak, Malaysia.

43. Mr Murice Utai Britten, Kuching, Sarawak, Malaysia.

44. Dr Kopli Bujang, Director of CTTC, Center for Technology Transfer, UNIMAS, Sarawak, Malaysia. E-mail bkopli@cttc.unimas.my

45. Prof. Noor Mohammad Butt (FIAS), Scientist Emeritus, Pakistan Atomic Energy Commission, PINSTECH, PO Nilore, Islamabad, Pakistan. E-mail nmbutt36@yahoo.com

46. Mr Ling Wang Choon, Senior Assistant Director, Forest Department Sarawak, Timber Research & Technical Training Centre, Forest Department, Kota Sentosa, 93660 Kuching, Sarawak, Malaysia. E-mail wcling@pc.jaring.my

47. Prof. Muhammad Iqbal Choudhary (FIAS), Director (Acting), H. E. J. Research Institute of Chemistry, University of Karachi, University Road, Karachi-75270, Pakistan. E-mail hej@ber.net.pk

48. Dr Riaz Ahmed Chowhan, Consultant, Free Medical Diagnostic Centre, House No. 5, KRL Officer's Colony, Rawalpindi, Pakistan.

49. Dr Michael Clegg, Foreign Secretary, US National Academy of Sciences, 500 Fifth Science and Technology NW, Washington DC 20001. E-mail mclegg@nas.edu

50. Prof. Ali A Al-Daffa' (FIAS), Prof. of Mathematics, King Fahd University of Petroleum and Minerals (KFUPM), PO Box 324, Dhahran 31261, Saudi Arabia. E-mail aldaffa@kfupm.edu.sa

51. Mrs Lulwah Al-Daffa', c/o King Fahd University of Petroleum and Minerals (KFUPM), PO Box 324, Dhahran 31261, Saudi Arabia. E-mail aldaffa@kfupm.edu.sa

52. Mr Noor Azima Mohd Dahlan, Environmental Control Officer, Natural Resources and Environment Board, 18-20th Floors, Menara Pelita, Petra Jaya, 93050 Kuching, Sarawak, Malaysia.

53. Datu Wilson Baya Dandot, Deputy State Secretary, Chief Minister's Department, Deputy State Secretary office, 19th Floor, Wisma Bapa Malaysia, 93502 Petra Jaya, Kuching, Sarawak, Malaysia. E-mail wilsonbd@sarawaknet.gov.my

54. Dayang Nor Hajijah Hj Awang Daud, Assistant Registrar, University Malaysia Sarawak, Faculty of Economics & Business, 94300 Kota Samarahan Sarawak, Malaysia. E-mail dhajijah@feb.unimas.my

55. Prof. Madya Dr Abdul Rahman Deen, Sarawak, Malaysia. E-mail abdrahman@sarawak.itm.edu.my

56. Mr Abdul Rahman Demi, Kuching, Sarawak, Malaysia.

57. Mr Kelvin Pudun Dennis, Student, FRST, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail ferut@yahoo.com

58. Dr Beatrice Descamps-Latscha, INSERM U507, Hopital Necker, 161 rue de Sevres, 75015 Paris, France. E-mail b.descamps@necker.fr

59. Prof. Ugur Dilmen (FIAS), Dean, Fatih University, Medical Faculty, Ciftlik Caddesi No. 57, 06510 Emek, Ankara, Turkey. E-mail udilmen@ttnet.net.tr

60. Ms Inson Bt Din, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

61. Prof. Ibrahima Mar Diop (FIAS), IAS Vice-President, Honorary Dean, Faculty of Medicine, UCAD, Clinique Fann Hock, Rue 55 angle 70, BP 15504, Fann, Dakar, Senegal. E-mail diopmar@sentoo.sn

62. Mr Tuan Haji Zahidin Bin Haji Dor, Kuching, Sarawak, Malaysia. E-mail zahidin@jls.gov.my

63. Prof. Mustafa Doruk (FIAS), Deptartment of Metallurgical and Materials Engineering, Middle East Technical University, 06537 Ankara, Turkey. E-mail mdoruk@metu.edu.tr

64. Mr Ahmad Zainuddin Drahman, UNIMAS, 94300, Kota Samarahan, Sarawak, Malaysia.

65. Datu Haji Hamzah Haji Drahman, Kementerian Perancangan & Pengurusan Sumber, Tingkat 16, Wisma Sumber Alam, Petra jaya, Kuching, Sarawak, Malaysia.

66. Salbiah Edman, UNIMAS, Faculty of Resource Science & Technology, 94300 Kota Samarahan, Sarawak, Malaysia.

67. Mr Zulkifli Elia, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

68. Mr Liaw Soon Eng, Resident Officer, Miri Division, 98000 Miri, Sarawak, Malaysia. E-mail liawse@sarawaknet.gov.my

69. Prof. Mehmet Ergin (FIAS), Fatih University, 34900 Buyukcekmece, Istanbul, Turkey. E-mail mht.ergin@veezy.com

70. Dr Muhammad Faheem, Dr A Q Khan Research Laboratories, PO Box 502, Rawalpindi, Pakistan.

71. Mr Abg Othman Abg Fata, Kuching, Sarawak, Malaysia.

72. Prof. Mohamed Baha-Eldin Fayez (FIAS), Emeritus Professor, National Research Centre, Tahrir Street, Dokki, Cairo, Egypt. E-mail mfayez@mcit.gov.eg

73. Mr Ahmad Hadinata Fuazi, University Malaysia Sarawak, FSKTM Kota Samarahan, 94300 Kota Samarahan, Sarawak, Malaysia.

74. Jong Chean Fuei, Environmental Control Officer, Natural Resources and Environment Board, 18-20th Floors, Menara Pelita, Petra Jaya, 93050 Kuching, Sarawak, Malaysia. E-mail jongcf@nreb.gov.my

75. Ms Dayangku Horiah BT. Awang Gani, Pustaka Negeri Sarawak, Jalan Pustaka Off Jalan Stadium, 93050 Petra Jaya, Kuching, Sarawak, Malaysia. E-mail dayanghg@sarawaknet.gov.my

76. Haji Mohd Morshidi Abd Ghani, Kementerian Pembangunan Sosial & Urbanisasi, Tingkat 3, Bangunan Masja, 93050 Petra Jaya, Kuching, Sarawak, Malaysia.

77. Prof. Mehdi Golshani (FIAS), Professor of Physics, Sharif University of Technology, Dept. of Physics, P. O. Box 11365, Tehran, Iran. E-mail golshani@ihcs.ac.ir

78. Mr Terry Gurubatham, Director, Compliance International, Kuala Lumpur, Malaysia. E-mail terry@professionalandexecutive.com

79. Prof. Hashim Mohamed El-Hadi (FIAS), Vice-Chancellor, Sudan International University, PO Box 12769 El Mogran, Khartoum, Sudan. E-mail hmelhadi@hotmail.com

80. Prof. Datuk Dr Yusuf Hadi, Vice Chancellor, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail yusuf@cans.unimas.my

81. Prof. Syed Z Haider (FIAS), Professor of Chemistry, Dhaka University, Dhaka 1000, Bangladesh. E-mail hshabbir@bdmail.net

82. Mr Zakaria Bin Hj. Halmi, Kuching, Sarawak, Malaysia. E-mail zakariah@sarawaknet.gov.my

83. Dr Sinin Bin Hamdan, Lecturer, University Malaysia Sarawak, Faculty of Engineering, UNIMAS, 94300, Kota Samarahan, Sarawak, Malaysia. E-mail hsinin@feng.unimas.my

84. Dr Khairuddin Abd. Hamid, Deputy Vice-Chancellor, UNIMAS, 94300, Kota Samarahan, Sarawak, Malaysia. E-mail khair@cans.unimas.my

85. Mr Ahmad Zaidi Hampden, UNIMAS, UITM Kota Samarahan, Kota Sentosa Kuching 94350, Sarawak, Malaysia.

86. Haji Jaliludin Md Hanafiah, UNIMAS, 94300, Kota Samarahan, Sarawak, Malaysia.

87. Dr Hj Sulaiman Hanapi, Deputy Vice-Chancellor (Student Affairs), UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

88. Mr Abg Shaffrul Hardie, Sarawak, Malaysia.

89. Dr. Wan Sulaiman Bin Wan Harun, Professor, Faculty of Resource Sciences & Technology, UNIMAS, 94300, Kota Samarahan, Sarawak, Malaysia. E-mail whwsulaiman@frst.unimas.my

90. Mr Hohd Amran Hasbullah, University Technology Mara, UITM, Kampus Samarahan, Cawangan Sarawak, 94300 Kota Samarahan, Kuching, Sarawak, Malaysia.

91. Mr Abdul Hadi Bin Hashim, Sarawak, Malaysia.

92. Dr Dyg Maryani Awg Hashim, University Technology Mara, UITM, Kampus Samarahan, Falculty Sciences, 94300 Kota Samarahan, Sarawak, Malaysia.

93. Mrs Sh Ranimah Wan Hashim, Kuching, Sarawak, Malaysia.

94. Mr Wan Alwi Bin Dato Sri Wan Hashim, Tingkat 15, Wisma Sumber Alam, Petra Jaya, Kuching, Sarawak, Malaysia.

95. Prof. Daisaburo Hashizume, Professor, Dep. Of Value and Decision Science, Tokyo Institute of Technology, c/o The Sasakawa Pan-Asia Fund, The Nippon Foundation Building, 4th fl, 1-2-2 Akasaka, Tokyo 107-8523, Japan.

96. Prof. Mohamed H A Hassan (FIAS), Executive Director, Third World Academy of Science (TWAS), c/o ICTP, Strada Costiera 11, 34100 Trieste. E-mail info@twas.org

97. Mr Zulkanain Bin Hassan, Senior Sales Manager, Hilton Kuching & Hilton Batang Ai Longhouse Resort, Jalan Tunku Abdul Rahman, PO Box 2396, 93748 Kuching, Sarawak, Malaysia. E-mail zulkanain.Hassan@hilton.com

98. Mr Mohamad Rashdan Hazemi, Limbang, Sarawak, Malaysia.

99. HJ. Sulaiman Bin Hj. Husaini, Resident, Resident Office, Samarahan Division, 94300 Kota Samarahan, Sarawak, Malaysia.

100. Prof. Abdul Latif Ibrahim (FIAS), No. 2, Jalan Bunga Raya 2/8, 40000 Shah Alam, Selangor, Malaysia. E-mail alatifbio@yahoo.com

101. Dr Akbar Ibrahim, Maktab Perguruan Batu Lintang, Jalan Kolej, 93200, Kuching, Sarawak, Malaysia. E-mail mpbl@tm.net.my

102. Dyg Hanani Abang Ibrahim, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

103. Mr Jaddil Zaidel Ibrahim, Executive Officer, Sarawak Timber Industry Development Corporation, Wisma Sumber Alam, Petra Jaya, Peti Surat 194, 93702 Kuching, Sarawak, Malaysia. E-mail pusaka@po.jaring.my

104. Mr Mohd Zamri Ibrahim, Sarawak, Malaysia.

105. Haji Rakawi Ibrahim, Perbadanan Stadium Negeri Sarawak, Peti Surat 2918, 93756 Kuching, Sarawak, Malaysia.

106. Dr Rosziati Bt. Ibrahim, Deputy Dean, FCSIT, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail rosziati@frt.unimas.my

107. Dr Isa Ipor, Lecturer, FSTS, UNIMAS, 94300, Kota Samarahan, Sarawak, Malaysia. E-mail ibipor@frst.unimas.my

108. Ms Adibah Bt Ismail, Lecturer, Maktab Perguruan Tan Abdul Razak, Jalan Dato Mohd Musa, 94300 Kota Samarahan, Sarawak, Malaysia.

109. Ybhg Dato' Haji Mohd Yusoff Jaafar, Kementerian Pembangunan Sosial & Urbanisasi, Tingkat 3, Bangunan Masja, 93050 Petra Jaya, Kuching, Sarawak, Malaysia.

110. Ms Noor Kamala Bte. Hj. Jalia, Student, University Malaysia Sarawak, Faculty of Resource Science & Technology, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail jnkamala@frst.unimas.my

111. Mr Janilabidin Bin Jamaludin, Lembaga Sungai-Sungai Sarawak, Tingkat 2, Electra House, Power Street, 93000 Kuching, Sarawak, Malaysia.

112. Mrs Razina Jamaludin, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

113. Prof. Mohamad Nazim Jambli, UNIMAS, 94300, Kota Samarahan, Sarawak, Malaysia.

114. Ms HJH. Kalsom Binti Jamil, Accountant, Admin Unit, Chief Minister's Department, 8th Floor, Wisma Bapa Malaysia, Petra Jaya, 93502 Kuching, Sarawak, Malaysia.

115. Prof. Mohammad Shamim Jairajpuri (FIAS), Aligarh Muslim University, Department of Zoology, Aligarh 202-002, India. E-mail jairajpurims@lycos.com

116. Mr Razek Jelihi, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

117. Mr Jong Hse Jun, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

118. Mr Syahrul Nizam Junaidi, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

119. Mr Mohd Kahirul Hafiz B. Juni, University Tun Abdul Razak, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

120. Dr Ismail Jusoh, Lecturer, UNIMAS, Faculty of Resource Science & Technology, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail jismail@frst.unimas.my

121. Encik Abu Bakar Bin Hj. Kana, Pejabat Daerah Meradong, Jalan Mahkamah, 96500 Bintangor, Malaysia.

122. Encik Abg Abdul Hamid Karim, Kuching, Sarawak, Malaysia.

123. Ms Sharifah Mariawati Wan Kassim, Assistant Registrar, Faculty of Engineering, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail wkmaria@feng.unimas.my

124. Prof. J. (Younis) Ario Katili (FIAS), Pancoran Indah Raya, Perdatam, Blok B No. A1, Jakarta Selatan, Indonesia. E-mail ilikatili@yahoo.com

125. Mrs J. (Younis) Ario Katili, Pancoran Indah Raya, Perdatam, Blok B No. A1, Jakarta Selatan, Indonesia. E- mail ilikatili@yahoo.com

126. Mr. Zunaide Bin Katun, Physicist, Sarawak Medical Department, Jalan Tun Abang Haji Openg, 93590 Kuching, Sarawak, Malaysia. E-mail zunaidef@yahoo.com

127. Prof. Abdel Quadeer Khan (FIAS), Special advisor to the Prime Minister, Prime Minister's Secretariat, PO Box 2631, Islamabad, Pakistan. E-mail krl@comsats.net.pk

128. Prof. Hameed Ahmed Khan (FIAS), Executive Director, COMSATS, Shahra-e-Jamhuriat, Opposite Pakistan Broadcasting House, Islamabad 44000, Pakistan. E-mail drhakhan@comsats.net.pk

129. Prof. Mostefa Khiati (FIAS), Villa 41, Cite du 20 Aout, Ould Romane, El Achour, Algiers, Algeria.
E-mail mkhiati@voila.fr

130. Mr Michitada Kondo, Associate Program Officer, The Sasakawa Peace Foundation, The Nippon Foundation Building, 4th fl, 1-2-2 Akasaka, Minato-ku, Tokyo 107-8523, Japan.

131. Prof. Zohra Ben Lakhdar (FIAS), University of Tunis, Faculty of Sciences, University Campus, Tunis 1060, Tunisia. E-mail zohra.lakhdar@fst.rnu.tn

132. Mr Aswandi B. Laman, Sarawak, Malaysia. E-mail muntawa@hotmail.com

133. Mr Mokhtaruddin Bin Lamsin, Archivist, National Archive of Malaysia, TKT 14, Bangunan Sultan Iskandar, 93300 JLN Simpang Tiga, Kuching, Sarawak, Malaysia. E-mail m767878@pc.jaring.my

134. Mr Ubaidillah Hj. Abdul Latip, Jabatan Residen Bahagian Bintulu, Wisma Residen, Jalan Pisang Keling, Off Jalan Tun Razak, Bintulu, Sarawak, Malaysia. E-mail ubaidial@sarawaknet.gov.my

135. Mr Awang Suhaili bin Ledi, Ibu Pejabat Jabatan Kehakiman Syariah Sarawak, Tingkat 4, Bangunan Mahkamah Syariah, Anjung Kanan, Jalan Satok, 93400 Kuching, Sarawak, Malaysia.

136. Mr Mohd Zaihan HJ Lek, Kuching, Sarawak, Malaysia.

137. Mr Halikul B. Lenando, UNIMAS, Kota Samarahan, 94300 Kuching, Sarawak, Malaysia.

138. Dr Shabdin Mohd. Long, Lecturer, Faculty of Resource Sciences & Technology, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail lshabdin@frst.unimas.my

139. Dr Wan Ali Bin Tuanku Madhi, Kuching, Sarawak, Malaysia.

140. Prof. Preben Maegaard, President World Wind Energy Association (WWEA), Folkcenter for Renewable Energy, Kammersgaardsvej 16, DK-7760 Hurup Thy, Denmark. E-mail pm@wwindea.org

141. Major Mamdouh Maharmeh, ADC of Prof. Majali, c/o Islamic Academy of Sciences, PO Box 830036 Amman 11183 Jordan. E-mail ias@go.com.jo

142. Dr Mohammed Ali Mahesar, Executive Secretary, COMSTECH, Constitution Avenue, Islamabad 44000, Pakistan. E-mail comstech@isb.comsats.net.pk

143. Dr Zahida Mahesar, c/o COMSTECH, Constitution Avenue, Islamabad 44000, Pakistan. E-mail comstech@isb.comsats.net.pk

144. Prof. Datin Napsiah Mahfoz, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

145. Mr Hartini Mahidin, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

146. Mr Ahmady Asrul Mahli, Research Assistant, UNIMAS, Engineering Faculty, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail aaasrul@yahoo.com

147. Prof. Abdel Salam Majali (FIAS), President, Islamic Academy of Sciences, PO Box 830036, Amman 11183, Jordan. E-mail ias@go.com.jo

148. Mrs Joan Mary Majali, c/o Islamic Academy of Sciences, PO Box 830036, Amman 11183, Jordan. E-mail ias@go.com.jo

149. Datin HJH Sarifah Binti Maji, Sarawak, Malaysia.

150. Prof. Iftikhar Ahmad Malik (FIAS), Dean, Foundation Medical College, 129 Hali Road, Westridge – I, Rawalpindi, Pakistan. E-mail fmcrwp@isb.paknet.com.pk

151. Dr James Dawos Mamit, Natural Resources and Environment, 18th Floor, Menara Pelita, 93050 Kuching, Sarawak, Malaysia. E-mail dawos-mamit@hotmail.com

152. Mr Haji Ali B. Hj Man, Kuching, Sarawak, Malaysia.

153. Prof. Badron Abd Manaf, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

154. Prof. Abdul Khalid Manap, Sarawak, Malaysia.

155. Hajah Rabyah Mohd Mansor, Unit Pembangunan Sumber Manusia, JKM, TKT 12, Wisma Bapa Malaysia, Petra Jaya, 93502 Kuching, Sarawak, Malaysia. E-mail rabyahml@sarawaknet.gov.my

156. Prof. Ahmed Marrakchi (FIAS), 2 Mohammed Bensaleh Street, Menzah 6, 1004 Tunis, Tunisia. E-mail marrakchi@planet.tn

157. Mr Azman Bujang Masli, Kuching, Sarawak, Malaysia.

158. Mr Talib Bin Bujang Masli, Kuching, Sarawak, Malaysia. E-mail talibbm@sarawaknet.gov.my

159. Prof. Kenichi Matsumoto, Professor Reitaku University, 2-1-1, Hikarigaoka, Kashiwa-shi, Chiba-Ken, 277-8686, Tokyo, Japan.

160. Datu Haji Putit Matzen, Yang Dipertua, Majlis Islam Sarawak, Tingkat 6, Bangunan Mahkamah Syariah, Jalan Satok, 93400 Kuching, Sarawak, Malaysia.

161. Prof. Akhmet Mazgarov (FIAS), Director, VNIIUS, N. Ershov str., 35-A, Kazan 420045, Tatarstan Republic, Russia. E-mail vniius@mail.ru

162. Mr Abg Mohd Atel Abg Medaan, Kuching, Sarawak, Malaysia.

163. Prof. Amdulla Mehrabov (FIAS), Middle East Technical University, Department of Metallurgical and Materials Engineering, 06531 Ankara, Turkey. E-mail amekh@metu.edu.tr

164. Puan Salmah Ibrahim Melina, Jabatan Penyiaran Sarawak, Jala P. Ramlee, 93614 Kuching, Sarawak, Malaysia.

165. Mr Mejar Kiprawi Bin Morshidi, Unit Keselamatan Negeri, Jabatan Ketua Menteri, Tingkat 8, Wisma Bapa Malaysia Petra Jaya, 93502 Kuching, Sarawak, Malaysia.

166. Mr Ismail Bin Haji Mosli, Kementerian Pembangunan Infrastruktur dan Perhubun, Tkt 4, Bangunan MASJA, Petra Jaya, 93050 Kuching, Sarawak, Malaysia. E-mail ismailm5@sarawaknet.gov.my

167. Mr Adam Badri Muhammad, c/o Jarajan Kimia, University Pertanian Malaysia, 43400 UPM, Selangor, Malaysia. E-mail crouse@pc.jaring.my

168. Prof. Badri Muhammad (FIAS), Professor, Jarajan Kimia, University Pertanian Malaysia, 43400 UPM, Selangor, Malaysia. E-mail crouse@pc.jaring.my

169. Prof. Ferid Murad, The John S Dunn Distinguished Chair of Physiology and Medicine, Director, Institute of Molecular Medicine, The University of Texas at Houston Medical School, Houston, Texas, United States of America. E-mail elias.almarcegui@uth.tmc.edu

170. Mr Encik Ose Murang, Unit Projek Khas, Jabatan Ketua Menteri, Tkt 14, Wisma Bapa Malaysia, 93502 Petra Jaya, Kuching, Sarawak, Malaysia. E-mail osem@sarawaknet.gov.my

171. Prof. Rujhan Mustaffa, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

172. Haji Abg Wahed Abg Muzi, Sarawak, Malaysia.

173. Mr Abang Mohd Shibli Abg. Mohd. Naillie, Pengurus Besar, Tabung Baitulmal Saraawak, Bangunan Tabung Zakat Dan Fitrah, Lot 154-155, Jalan Haji, Taha, 93400 Kuching, Sarawak, Malaysia. E-mail shibli@pd.jaring.my

174. Prof. Ibrahim Al-Naimi (FIAS), Chemistry Department, University of Qatar, PO Box. 2713, Doha, Qatar. E-mail chnpresident@qatar.net.qa

175. Ms Hayati Binti Narayan, Asst. Director of Labour, Labour Department Sarawak, Tingkat 13, Bangunan Sultan Iskandar, Jalan Simpang Tiga, 93532 Kuching, Sarawak, Malaysia.

176. Prof. Anwar Nasim (FIAS), Adviser Science, COMSTECH Secretariat, Constitution Avenue, Islamabad, Pakistan. E-mail anwar_nasim@yahoo.com

177. Mrs Parvez Nasim, c/o COMSTECH Secretariat, Constitution Avenue, Islamabad, Pakistan. E-mail anwar_nasim@yahoo.com

178. Mr Law Ing Nguong, Environmental Control Officer, Natural Resources and Environment Board, 18th-19th & 20th Floors, Menara Pelita, Petra Jaya, 93050 Kuching, Sarawak, Malaysia.

179. Ms Rabuyah Binti Ni, Research Assistant, UNIMAS, Faculty of Resource Science & Technology, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail aku-amy2003@yahoo.com

180. Mr Ameer Gert Nielsen, Director International Business Development, SPD Innovative Technologies Sdn Bhd, PO Box A266, Kenyalang Park, 93804 Kuching, Sarawak, Malaysia. E-mail sierabm@tm.net.my

181. Dr Kamaliah Binti Mohamad Noh, Principal Assistant Director, State Health Department, Medical Headquarter, Family Health Unit, Tun Abang Haji Openg Road, 93590 Kuching, Sarawak, Malaysia. E-mail kamaliah@sarawakhealth.gov.my

182. Datu Dr Yusoff Nook, Unit Keselamatan Negeri, Jabatan Ketua Menteri, Tingkat 19, Wisma Bapa Malaysia, Petra Jaya, 93502 Kuching, Sarawak, Malaysia.

183. Dr Salleh Mohammad Nor, Vice President & Chairman, Antarctica Task Force, Academy of Sciences Malaysia 902-4, Jalan Tun Ismail, 50480 Kuala Lumpur. E-mail sallehmn@yahoo.com

184. Tan Sri Datuk Amar Dr Alfred Jabu Anak Numpang, Deputy Chief Minister of Sarawak and Minister of Rural Development and Land Development Sarawak, Wisma Bapa Malaysia, Petra Jaya, 93502 Kuching, Sarawak, Malaysia.

185. Mr Haji Sam Bin Haji Ojeh, Ibu Pejabat Jabatan Kehakiman Syariah Sarawak, Tingkat 4, Bangunan Mahkamah Syariah, Anjung Kanan, Jalan Satok, 93400 Kuching, Sarawak, Malaysia.

186. Ms Zahrah Abang Othman, Senior Assistant Director, Information and Communication Technology, 4th Floor, Wisma Bapa Malaysia, 93502 Petra Jaya, Kuching, Sarawak, Malaysia.

187. Prof. Korkut Ozal (FIAS), Founder, AKOZ Charity Foundation (WAKF), Kisikli Caddesi, 18 Blok B, Altunizade, Uskudar, Istanbul, Turkey. E-mail korkutozal@hotmail.com

188. Tuan Haji Wan Liz Bin Wan Ozman, Pejabat Setiausaha Kewangan Negeri, Tingkat 17 & 18, Wisma Bapa Malaysia, Petra Jaya, 93502 Kuching, Sarawak, Malaysia. E-mail lizo@sarawaknet.gov.my

189. Prof. Munir Ozturk (FIAS), 915 Sokak, Nu 200, Bornouq, Izmir, Turkey. E-mail munirozturk@hotmail.com

190. Abg Zaidel Bin Abg Pauzi, Kementerian Alam Sekitar dan Kesihatan Awam, Tingkat 2, Bangunan MASJA, Petra Jaya, 93050 Kuching, Sarawak, Malaysia.

191. HJ Daud b. Hj Piee, Pejabat MARA Negeri, Peti Surat No 1352, Kuching, Sarawak, Malaysia. E-mail daud@mara.gov.my

192. Ms Then Yin Ping, Student, UNIMAS, Faculty of Resource Science & Technology, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail then904@yahoo.com

193. Encuk Deraman Anak Pingan, Limbang, Sarawak, Malaysia.

194. Mr Anpu Malar A/P Ponniah, Assistant Director, Labour Department Sarawak, Pejabat Tenaga Kerja, Lot 1937, 1938, 1939, Tkt. 1 & 2, Bangunan Cinmuk Commercial Center, Kota Sentosa, Kuching, Sarawak, Malaysia.

195. Miss Zabidah Putit, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

196. Ms Laila Subhi Qasem, c/o University of Jordan, Amman POBox 13300, Jordan. E-mail ubcc@go.com.jo

197. Prof. Subhi A Qasem (FIAS), Professor Emeritus, University of Jordan, Amman PO Box 13300, Jordan. E-mail ubcc@go.com.jo

198. Dr Iqbal Hussain Qureshi, Scientist Emeritus, Pakistan Institute of Nuclear Science and Technology, (PINSTECH), PO Nilore, Islamabad, Pakistan. E-mail driqbalqureshi@yahoo.com

199. Prof. Mazhar M Qurashi (FIAS), Secretary, PAHPS, Pakistan Academy of Sciences, Constitution Avenue, G-5, Islamabad, Pakistan. E-mail pasisb@yahoo.com

200. Sh Raha Wan Abd Rahman, UNIMAS, Faculty of Resource Science & Technology, 94300 Kota Samarahan, Sarawak, Malaysia.

201. Mr Muhammad Humaizy Harmy Bin Abd Rapor, Assistant Director, Inland Revenue Board Malaysia, 93600 Kuching, Sarawak, Malaysia.

202. Mr Nasri Bin Rasad, Lembaga Sungai-Sungai Sarawak, Tingkat 2, Electra House, Power Street, 93000 Kuching, Sarawak, Malaysia.

203. Prof. Samia Mohamed Rashad, Professor of Elect. Power, Head of Nuclear Engineering, Atomic Energy Authority, National Center for Nuclear Safety and Radiation Control, 3 Ahmed El Zomor, Nasr City, 11762, PO Box 7551, Egypt. E-mail Samia_Rashad@hotmail.com

204. Mr Kamsiah Ab Rashid, Kuching, Sarawak, Malaysia.

205. Mr Haji Sebli B. Rapaee, Kuching, Sarawak, Malaysia.

206. Ms Raynee Ramliza Raybayi, Selangor, Sarawak, Malaysia.

207. Mr Seperi Ben Reduan, Kuching, Sarawak, Malaysia.

208. Dr Siti Zaliha Bt. Reduan, Maktab Perguruan Batu Lintang, Jalan Kolej, 93200 Kuching, Sarawak, Malaysia.

209. Dr Mohammad Hirman Rizom, Kuching, Sarawak, Malaysia.

210. Abang Kiprawi B. Abang Rosli, Kuching, Sarawak, Malaysia.

211. Mr Zulkarnain Bin Rosli, Assistant Director, Chief Minister's Department, Admin. Unit, Chief Minister's Department, 8th Floor, Wisma Bapa Malaysia, Petra Jaya, 93502 Kuching, Sarawak, Malaysia.

212. Mr Zuraimi Bin Sabki, CEO/General Manager, Brooke Dockyard & Eng. Works Corpn, Jalan Bako, Sejingkat, Sarawak, Malaysia. E-mail brooke@po.jaring.my

213. Mr Johan B. Sabu, Production Planner, POS Malaysia BHD, Pusat Mel Kuching, 93610 Kuching, Sarawak, Malaysia.

214. Ms Hayati Binti Sahari, Resident Officer, Miri Division, 98000 Miri, Sarawak Malaysia. E-mail hayatis3@sarawaknet.gov.my

215. Mr Ali Mohtar B. Sahmat, Kuching, Sarawak, Malaysia.

216. Mr Mohamad Taufek B. Sahran, Senior Executive Officer, Hikmah (Harakah Islamiah) Hikmah Headquarters, Jalan Tun Abdul Rahman Yakub, Petra Jaya, 93050 Kuching, Sarawak, Malaysia. E-mail hikmah@po.javing.my

217. Prof. Salim B. Said, Professor, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail ssalim@feng.unimas.my

218. Mr Sanib Haji Said, Director, Sarawak Museum Department, Jalan Tun Abang Haji Openg, 93566 Kuching, Sarawak, Malaysia. E-mail Sanibs@sarawaknet.gov.my

219. Mr Mohd Suffian Saidi, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

220. Mr Abd Rahman Saili, Tabung Baitulmal Sarawak, UNIMAS, Lot 154-155, JLN HAJI, Taha, 93050 Kuching, Sarawak, Malaysia.

221. Prof. Hussein Samir Salama (FIAS), Professor, National Research Centre, El-Tahrir Street, Dokki, Cairo, Egypt. E-mail hsarsalama@hotmail.com

222. Mr Ismawie Bin Salleh, Lundu, Sarawak, Malaysia.

223. Mr Mazlan B. Abg Salleh, Kementerian Alam Sekitar dan Kesihatan Awam, Tingkat 2, Bangunan MASJA, Petra Jaya, 93050 Kuching, Sarawak, Malaysia.

224. Prof. Mohd Azib Salleh, Dean, Centre for Graduate Studies, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail azib@pps.unimas.my

225. Prof. Samaun Samadikun (FIAS), Senior Researcher, Inter University Research Center on Microelectronics Technology, Bandung Institute of Technology, Jl. Ganesha 10, Bandung 40132, Indonesia. E-mail samaun@standfordalumni.org

226. Mr Mustapa Bin ABG Sapawi, Sarawak, Malaysia.

227. Mr Andi Bin Sapli, Assistant Security Officer, Kuching Port Authority, P.O.Box 530, Jalan Pelabuhan, 93710 Kuching, Sarawak, Malaysia. E-mail hq@kuport.com.my

228. Ms Taghreed Saqer, Executive Secretary, Islamic Academy of Sciences, PO Box 830036, Amman 11183 Jordan. E-mail tsaqer@hotmail.com

229. Mr Mahri Bin Sarpawi, Pejabat Daerah Betong, 95700 Betong, Sarawak, Malaysia. E-mail mahris@sarawaknet.gov.my

230. Mr Abdul Rahman Sebli, Kuching, Sarawak, Malaysia.

231. Dr Lau Seng, Associate Professor, UNIMAS, IBEC, 94300 Kota Samarahar, Sarawak, Malaysia. E-mail lauseng@ibec.unimas.my

232. En Loong Sun Seng, Maktab Perguruan Batu Lintang, Jalan Kolej, 93200 Kuching, Sarawak, Malaysia.

233. Ms Rafidah Bte Ahmad Shafiee, Unit Pembangunan Sumber Manusia, TKT 12, Wisma Bapa Malaysia, Petra Jaya, 93502 Kuching, Sarawak, Malaysia.

234. Prof. Misbah-ud-Din Shami (FIAS), Secretary General, Pakistan Academy of Sciences, G-5/2, Constitution Avenue, Islamabad, Pakistan. E-mail pasisb@yahoo.com

235. Prof. Ahmad Shamsul Islam (FIAS), University of Texas, Department of Molecular Cell and Development Biology, Austin, TX 78713, USA. E-mail aislam24@bracuniversity.ac.bd

236. Prof. Muthana Shanshal (FIAS), Department of Chemistry, College of Science, University of Baghdad, Jadirriya, Baghdad, Iraq. E-mail mshanshal2003@yahoo.com

237. Siti Ramah Bt Hj. Mohd. Shariff, Kementerian Alam Sekitar dan Kesihatan Awam, Tingkat 2, Bangunan MASJA, Petra Jaya, 93050 Kuching, Sarawak, Malaysia.

238. Mr Syed Tarmizi Syed Shazali, Lecturer, UNIMAS, Faculty of Engineering, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail starmizi@feng.unimas.my

239. Encik Ling Kai Siew, Pejabat Daerah Meradong, Jalan Mahkamah, 96500 Bintangor, Sarawak, Malaysia.

240. Prof. Ahmadou Moustapha Sow (FIAS), Professor of Internal Medicine, Polyclinique Cheikh El-Hadj Malick, Rue B angle Allees Ababacar SY, Dakar, Senegal. E-mail ahmadoumoustapha@sentoo.sn

241. Mr Osman Bin Sulai, Jabatan Imigresen Negeri, Tingkat 1 & 2 Bangunan Sultan Iskandar, Jalan Simpang Tiga, 93550 Kuching, Sarawak, Malaysia.

242. Datu Ahmad Termizi Sulaiman, Kuching, Sarawak, Malaysia.

243. Tuan Haji Halpi Bin Sulaiman, Lembaga Tabung Haji Negeri Sarawak, Lot 16-18, JLN Satok, 93400 Kuching, Sarawak, Malaysia.

244. Mr Daniel Supit, District Officer, Administration Sarikei Division, Pejabat Daerah, 96100 Sarikei, Sarawak, Malaysia.

245. Mr Bolhassan Iskandar Taibi, Tabung Baitulmal Sarawak, Lot 154-155, Bangunan Zakat Dan Fitrah, Jalan Haji Taha, 93400 Kuching, Sarawak, Malaysia.

246. Mr. Misnu Bin Haji Taha, Director, Islamic Religious Department, Sarawak, Satok Road, 93400 Kuching, Sarawak, Malaysia. E-mail misnu@sarawaknet.gov.my

247. Mr Rahim Tamel, GIS Executive, Information and Communication Technology (ICT), 4th Floor, Wisma Bapa Malaysia, 93502 Petra Jaya, Kuching, Sarawak, Malaysia.

248. Mrs Hanita Tambi, Kuching, Sarawak, Malaysia.

249. Datu Nillie Tangai, Majlis Adat Istiadat Sarawak, Level 4, Wisma Satok, 93400 Kuching, Sarawak, Malaysia.

250. Encik Supian Tarmizi Haji Mohd Tazuddin, Kuching, Sarawak, Malaysia.

251. Mdm Norsinah Binti Tompeng, Pejabat Mufti Negeri Sarawak, Tingkat 6, Bangunan Mahkamah Syariah, (Anjung Kanan) Jalan Satok, 93400 Kuching, Sarawak, Malaysia. E-mail norsinat@sarawaknet.gov.my

252. Mr Mohammed Ali Toure, Islamic Development Bank, P O Box 9201, Jeddah 21413 Saudi Arabia. E-mail mtoure@isdb.org.sa

253. Hj Abdul Razak Tready, Kuching, Sarawak, Malaysia.

254. Mr Andrew Alek Tuen, Professor, UNIMAS, Faculty of Resource Science and Technology, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail aatuen@frst.unimas.my

255. Dr Samsudin Tugiman, Executive Director, Academy of Sciences Malaysia, 902-4, Jalan Tun Ismail, 50480 Kuala Lumpur, Malaysia. E-mail samsudin@akademisains.gov.my

256. Prof. Ahmet Hikmet Ucisik (FIAS), Bogazici University, Biomedical Engineering Institute, 80815 Bebek, Istanbul, Turkey. E-mail hikmet45@hotmail.com

257. Mr Bedui Bin Une, Principal Secondary School, SMK DPHA Gapor, Jalan Tun Jugah, Kuching, Sarawak, Malaysia.

258. Mr Mohd Ibrahim Bin Mohd Usof, Pejabat Mufti Negeri Sarawak, Tingkat 6, Bangunan Mahkamah Syariah, (Anjung Kanan) Jalan Satok, 93400 Kuching, Sarawak, Malaysia. E-mail ibrahimu@sarawaknet.gov.my

259. Dr Resat Uzmen, President's advisor, Turkish Atomic Energy Authority (TAEA), Cekmece Nuclear Research and Training Centre, P. K. 1 Havaalani 34149, Istanbul, Turkey. E-mail uzmenr@hotmail.com

260. Miss Rasidah Abd Wahab, UNIMAS, Medical & Health Faculty, 94300 Kota Samarahan, Sarawak, Malaysia.

261. Mr Haji Sharaie B. Wahab, Kuching, Sarawak, Malaysia.

262. Prof. Muhammad Anwar Waqar (FIAS), Director of Research and Professor of Cell Biology, Sindh Institute of Urology and Transplantation (SIUT), Dow Medical College and Civil Hospital, Karachi 74200, Pakistan. E-mail anwarwaqar@hotmail.com

263. Mr Haji Hadi bin Wasli, Ibu Pejabat Jabatan Kehakiman Syariah Sarawak, Tingkat 4, Bangunan Mahkamah Syariah, Anjung Kanan, Jalan Satok, 93400 Kuching, Sarawak, Malaysia.

264. Prof. John Webb, Professor of Chemistry, Murdoch University, Murdoch, Western Australia 6150, Australia. E-mail johnwebb@central.murdoch.edu.au

265. Mr Mohd Ashree Wee, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

266. Prof. Ibrahima Wone (FIAS), Villa No. 9059, Sacre Coeur III, Dakar, Senegal.
E-mail ibawone@yahoo.fr

267. Ms Ang Shin Ying, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

268. Dr Awangku Abdul Rahman B. PGN. Hj. Yusof, Deputy Dean of Engineering Faculty, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail pyaarahman@feng.unimas.my

269. Mr Mohammad Alfian B. Yusop, Student, FSTS, UNIMAS, 94300 Kota Samarahan, Sarawak, Malaysia.

270. Ms Suhailah Binit Za'afar, Unit Projek Khas, Jabatan Ketua Menteri, Tingkat 14, Wisma Bapa Malaysia, 93502 Petra Jaya, Kuching, Sarawak, Malaysia. E-mail Subailah@sarawaknet.gov.my

271. Puan Sri Asma Bee Bt Zainal Ariffin, Selangor, Malaysia. E-mail tsomar@modalperdana.com

272. Eng. Moneef R Zou'bi, Director General, Islamic Academy of Sciences, PO Box 830036, Amman 11183, Jordan. E-mail mrzoubi@ias-worldwide.org; mrzoubi@yahoo.com

Council Members of the Islamic World Academy of Sciences (1999-2003)

President:	**Dr Abdel Salam Majali**	Jordan.
Vice-President:	**Dr Iba Mar Diop**	Senegal.
Vice-President:	**Dr Ali Kettani***	Morocco.
Vice-President:	**Dr Misbahuddin Shami**	Pakistan.
Treasurer:	**Dr Adnan Badran**	Jordan.
Secretary General:	**Dr Mehmet Ergin**	Turkey.
Member:	**Dr Naci Bor**	Turkey.
Member:	**Dr Sayed Zahir Haider**	Bangladesh.
Member:	**Dr Mohamed H A Hassan**	Sudan.
Member:	**Dr Naeem Ahmad Khan**	Pakistan.
Member:	**Dr Zaghloul El-Naggar**	Egypt.

Council of the Islamic World Academy of Sciences (2003-2007)

President:	**Dr Abdul Salam Majali**	Jordan.
Vice-President:	**Dr J Younis Katili**	Indonesia.
Vice-President:	**Dr Ahmed Marrakchi**	Tunisia.
Vice-President:	**Dr Misbahuddin Shami**	Pakistan.
Treasurer:	**Dr Adnan Badran**	Jordan.
Secretary General:	**Dr Mehmet Ergin**	Turkey.
Member:	**Dr M Shamsher Ali**	Bangladesh.
Member:	**Dr Naci Bor**	Turkey.
Member:	**Dr Mohamed H A Hassan**	Sudan.
Member:	**Dr Anwar Nasim**	Pakistan.
Member:	**Dr Muthana Shanshal**	Iraq.

IAS Executive Staff

Eng. Moneef R Zou'bi	*Director General.*
Ms Lina Jalal	*Programme Officer*
Ms Taghreed Saqer	*Executive Secretary.*
Ms Hind Bilbessi	*Programme Officer*

*Passed away, 2001, Prof. Hamza Kettani elected, November 2001.

Patrons of the Islamic World Academy of Sciences

His Excellency the President of the Islamic Republic of Pakistan.
His Royal Highness Prince Al Hassan Ibn Talal of the Hashemite Kingdom of Jordan, Founding Patron.

Honorary Fellows of the Islamic World Academy of Sciences

1. His Excellency President of the Turkish Republic of Northern Cyprus.
2. Datuk Patinggi Tan Sri Haji Dr Abdul Taib Mahmud, Chief Minister, State of Sarawak, Malaysia.
3. His Excellency Dato' Seri Dr Mahathir Mohamad, Prime Minister of Malaysia.
4. Prof. Ferid Murad, 1998 Nobel Laureate (Medicine), USA.
5. His Excellency Nursultan Abishevich Nazarbayev, President of the Republic of Kazakhstan.
6. Dr Enver Oren, President and Chairman, Ihlas Gazetecilik Holding, Turkey.
7. Sheikh Hamad Al-Zamil, Chairman, Al-Zamil Group, Saudi Arabia.
8. Prof. Ahmed Zewail, 1999 Nobel Laureate (Chemistry), Egypt/USA.
9. *The late* Dr Hakim Mohammed Said, President, Hamdard Foundation, Pakistan.

Fellows of the
Islamic World Academy of Sciences
(August 2006)

1. Prof. Omar **Abdul Rahman**	Malaysia	Veterinary Medicine
2. Prof. Naim **Afgan**	Bosnia-Herzegovina	Mechanical Engineering
3. Prof. Ishfaq **Ahmad**	Pakistan	Physics
4. Prof. Askar **Akayev**	Kyrghyzistan	Computer Engineering
5. Prof. Sajjad **Alam**	Bangladesh/USA	Physics
6. Prof. M Shamsher **Ali**	Bangladesh	Physics
7. Prof. Qurashi Mohammed **Ali**	Sudan	Medicine/Anatomy
8. Prof. Huda Saleh Mehdi **Ammash**	Iraq	Biology
9. Prof. Wiranto **Arismunandar**	Indonesia	Mechanical Engineering
10. Prof. Muhammad **Asghar**	France	Physics
11. Prof. Attia A **Ashour**	Egypt	Mathematics
12. Prof. Saleh A **Al-Athel**	Saudi Arabia	Mechanical Engineering
13. Prof. Ahmad Nawawi **Ayob**	Malaysia	Botany
14. Prof. Ahmad Abdullah **Azad**	Bangladesh/Australia	Biochemistry
15. Prof. Agadjan **Babaev**	Turkmenistan	Geography
16. Prof. Adnan **Badran**	Jordan	Biology
17. Prof. Ibrahim Gamil **Badran**	Egypt	Medicine
18. Prof. Farouk **El-Baz**	USA	Geology
19. Prof. Kazem **Behbehani**	Kuwait	Immunology
20. Prof. Azret Yusupovich **Bekkiev**	Balkar/Russia	Physics
21. Prof. Naci **Bor**	Turkey	Medicine
22. Prof. Rafik **Boukhris**	Tunisia	Medicine
23. Prof. Mohammad Ilyas **Burney**	Pakistan	Medicine
24. Prof. Noor Mohammad **Butt**	Pakistan	Physics
25. Prof. Muhammad Iqbal **Choudhary**	Pakistan	Organic Chemistry
26. Prof. Ali A **Daffa'**	Saudi Arabia	Mathematics
27. Prof. Mamadou **Daffe**	Mali/France	Biochemistry
28. Prof. Fakhruddin **Daghestani**	Jordan	Mechanical Engineering
29. Prof. Ramazan **Demir**	Turkey	Biology
30. Prof. Oussaynou Fall **Dia**	Senegal	Geology
31. Prof. Ugur **Dilmen**	Turkey	Medicine
32. Prof. Ibrahim Mar **Diop**	Senegal	Medicine
33. Prof. Mustafa **Doruk**	Turkey	Metallurgical Engineering
34. Prof. Mehmet **Ergin**	Turkey	Chemical Engineering
35. Prof. Mohamed B E **Fayez**	Egypt	Chemistry
36. Prof. Mehdi **Golshani**	Iran	Physics
37. Prof. Kadyr G **Gulamov**	Uzbekistan	Physics
38. Prof. Hashim M **El-Hadi**	Sudan	Veterinary Medicine
39. Prof. Mahmoud **Hafez**	Egypt	Entomology
40. Prof. Syed Zahir **Haider**	Bangladesh	Chemistry
41. Prof. Kemal **Hanjalic**	Bosnia-Herzegovina	Mechanical Engineering
42. Prof. Mohammad **Hamdan**	Jordan	Mathematics
43. Prof. Mohamed H A **Hassan**	Sudan	Mathematics
44. Prof. Ali Ali **Hebeish**	Egypt	Chemistry
45. Prof. Bambang **Hidayat**	Indonesia	Astronomy
46. Prof. Abdul Latif **Ibrahim**	Malaysia	Microbiology
47. Prof. Mohammad Shamim **Jairajpuri**	India	Zoology
48. Prof. J (Younis) Ario **Katili**	Indonesia	Geology
49. Prof. Hamza **El-Kettani**	Morocco	Physics and Chemistry
50. Prof. Pulat K **Khabibullaev**	Uzbekistan	Physics
51. Prof. Salambek **Khadjiev**	Chechnya	Chemistry
52. Prof. Idriss **Khalil**	Morocco	Mathematics

53. Prof. Abdul Qadeer **Khan**	Pakistan	Metallurgical Engineering
54. Prof. Hameed Ahmed **Khan**	Pakistan	Physics
55. Prof. Naeem Ahmad **Khan**	Pakistan	Physics
56. Prof. Mostefa **Khiati**	Algeria	Medicine
57. Prof. Abdelhafid **Lahlaidi**	Morocco	Medicine
58. Prof. Zohra Ben **Lakhdar**	Tunisia	Physics
59. Prof. Abdel Salam **Majali**	Jordan	Medicine
60. Prof. Iftikhar Ahmad **Malik**	Pakistan	Medicine/Pathology
61. Prof. Ahmed **Marrakchi**	Tunisia	Electronic Engineering
62. Prof. Akhmet **Mazgarov**	Tatarstan/Russia	Petrochemistry
63. Prof. Syed Qasim **Mehdi**	Pakistan	Molecular Biology
64. Prof. Amdoulla **Mehrabov**	Azerbaijan	Materials Science
65. Prof. Sami **Al- Mudhaffar**	Iraq	Biochemistry
66. Prof. Badri **Muhammad**	Malaysia	Chemistry
67. Prof. Zaghloul **El-Naggar**	Egypt	Geology
68. Prof. Ibrahim Saleh **Al- Naimi**	Qatar	Chemistry
69. Prof. Anwar **Nasim**	Pakistan	Genetics
70. Prof. Jamal **Nazrul-Islam**	Bangladesh/UK	Mathematics
71. Prof. Souleymane **Niang**	Senegal	Mathematics
72. Prof. Gulsen **Oner**	Turkey	Medicine
73. Prof. Ramdane **Ouahes**	Algeria	Chemistry
74. Prof. Korkut **Ozal**	Turkey	Civil Engineering
75. Prof. Mehmet Nimet **Ozdas**	Turkey	Mechanical Engineering
76. Prof. Sinasi **Ozsoylu**	Turkey	Medicine
77. Prof. Munir **Ozturk**	Turkey	Biology
78. Prof. Iqbal **Parker**	South Africa	Biochemistry
79. Prof. Syed Muhammad **Qaim**	Germany	Nuclear Chemistry
80. Prof. Subhi **Qasem**	Jordan	Agriculture
81. Prof. Mazhar M **Qurashi**	Pakistan	Physics
82. Prof. Atta-ur-**Rahman**	Pakistan	Chemistry
83. Prof. Najih Khalil **El-Rawi**	Iraq	Civil Engineering
84. Prof. **Riazuddin**	Pakistan	Physics
85. Prof. Makhmud **Salakhitdinov**	Uzbekistan	Mathematics
86. Prof. Hussein Samir **Salama**	Egypt	Entomology
87. Prof. Eldar Yunisoglu **Salayev**	Azerbaijan	Physics /Mathematics
88. Prof. Samaun **Samadikun**	Indonesia	Electronic Engineering
89. Prof. Lorenzo **Savioli**	Italy	Medicine
90. Prof. Misbah-Ud-Din **Shami**	Pakistan	Chemistry
91. Prof. Ali **Al-Shamlan**	Kuwait	Geology
92. Prof. Ahmad **Shamsul-Islam**	Bangladesh	Botany
93. Prof. Muthana **Shanshal**	Iraq	Chemistry
94. Prof. Ahmedou M **Sow**	Senegal	Medicine
95. Prof. Mahmoud **Tebyani**	Iran	Electronic Engineering
96. Prof. Ahmet Hikmet **Ucisik**	Turkey	Materials Science
97. Prof. Mohammed A **Waqar**	Pakistan	Biochemistry
98. Prof. Ibrahima **Wone**	Senegal	Medicine
99. Prof. Bekhzad **Yuldashev**	Uzbekistan	Physics/ Mathematics
100. Prof. Mikhael **Zalikhanov**	Balkar/Russia	Glaciology/Biology

Deceased Fellows of the Islamic World Academy of Sciences

Prof. Mohammad **Ibrahim**	(1911-1988)	Bangladesh.
Prof. Djibril **Fall**	(1930-1992)	Senegal.
Prof. Salimuzzaman **Siddiqui**	(1897-1994)	Pakistan.
Prof. Abdus Salam **Mia**	(1925-1995)	Bangladesh/USA.
Prof. Suleiman Gabir **Hamad**	(1937-1996)	Sudan.
Prof. Mohammad R **Siddiqi**	(1908-1998)	Pakistan.
Prof. Abdullah M **Sharafuddin**	(1930-1998)	Bangladesh.
Prof. Achmad **Baiquni**	(1923-1998)	Indonesia.
Prof. Mumtaz Ali **Kazi**	(1928-1999)	Pakistan.
Prof. Faramaz G **Maksudov**	(1930-2000)	Azerbaijan.
Prof. Ali **Kettani**	(1941-2001)	Morocco.
Prof. Mohamed Kamel **Mahmoud**	(1926-2003)	Egypt.

Laureate(s) of the IAS
Ibrahim Memorial Award

Prof. Ugur **Dilmen**	1996	Turkey.
Prof. Mohammad **Abdollahi**	2006	Iran.

IAS Supporters

The Hashemite Kingdom of Jordan
The Islamic Republic of Pakistan
The State of Kuwait
The Republic of Turkey
Malaysia
The Republic of Senegal
The Republic of Sudan
The Islamic Republic of Iran
The State of Qatar
The Republic of Tunisia
The Kingdom of Morocco
The State of Sarawak/Malaysia
The Republic of Indonesia

The OIC Standing Committee on Scientific and Technological Co-operation (COMSTECH).
The Islamic Development Bank (IDB).
The OPEC Fund for International Development, Vienna, Austria.
Arab Potash Company, Jordan.
United Nations Educational Scientific and Cultural Organisation (UNESCO).
Islamic Educational Scientific and Cultural Organisation (ISESCO).
The World Bank.
The United Nations Environment Programme (UNEP).
Kuwait Foundation for the Advancement of Sciences (KFAS).
Turkish Scientific and Technical Research Council (TUBITAK).
The Royal Scientific Society (RSS), Jordan.
Pakistan Ministry of Science and Technology.
Ministry of Science, Technology and the Environment, Malaysia.
University Cheikh Anta Diop, Dakar, Senegal.
Ministry of Higher Education and Scientific Research, Sudan.
National Centre for Research, Sudan.
Ministry of Culture and Higher Education, Iran.
Iranian Research Organisation for Science and Technology (IROST).
The Academy of Sciences, Tehran, Iran.
The Academy of Medical Sciences, Tehran, Iran.
Saudi Arabian Oil Company, Saudi Arabia (ARAMCO).
Ihlas Holding, Turkey.
Arab Bank, Jordan.
Jordan Kuwait Bank, Jordan.
Rafia Industrial Company, Jordan.
Secretariat of State for Scientific Research and Technology, Tunisia.
Academy of the Kingdom of Morocco.
Petra Private University, Jordan.

Higher Council of Science and Technology (HCST), Jordan.
Pakistan Academy of Sciences.
Majlis Islam Sarawak, Malaysia.
Tabung Baitulmal Sarawak, Malaysia.
Sasakawa Peace Foundation, Tokyo, Japan.
Perdana Leadership Foundation, Malaysia.
Royal Jordanian Airlines.
Arab Jordan Investment Bank, Amman, Jordan.
National Centre for Human Resources Development, Amman, Jordan.
Al Bukhary Foundation, Malysia.
Bilkent University, Ankara, Turkey.

IAS Waqf

Islamic World Academy of Sciences
Jordan Islamic Bank
Shemeisani Branch
Account No.: 809/$91
Telephone : 5677107
Facsimile : 5691700
PO Box 925997
Amman 11110
Jordan.

IAS Endowment Fund

Islamic World Academy of Sciences
Arab Bank
Fifth Circle Branch
Account No : 0134/034765-5/710
Telephone : 5526870
Facsimile : 5526874
PO Box 141107
Amman
Jordan.

IAS on the Internet
http://www.iasworld.org