New Horizons: Nuclear Energy in a Changing World

16 - 17 September 2003
Scientific Forum
during the 47th Regular Session of the IAEA General Conference
Conference Room C, Austria Center
Vienna, Austria

Organized by the
International Atomic Energy Agency

TUESDAY, 16 SEPTEMBER 2003

10:00 – 13:00 hours

Opening Address: **M. ElBaradei, Director General, IAEA**

Session 1: Innovative Approaches: Nuclear Power

The keynote presentations will be followed by a panel discussion including the keynote speakers and the following panellists: *J.F. Ahearne,* USA; *P. Bernard,* France; *V.K. Chaturvedi,* India.

Moderator: *R. Chidambaram,* India

Keynote Speakers:

R. Cirimello, Argentina, "Outcome of the June IAEA Conference on Innovative Technologies for Nuclear Fuel Cycles and Nuclear Power"

W. D. Magwood IV, USA, "International Initiatives in the Development of Innovative Technologies: GIF and other collaborative initiatives"

V. M. Mourogov, IAEA, "International Initiatives in the Development of Innovative Technologies: Recent developments and future of INPRO Project"

E. Moniz, USA, "The Future of Nuclear Power – An Interdiscipilinary MIT Study"

K.L. Peddicord, USA, "Hydrogen Utilization and the Role of Nuclear Energy"

E. P. Velikhov, Russian Federation, "Status and Prospects of Nuclear Power from Fusion and from Fission"

13:00 – 15: 00 hours Break

TUESDAY, 16 SEPTEMBER 2003

15:00 – 18:00 hours

Session 2 – Part 1: Innovative Approaches; Nuclear Medicine

The keynote presentations will be followed by a panel discussion including the keynote speakers and the following panellists: *A. Ellmann,* South Africa; *E. Bobadilla Lopez,* Chile; *A. Padhy,* IAEA.

Moderator: *K. E. Britton,* UK

Keynote Speakers:

T. Chaiwatanarat, Thailand, "Development of Internet-based Study Materials for Teaching and Training in Nuclear Medicine: Results of an IAEA Coordinated Research Project"

V. Fidler, Slovenia, "Development of Regional Tele-medicine Software for Efficient Low-cost Communication"

Session 2 – Part 2: Innovative Approaches; Self-reliant Institutions

The keynote presentations will be followed by a panel discussion.

Moderator: *W.E. Stumpf,* South Africa

Keynote Speakers:

J. Mengatti, Brazil, "Self-Reliance Politics in Radioisotopes Production"

M. Daud, Malaysia, "Developing Sustainability and Self-Reliance – Challenges and Limitations"

E. Akaho, Ghana, "Developing Greater Self-Reliance in the Nuclear Sector in Ghana"

WEDNESDAY, 17 SEPTEMBER 2003

10:00 – 13:00 hours

Session 3: IAEA Safety Standards: Towards Global Application

The keynote presentations will be followed by a panel discussion including the keynote speakers and the following panellists: *J. Takala,* International Labour Office; *B.C. Bhatt,* India; *J-L. Nigon,* France.

Moderator: *J. Laaksonen*, Finland

Keynote Speakers:

L. Williams, UK, "Making a Difference in the 21st Century: The Continuing Evolution of the IAEA Standards"

L. Green, World Nuclear Transport Institute, "The Industry Commitment to Global Transport Safety Standards"

C. Schandorf, Ghana, "Application of the IAEA Safety Standards: Ghanaian Experience"

C. Waeterloos, European Commission, "Use of IAEA Safety Standards in the Development of European Safety Standards"

13:00 – 15:00 hours Break

WEDNESDAY, 17 SEPTEMBER 2003

15:00 – 18:00 hours

Session 4: Safeguards Technology: Challenges and Limitations

The keynote presentations will be followed by a panel discussion including the keynote speakers and the following panellists: *K. Mayer,* Germany*; C. Jonsson,* Sweden; D. *Tillwick,* South Africa; *V. Kuchinov,* Russian Federation.

Moderator: K. Naito, *Japan*

Keynote Speakers:

T. Renis, IAEA, "Drawing Safeguards Conclusions for the State as a Whole: The Role of Safeguards Technology"

D. Fischer, IAEA, "The Use of Environmental Sampling to Detect Indications of Undeclared Nuclear Activities"

M. Nicholas, IAEA, "The Importance of Open Source Information and Satellite Imagery Analysis in Safeguards Implementation"

M. Aparo, IAEA, "Future Safeguards Equipment Needs and Technology"

SYNOPSES

The following summaries are based on information provided by the presenters. The views expressed remain the responsibility of the named authors and do not necessarily reflect those of the government of the Member State(s) or organization of the author. The IAEA cannot be held responsible for any material reproduced in this book.

Session 1: Innovative Approaches; Nuclear Power

Outcome of the IAEA International Conference on Innovative Technologies for Nuclear Fuel Cycles and Nuclear Power held 23-26 June 2003 in Vienna

R. O. Cirimello, Argentina
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The International Atomic Energy Agency, in co-operation with the World Nuclear Association, the World Energy Council, the International Science and Technology Center and the Electric Utilities Cost Group, organized the International Conference on Innovative Technologies for Nuclear Fuel Cycles and Nuclear Power, in Vienna from 23 to 26 June 2003. The main objectives of the Conference were to facilitate exchange of information between senior experts and policy makers from Member States and international organizations on important aspects of the development of innovative technologies for future generations of nuclear power reactors and fuel cycles; to create an understanding of the social, environmental and economic conditions that would facilitate innovative and sustainable nuclear technologies; and to identify opportunities for collaborative work between Member States and international organizations and programmes. There were seven sessions; four were devoted to talks on specific topics by 21 invited speakers drawn from 11 Member States and one full-day session to 21 oral presentations and 26 poster presentations of accepted papers. Part of the opening session and two half-day sessions were devoted to panel discussions in which 23 panellists from 9 Member States and 5 international organizations took part. The conference succeeded in bringing together top managers, policy makers and specialists from developed and developing countries as well as representatives of R & D activities in MS and international projects. All relevant aspects of innovative technologies for nuclear fuel cycles and nuclear power were discussed in an open, frank and objective manner with the following conclusions.

No large increase in the use of nuclear energy is foreseen in the near and medium term, but is likely in the long term if developing country per-capita electricity consumption reaches that of the developed world. The nuclear sector including regulators view an increased use of nuclear energy as the solution for global sustainable energy needs considering that significant reductions in CO_2 emissions would be required. Although the current nuclear technology is considered to have matured as an industry, innovation is foreseen for further improvement of safety, economy, sustainability, non-proliferation, etc.

On the other hand, the general public, politicians and environmental NGO's (Non Governmental Organizations) in many countries view nuclear specialists with distrust. In their view nuclear energy is not needed in the short and medium term and likely not also in the long term. Innovative fuel cycles and nuclear power technologies have to achieve inherent safety, proliferation resistance, foolproof measures against terrorist acts and sabotage, etc., even for being considered as an option.

Thus there is a gap to be bridged if the potential benefits of nuclear energy are to be realized for peace and prosperity of humanity. Technical measures such as well defined user-requirements, improved design concepts and applications in addition to electricity generation, have to be developed. Communication has to be substantially improved both within the nuclear community and with the public and society at large. Apart from achieving acceptable economic targets in terms of cost per installed kilowatt and investment cost, it would be necessary to seek appropriate solutions for improving the investment attractiveness of nuclear plants in developing countries.

There was a broad agreement amongst the participants that international collaboration in general and the collaboration especially between Gen IV and INPRO initiatives should be improved and substantially expanded. The IAEA is expected by all to play a key role in coordinating international efforts to develop innovative technologies.

International Initiatives in the Development of Innovative Technologies: GIF and other Collaborative Initiatives

William D. Magwood, IV, Director
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World demand for energy is growing at a rate of 2.3% per year and will increase by 43% by 2025. Nuclear energy can address this demand if it is deployed in the near-term. Currently, the United States is the world's largest supplier of commercial nuclear power with 103 commercial nuclear plants producing electricity in the United States. The U.S. National Energy Policy (NEP) released in May 2001 supports further development of nuclear energy by developing advanced nuclear fuel cycles and next generation technologies and advanced reprocessing and fuel treatment technologies. At the U.S. Department of Energy, Office of Nuclear Energy, several programs have been initiated to implement the recommendations of the NEP. The U.S. led Generation IV International Forum (GIF) is an eleven-member group interested in jointly defining the future of nuclear energy research and development. A Generation IV Technology Roadmap was prepared by the GIF member countries that identified the six most promising reactor system and fuel cycle concepts and the R&D necessary to advance these concepts for potential commercialization by 2030. These concepts included a gas-cooled fast reactor, lead alloy liquid metal-cooled reactor, molten salt reactor, sodium liquid metal-cooled reactor, supercritical water-cooled reactor and very high temperature gas reactor. The concepts offer advantages in the areas of economics, safety and reliability, sustainability, and nuclear nonproliferation. Furthermore, the Advanced Fuel Cycle Initiative was initiated to reduce the volume of spent nuclear fuel and thereby reduce the cost of geologic disposal, reclaim spent fuel's valuable energy and reduce inventories of civilian U.S. plutonium, and reduce radiotoxicity of spent fuel. By initiating these programs, the U.S. hopes to further nuclear energy as a viable energy source today and in the future.

International Initiatives in the Development of Innovative Technologies: Recent Developments and Future of INPRO Project

V.M. Mourogov
Deputy Director General
Head of the Department of Nuclear Energy
IAEA

Our topic is “New Horizons”, which implies looking beyond old horizons. We began INPRO by asking whether nuclear energy could be a key, substantial part of particularly developing countries meeting their energy needs for sustainable development for the long-term future. It is in the developing countries where population growth will be highest in the next 100 years. It is in the developing countries where development needs are the greatest. And it will be in meeting the concerns of the developing countries, that we are truly challenged to think beyond, and go beyond, old horizons.

INPRO studied the new scenarios of the Intergovernmental Panel on Climate Change (IPCC), particularly their conclusions about nuclear power and nuclear generated hydrogen, and the answer is, “yes”, nuclear energy has a major role to play, and, “yes”, the scenarios anticipate a major long-term shift in the market for nuclear energy toward today’s developing countries.

The focus in Phase-IA has been on defining requirements that innovative nuclear concepts should meet to be part of successfully turning the potential for nuclear expansion into a reality. These requirements are different from requirements a supplier might formulate to help him win the next reactor order in the OECD. They reflect a global perspective, a long-term perspective, and an integrated perspective incorporating not just the reactor, but also the front- and back-ends of the fuel cycle, and even institutional and infrastructure factors.

Formulating such new requirements is a challenge, and it would be over-confident to present our first draft, so to speak, as our final draft. Phase-IB of INPRO is indeed in the midst of several case studies to test the requirements as currently formulated and identify improvements to make them ever more useful. But even excellent requirements would have limited value without an understandable, transparent, but comprehensive mechanism for applying them to new candidate concepts, for comparing alternatives, and for drawing conclusions about future research and development directions. An essential part of this mechanism has to be nuclear system modelling, and we believe that extensive international co-operation is essential here. And we also believe the Agency can contribute an established, inclusive, productive forum with experience, expertise and networks in safeguards, safety, technology, planning, institutional mechanisms and all aspects and stages of the fuel cycle.

We look forward to broad collaboration as we continue with INPRO. It is necessary if we are to move beyond old horizons, to explore the full potential of internationalisation options for fuel cycle components – as the Director General raised in his speech yesterday – and to respond to the new needs of the new century to integrate into the global nuclear system a new generation of nuclear users from interested developing country Member States.

The Future of Nuclear Power - An Interdisciplinary MIT Study

Ernest J. Moniz, Professor of Physics,
and Director of Energy Studies,
Laboratory for Energy and the Environment, Massachusetts Institute of Technology
Cambridge, MA, USA

An interdisciplinary MIT faculty group studied the future of nuclear power because it is an important option for meeting electricity needs without emitting carbon dioxide. The economics, safety, waste management, and nonproliferation challenges of enabling a possible global mid-century deployment of about 1000 GWe were addressed through a set of findings and policy recommendations:

- Such a mid-century growth scenario will be based primarily on thermal reactors operated in a once-through mode.
- A merchant plant model of costs shows that, if nuclear power is to be competitive with coal and natural gas, industry must demonstrate its plausible but unproved claims of significant reactor capital cost reduction and the social costs of greenhouse gas emission need to be internalized. For the United States, we recommend electricity production tax credits for a set of "first mover" plants.
- Long term storage of spent fuel prior to geological emplacement, specifically including international spent fuel storage, should be systematically incorporated into waste management strategies. The scope of waste management R&D should be expanded significantly; an extensive program on deep borehole disposal is an example.
- The current international safeguards regime should be strengthened to meet the nonproliferation challenges of globally expanded nuclear power. The Additional Protocol needs to be implemented; the accounting/inspection regime should be supplemented with strong surveillance and containment systems for new fuel cycle facilities; safeguards should be implemented in a risk-based framework keyed to fuel cycle activity.
- A major international effort should be launched to develop the analytical tools and to collect essential scientific and engineering data for integrated assessment of fuel cycles. Large demonstration projects are not justified in the absence of advanced analysis and simulation capability.
- Public acceptance is critical to expansion of nuclear power. In the United States, the public does not yet see nuclear power as a way to address global warming.

The full report is available electronically at http://web.mit.edu/nuclearpower/.

Hydrogen Utilization and the Role of Nuclear Energy

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Over the upcoming years and decades, it is anticipated that the need to develop energy strategies to substitute for oil and gas will become increasingly acute. This will be motivated by declining supplies and increasing prices, and by considerations of CO_2 emissions to the atmosphere by fossil fuels. Nuclear energy as a source and hydrogen as an energy carrier offer many attractive features.

Electricity from nuclear energy can already be utilized for hydrogen production through optimized hot electrolysis. However, new Generation IV designs with high temperature gas reactors or heavy metal systems may be coupled with promising thermo chemical production processes such as the I-S or Ca-Br processes. Thermo chemical production of hydrogen offers the dual attraction that the source material is water and there is no resulting CO_2. The efficiencies of the thermo chemical processes may approach 50%. This could provide for attractive economics.

Early opportunities may exist for demonstration and implementation of nuclear generated hydrogen. The need for hydrogen in the refining industry is growing significantly. This demand is the result of using increasingly heavier crude oils in the manufacture gasoline and other petroleum products. Consequently, additional quantities of hydrogen are required to meet performance and environmental requirements. Currently natural gas serves as the feedstock for hydrogen production through steam reforming methods. If the price of natural gas remains at current levels or climbs, alternative approaches to hydrogen production will become attractive. In addition, in some locations, the infrastructure already exists that can favorably accommodate nuclear generated hydrogen. Strategic planning based on emerging designs and technologies coupled these new uses of nuclear energy offer important opportunities. The needs of the refining industry may represent the first large scale use of nuclear energy for hydrogen production and an initial but critical step to the "hydrogen economy."

Status and Prospects of Nuclear Power from Fusion and from Fission

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The advantages of nuclear power from fusion are inexhaustible fuel resources, ecological attractiveness, inherent safety, significantly lower level of radioactive wastes, and absence of the materials which could be used for weapons. Since the 1950s the intensive work resulted in a unique scientific and technological database. In 1985 M. Gorbachev, F. Mitterand and R. Reagan suggested to create the first experimental fusion reactor on an international basis. In 1988 an international team comprising specialists of the USSR, USA, EC and Japan started activities on the design of a reactor, which was named ITER, with active support from the IAEA. An engineering design of the 500 MW reactor was completed in 2001. The negotiations concerning ITER construction have been started. Canada, Japan, France and Spain proposed options for site selection. Canada, China and the Republic of Korea have joined the countries that had pioneered the project. The ITER would have important socio-economical and political implications for the world community. The time for creating such a reactor is ripe.

The nuclear power from fission is an advanced technology providing for 16% of electricity in the world. The IAEA' project INPRO was started after the Russian Federation President Vladimir V. Putin stated his Initiative at the UN General Assembly in 2000. This project addresses the strategic issues of development of future nuclear energy for the world from nuclear fission. INPRO has made a conclusion that Nuclear Fuel Cycle (NFC) is a system-creating factor. Prospects of such power depend on the solution of NFC back-end problem. It is necessary to begin the formation of NFC international structures, as a major component of the world fission power system. The establishment of an international research centre on spent fuel treatment technology and on radioactive waste storage is a practical step in this direction.

Session 2: Innovative Approaches; Nuclear Medicine

Development of Internet-based Study Materials for Teaching andTraining in Nuclear Medicine: Results of an IAEA Coordinated Research Project

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Nuclear medicine is one of medical specialties, which is heavily involved with graphic, imaging, numeric data and text. In the past, Nuclear Medicine manuscripts and books needed to be published with high quality printing to ensure the best standards. But with WWW technology it is possible to obtain high quality graphic displays through the use of personal computer. It provides a perfect tool for learning. Now a day, with integrated dynamic HTML, JAVA script, as well as server programming, such as Professional Home Page (PHP) technology, the making of interactive web page is possible. It means that learners can individually select the lessons that suit their preferences, basic knowledge and interest. This project was initiated in order to make the most of this new technology for nuclear medicine learning, especially for those in the developing countries where there are still lacks of good quality teaching and training programmes. It was also envisaged to create a central source for nuclear medicine teaching materials. The main objectives of the project were to develop database file to store data of the teaching case studies and to develop template web site to host the teaching materials which are teaching case studies, multimedia applications and slide collections.

The web pages were written using PHP server programming language technology, which can be run on PHP, enabled web server. Teaching cases are stored in database on the server computer. On request by Internet user, PHP program will retrieve data from the database and display in HTML format on user's computer. User can search and see the case studies available in database according to his/her interest. Search can be made using one or more of these criteria: diagnostic system, diagnostic pathology and scintigraphic type. The cases can be displayed in known or unknown case formats. In the known case format presentation, user can go through the case with all available information displayed on the page. But for unknown case format presentation, no information will be immediately displayed, user can make a guess on the case for self-learning and self-evaluation. And when user would like to see the answer he/she can click and the information will then be immediately shown up. The interesting part of the program is that it is designed in a way that teaching case studies can be submitted directly from anywhere in the world by internet browser. User who would like to contribute the case studies will use a form to submit case data along with images. When submitted, data and images will be stored in the server and ready to be served on request. With this method, unlimited expansion of the material is possible with only minimal manual maintenance.

Integration of medical education into the Internet technology is becoming very popular and nuclear medicine is not an exception. Its advantages include available technology and software, cost-effectiveness, easy operations, globally and uninterrupted information access. Even if Internet connection is not possible, this technology also enables off-line browsing of the data stored in any type of storage system such as CD-ROM, hard disk etc. There are many nuclear medicine teaching resource web sites, but some limitations do exist. For example most of them use static page presentations, some use only partial interactive technique and some provide limited access. The template web site created in this research project has shown the feasibility of the technology. It integrates client-site, sever-site programming and database connection technology to create a powerful interactive teaching resource. Learners from anywhere in the world, who can access to the Internet, can enjoy this resource according to their preference. They can also get the teaching materials for their own teaching activities, this will greatly save time and enhance the teaching process. There are still some anticipated problems such as the limitation of data transfer for on-line users, especially for those in the remote areas. Compared to other image modalities, nuclear medicine imaging modalities may not face much of the problems due to their relatively small image size.

Another problem is the non-standardization of the dynamic HTML format. There are many differences between browser software, which makes interactive web page extremely difficult. We still have several problems, but hope that they would be solved soon.

Development of Regional Tele-medicine Software for Efficient Low-cost Communication

V. Fidler[1], M. Medved[1], Y. Xie[2] and A.K. Padhy[2]
[1]Ljubljana University, Slovenia and [2]Nuclear Medicine Section, IAEA, Vienna

For the last 30 years, the gamma camera has been the basic nuclear medicine device for imaging the distribution of a radioapharmaceutical in the body. It consists of a sensitive detector system for high penetrating gamma rays, a lead collimator, positional and energy selective electronics and a computer system for digitizing, acquisition, processing and communication of image data. Due to high financial expenses for renewal and maintenance of this technology, the IAEA started ten years ago the upgrading projects to develop an acquisition board, low-cost acquisition/processing PC based hardware and software with included tools for Internet communication (Telemedicine) for the quality improvement of Nuclear Medicine in developing countries with 2-3,000 analog/semi-digital planar and 1-1,500 SPECT/WB semi-digital/digital gamma cameras. The main goal of the Telemedicine project is an exchange of image data from all gamma cameras in the network, transfer of a specialist's knowledge and experience, tele-maintenance of imaging systems and availability of extensive educational resources.

The IAEA acquisition upgrading system was designed with the help of 3D electronic/digital design software and built from modern micro analog/digital components. The acquisition electronic board was made on a single four-layer printed card with ISA bus communication, acquisition/processing software in DOS, archiving on CD, printing images and report text documents on low-priced laser/inkjet printers and network communication using TCP/IP protocol. The latest USB 2.0 communication technology was introduced to the acquisition board to increase the connection speed with the computer by forty times. Most frequently the faulty electronic console for analog and semi-digital gamma cameras was replaced by a minimized but functionally equal electronic board. Builder C++ Windows tools for acquisition/ processing software and DELPHI tools for the patient database system upgraded out-of-date DOS software. New communication software between the gamma camera's PC acquisition/ processing system (Client) and the country's central server (Coordinating Server) was developed from available free software and a specially developed code for file and text (HTML format) sharing, image file format conversions and tools for powerful graphic station with a 3D engine for display and additional analysis of nuclear medicine and radiology images. The upgrading system was distributed and applied in more than 50 developing countries at the expense of less than 10 % of the price of commercial systems. It was tested at expert validation meetings. In several regional workshops, technical/medical staff was well trained.

With the upgraded system, any user can acquire images from any analog/semi-digital gamma camera in static, dynamic and gated mode, convert them to digital form, store them into computer memory, process with the set of standard clinical and quality control programs, make and print a report, send all the data through the Internet network to an expert coordinating center for direct or indirect consultation and archiving the data on central or local mass storage media. In the future, the software for coordinating and regional servers should be developed for assuring high standard data security (HTTPS protocol), online tele-videoconferencing, remote access (tele-maintenance), a server database for image studies and text documents, and web browsing for educational data. Electronic/digital components for accessing high voltage or preamplifier gain from every PMT and internal power supply voltage of the gamma camera's detector should be added to the acquisition card for providing effective, fast and low-cost tele-maintenance.

Session 2: Innovative Approaches; Self-reliant Institutions

Self-Reliance Politics in Radioisotopes Production

Jair Mengatti

National Comission of Nuclear Energy (CNEN), Brazil

The Energetic and Nuclear Research Institute (IPEN), owned by National Commission of Nuclear Energy (CNEN), is a non-profit government institution that produces on a national scale more than 18 radioisotopes and radiopharmaceuticals for nuclear medicine. These radiopharmaceuticals are used in the diagnosis and treatment of more than 1.5 million people in Brazil. This level of production was achieved through the creation of new technologies and automation solutions, because of the difficulty and cost on importation of raw materials and labeling compounds ready for use.

In Brazil, only CNEN has authorization to import, manipulate and distribute radiopharmaceuticals. Therefore, the quality of those radioisotopes must comply with international specifications and regulations. Much research and 40 years of improvements has won IPEN international approval for the radiopharmaceuticals that it produces, and quality standards and specifications are today as good as in any other developed country. IPEN has even developed a few solutions in radioisotope production for others countries, such as Cuba and soon Peru.

The first step towards self-production was the acquisition of a cyclotron (Cyclone-30) and the improvement of the reactor power from 2 MW to 5 MW. Many technical visits were made to radiopharmaceutical institutions around the world with the purpose of bringing self-reliance and self-development solutions to IPEN. The international radiopharmaceutical community has always contributed to this effort, and only with their help our self-development and self-reliance could be possible.

IPEN has ISO 9001-2000 certification and has made efforts to improve the installations in order to achieve Good Manufacturing Practice. Every effort we make today has the goal of making radiopharmaceuticals available for therapy at the most competitive price possible for our institution.

Developing Sustainability and Self-reliance: Challenges and Limitations

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Many nuclear institutions in the world, especially the developing countries, are heavily dependent on the financing provided by the government for their activities. In August 2000, Malaysia in cooperation with the International Atomic Energy Agency (IAEA), organized a Regional Seminar on Strategies and Approaches towards Self-reliance and Sustainability of National Nuclear Institutions (NNIs). As a result of the forum and deliberation of the seminar, there is now a greater awareness among the member states that there should be a paradigm shift in the thinking of policy and decision makers. The main challenges and limitations faced by these policy and decision makers are firstly, in order that nuclear institutions to stay relevant in the context of mainstream socio-economic development, the NNIs must generate revenue to achieve self-reliance and sustainability. Secondly, the need for the NNIs to fulfil social obligations, i.e., provision of reasonably good and low cost technology to support food and agriculture production; health care system; safe industrial development and clean environment. Thirdly, to improve the image and acceptance of nuclear technology by the consumers and public in the face of proliferation of nuclear-arms race.

Malaysia has been successful in addressing these conflicting requirements and challenges, i.e. generating revenue for sustainability and at the same time providing services and consultancy at a reasonable rate. The Malaysian Institute for Nuclear Technology Research (MINT) is now 30% sustainable in terms of operational costs via provision of services and consultancies to both private and government agencies. Technical services are provided in the areas of Industrial Technology (e.g. ND evaluation); Radiation Processing Services (e.g., medical product sterilization and food and herbal irradiation, and cross-linking of wire and cables); Dosimetry Services for personal and radiation equipment (e.g. personal dosimetry, calibration of survey meter); Provision of Training in safety and health, NDT, Medical X-ray, etc. The consultancy services focus on the area of Environmental Study and Evaluation; Technical and Engineering Services; Quality Assurance for Nuclear Instruments; Agro Technology, etc. The management of such services and consultancies, which includes marketing and costing, business negotiations and other related activities, is coordinated by a center called the *Customer Service Unit*. MINT also practices *the concept of technology to market chain*, which enhances transfer of technology from the laboratory to the end-users. It is also important to note that the expertise to supply services and consultancies to industries and public sector has been developed over the years with the cooperation of the IAEA since the inception of MINT in 1972.

In Malaysia, perhaps unlike in some countries, nuclear technology has gained wide acceptance and encountered little resistance from the public and industries. Among the strategies to gain wider acceptance are the following: MINT placed a great importance on the relationship and rapport with existing and prospective customers and end-users, and the media (radio, TV and newspaper). MINT's personnel appear in such media regularly to explain to the public the importance and benefits of nuclear technology; MINT also accepts visitors at the premises, and conducts lectures at schools and institutions of higher learning as part of our outreach program; MINT regularly takes part in trade fairs and exhibitions to promote our products and services; MINT also buys advertising space in business directories and major newspapers to reach some selected and potential customers in a professional manner; service centers are certified with quality systems, e.g. ISO 9001:2000, ISO

17025, EN 46000, USFDA, etc; strategic alliances and smart partnerships with national and international agencies; and at the regional level, MINT also has been actively involved in the forum organized by IAEA, RCA and FNCA on technical matters as well as public acceptance programs for nuclear technology.

In conclusion, well-designed and proper management of products and services which fulfil customer needs and statutory requirements, coupled with continuous quality improvement systems are key and important recipes to win customer trust, hence generate self-reliance and sustainability of NNIs.

Developing Greater Self-Reliance in the Nuclear Sector in Ghana

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Due to severe cuts and drastic decline in government subvention for the promotion of nuclear and biotechnology techniques in Ghana, a new law has been enacted which empowered Ghana Atomic Energy Commission (GAEC) to encourage and promote the commercialisation of R & D results through its three institutes and five centres. Therefore, the Commission requested the International Atomic Energy Agency through the African Regional Co-operation Research Agreement (AFRA) for an expert team from NECSA, South Africa, to critically evaluate its R & D activities, core competencies and structures with the aim of refocusing them to be more responsive to end-user and national development needs.

Strategic and marketing plans prepared for some related viable facilities were revised and recommendations that were made were implemented. The 30-kW research reactor designed mainly for neutron activation analysis was used to render analytical services to clients from industries and mining companies. In addition to the application of radioisotopes in plant investigations in the petroleum refinery, the reactor group generated US $30,000 in the year 2000, which is about 20% of the annual budget of the centre. In the same year, the 50-kCi gamma irradiation facility utilizing a Co-60 radioactive source generated US $14,250 and the use of non-destructive testing equipment yielded US $7,612. The Radiation Protection Institute through personal monitoring services and radionuclide contamination certification for food items generated an amount of US $60,000, which is 40.5% of the government subvention for personnel emolument and administrative expenses.

Exhibiting greater commitment to commercialisation and with efforts made towards harnessing nuclear and biotechnology techniques for socio-economic benefits and self-reliance, GAEC has established a Business Development Unit (BDU). The Unit is to prepare Business Plans for identified demand-driven R & D activities and services, plan and coordinate all capital mobilisation activities, promote technologies to the public, and negotiate sale of technologies and arrange partnerships with stakeholders. The Commission has benefited from a grant of US $188,014 to produce planting materials for a local company, Bio Plantlets (Gh) Ltd. Proposals have been submitted seeking financial assistance for upgrading the Co-60 source to generate income through food preservation and medical sterilization. Non-destructive services for manufacturing industries, analysis of fertilizers, plant investigations of chemicals and mining industries are some of the activities to enhance income generation towards the attainment of a greater self-reliance in the nuclear sector in Ghana. Undoubtedly, the benefits derived from IAEA technical co-operation programs and AFRA projects for human resource development, quality control management, information and communication technology, etc. will largely support the commercialisation program.

Session 3: IAEA Safety Standards; Towards Global Application

Making a Difference in the 21st Century: the Continuing Evolution of the IAEA Safety Standards

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History

Historically, wide international acceptance of BSS (basis: ICRP and UNSCEAR) as leading thematic safety standards and Transport Regulations as activity specific standards.

Safety standards for nuclear installations were originally based on different national practices / designs. This was reflected in early IAEA nuclear safety standards that became a common denominator. Greater international awareness and accidents (Chernobyl) triggered the need for common high-level standards on a universal basis, to support a global safety regime. This was needed as a factor in restoring public and political trust in nuclear technology.

Present

Through ongoing and planned periodic reviews and – if needed – revisions safety standards are kept current. Where gaps are identified new safety standards are developed. Presently, all IAEA safety standards reflect an international consensus on what constitutes a high level of safety for protecting people and the environment.

Standards cover all relevant areas: thematic and as well as facility/activity related; they are hierarchically arranged in categories: Safety Fundamentals, Safety Requirements and Safety Guides.

Through CSS and Committees in areas of nuclear installation, radiation, transport and waste safety consensus is built. Member States (MS) can participate in all Committees and there is also involvement of international organizations; MS comments on all drafts; Board approves Safety Fundamentals and Requirements. This process develops buy in and sharing of knowledge.

The main users are regulators and organizations involved in nuclear and radiation related facilities and users of radioactive materials.

Vision

IAEA safety standards are the global reference point for safety.

Our common challenge: ensure use by regulators in all States. They should check that national regulations are in agreement with IAEA safety standards and safety level expressed in them. Use in peer reviews as practiced under the Safety Convention and Joint Convention meetings of the Contracting parties. Result: proper basis for the IAEA safety standards as the global reference point.

Industry and others users of nuclear technologies have a vested interest to ensure that there exists only one set of internationally agreed standards (underpin globalization of standards). At the same time they should ensure smooth implementation of standards in the daily practice, i.e. in using nuclear energy, nuclear technologies and radioactive sources. Feedback from all users is essential for the success of the IAEA safety standards.

The Industry Commitment to Global Transport Safety Standards

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Standards and regulations have no intrinsic practical effect without taking into account those who are the object of such standards and regulations. Standards and regulations do not become operationally effective until they are implemented by the entities which are subject to them. Accordingly, there is a necessary synergy between the regulator and the regulated - the regulators whose task it is to make and enforce the rules for safe, efficient and reliable transport, and those whose job it is to transport within the rules.

No sector of transport is regulated more stringently than the nuclear transport industry. The nuclear transport industry is subject to a comprehensive, inter-connected regime of international, modal and national regulations and standards. The IAEA transport safety regulations, the so-called TS-R-1, are at the heart of that international regulatory regime. Appropriate provisions of TS-R-1 are incorporated in the regulations and standards of the International Maritime Organization (IMO) for marine transport, the International Civil Aviation Organization (ICAO) for air transport, the ADR, RID and ADN for road, rail and inland waterways in Europe, and the regulatory regimes of the IAEA Member States themselves. The IAEA transport safety regulations are reviewed every two years and amended or revised as appropriate to ensure they are up-to-date.

There is a widespread recognition today that maintaining transport options in the interest of bringing the benefits of nuclear energy where they are wanted the world over requires open and sustained dialogue between regulator and the regulated. There is a clear determination on the part of the nuclear transport industry and the key international organisations to dialogue, and the World Nuclear Transport Institute provides a vehicle for taking part in this dialogue. Equally, industry must take the opportunities afforded it to inform the regulators, the IAEA and others of the context in which industry performs its essential services, and to be engaged in the regulation review and implementation processes.

Under WNTI auspices, companies integrally involved with effecting shipments of radioactive materials meet regularly to analyse changes and proposed revisions to applicable regulations, to discuss relevant research activities and practical experiences and to develop approaches for ensuring the continued safe movement of radioactive materials. Active working groups are focusing on issues such as interpretations of, and proposed revisions to, TS-R-1, packaging requirements for the transport of uranium hexafluoride, and issues related to marine transport of Class 7 cargoes.

The nuclear transport industry takes its responsibilities seriously. The industry has come together, through the World Nuclear Transport Institute, to collaborate in ensuring that it continues to meet its commitments to safety. A fuller sharing among major stakeholders of experiences in reviewing and operating within the international transport safety regime can only increase understanding, and potentially contribute to greater efficiencies to all concerned.

Application of the IAEA Safety Standards: Ghanaian Experience

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Under the terms of Article III of its statute IAEA has established standards for protection against ionizing radiation and safety of radiation sources and provide for the application of these standards to peaceful nuclear activities. The IAEA SAFETY STANDARDS SERIES (SSS) cover nuclear safety, radiation safety, transport safety and waste safety and general safety. The hierarchy of the standards comprise; Safety Fundamentals; Safety Requirements; Safety Guides and other safety related documents. Advisory committees oversee the development of the safety standards. The IAEA SAFETY STANDARDS are not legally binding on Member States. They may be adopted at the discretion of Member States for use in national legislation and regulations in respect of development and application of nuclear energy for peaceful purposes. The Standards are binding on IAEA as far its operations and on Member states who receive assistance from the Agency in the development and application on nuclear and nuclear – related activities. The challenges posed by the adoption and application of the safety standards series include: the development of a structure that is compatible with that of SSS ; management and leadership; government commitment; availability of qualified experts and consultants to oversee the drafting and review of documents for approval by the National Competent Authorities; the long bureaucratic process of enactment of legislation and regulations; political and institutional instability; availability of adequate numbers of well trained and qualified and committed persons to regulate the application and implementation of the provisions of the adopted safety standards. The Ghanaian approach to the adoption and application of the safety standards is highlighted in this address.

Use of IAEA Safety Standards in the Development of European Safety Standards

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The harmonisation of safety standards at an EU level is not a new idea. Work has gone on since 1975. Much of this work has been inseparable from the work on standards done at the IAEA. A set of basic safety principles were published by the Commission in 1981 that tied safety to the legally binding "basic safety standards" for radiation protection adopted under Chapter III of the Euratom Treaty. Parallel and similar work was being carried out at the IAEA.

Starting from a very similar base, the two activities have more recently developed differently, the IAEA worked on the further development and revision of nuclear safety standards while the European Commission activities tended more towards the practical harmonisation of general safety requirements for design and operation.

The EU has basic safety standards for radiation protection. These are nearly identical to those developed by the ICRP and used by the IAEA, but are binding within the EU territory.

Why a push for common standards now?
The Nuclear Safety Convention highlighted the benefits of an international nuclear safety regime. The EU Member States realised that the task of assessing nuclear safety in the countries candidate for accession was hampered by lack of common standards or practices.

The European Parliament called on the EU to adopt common safety standards (in July 2002). The Member States themselves agreed that a high level of nuclear safety is needed throughout the EU (Laeken Summit). The European Court of Justice ruling of December 2002 clearly stated that EU could not artificially separate radiation protection from nuclear safety.

The IAEA is currently clarifying and ordering its numerous safety requirements and guidelines. The European Commission and many Member States are involved in the work. Once the IAEA has completed this process we will implement the results in the EU, but in a binding way.

Session 4: Safeguards Technology; Challenges and Limitations

Drawing Safeguards Conclusions for the State as a Whole: The Role of Safeguards Technology

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Events in the early 1990s, including the discovery of Iraq's clandestine nuclear programme, highlighted the importance of strengthening safeguards, including the IAEA's ability to detect indications of undeclared nuclear material and activities in States with comprehensive safeguards agreements. Since that time, the Agency has introduced a number of measures to strengthen the effectiveness and improve the efficiency of safeguards. In the strengthened safeguards system, the focus has shifted from safeguards implementation at the facility level to consideration of safeguards implementation for each State as a whole.

The State evaluation process is the key mechanism for drawing safeguards conclusions for each State as a whole. The safeguards-relevant information about a State is obtained from a variety of sources; from States themselves, pursuant to the reporting requirements in their respective safeguards agreements and on a voluntary basis; by Agency safeguards inspectors in the course of their in-field inspection and other verification activities; from open sources such as professional journals, commercial satellite imagery and the media; and from other sources.

The Secretariat's safeguards conclusions, the bedrock of the types of assurance that it can provide, derive from ongoing activities based on information collection, processing, analysis, evaluation and storage. These activities pose technological challenges from two aspects: implementing safeguards verification technology to conduct activities under comprehensive safeguards agreements and additional protocols effectively and efficiently; and having a robust information technology infrastructure to store, process and analyze the wider variety of information in a reliable and secure manner.

The presentation will address those technological challenges, in particular the requirements, capabilities and limitations of safeguards technology.

The Use of Environmental Sampling to Detect Indications of Undeclared Nuclear Activities

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Environmental Sampling is a powerful tool for confirming declared operations in facilities and for detecting clandestine nuclear activities, be it from a declared or undeclared location. Since environmental sampling (ES) was introduced as a safeguards verification measure in 1996, thousands of environmental samples have been taken during:

- routine inspections under comprehensive safeguards agreements;
- complementary access activities under additional protocols;
- design information verification activities; and
- other campaigns to confirm the completeness of State declarations.

The Agency has gained valuable experience in analyzing and evaluating environmental samples, and understanding the results in the context of a State's nuclear activities. However, the environmental sampling process (i.e. sample collection and analysis with subsequent data evaluation and reporting) needs to be continually reviewed and refined to maximize its effectiveness as a safeguards tool.

Environmental sample analysis and data evaluation will always be a process that is measured in months rather than weeks or days. However, in the last few years the evaluation time has lengthened because of the expanding role of ES as a safeguards measure and the consequent increase in samples collected. Steps have already been taken to reduce this cycle time but it is a matter that needs continuous monitoring and optimization.

The analytical results from ES are evaluated, along with many other sources of information, as part of the State evaluation process. The State evaluation, as documented in a State Evaluation Report, constitutes the basis for the Agency's assessment of a State's nuclear fuel cycle and the drawing of safeguards conclusions. As a follow-up to questions or inconsistencies identified in the State evaluation process, further actions, which could include ES, might be required. The effectiveness of ES can be strengthened with improved sampling strategies and the use of all relevant information to evaluate analytical results.

The Importance of Open Source Information and Satellite Imagery Analysis in Safeguards Implementation

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Since 1996, the analysis and evaluation of open source information, including satellite imagery, has become key to safeguards implementation. The Department of Safeguards' dedicated, open source database now contains over 4 million records. The satellite imagery database has approximately 7000 images.

An important strategy is to collect open source information from as many diverse sources as possible. Information is collected from many geographical regions and in different languages. The types of information collected range from general news reports to highly specialized technical articles. Source diversity contributes towards the important objective of assessing the credibility of information obtained.

Open sources provide a solid basis for assessing whether a State has the economic and industrial capabilities to support the development of nuclear weapons. Scientific literature is also a valuable indicator of nuclear capabilities and of dual-use technologies used in non-nuclear applications that could also be applied to nuclear ones. Information relating to company and business activities is important for improving knowledge of imports and exports of safeguards relevance and for assessing technological capabilities in the States concerned.

Commercial satellite imagery is a powerful tool used in conjunction with open sources and with State-declared information which gives details of specific geographical locations. Routinely, satellite imagery is used to assess the functions and capabilities of research and nuclear fuel cycle facilities. It can also be helpful in detecting any changes in the features and characteristics of locations of safeguards relevance and in the identification of nuclear-related activities.

For the future, it will be important to utilize software applications of greater sophistication in order to extract the knowledge from the large and rapidly growing databases of open source and satellite imagery information. Keyword search and retrieval technologies will remain at the core, but will need to be augmented with more advanced, conceptual approaches in data-mining.

Future Safeguards Equipment Needs and Technology

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As a result of more than 30 years of accumulated field experience, the IAEA has established a wide and sound range of equipment and techniques for use in safeguards implementation activities.

As a consequence of a rapidly changing technology marketplace, and with the introduction of the strengthened safeguards system, the Agency must now adapt itself to new challenges so that it can continue to use appropriate and sustainable equipment in a cost effective and efficient manner.

Four of the major challenges facing the Agency in the future are as follows:

- Having the capability to maintain a sound equipment management infrastructure in a fast developing technical environment (equipment sustainability);
- Having the capability to upgrade existing techniques and methods for strengthened and integrated safeguards
- Ensuring the capability for implementing safeguards at new facilities;
- Improving the capability to detect undeclared nuclear material and nuclear facilities.

All equipment authorized for inspection use undergoes extensive testing to ensure their suitability, usability and reliability. Taking into account the high cost of equipment development and implementation, and a substantial inventory of existing safeguards equipment, the Department of Safeguards needs the efficient adaptation of its equipment inventory in order to function effectively within budget constraints and to satisfy new requirements stemming from additional protocol activities. Achieving cost-effectiveness in an environment of rapidly evolving technology requires strong and technically competent in-house resources that take the Department's constraints and requirements as a first priority and are able to focus on equipment sustainability and adaptability. The advantage of such an approach is that it establishes greater independence of safeguards equipment development from national and corporate interests, and achieves greater effectiveness in the use of equipment funds.

To ensure the availability of equipment meeting new inspection requirements, future equipment needs will focus on more sensitive devices that can detect undeclared nuclear material and on other devices that can continuously monitor environmental parameters. For example, laser technology can be used for the detection of undeclared enrichment facilities. Other techniques, such as airborne monitoring and wide area environmental monitoring, could be adapted for the detection of undeclared nuclear material and nuclear facilities.

This presentation reviews the challenges facing the Agency in its bid to provide equipment for strengthened and integrated safeguards implementation approaches, discuss future equipment requirements, and suggest various options to meet those challenges.

SCIENTIFIC MEETINGS SCHEDULED BY THE IAEA

2003

International Symposium on Applications of Gene-based Technologies for Improving Animal Production and Health in Developing Countries
6–10 October, Vienna, Austria

International Conference on the Protection of the Environment from the Effects of Ionizing Radiation
6–10 October, Stockholm, Sweden

International Conference on Research Reactor Utilization, Safety, Decommissioning, Fuel and Waste Management
10–14 November, Santiago, Chile

2004

International Symposium on Nuclear Oncology
19-23 January, Porto Alegre, Brazil

International Conference on Topical Issues in Nuclear Safety
24-28 May, Vienna, Austria

International Conference on Fifty Years of Nuclear Power - the Next Fifty Years
28 June - 2 July, Moscow/Obninsk, Russian Federation

International Symposium on Quality Assurance for Analytical Methods in Isotope Hydrology
25-27 August, Vienna, Austria

International Conference on Isotopes in Environmental Studies
30 August - 3 September, Monaco

International Conference on "Nuclear Power in the 21st Century"
October/November, Paris, France

20th IAEA Fusion Energy Conference
1-6 November, Vilamoura, Portugal

For information on forthcoming scientific meetings, please consult the IAEA WorldAtom website:
http://www.iaea.org/worldatom/Meetings/