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The IAEA's Contribution to the Peaceful Use of Nuclear Power

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Since its inception fifty years ago, the IAEA has been discharging its role as an international body entrusted with the responsibility for channelising the exploitation of the great potential of atomic energy for the welfare of mankind. This role, as defined in its statute, includes several activities associated with the promotion of research, development, application and safety of atomic energy for peaceful uses throughout the world.

The Agency has been very effective in promoting the exchange of information, co-operative research and technical co-operation among its member states in the multiple thematic, technological and institutional areas relevant to nuclear power. The IAEA Safety Standards have become the main reference for the development of national regulatory documents in many countries. The information exchange activities have contributed to the creation of a wealth of knowledge, available in the form of well-documented reports on several aspects of nuclear power. A recently published TECDOC, for example, provides a very well-structured description of the design trends for twenty-six innovative small and medium reactors with on-site refueling. The Coordinated Research Projects (CRPs) have immensely helped in the upgrading of knowledge in several areas of the nuclear power technology. The outcomes of such CRPs, for example, have ranged from the development of better models of thermohydraulic phenomena and inter-comparison of computer codes, to the inter-comparison of techniques for pressure tube inspection and diagnostics — an exercise that required movement of pressure tube samples across the boundaries of several participating Member States. In the area of reactor design too, several CRPs have provided valuable inputs to the designers. One of the on-going CRPs, for example, addresses validation, verification and improvement of methodologies and computer codes used for the calculation of reactivity coefficients in liquid metal fast reactors. The free availability of practically all the publications arising out of these activities on the IAEA web site has greatly benefited the entire nuclear community.

Throughout the eventful history of nuclear power in the world, the activities of the IAEA have been consistent with the expressed needs of the world community. Today the world seems to be at the threshold of a nuclear renaissance.

Considering the progressive depletion of fossil fuel reserves, and the urgent need for addressing the global warming related concerns, nuclear energy is expected to emerge as a major option to substantially contribute to meeting the future global energy needs. The trend of the data provided in the Human Development Report 2005, suggests that a per capita electricity consumption of at least 5000 kWh/year is needed for reaching a state of moderately high human development. With this stipulation, together with the expectation that at least half of the total energy demand may need to be met with nuclear, a simple calculation shows that the world may eventually need between 3000 to 4000 nuclear power reactors of different capacities for electricity generation. The number may at least double with the use of nuclear energy to provide an alternative to fluid fossil fuels, in the form of hydrogen and synthetic liquid fuels, for transportation applications. The goal of attaining such a large population of nuclear power reactors is independent of any projected scenario for growth; although a scenario will help in estimating the time when the goal can be reached. It is also worth noting that a large number of these reactors may need to be located in regions with high population densities.

Although there is an inevitable need to substantially enhance the global reach and volume of nuclear power deployment for a wide variety of applications, the fact remains that since 1985 the spread of nuclear power to new countries has remained dormant, with no further addition to the number of countries with nuclear power reactors either under construction or in operation (see Figure-1). The issues related to the large-scale deployment of nuclear power with a multi-fold increase in the number of reactors and associated fuel cycle facilities can be addressed only with innovative technologies and institutional arrangements. The Agency has already envisaged this challenge and initiated the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). The future activities of the Agency should serve to facilitate the development of the innovative solutions required to meet the multiple challenges inherent in the projected scale of deployment of nuclear power throughout the world. These solutions should include deployment of proliferation resistant technologies together with a robust framework for international cooperation, to address both proliferation and fuel supply concerns. The criteria for the safety, including environmental safety, for these systems should be consistent with the increase in the number of nuclear facilities, and should address a possible need to locate these facilities close to population centers, in accordance with siting rules generally applicable to conventional major industrial facilities. Economic competitiveness is a function of time-frame, geographical region and application area of deployment. Logically, therefore, the innovative systems should be economic enough to facilitate their early and wide deployment.

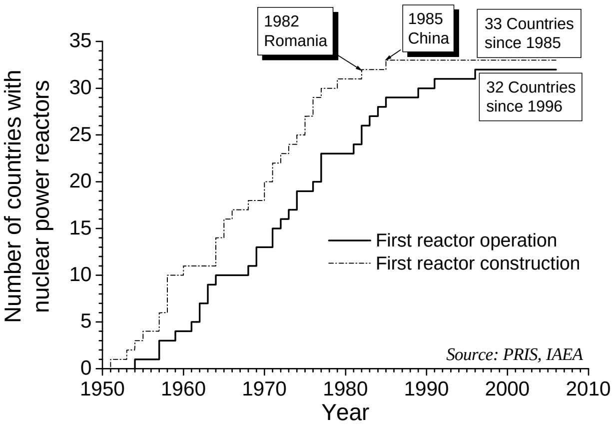

Figure-1: Time line of the growth in number of countries with nuclear power reactors

The challenges associated with the various aspects of global expansion of nuclear power growth are thus quite substantial. In this context, a crisp and focused goal, that would be of a high priority for many developing countries, with large unfulfilled energy demands and high population densities, was expressed as an ambitious vision by me, in the recently held 9th INPRO Steering Committee meeting, in the following words:

"Four decades from now, in any country of the world, it should be possible to start replacing fossil fuelled power plants, at the same urban or semi-urban site where these are located, with advanced NPPs that would, more economically, deliver at least twice the power that was being produced by the replaced plants".

The IAEA has a very important future role to play in achieving the timely realisation of such a vision for the benefit of mankind.

Philip Tipping

Chairman of IAEA Technical Working Group-LMNPP

Swiss Federal Nuclear Safety Inspectorate

Commercial exploitation of nuclear power has just passed the 50-year mark, and right from the start, the IAEA Division of Nuclear Power, Department of Nuclear Energy has followed the evolution of the peaceful use of nuclear power. Concerns for the environment, as well as political issues associated with the supply and costs of fossil-based energy sources, are becoming increasingly important to the world's ecological and economical development.

Continuous improvement to nuclear power plant systems, structures and components (SSCs) has taken place over the years. Experience in nuclear power plant operation, benefits taken from on-going research and also the exchange of information has resulted in a mature, reliable and cost-effective industry. Notwithstanding, there still remains much to be done in order to face future challenges to the continued use of nuclear power.

What are these challenges, and how can the IAEA address them and supply information to those Member States (MS) intending to use or are currently using nuclear power? Apart from political or security-based issues, which are clearly important but out of the scope of this present article, there are many aspects that require near, medium and long-term action, since the age distribution of the world's nuclear power plant fleet shows that a significant number of nuclear power plants will be approaching their end of design lifetime and/or current licence period to operate in the next 5-20 years. End of design lifetime or current licence do not necessarily equate with the end of safe operation lifetime simply because nuclear power plants have been continually refurbished and back-fitted with safety and reliability-related features, SSCs have been replaced using improved materials and optimized operating conditions implemented.

Actually, irrespective of their chronological age, many nuclear power plants operating today may be classed as being in a better overall condition compared to when they were first commissioned. Given that safety levels can be well maintained or even improved on, and licensing conditions are continually complied with, there are no technological arguments preventing nuclear power plants from operating beyond their design lifetimes (i.e. long-term operation). Furthermore, drawing benefit from the state of science and technology in surveillance, inspection and monitoring, many nuclear power plants can justifiably continue to operate safely for a significant number of years after expiry of the design lifetime or original licence particularly if they have established appropriate plant life management (PLiM) programmes.

A plant life management programme is the integrated programme of nuclear power plant ageing management programmes and economic planning to maintain a high level of safety, optimize the operation, maintenance and service life of SSCs, maintain an acceptable level of performance (nuclear power plant availability), maximize return on investment over the service life of the nuclear power plant and to provide nuclear power plant operators/owners/utilities with optimum pre-conditions to achieve this.

PLiM programmes, which may be combined with power up-rates, are going to be future core features of those nuclear power plants going for long term operation. It will necessitate on-going and comprehensive updating of plant life management programmes to monitor any impact of power up-rate on the systems structures and components and operational characteristics of a given nuclear power plant. Such tasks will require significant human and financial resources and also supportive action from the IAEA to facilitate dedicated workshops and information exchange on key issues on plant life management, including power up-rate.

Regarding PLiM programmes, it is necessary to ensure that sufficient numbers of well-trained nuclear power plant personnel are going to be available. They must be able to access and implement operational and safety lessons learned based on sound plant life management principles and to have the benefit of passed-on knowledge. Already the nuclear industry is facing a situation where significant numbers of operators and technicians from the 1960s-1970s are approaching retirement age. It is therefore essential for the IAEA, the nuclear industry, and its regulators, to follow up strategies on the training of future nuclear power plant engineers. Knowledge management and transfer will become increasingly important.

Other future issues facing the nuclear power industry will be the impact of the deregulation of electricity markets and the ever-increasing requirement for economic operation. This, coupled with the necessity for safety at all times, will add further demands on operators, regulators and the IAEA alike. Aspects of management systems, event notification and learning from experience, nuclear power plant organization and safety culture, the increased use of digitally-based information and control technology in nuclear power plants, human factors and even decommissioning and radwaste disposal will all demand increased attention in the future. . Knowledge management and transfer will become increasingly important

Following the success of the first IAEA international symposium on Plant Life Management, held in Budapest, Hungary in November 2003, the second symposium will be held at the Shanghai International Convention Centre, China from 15 to 18 October 2007. The final programme has been agreed on by the organizing committee, representatives from China and the IAEA. Details concerning this International Symposium, and call for papers, are available from http://www.iaea.org/meetings. It can be seen that the Second International Symposium will be of a highly informative value and not to be missed by anyone involved in the nuclear power industry and its regulation. The scope of the second international symposium will cover the following areas:

1. Approaches to Plant Life Management, 2. Economics of Plant Life Management, 3. Ageing Management and Related Operational Programmes, 4. System, Structure and Component Design Modification, Refurbishment and Replacement, 5. Managerial Issues Concerned with PLiM and 6. Regulatory Issues Concerned with PLiM.

Finally, the Technical Review Series on "Principles and Guidelines on Plant Life Management for Long-Term Operation of Light Water Reactors", and "Nuclear Power Plant Life Management Processes: Guidelines and Practices for Heavy Water Reactors" will be published by IAEA in the autumn of 2006. Also, after the Mihama 3 nuclear power plant accident, in Japan in August 2004, the IAEA responded quickly and called a special workshop to examine the root-causes and issues involved and the information was collected and issued in the form of a technical proceeding "Material Degradation and Related Managerial Issues at Nuclear Power Plants", in 2006. This is just one example, among many others, of how the IAEA facilitates the supply of technical information to inform MS of the possible need for action.

The IAEA has consistently followed and promoted the peaceful use of nuclear energy in MS and, in view of the growing demand for energy as countries develop and industrialize, it will continue to do so in the future.

Message from the Director

The IAEA publishes a Nuclear Technology Review report every year which is an overview of the progress made and trends within Nuclear Energy (Reactor and Cycle) and Nuclear Applications (such as Radiation Therapy, Sterile Insect Technique etc.).

In the Nuclear Technology Review 2006, it was stated that "while the outlook for nuclear power still remains mixed, 2005 has been a year of rising expectations".

While celebrating the 50 year anniversary of the IAEA it is fortunate that we can observe that the time is approaching for a resurgence of the use of nuclear energy. This is after the industry saw new construction dwindling since the middle of the 1980s.

After all, the IAEA, according to its statute, should work with Member States to "accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world", while working against the misuse of nuclear material for weapons programmes.

Although additional new capacity since the mid-1980s has been small, nuclear electricity's share has remained around 16%, meaning nuclear electricity generation increased by 40% during this time period. I should note that nuclear power worldwide currently displaces 600 million tonnes of carbon emission each year, which is significantly higher than the total amount that we estimate will be avoided by the Kyoto Protocol in 2010.

This increased electricity generation is due to the combined effect of availability increases, capacity additions and power uprating.

Underlying the availability increase are such factors as increased information exchange among operators to enable them to emulate best practice, cultural changes within the industry with a focus on continual improvement, risk-informed performance-based regulation, and consolidation in the industry such that more nuclear plants are being operated by those who do it best.

This has resulted in improvements in operational performance which is accompanied by improvements in safety performance such as a continuous decline in unexpected shutdowns and the number of challenges to safety systems. But the overall challenge is that we must keep in mind that "good is not good enough".

Looking ahead, and considering the next few decades, not 50 years, three activities would be considered essential for the Division of Nuclear Power (NENP).

PLiM and Management System

The first is continued support to the Member States for a continued safe, secure, reliable and efficient operation that includes appropriate Plant Life Management (PLiM) and integrated Management System activities, for which NENP is prepared to enhance its support to the Member States in programmatic activities. My humble observation is that technology, especially LWR, is considerably mature but still plagued by incidents which continue due to inappropriate management, lack of questioning attitude, ownership and responsibility.

Support of infrastructure building as a part of response to rising expectation

Secondly, the IAEA is receiving many requests to assist Member States with energy planning, including nuclear power in general, and the possibility of considering first nuclear power plants. Some countries with operating units are considering expansion plan from the current fleet (Examples shown on Table 1). In particular, interest is growing from Member States currently not operating any nuclear power plant or from countries wishing to expand from a small number of units.

The background for such increased interest includes:

- Growing energy demands,
- Growing concern over energy security, and
- Growing environmental concerns.

Member State	*Current capacity in 2005 (Electricity share)*	*Expected capacity (Electricity share)*	*Expansion*
China	6.6 GW(e) (2.3%)	40 GW(e) (4%) by 2020	X 6
India	3.0 GW(e) (2.8%)	29.5 GW(e) (10%) by 2022 50 GW(e) by 2030	X 9
Republic of Korea	16.8 GW(e) (39%)	26.6 GW(e) (34.6%) by 2015	X 1.6
Russia	21.7 GW(e) (16%)	35 GW(e) (18.6%) by 2016	X 1.6

Table 1. Examples of nuclear power expansion plan

In support of those countries, infrastructure building in the nation or region will be a key issue. In contrast to physical or industrial capacity, soft infrastructure involves aspects such as legal and institutional arrangements (legal framework, regulation, liability & insurance schemes, IAEA Safeguards agreements, security arrangement, international conventions), securing resources (capital, competent engineers, Uranium) and socio-political elements (stable and good governance, public acceptance, and public participation in the decision-making process).

The IAEA has been working to support Member States' needs in this area and is considering strengthening support, by the inter-departmental coordinated activities, through identifying those needs, clarifying the IAEA's expectations and providing milestones for them to assess the status and to prioritize their activities.

Innovation

Third is innovation. Along the line of the action plan following UN Conference on Environment and Development (Rio de Janeiro, 1992), a set of Energy Indicators for Sustainable Development (EISD) was established in 2005, by the concerted efforts of the UN-related organizations and others, in order to enable measurement of a country's state of development and monitoring of its progress. As you look at the EISD, you will recognize that the attributes of nuclear energy technologies have great relevance. Having a nuclear option in the nation's energy portfolio would greatly improve the nation's energy indicators in the three dimensions of Society, Economy and Environment.

The concept of sustainable development is "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

The well known Brundtland report in 1987 defined this and also recognized that achieving global equity and sustainable growth would require technological and social changes.

Of great importance in discussing sustainable growth is to consider technological innovation (in energy, such as efficiency in energy use, and a departure from carbon-intensive transportation system by the use of hydrogen generated from non-fossil sources).

In the field of innovation of nuclear energy systems, NENP continues programmatic activities to stimulate innovation and to provide an exchange of information. As one such example, INPRO provides not only an assessment methodology linked with sustainable development but also is launching new phase that includes collaborative projects.

Continued support

The key to delivering the services described above is your continued support for the activities in NENP. The strength of our activities in NE are (a) Member State trust that we are a source of objective and impartial information, and (b) we are allowed continued support from international experts.

A major goal for NENP is to strengthen our relationships with Member States by collecting inputs to the Agency and by disseminating information produced by the Agency's activities among our customers.

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Nuclear Power Plant Operating Performance and Life Cycle Management

Nuclear Energy Trends

CURRENT STATUS OF NUCLEAR POWER

Currently the nuclear industry consists of 442 nuclear power plants (NPP) in operation with a total net installed capacity of 369.6 GW(e). In addition there are 6 operational units with a total net capacity 3.1 GW(e) in long-term shutdown. 27 reactor units with capacity 21.9 GW(e) are under construction. During the first half of 2006 two new units were connected to the grid (Tianwan 1 in China and Tarapur 3 in India), one unit was shut down (Jose Cabrera in Spain) and construction of two new units has been initiated (Quinshan II-3 and Lingao 4 in China).

TREND OF NUCLEAR ENERGY PRODUCTION AND CAPACITY

Nuclear electricity production is continuously growing since the nuclear industry inception. The reasons for its growth are: new capacity installation, uprating of operating plants and energy availability improvement.

From 1975 through 2005, global nuclear electricity production increased from 326 to 2626 TW•h. Installed nuclear capacity rose from 72 to 368 GW(e) due to both new construction and uprates at existing facilities.

In Figure 1 the red bars show the growth in global nuclear electricity production since 1980 (measured against the right scale). The yellow bars show the growth in installed capacity measured against the left scale.

Different trends of installed capacity and energy production indicate that since the beginning of 1990s, when construction of new units had been slowed down, utilization of nuclear capacity has become more efficient.

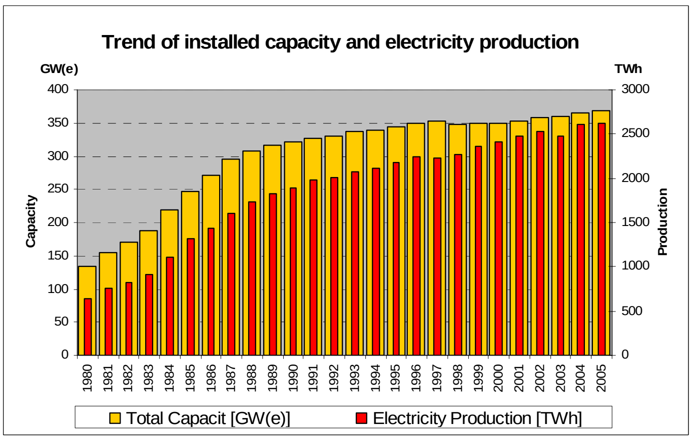

Figure 1: Nuclear energy production

WORLDWIDE ENERGY AVAILABILITY

The average global energy availability factor (EAF) was 82.8% in 2005. For comparison the global energy availability factor was 72% in 1990 and 66 in 1980.

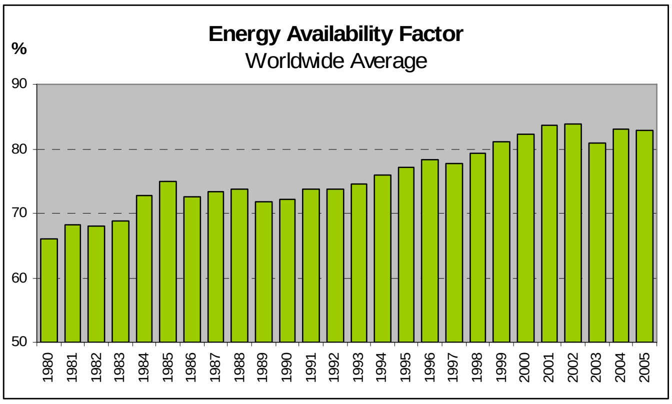

Figure 2: Energy Availability Factor

The increasing EAF trend averaged around 1% per year in 1990s. Results of last three years were affected by long-term shutdown of 17 TEPCO units (2003 and 2004) and extended reconstructions of several old reactor units.

Plant availability is influenced by internal (under plant management control) and external causes. An internally caused unavailability can be broken down to planned and unplanned ones.

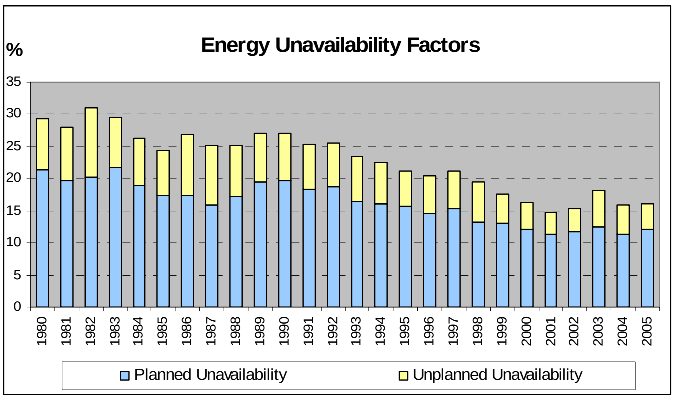

Figure 3: Trend of Planned and Unplanned Unavailability

In last four years the steady decrease in both planned and unplanned energy unavailability factors has halted. The planned unavailability factor decreased continuously from about 20% at the beginning of 1980s to around 12% in the last years. This is a result if improved management of planned outages for refueling and maintenance. The improvement in the unplanned energy availability is also significant. It has decreased threefold since 1980.

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Nuclear Power Plant Instrumentation and Control Technologies

Nuclear power plants (NPPs) rely on instrumentation and control (I&C) systems extensively for performing protection, control, monitoring and display functions. I&C systems are installed throughout the plant and are vital parts of both normal and emergency operations. During the past decades, although analog I&C and measurement systems provided the above functions satisfactorily, NPPs are facing challenges in several I&C areas with ageing and obsolete components and equipment. With license renewals and power uprates, the long-term operation and maintenance of obsolete I&C systems may not be a cost-effective and reliable option. The effort needed to maintain or increase the reliability and useful life of existing I&C systems may be greater in the long run than that of modernizing I&C systems or replacing them completely with new digital systems. The increased functionality of the new I&C systems can also open up new possibilities to better support the operation and maintenance activities in the plant.

The IAEA recognizes the importance of the profound role the I&C systems play in the reliable, safe, efficient, and cost-effective operations of NPPs by supporting the activities of the Department of Nuclear Energy's Technical Working Group on Nuclear Power Plant Control and Instrumentation (TWG-NPPCI). The Working Group was established in June 1970 following the recommendation of the IAEA Technical Panel on Instrumentation for Nuclear Power Plant Control convened in March 1969. The first regular meeting of the Working Group was held in March 1971 with 25 participants from 15 Member States and two international organizations. The first Specialists' Meeting organized by the Working Group in the same year had a title of "Use of Computers in the Operation of NPPs". In hindsight, this was a surprisingly visionary move at a time when computers were used mainly in research laboratories. The growing importance of I&C was also recognized by holding an IAEA Symposium exclusively on NPP I&C in January 1973 in Prague, Czechoslovakia. This was followed by several Specialists' Meetings on I&C technical issues. The next large IAEA Symposium on NPP I&C was held five years later in April 1978 in Cannes, France. Both Symposia focused on technical and engineering areas of such innovative applications as reactor noise analysis for surveillance, on-line testing and failure detection, 'man-machine interface', automatic protection and control systems, and "digital computing systems in safety related applications". Understandably, in those days, the phrase "the management of …" was still absent from the agenda and the proceedings of the Symposia.

The TWG-NPPCI's membership currently includes the following thirty Member States and three international organizations: Argentina, Australia, Austria, Belgium, Brazil, Canada, China, Czech Republic, Finland, France, Germany, Hungary, India, Italy, Japan, Republic of Korea, Mexico, Netherlands, Norway, Pakistan, Poland, Romania, Russian Federation, South Africa, Spain, Sweden, Switzerland, Ukraine, United Kingdom, United States of America, OECD/NEA, European Commission JRC, and IEC TC45. The most recent meeting of the TWG-NPPCI was held in May 2005 in Vienna with sixty-five participants. The meeting report is available at www.iaea.org/OurWork/ST/NE/NENP/twg_nppc.html. The next meeting of the TWG-NPPCI will be the 21st meeting of the advisory body, and it will be held in May 2007.

The challenges the nuclear utilities are now facing have been also reflected in the scope of three recent IAEA I&C technical meetings with the following titles: (1) On-line Condition Monitoring of Equipment and Processes in Nuclear Power Plants Using Advanced Diagnostic Systems, (2) The Impact of Modern Technology on Instrumentation and Control in Nuclear Power Plants, and (3) Implementing and Licensing Digital Instrumentation and Control Systems and Equipment in Nuclear Power Plants. The topics discussed at these technical meetings included the following larger issues:

- On-Line Condition Monitoring Techniques, Applications and Data Acquisition Systems
- Implementation of On-Line Monitoring for Instrument Channels, Reactor Systems and Processes
- Loose Parts Monitoring and Vibration Monitoring Systems; Anomaly Detection and Diagnostics
- Nuclear Power Plant Control Room & Human System Interface Modernization
- Challenges for Utilities and Regulators in Implementing & Licensing Digital I&C Systems
- Reliability of Software in Digital I&C-Systems; Design Process for Safety Critical I&C systems
- New Sensor Technology and Signal Processing Techniques

For more information visit http://www.iaea.org/OurWork/ST/NE/NENP/NPES/Activity/infrastr.html.

The IAEA I&C technical meetings to be held this year will cover a wide variety of I&C issues relevant to safety system modernization, plant performance improvements, power uprating, and I&C cyber security. In addition, the work on six new I&C-related technical documents has been already started or will be started this year. These I&C documents support improvements in both the cost-effectiveness and the safety of operation and maintenance activities. The consultancy meetings cover the following areas:

- Integration of Analog and Digital I&C Systems in Hybrid Main Control Rooms.
- Avoiding Common Cause Failures in Digital I&C Systems.
- On-line Monitoring for NPPs; Process and Component Condition Monitoring and Diagnostics.
- The Role of I&C Systems in Power Up-Rating Projects in Nuclear Power Plants.
- Implementing and Licensing Digital I&C Systems and Equipment in Nuclear Power Plant.
- Testing the Dynamic Response and Effectiveness of Reactor Protection Systems and Their Instrumentation.

For more information please visit http://www.iaea.org/OurWork/ST/NE/NENP/NPES.

It is expected that the trend of moving from analog to digital-based I&C systems continues. This will be supported by new communications media (cables, fibers, wireless bands, field buses), building station-wide data networks and communication paths between safety and non-safety systems. Computational platforms (computers, programmable logic controllers, application specific integrated circuits, networked field devices, smart sensors) will play an increasing role in both I&C upgrades for plant life extension and for new NPP designs.

On the measurement side of I&C, existing analog technologies for sensors and detectors interfacing with the processes in the plant will be made more reliable (e.g. by eliminating drifts), more maintainable, and more robust to environmental factors. The applications of new sensors, sensing techniques, and measurement systems (e.g. silicon carbide three-range flux monitors, fuel mimic power monitor or constant temperature power sensor, Johnson noise thermometer) are also expected, however, their transition from laboratory prototypes to reliable industrial products may take a long time.

The activities under the IAEA's Technical Working Group on NPP I&C support both the engineering and the management aspects of I&C projects. This includes I&C modernization projects in existing NPPs and the design of I&C systems in new NPPs as well. The scope of activities (meetings, expert missions, workshops) and documents (TECDOCs, proceedings) cover the I&C aspects of a wide range of technical areas from sensing technologies and process measurements through power uprates and plant life extension to software qualification and cyber security. The role of the working group is expected to increase in the future as Member States plan to expend their NPP capabilities.

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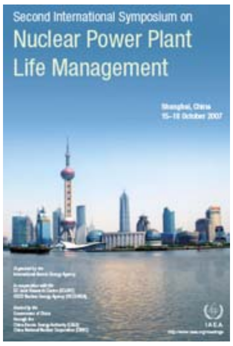
Integrated NPP Life Cycle Management

For many operating nuclear power plants, it has been demonstrated to the satisfaction of the relevant regulators that they are capable of safe and efficient operation for a significantly longer period than was envisaged when they were designed, with lifetimes of 50 to 60 years being likely in many cases. This indicates the importance of plant life management (PLiM) of existing nuclear plants for continued operation. PLiM is the integration of ageing management, including obsolescence, and economic planning over the remaining operating term of a nuclear power plant to optimize the operation, maintenance, reliability and service life of SSCs, maintain acceptable levels of performance, and maximize return on investment, while maintaining safety. For guidelines on plant life management for light water reactor (LWR) and pressurized heavy water reactor (PHWR), the IAEA published recently two technical documents, Technical Reports Series No. 448 for LWR and IAEA-TECDOC-1503 for PHWR. Also the IAEA is planning to hold an international symposium on PLiM in October 2007 in Shanghai, China. Detailed information is available at the web site http://www-pub.iaea.org/MTCD/Meetings/Announcements.asp?ConfID=155.



Benefits of PLiM:

- Reduces unplanned outage due to equipment failure
- Reduces operating costs
- Mitigates risks of critical components to power generation
- Improves equipment reliability and availability
- Prioritizes of competing options for capital
- Prioritizes of plant modifications and planning for implementation
- Estimates of capital upgrades and development of a long term improvement plan

The IAEA established an international working group dedicated to reactor pressure vessel embrittlement in 1968. Over time, the focus of work evolved to cover the increasing needs of Member States and finally, in 2001, the Technical Working Group on Life Management of Nuclear Power Plants (TWG-LMNPP) was created. The aim of the TWG-LMNPP was to draw on global expertise to provide Member States with crucial information on nuclear power plant ageing and life management. A further aim of the TWG-LMNPP was to facilitate the exchange of information and experience in the field of understanding and monitoring of ageing mechanisms affecting main NPP systems and components.

The IAEA has sponsored a series of Coordinated Research Projects (CRPs) that have led to a focus on reactor pressure vessel (RPV) structural integrity application of measured best irradiation fracture parameters using relatively small test specimens. From CRP phase 1 to phase 9, the IAEA issued many technical documents such as IAEA-176, Technical Reports Series No. 265, 429 and TECDOC-1230, 1435, 1441 and 1442.

The need for engineering support in operation, maintenance and life management is becoming more evident in the implementation and decision making processes of large-scale engineering projects, such as life extension, power uprating, outage optimization, and replacement of large systems and components. It involves engineering support for technological, economic, and managerial tasks that would allow nuclear power plants to compete successfully throughout their service life in changing energy markets, with a profound economic impact on the nuclear power plant owner/operator and possibly on national economies. To meet Member States' requirements, the following activities are planned for 2008 and 2009.

- Plant Life Management, Ageing, and Obsolescence
- Power Uprating and Modifications Projects
- Heavy Components Replacement for LWR and HWR
- Outage, Maintenance, and Inspection Activities

The project will contribute to the exchange of experiences and applications of advancements in science and technology concerning applications such as prediction of material degradation, application of new surveillance/diagnostics techniques, and information security throughout the operating organization.

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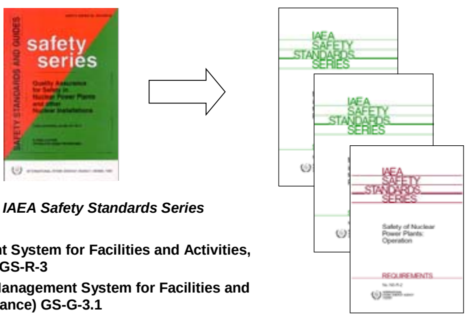
Improving Organizational Performance

IAEA Safety Standards on Management Systems

Quality assurance was identified as one of the five areas of the Safety Standard program for the development of Safety Standards. The IAEA Advisory Committee on Safety Standards (now Commission of Safety Standards, CSS) decided in its first meeting to include quality assurance under the category of General Safety recognizing the relevance of the quality assurance Standards in the four areas of nuclear, radiation, waste and transport safety.

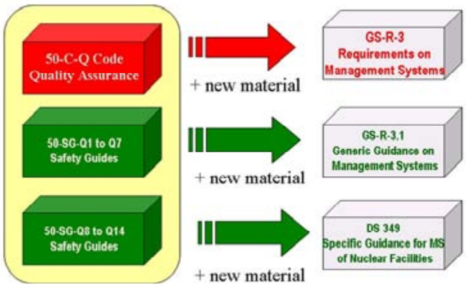


There are 3 new IAEA Safety Standards Series documents:

- The Management System for Facilities and Activities, (Requirements) GS-R-3
- Application of Management System for Facilities and Activities, (Guidance) GS-G-3.1
- Application of Management System for Nuclear Facilities, (Guidance) Currently DS349

The IAEA highest level documents on the subject were the Safety Standards on quality assurance, issued as Safety Series No. 50-C/SG-Q (1996), which includes a Code and 14 Safety Guides.

In 2001 it was recognized by the Nuclear Safety Standard Committee (NUSSC) that there is a need for a revision of 50-C/SG-Q (1996) in order to reflect the latest developments in the quality assurance and quality management area. A proposal was prepared by Nuclear Power Engineering Section and presented to NUSSC, who welcomed the new concept. The term "Management System" has been adopted in the revised series of documents instead of the term quality assurance/quality assurance programme. This development integrates all aspects of managing a nuclear facility, including the safety, health, environmental, security, quality and economic requirements into one coherent system. Through detailed planning and several Technical and Consultants meetings the initial drafts were prepared and endorsed by the Safety Standard Committees and the Commission. The documents were approved by the Commission in November 2005, and the requirement document, GS-R-3 was approved by the Board of Governors in March 2006. The final approvals of the safety standards on Management Systems put the finishing touch to the extensive work performed by the Agency since 2001. During this last 5 years the NE and NS staff worked jointly aiming to coordinate their efforts and produce the management system standards in a consistent and agreeable way. The development process of the GS-R-3 is an excellent example of the benefits of the "one house approach".



The new set of Safety Standards directed to establish requirements and provide guidance for implementing Management Systems that integrate safety, health, environmental, security, quality, and economic objectives. The IAEA Code 50-C-Q (1996) and developments within the International Organization for Standardization (ISO) ISO 9001:2000 and ISO14001: 1996 publications are considered in developing this comprehensive, integrated set of Management System requirements. Member States experience in developing, implementing and improving Management Systems is also taken into account.

The aim of the new set of Safety Standards is to provide requirements and guidance for implementing an effective Management System that:

- Integrates all aspects of managing nuclear installations and activities including the safety, health, environmental, security, quality and economic requirements in a coherent manner,
- Describes the planned and systematic actions necessary to provide adequate confidence that all these requirements can be satisfied, and
- Supports the enhancement and improvement of organizational and safety culture.

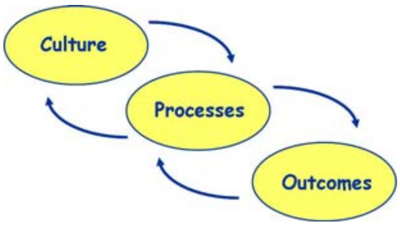
This integration aims to ensure that economic, environmental, health, security and quality matters are not considered separately to safety matters, to avoid any potential negative impact on safety. The three main elements of the management system safety standards are:

- Safety Requirements GS-R-3 specifies the Management System requirements for all nuclear installations and activities, that is based on the Code 50-C-Q and other relevant international standards. It was released in July 2006 and can be downloaded from: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1252_web.pdf.
- The Safety Guide GS-G-3.1 provides thematic guidance for each of the requirements contained in GS-R-3 and applicable to all nuclear facilities and activities. GS-G-3.1 will include all of the relevant guidance material that is contained in current Safety Guides 50-SG-Q1 to Q7 as well as new material. It was released in July 2006 and can be downloaded from: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1253_web.pdf.
- Draft Safety Guide (DS349) will provide specific guidance for Management Systems for nuclear facilities. It will include all of the relevant guidance material that is contained in current Safety Guides 50-SG-Q8- Q14 as well as new material. The expected publication date is 2007

Management systems and culture

When developing the new set of IAEA Safety Standards for Management Systems it was recognized at an early stage that with an integrated approach to management systems it was necessary to include the aspect of culture. With an integrated approach, the aspects of the management system that define processes and practices need to be combined with people's values, attitudes and behaviours in order for the organization to fully reach it's goals and objectives.

The management system will both influence and be influenced by the overall culture of the organization.



In order to achieve desired outcomes it is necessary to consider the formal processes and strategies of the organization and at the same time recognize that they have been produced based on the thinking prevalent in the organizational culture. The way in which the management system is implemented will in turn have an impact on the values, attitudes, and behaviours of the members of the organization i.e. the organization's culture.

For a nuclear organization an integrated approach to the achievement of all the goals of the organization should be addressed in a way that ensures that safety is not compromised. Therefore the management system should provide structure and direction to the organization in a way that promotes and enables the development of a strong safety culture together with the achievement of high levels of safety performance.

Since the introduction of the concept of safety culture the IAEA has broadened it's perspective further with attention focused on obtaining a deeper understanding of the actual concept of culture and particularly organizational culture. The IAEA guidance documents and support services has reflected the needs of Member States to first get a better understanding of the concept itself, then how to assess, enhance and continuously improve and sustain a strong safety culture particularly during times of change. The latest developments have been the integrated approach to management systems where the organizational culture and safety culture is seen as crucial elements of the successful implementation of this system and the attainment of all the goals and particularly the safety goals of the organization.

A culture is learned and is particularly influenced by how the leaders of the organization behave and act and the values they communicate. The leader's role is to 1) define reality: where are we today? 2) define the vision: where do we want to be? and 3) define how to get there. You then need to know what characteristics and attributes you want to see in the workplace, and what you want the culture to achieve.

In the new generic Safety Guide (GS-G-3.1) of IAEA Safety Standards for Management Systems a set of characteristics and their corresponding attributes for safety culture have been defined. The main characteristics are illustrated in the following figure:

Each of the 5 safety culture characteristics are further specified by attributes (not presented here). To begin with, any organization wanting to understand their safety culture and seek for areas for improvement can start by reviewing these characteristics and attributes in order to identify where its strengths and weaknesses are.

IAEA support to continual improvement of management systems, culture and safety culture

The IAEA has developed a set of services aimed at assisting its Member States in establishing, implementing, assessing and continually improving an integrated management system based on best international practices and standards, including the IAEA Safety Standards, and other relevant IAEA guidance documents.

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Strengthening National and Regional Nuclear Power Infrastructures

Overview of past and current IAEA activities

The infrastructure to support the implementation of a new nuclear power project has many components, ranging from the physical facilities and equipment associated with the delivery of the electricity, the transport of the material and supplies to the site, the site itself, and the facilities for handling radioactive waste, to the legal and regulatory framework within which all of the necessary activities are carried out, and the human and financial resources necessary to implement the required activities.

The Agency is accomplishing activities supporting the development and implementation of nuclear power infrastructure for more than 20 years. The support is being provided through programmes directed to specific needs of requesting countries under Technical Cooperation (TC) projects delivering training and advice in all infrastructure areas. In particular, extensive practical guidance was developed and made available through the publication of technical documents. The list of publications goes back to 1980, when a guidebook on "Manpower development for nuclear power" was issued. It was followed by another 17 publications produced until today on infrastructure subjects.

The most recent publication is TECDOC-1513 on "Basic infrastructure for a nuclear power project", issued in June 2006. This report provides initial guidance on the infrastructure that a country needs to develop in order to ensure that it is prepared for the introduction of a nuclear power plant. This infrastructure is relevant whether the nuclear power plant is planned for the production of electricity, or for seawater desalination.

A finalized document on the sharing of infrastructure describes areas where countries may be able to achieve the required level of infrastructure by sharing resources and facilities. This is intended to enable countries to realise where they can be more effective by working with other countries, either in their region, or elsewhere. This document will be published as a TECDOC before the end of 2006.

The Agency is further developing documents to provide guidance on planning for nuclear power projects and programmes. These documents will replace several documents produced during the last 20 years, and will reflect the changing social and commercial environment which the application of nuclear energy must now consider. A document currently in development will provide guidance regarding the planning for the first nuclear power plant in a country.

At present there are TC projects related directly to the development of nuclear power plants and associated infrastructure for six Member States, and related to the preparation for the production of desalinated water from nuclear power plants for another six Member States. There are also fourteen TC projects related to energy planning for countries which do not currently operate nuclear power plants. At the moment there are nine requests from other Member States for new TC projects in support of nuclear power applications. In addition, in 2007, two regional TC projects will commence to assist with infrastructure support for countries considering the introduction of nuclear power.

Topics relating to the nuclear power infrastructure are addressed by different parts of the Agency and require close coordination among relevant Agency activities. An inter-Departmental group, established in the Secretariat to develop a coordinated approach to providing support to interested Member States, has identified several policy issues that need to be considered, and has proposed means of improving coordination within the Agency of the required actions.

Trends and future activities

In September 2005, in resolution GC(49)/RES/12 Part G, the 49th IAEA General Conference recognized “that the development and implementation of an appropriate infrastructure to support the successful introduction of nuclear power and its safe and efficient use is an issue of central concern, especially for countries that are considering and planning for the introduction of nuclear power”.

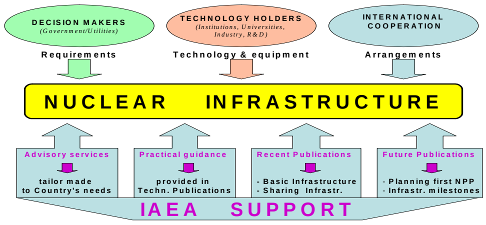
Since the 49th IAEA General Conference, there has been a significant increase in the number of Member States expressing interest in nuclear power. The Agency is able to provide advice on what steps need to be taken to be ready to introduce nuclear power.

The nuclear infrastructure of a country is built up on the basis of the requirements imposed by the decision makers, the technology and equipment provided by the technology holders and the international cooperation arrangements. The IAEA can provide effective support for the growing demand in the development and implementation of nuclear infrastructure through the provision of advisory services focused on specific country’s needs and the practical guidance made available through the extensive series of technical publications.

In planning the future support activities in the infrastructure area, the Agency is aiming to address emerging issues such as those mentioned below.

The changing global environment is likely to influence the infrastructure necessary for construction and operation of nuclear power plants. Depending on the Member States’ needs, issues such as financing arrangements for capital intensive nuclear power plants, international design approval, harmonization of codes and standards, and assurance of fuel cycle services would need to be addressed.

The issues of investment risk related to nuclear power will be considered, and a review of how the perceived investment risk can be reduced by improvements in international infrastructure and co-operation will be investigated.



Regional and inter regional arrangements to support the infrastructure will require further co-operation between many Departments of the Agency, particularly in the field of fuel supply and the storage, management and processing of spent fuel.

The development of a national capability through the establishment of the appropriate technical infrastructure to support nuclear power provides a potentially significant benefit to national development. This will be investigated in order to assess the comparative risk and benefits from the application of nuclear energy.

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The Evolution of Improvements in Training and Performance of NPP Personnel

Training of nuclear power plant personnel is an area in which the Nuclear Power Division has provided extensive methodological and practical support to the IAEA Member States since the founding of the Agency nearly 50 years ago.

One of the important lessons learned from the Three Mile Island (TMI) accident in 1979 was that there were deficiencies in the way that NPP personnel were trained to carry out their duties. Based upon these conclusions, the IAEA and other national and international organizations initiated an effort for the Systematic

Approach to Training (SAT) to be adopted as an international standard for the nuclear power industry.

During recent decades new training needs and demands for improving human performance have appeared in the nuclear industry, including the following:

- integrated management systems;
- more demanding safety requirements;
- implementation of emergency procedures; more attention to emergency preparedness; training on the beyond design basis accident (BDBA) management;
- challenge to increase both NPP and training efficiency and effectiveness;
- equipment and workforce ageing;
- use of training as a tool for preservation of knowledge;
- modernization of plants;
- upgrades of training tools including full-scope simulators;
- programmes for optimization of NPP maintenance;
- a growing number of decommissioning projects;
- availability of new computer-based training technologies;
- increasing attention to the competence of NPP managers;
- development of infrastructures in countries expanding their nuclear power sectors or initiating nuclear power programmes.

The opening of electricity markets has led some nuclear power plants to be under serious economic pressure with a demand for cost reductions and performance improvements. These factors necessitate NPPs to make their training more cost-effective. As the nuclear power industry continues to be challenged to maintain high safety standards, while responding to the pressures of more competitive energy markets, it becomes more important than ever to maintain excellence in human performance and ensure that NPP personnel training adds value to the organization. During this time, it has been increasingly recognized that in order to achieve excellence in human performance, in addition to technical competencies it is also important to focus on open communication; teamwork; leadership; problem resolution; safety consciousness; business performance; ethics and professionalism.

The IAEA Division of Nuclear Power (NENP) is continually evaluating training needs and trends, to ensure that the content of its programmes and projects is based upon Member State needs. The IAEA Technical Working Group on Training and Qualification of Nuclear Power Plant Personnel (TWG-T&Q) — established in 1994 — has been an invaluable tool. All 30 Member States with operating NPPs have members of the TWG-T&Q.

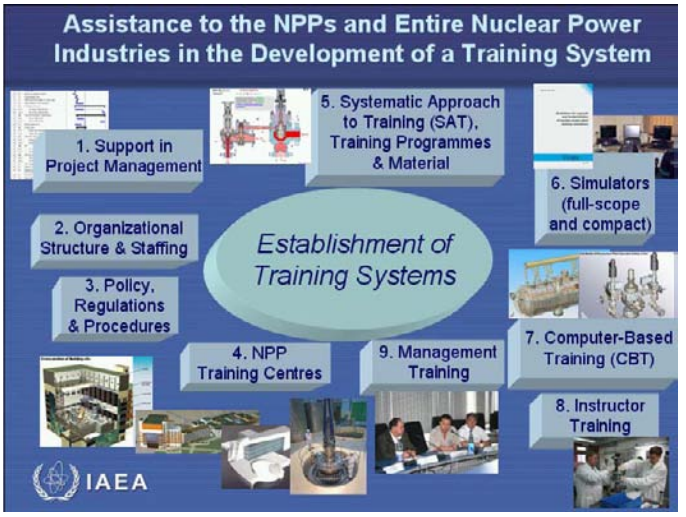


Figure 1. Assistance in establishing training systems

Operational and safety performance indicators have shown significant improvements in NPP performance in the past 20 years. Training and human performance initiatives have significantly contributed to these improvements and are expected to make continuing contributions to further improvements.

The IAEA provides a wide range of services to Member States for improving training and performance of all categories of personnel, and for various phases of a nuclear facility life cycle (including construction, commissioning, operation and decommissioning). Fig. 1 shows the main areas of our assistance. This assistance is provided through accumulating experiences and publishing good practices documents and guidelines in training field; convening technical meetings; performing training workshops and courses; conducting expert missions and assist visits; developing and supplying products such as training procedures, training material, advanced computer-based systems, simulators and other training tools.

In 2000, the TWG-T&Q recommended that the IAEA develops a mechanism for more efficient and effective sharing of information regarding training of nuclear industry personnel. Based upon this recommendation, in 2004, the IAEA put into service a web-based tool the Electronic Nuclear Training Catalogue ENTRAC http://entrac.iaea.org. ENTRAC now has 280 registered users.

If you have further questions regarding this topical area or registering for ENTRAC, please contact Tom Mazour T.Mazour@iaea.org or Alexey Kazennov A.Kazennov@iaea.org

Coordination of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)

The IAEA General Conference (2000) has invited "all interested Member States to combine their efforts under the aegis of the Agency in considering the issues of the nuclear fuel cycle, in particular by examining innovative and proliferation-resistant nuclear technology" (GC(44)/RES/21) and also invited Member States to consider contributing to a task force on innovative nuclear reactors and fuel cycle (GC(44)/RES/22). In response to this invitation, in 2000 the IAEA initiated an International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). Thereafter, INPRO activities have been continuously endorsed by resolutions of the IAEA General Conferences and corresponding United Nations general Assemblies.

At the G-8 meeting, held on July 16th, 2006, in St. Petersburg, Russian Federation, the heads of state and government adopted the following statement on global energy security: "The development of innovative nuclear power systems is considered an important element for efficient and safe nuclear energy development. In this respect, we acknowledge the efforts made in the complementary frameworks of the INPRO project and the Generation IV International Forum",

INPRO is addressing a full spectrum of user requirements for innovative technologies and has developed a methodology and guidance for the comparison of different innovative approaches to nuclear energy systems taking into account variations in potential demands across countries. INPRO can make major contributions to ensure a meaningful role of nuclear energy in worldwide sustainable development within the 21st century by focusing on economic aspects and societal acceptability issues, and those areas where the IAEA can make unique contributions, such as proliferation resistance, nuclear safety and security, waste management and sustainability issues, and by providing assistance to Member States in the definition of consistent nuclear strategies and in fostering increased international cooperation. INPRO is also examining legal and institutional developments that could facilitate development and deployment of innovative nuclear energy systems (INSs) in certain groups of countries and worldwide.

The objectives of INPRO, as defined in the Terms of Reference, are:

- To help to ensure that nuclear energy is available to contribute in fulfilling, in a sustainable manner, energy needs in the 21st century;
- To bring together all interested Member States, 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 that use sound and economically competitive technology, based — to the extent possible — on systems with inherent safety features and minimize the risk of proliferation and the impact on the environment;
- To create a process that involves all relevant stakeholders that will have an impact on, draw from, and complement the activities of existing institutions, as well as ongoing initiatives at the national and international level.

INPRO is an Agency-wide project, being coordinated by the Department of Nuclear Energy with contributions from all relevant Agency's Departments and Divisions. The framework for implementation of the Project consists of the following:

- The Steering Committee (SC), comprising as members, senior officials from INPRO Members and, as observers, representatives from interested IAEA Member States and International Organizations. IAEA project management is also represented. The Steering Committee meets as appropriate (approximately two times per year) to provide overall guidance, advise on planning and methods of work and to review the results achieved;
- The International Coordinating Group (ICG), comprising Cost Free Experts from INPRO Members and a regular staff specially assigned for INPRO, which coordinates and implements the project on the basis of experts' work in Member States and International Organizations;
- Technical experts from IAEA Member States, which are convened as appropriate by the ICG to consider specific subjects; and
- The Agency support, including project management, coordination, administrative and technical support.

As of June 2006, the following 26 Member States and International Organizations have become INPRO Members: Argentina, Armenia, Brazil, Bulgaria, Canada, Chile, China, Czech Republic, France, Germany, India, Indonesia, Japan, Republic of Korea, Morocco, Pakistan, Russian Federation, Slovakia, South Africa, Spain, Switzerland, Netherlands, Turkey, Ukraine, USA and the European Commission, and the membership is increasing. Members contribute to the project by providing funds, experts and studies.

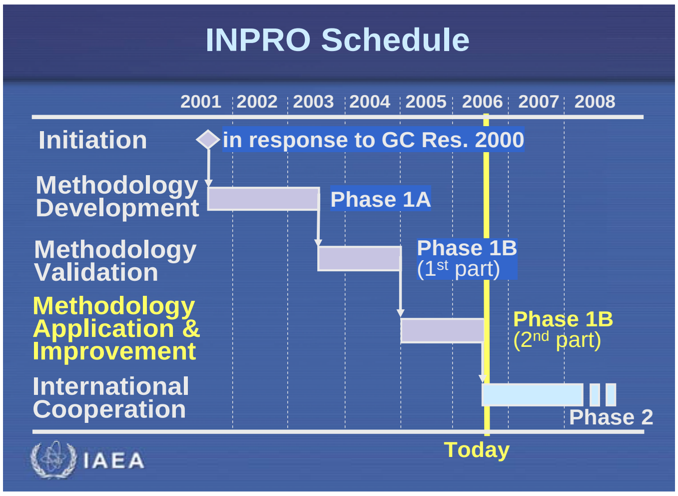
In total, 29 Cost Free Experts have been nominated by INPRO Members and worked or continue to work at the Agency as members of the INPRO International Coordinating Group.

Prior to 2004 INPRO was implemented using mostly extra-budgetary resources offered by INPRO Members. The extra-budgetary contributions in 2003 — 2005 were provided by Bulgaria, Canada, Pakistan, Switzerland, Turkey, and the Russian Federation. In July 2003 the IAEA Board of Governors agreed to include INPRO partly in the regular budget of the Agency, starting from 2004.

The project is implemented in two phases. Phase 1, started in 2001, includes two sub phases, Phase-1A and Phase-1B (parts 1 and 2),

The main output of Phase-1A (completed in June 2003) is the IAEA report TECDOC-1362 "Guidance for the Evaluation of Innovative Nuclear Reactors and Fuel Cycles" issued in June 2003.

The main output of Phase-1B (Part 1), completed in December 2004, is the IAEA report TECDOC-1434 "Methodology for the assessment of innovative nuclear reactors and fuel cycles".



Based on a decision of the 9th INPRO steering committee, INPRO has entered into Phase 2 in July 2006. Terms of Reference for the Phase 2 foresee that INPRO will continue in three directions: (1) On further improvement of the INPRO methodology based on the feedback from INS assessments, (2) on institutional/infrastructure oriented topics, and (3) on collaborative project oriented activities.

The framework and implementation options for collaborative projects for INS developments within Phase 2 have been worked out by an ad-hoc meeting in April 2006. The framework was endorsed by the 9th Steering Committee held in July 2006. This framework includes creation of synergy with other international initiatives.

Major elements of the current activities include the finalization of the INPRO User Manual, which will assist users in the application of the methodology for INS assessments, defining and modeling of INS deployment scenarios, and the facilitation of INS assessments by Member States on a national or international basis. Seven out of the expected nine chapters of Manual for methodology have been released by July 2006 and the rest of chapters should be released by the end of 2006.

Several assessments of INSs, performed by INPRO members on a national or international basis, are ongoing:

- Joint assessment based on a closed fuel cycle with fast reactors (Russian Federation, Canada, China, France, India, Japan , Republic of Korea, and Ukraine);
- Assessment of hydrogen generating INS in national energy mix (India);
- Study on the transition from the current fleet towards Generation IV fast neutron systems (France);
- Assessment of additional nuclear generation capacity in the country for the period 2010-2025 for the evaluation of NFC strategies (Argentina);
- Assessment of INS for countries with a small electricity grid (Armenia);
- Holistic assessment on complete DUPIC fuel cycle in the area of proliferation resistance (Republic of Korea);
- Two independent assessment studies on IRIS and FBNR (Brazil);
- Assessment study of NPP economics (Morocco);
- Assessment of advanced HTGR (China);
- Assessment of national INS (Ukraine); and
- Assessment of INS to meet energy demand during periods of raw materials insufficiency (Czech Republic, Bulgaria, Poland, Russian Federation, Slovakia).

The assessments performed are expected to contribute to identifying the needs and platforms for collaborative projects on an international scale and also to provide valuable feedback for further improvement of INPRO methodology.

While some Member States may still require Agency assistance in assessment of various INS options, the main objective of Phase 2 is to encourage and support IAEA Member States in facilitating the development, demonstration and deployment of safe, competitive, environmentally clean, and proliferation resistant INSs for sustainable development.

IAEA/INPRO pursues increased synergy and cooperation with other international efforts targeted at innovative technology development, such as the Generation-IV International Forum (GIF). INPRO already participates in the GIF working groups for proliferation resistance and physical protection, economics and safety, and, as an observer, in the meetings of the Generation-IV International Forum (GIF) Policy and Expert Groups.

INPRO Web page: http://www.iaea.org//INPRO.

Technology Development for Advanced Reactors

Advanced Technologies for Water-Cooled Reactors

The IAEA's Project in Advanced Technologies for Water-Cooled Reactors has evolved from an initiative in 1987 by then Director General Hans Blix. At that time, just after the Chernobyl accident, Dr. Blix formed the International Working Group on Advanced Technologies for Water Cooled Reactors, stressing that this initiative would provide a forum for Member States to exchange information on technological developments incorporating enhanced safety features and on advanced technologies and new concepts for water cooled reactors. Considerable collaboration was carried out within the frame of this International Working Group, and in 1995, at the suggestion of then Chairman of the IAEA Board of Governors, and Chairman of the Atomic Energy Commission of India, Dr. Chidambaram, it was realized that the intense collaboration desired by the Member States warranted the establishment of two Groups, addressing respectively Advanced Technologies for LWRs and Advanced Technologies for HWRs, which would collaborate in areas of common technologies of interest to both Groups.

Figure 1. Construction of the European Pressurized Water Reactor in Finland — Positioning of the bottom part of the metallic liner on the base slab (May 2006; credit: Framatome ANP)

Presently, the two Groups, now called the Technical Working Groups on Advanced Technologies for LWRs and HWRs (the TWG-LWR and the TWG-HWR) focus on technology development for improving the economics of water-cooled reactors, while meeting stringent safety objectives. The Member States and international organizations represented in the TWG-LWR are Argentina, Belgium, China, Czech Republic, Finland, France, Germany, India, Italy, Japan, Republic of Korea, the Russian Federation, Spain, Sweden, Switzerland, the United Kingdom, the United States of America, the OECD-NEA, and the European Commission.

The Member States represented in the TWG-HWR are Argentina, Canada, China, India, Republic of Korea, Pakistan, Romania and the Russian Federation.

The most recent meetings, convened with some joint sessions to address common technological issues, were the 12th meeting of the TWG-LWR and the 8th meeting of the TWG-HWR, convened in December, 2005.

Figure 2. WWER-1000 units — Tianwan 1 and 2in China (credit: Gidropress)

On the advice, and with the support of the IAEA Department of Nuclear Energy's TWG-LWR and the TWG-HWR, the IAEA conducts activities on international information exchange, co-operative research and collaborative assessments of advanced water-cooled reactor technology. Also, to provide balanced and objective information on technology status and development trends to all Member States, the IAEA periodically publishes Status Reports on advanced LWR and HWR designs. The IAEA recently published a Status Report on Advanced LWR Designs (TECDOC-1391), a Report on the Status and Projected Development of HWRs (TRS-407), and a report on recent Construction and Commissioning Experiences with Evolutionary Water-Cooled NPPs (TECDOC-1390). Further, a Collaborative Assessment has reviewed proven means and new approaches for reducing capital cost of new plants while meeting stringent safety requirements (TECDOC-1290).

Figure 3. Reactors being considered by US utilities for deployment by 2015 — ABWR, AP1000, ESBWR, EPR

A new approach to improve economics through plant simplification involves development of passive safety systems based on natural circulation. To facilitate cooperation on this approach, the IAEA is conducting a Coordinated Research Programme (CRP) on natural circulation phenomena, modelling and reliability of passive systems, and has published a document on the present state of knowledge of natural circulation (TECDOC-1395). In another collaborative effort to support development of Super-Critical Water Cooled Reactors (SCWRs), the IAEA is organizing a new CRP on heat transfer and thermo-hydraulics code testing for SCWRs.

Other activities include cooperation on validation of thermo-hydraulics codes (TECDOC-1395); establishment of a thermo-physical properties database for LWR and HWR materials (http://www.iaea.org/THERPRO); and inter-comparison of inspection and diagnostic techniques for pressure tubes of HWRs (TECDOC-1499).

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Technology Advances in Fast Reactors and Accelerator Driven Systems

It is reasonable to assume that nuclear power will be accepted as a contributor to the world's energy supply mix only if it meets a necessary condition: it has to be sustainable (i.e. somewhat simply put, last for more than just a few decades), which implies that it must have convincing responses to both the natural resources and waste management issues. It is further reasonable to assume that the sustainability goals vis-à-vis natural resources and long-lived radioactive waste management will be met by systems involving several innovative reactor types and fuel cycles operating in symbiosis. Apart from cost effectiveness, simplification, and safety considerations, a basic requirement to these reactor types and fuel cycles will be flexibility to accommodate changing objectives and boundary conditions. This flexibility can only be assured with the deployment of the fast neutron spectrum reactor technology, and fuel reprocessing. This is the scope of IAEA's project on "Technology Advances in Fast Reactors and Acelerator Driven Systems".

Figure 1. Construction of the Prototype Fast Breeder Reactor (PFBR) at Kalpakkam, India — Reactor Vault Base Preparation (April 2006; Credit: IGCAR)

This project has evolved from an initiative in 1967 by then Director General Sigvard Eklund. Since the early 1950s, vigorous fast reactor R&D and technology development programs were pursued worldwide, leading to the construction and operation of experimental and prototype fast reactors: the US were the first, with Clementine becoming critical in 1946, and the first nuclear electricity kilowatt-hours produced in December 1951 by a fast reactor, the EBR-I in Idaho. The US program continued with basic R&D and construction of fast reactors of increasing power (EBR-II, FERMI, and FFTF). The USSR (BR-10, BOR-60), the UK (DFR), and France (RAPSODIE that became critical in January 1967) also initiated fast reactor development programs and built their own experimental fast reactors. A few years later, Germany and Japan started their national fast reactor development programs and constructed experimental fast reactors (JOYO and KNK, respectively). Eklund's initiative in response to this growing interest expressed by Member States was to establish the "permanent International Working Group on Fast Reactors (IWG-FR) under IAEA auspices" to provide a framework for international information exchange in this area. Six countries were among the founding members: France, Germany, Japan, UK, USA, and USSR.

In the next years, the pace of fast reactor development picked up, and the programs were at their peaks by 1980. The experimental reactors were operating in many countries, providing the R&D tools (mainly as irradiation facilities) for the various commercial size prototype fast reactor development programs, e.g. Phénix, Superphénix in France, SNR-300 in Germany, MONJU in Japan, PFR in the UK, CRBR in the USA, and BN-350, BN-600 in the USSR.

In its first 20 years of existence, the IWG-FR was functioning as the sole international platform for information exchange and collaborative research and technology development projects on a wide range of issues that were closely linked to the Member States' large and vigorous fast reactor development programs and the respective design, construction, and commissioning activities, as well as to the operation of fast reactors. In those years, the IAEA convened on a regular basis scientific and technical meetings on the three main topics of interest, i.e. Reactor Physics, Liquid Metal Technology, and Fast Reactor Safety (in average five scientific meetings per year). Just to name a few highlights of the considerable collaboration carried out in that period within the framework of the IWG-FR: the critical review of, and consensus finding in the issue of α_{Pu} (ratio between the capture and fission probabilities of a neutron interacting with a plutonium nucleus) (in collaboration with IAEA's Data Division); the publication of status reports; the collection of fast reactor plant parameters and establishment of the corresponding data bases, etc.

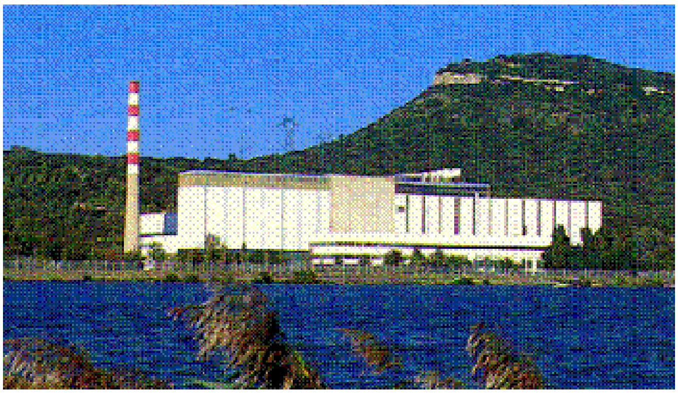

Figure 2. Prototype 250 MW(e) Fast Breeder Reactor Phénix (Credit: CEA/EdF)

While interest in this technology was increasing in developing countries, the next 10 years saw a gradual decline in fast reactor activities in the West. By 1994, in the USA, the CRBR had been cancelled and FFTF and EBR-II had been shut down. In France, Superphénix was shut down at the end of 1998; SNR-300 in Germany was completed but not taken into operation, and KNK-II was permanently shut down in 1991. In the UK, PFR was shut down in 1994; and in Kazakhstan BN-350 in 1998. Looking back, it has to be admitted that there simply was no economic need for fast breeder reactors and thus, at least in the West, the technology fell victim to the anti-nuclear attacks with waste, safety, and proliferation being at the top of the opponents' list. Had there been a compelling economic need for fast breeder reactors and the accompanying fuel reprocessing, the issues put forward by the opponents would have diminished in importance as the existing, adequate solutions addressing them were implemented. In this period, the IWG-FR's activities focused on the analysis and evaluation of advanced fast reactor concepts, on collaborative R&D activities addressing generic topics relevant to advanced fast reactor concepts, and on the systematic review of operational experience, as part of knowledge "accumulation and transmission".

An important extension of the IWG-FR's work scope occurred in 1994 upon an initiative of then Director General Hans Blix. Following the realization of the fast neutron system's potential with regard to the back-end of the fuel cycle, the IAEA convened under the chairmanship of then Deputy Director General B.A. Semenov a high level panel of distinguished scientists to discuss scientific, technological and economics aspects of sub-critical fast systems driven by external neutron sources, the worldwide R&D status and needs, and the possible role that the IAEA could play to foster international collaboration in this area. The outcome of the process initiated by this Advisory Committee Meeting was to include fast neutron sub-critical systems driven by external sources [e.g. Accelerator Driven Systems (ADS)] for energy production and transmutation into the work scope of the IWG-FR, which, in 2001, was renamed Technical Working Group on Fast Reactors (TWG-FR).

The fast reactor, which can generate electricity and breed additional fissile material for future fuel stocks, is a resource that will be needed when economic uranium supplies for the advanced light water reactors or other thermal-spectrum options diminish. Further, the fast-fission fuel cycle in which material is recycled offers the flexibility needed to contribute decisively towards solving the problem of growing 'spent' fuel inventories by greatly reducing the volume of high-level waste that must be disposed of in long-term repositories. This is a long-term waste management option that demands particular attention. In recognition of the fast reactor's importance for the sustainability of the nuclear option, currently there is worldwide renewed interest in fast reactor technology development, as indicated, e.g. by the outcome of the Generation IV International Forum (GIF) innovative technology review, which concluded with 3 out of 6 innovative systems to be fast neutron reactors (gas cooled fast reactor, sodium cooled fast reactor, and heavy liquid metal cooled fast reactor, plus a fast core for a 4th concept, the super-critical water reactor). Accordingly, the IAEA is responding to expressed Member States needs in the area of fast neutron systems through TWG-FR initiated international information exchange and collaborative R&D activities.

Currently, the TWG-FR comprises 14 IAEA Member States: Belarus, Brazil, China, France, Germany, India, Italy, Japan, Kazakhstan, Republic of Korea, Russia, Switzerland, United Kingdom, and United States of America, as well as the OECD/NEA, and the European Commission (EC), and Belgium and Sweden as observers. Still the only global forum for information exchange and collaborative research and technology development projects in the area of fast neutron systems, the TWG-FR advises the Deputy Director General-Nuclear Energy on status of and recent results achieved in the national technology development programs relevant to the TWG-FR's scope, and recommends activities to the IAEA that are beneficial for these national programs. It furthermore assists in the implementation of corresponding IAEA activities, and ensures that, through continuous consultations with officially nominated representatives of Member States, all technical activities performed within the framework of the Nuclear Power Technology Development sub-programme (project on Technology Advances in Fast Reactors and Accelerator Driven Systems) are in line with expressed needs from Member States.

The TWG-FR has mostly focused on experimental and theoretical aspects of fast reactor technology and safety. A benchmark test with experimental data was conducted to verify and improve the codes used for the seismic analysis of reactor cores. A coordinated research project was conducted to apply acoustic signal processing for the detection of boiling or sodium/water reactions in liquid metal cooled fast reactors. Benchmark analyses addressed accident behavior and design improvements of the Russian BN-800 reactor within the frame of a collaborative project between the IAEA and the European Commission. In cooperation with the Department of Nuclear Safety, assistance was provided to ensure safe operation during the remaining lifetime and the development of an effective decommissioning programme for the BN-350 reactor in Kazakhstan. A coordinated research project is being conducted with the objective to reduce the calculational uncertainties of the LMFR reactivity effects. A new coordinated research project on “Analyses of and Lessons Learned from Operational Experience with Fast Reactor Equipment and Systems” will be initiated later in 2006. To foster the exchange of technical information and to contribute to the preservation of the base of liquid metal cooled fast reactor technology, an updated database (FRDB), available on the Internet, has been developed.

As for the ADS area, the project’s activities included the preparation of status reports on advanced reactor technology development, the conduct of technical information exchange meetings and coordinated research projects on the use of thorium fuel in accelerator driven systems, and on reactors to constrain plutonium production and to reduce long-term waste toxicities. In particular, the IAEA provided for a review and comparison of different options to achieve these aims, including review of new technical measures to achieve proliferation resistance. In another TWG-FR activity, participants from 20 institutions in 15 Member States and one international organization joined forces in the coordinated research project on Studies of Advanced Reactor Technology Options for Effective Incineration of Radioactive Waste. Recently, a new coordinated research project on “Analytical and Experimental Benchmark Analyses of Accelerator Driven System” was launched. The specific objective of this coordinated research project is to improve the present understanding of the coupling of an external neutron source (e.g. a spallation source in the case of the ADS) with a multiplicative sub-critical core. Participants from 27 institutions in 18 Member States are performing computational and experimental benchmark analyses using integrated calculation schemes.

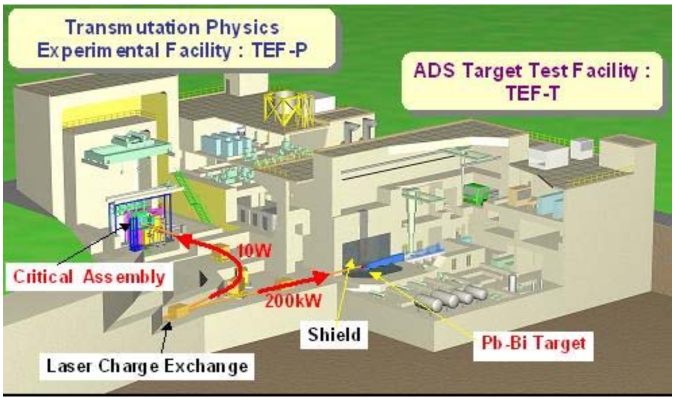

Figure 3. Transmutation Experimental Facility (TEF) Planned at the Tokai Site (Credit: JAEA)

To harmonize efforts, the elaboration of a database of existing and planned experimental facilities, as well as R&D programmes for accelerator driven systems and related research and development was initiated in 1997.

For more information see http://www.iaea.org/inis/aws/fnss/index.html.

Common Technologies and Issues for Small and Medium Sized Reactors

In the near term, most new NPPs are likely to be evolutionary designs building on proven systems while incorporating technological advances and often the economics of scale, resulting from the reactor outputs of up to 1600 MW(e). For the longer term, the focus is on innovative designs aiming to provide increased benefits in the areas of safety and security, non-proliferation, waste management, resource utilization and economy, as well as to offer a variety of energy products and flexibility in siting and fuel cycle options. Many innovative designs are reactors within the small-to-medium size range, having an equivalent electric power less than 700 MW(e) or even less than 300 MW(e); these are classified as small and medium sized reactors (SMRs).

As of 2006, more that 50 concepts or designs of innovative SMRs are being analyzed or developed in Argentina, Brazil, China, Croatia, France, India, Indonesia, Italy, Japan, the Republic of Korea, Lithuania, Morocco, Russian Federation, South Africa, Turkey, USA, and Vietnam. SMR development covers all principle reactor types, i.e. water-cooled, gas cooled, liquid metal cooled and molten salt cooled reactors, and some unusual combinations thereof. The projected timelines of readiness for deployment are generally between 2010 and 2030.

SMRs may provide an attractive and affordable nuclear power option for many developing countries with small electric grids, insufficient infrastructure and limited investment capability. Multi-module power plants with SMRs may offer energy production flexibility that energy market deregulation might call for in the future in many countries. SMRs are also of particular interest for co-generation and many advanced future process heat applications. Some small reactor designs incorporate an option of operation without on-site refuelling, which may help reduce the obligations of a user for spent fuel and waste management and offer possibly greater non-proliferation assurances to the international community. SMRs have many common technology development issues related to the provision of high competitiveness and enhanced proliferation resistance and plant security in targeted energy markets.

Reflecting on the developments in Member States, the IAEA carries out a dedicated project “Common Technologies and Issues for SMRs”; it has an objective to ensure progress in the development of key enabling technologies and in the resolution of enabling infrastructure issues common to SMRs of various types. The activities include coordinated research projects (CRP) on important topics of design and technology development and assessment of various SMR options; preparation of status reports of innovative SMR designs; preparation of topical reports on important common issues for SMRs such as strategies to overcome loss of economies of scale and to incorporate passive safety design options, or options to reduce or eliminate a emergency planning zone to enable SMR siting near population centres; organization of workshops on deployment and application potential of SMRs of certain lines, and provision of support to the Technical Cooperation programme. Experts from 16 member states and international organizations carry out these activities under coordination from IAEA secretariat.

The Web page of a project “Common technologies and issues for SMRs” is: http://www.iaea.org/OurWork/ST/NE/NENP/NPTDS/Projects/SMR/index.html

Figure 1. Views of a NPP and a nuclear setam supply system with KLT-40S reactor (floating plant construction was started in the Russian Federation in June 2006 and is to be completed in 2010)

Advances in Gas Cooled Reactor Technology

Gas-cooled reactor design concepts have been evolving since the 1940s and in recent years there have been a surge of global interest in their modular variants due to their promising features of enhanced safety and improved economics. Modular HTGR designs are currently considered one of the leading reactor concepts being considered for future nuclear power plant deployment. In addition to their high efficiency in electricity generation, HTGR designs are also well placed for co-generation of process heat, promising high thermal efficiency. Potential process heat applications include high-temperature applications such as hydrogen production and low-temperature applications, such as seawater desalination and district heating.

Since the 1970s, major IAEA HTGR activities have been conducted with advice and support from the Technical Working Group on Gas Cooled Reactors (TWG-GCR) and are directed towards the exchange of scientific and technical information between Member States to minimize design uncertainties and optimise inherent safety features. Current activities include three CRPs. CRP-5 on HTGR performance evaluation, which focuses on core physics and thermal-hydraulics benchmarking, CRP-6, which focuses on advances in HTGR fuel technology and a new CRP-7, which addresses the potential of HTGRs for process heat applications, including hydrogen production and seawater desalination. In addition, conferences, topical meetings, and training workshops are organized periodically to facilitate information exchange.

Members of the TWG-GCR, established in 1978 are China, Republic of Korea, France, Netherlands, Germany, Russian Federation, Indonesia, South Africa, Japan, Turkey, USA, United Kingdom.

On the international level, HTGR-related R&D projects are under way in several Member States, including South Africa, China, Japan, Russia, the US, countries of the European Union and the Republic of Korea.

In South Africa, PBMR (Pty) Ltd is accelerating its efforts on licensing work on a 165 MW(e) Pebble Bed Modular Reactor, which is expected to be commissioned around 2010. The South African government has already allocated initial funding for the project and orders for some lead components have already been made.

In China, work continues on safety tests and design improvements for the 10 MW(th) High Temperature Gas-cooled Reactor (HTR-10) and there are plans to design and construct a power reactor prototype (HTR-PM).

In Japan, a 30 MW(th) High Temperature Engineering Test Reactor began operation in 1998 and work continues on safety testing and coupling to a hydrogen production unit. A 300 MW power reactor prototype is also under consideration.

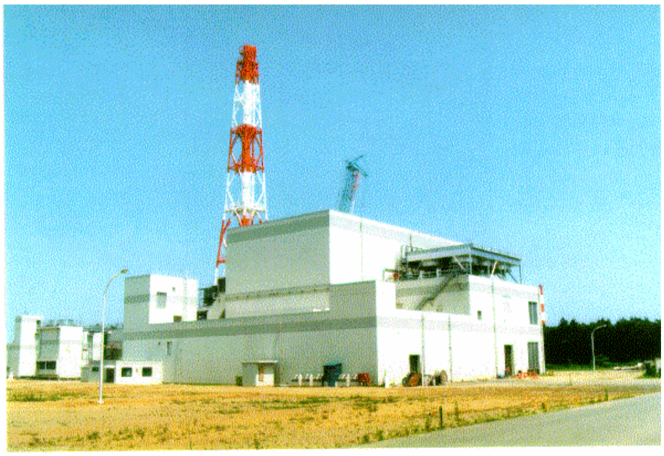

Figure 1. JAEA's High Temperature Engineering Test Reactor has the capability to operate at a core outlet temperature of 950 ºC and is utilized to investigate technologies for advanced HTGRs, to demonstrate nuclear process heat applications, and to serve as an irradiation test facility for high temperature research activities (Courtsey of Japan Atomic Energy Agency)

Russia, in cooperation with the US, continues its research and development work on a 284 MW(e) Gas Turbine Modular Helium Reactor (GT MHR) for Plutonium burning.

France has an active R&D programme on both thermal as well as fast gas reactor concepts and in the US, efforts by the Department of Energy (DOE) continue on the qualification of advanced gas reactor fuel, with work being performed at major organizations such as the Idaho National Laboratory and Oak Ridge National Laboratory.

The IAEA is following progress of these activities, coordinating research and facilitating information exchange among Member States.

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Web site: http://www.iaea.org/htgr.

Support for Non-Electric Applications of Nuclear Power

Support for Demonstration of Nuclear Seawater Desalination

Desalination as a source of fresh water

Recent statistics show that 2.3 billion people live in water-stressed areas and among them 1.7 billion live in water-scarce areas, where the water availability per person is less than 1000 m^3/year. The situation is going to worsen further, statistics show that by 2025 the number of people suffering from water stress or scarcity could swell to 3.5 billion and 2.4 billion of them are expected to live in water-scarce regions. Water scarcity is a global issue, and every year new countries are affected by growing water problems.

Therefore, the Millennium Declaration by UN General Assembly in 2000 set up a target to halve, by the year 2015, the world population who are unable to reach, or to afford safe drinking water. Vision 21 for Hygiene, Water supply and Sanitation has a target to provide water, sanitation & hygiene for all by 2025.

Better water conservation, water management, pollution control and water reclamation are all part of the solution. So too are new sources of fresh water, including the desalination of seawater. Desalination technologies have been well established since the mid-20th century and widely deployed in the Middle East and North Africa. The contracted capacity of desalination plants has increased steadily since 1965 and is currently about 36 million m^3/d worldwide.

Figure 1. El-Dabaa (Egypt) experimental facility

Nuclear Desalination Activities in the Member States

In recent years, the option of combining nuclear power with seawater desalination has been explored and is a feasible option to meet the growing demand for potable water. Over 175 reactor-years of operating experience on nuclear desalination have been accumulated worldwide. Several demonstration programs are also in progress to confirm its technical and economical viability under country-specific conditions, with technical co-ordination or support of the IAEA.

Figure 2. NDDP Site at Karachi Nuclear Power Complex

Japan has over 145 reactor-years of nuclear powered desalination experience. Kazakhstan accumulated 26 reactor-years before shutting down the Aktau fast reactor in 1999. A number of nuclear desalination demonstration projects have been undertaken in recent years. A Nuclear Desalination Demonstration Project at Kalpakkam has completed three years of successful operation. The MSF section is under advanced stage of completion. In Pakistan, a 1600 m^3/d MED plant is being setup utilising heat from the Karachi Nuclear Power Plant. The Russian Federal Agency for Atomic Energy (ROSATOM) has taken a decision to start construction of a small floating barge mounted heat and power cogeneration nuclear plant in 2006 based on KLT-40C at Severodvinsk. The E1-Dabaa Experimental RO Desalination Facility in Egypt is undergoing trial commissioning runs. The construction project of the SMART pilot plant for performance verification of the reactor and desalination technology is in progress.

Ongoing and future activities at the IAEA

The results of the CRP on “Optimization of the Coupling of Nuclear Reactors and Desalination Systems” were published as IAEA-TECDOC-1444 (2005).

The CRP on “Economic Research on, and Assessment of, Selected Nuclear Desalination Projects and Case Studies” launched in 2002 has participating institutes from 11 Member States.

The updated version of DEEP has been released in September 2005. It is now available to download under a licence agreement.

INDAG met in February 2006 presenting the status of activities in the Member States, reviewing the Agency’s activities and making several recommendations.

A Status Report on Nuclear Desalination Activities in the Member States is in publication. This would be useful for managers and decision makers considering deployment of nuclear desalination projects.

An International Conference on Non-electrical Applications of Nuclear Power-Seawater desalination, hydrogen production and industrial application is to be held at Oarai, Japan in April 2007.

Nuclear Production of Hydrogen

Hydrogen as an energy carrier is receiving increasing attention both in industrialized countries and in developing countries, and nuclear energy is well placed as an efficient and clean source of energy for its production. Activities are pursued in several IAEA Member States to realize hydrogen’s potential in solving energy security, diversity, and environmental needs. Member States can benefit from sharing information and knowledge, performing collaborative assessments, and pooling resources for conducting collaborative research on production of hydrogen with nuclear energy. Such collaboration can facilitate the movement from today's fossil-based energy economy to a future sustainable hydrogen-oriented economy with fuel cell energy converters.

NPTDS has been fostering collaboration on hydrogen production for more than a decade, for example publishing TECDOC-1085 on “Hydrogen as an energy carrier and its production by nuclear power” and TECDOC-1236 reporting the results of a CRP on “Design and evaluation of heat utilization systems for the High Temperature Engineering Test Reactor in Japan”.

In 2004 SAGNE noted that nuclear hydrogen production has become of great interest as an energy carrier, and stated that the Agency should “show leadership in this arena, which offers the opportunity to couple hydrogen production with nuclear power in a sustainable way”. This led to the creation of a project on “Nuclear Production of Hydrogen” within the nuclear power technology development Subprogramme for 2006-7.

Specific objectives are to (a) keep Member States better informed on means for producing hydrogen with nuclear energy, and on advances in technologies for hydrogen production by nuclear energy; and (b) to provide a forum for information exchange, cooperative research, and collaborative assessments of safe and economical approaches for hydrogen production systems with nuclear reactors.

Nuclear energy can be used for hydrogen production by using nuclear produced electricity for water electrolysis at distributed sites as well as by using nuclear heat from nuclear reactors for indirect thermo-chemical water–splitting cycles. Production of hydrogen by nuclear electricity and/or nuclear heat would open the application of nuclear energy for the transportation sector and reduce the reliance of the transportation sector on fossil fuel with the associated price volatility, finite supply and greenhouse gas emissions.

Producing hydrogen with electrolyzers is a means for distributed hydrogen generation at the point of delivery to the customer, such as at a fuelling station. Although the efficiency of hydrogen production by electrolyzers is lower than with higher temperature electrolysis or high temperature thermo-chemical processes, such distributed production could play an initiating role, because of the lower capital investment and especially until large networks for hydrogen distribution become common. In the longer term, production of hydrogen at central nuclear stations connected to extensive distribution networks may become cost efficient, with distributed production continuing to meet some needs.

Some experience for high temperature applications of nuclear energy is available on the laboratory scale and from component tests for earlier development programmes for HTGR applications. Significant R&D is still required before large-scale deployment such as steam reforming of methane and thermo-chemical cycles for production of hydrogen.

A programme is on-going in Japan with the goal of demonstrating the use of heat from HTGRs for production of hydrogen by steam reforming of methane. In the USA, construction of an advanced reactor for hydrogen production is under consideration.

The several thermo-chemical cycles and hybrid thermo-chemical/electrochemical cycles for hydrogen production by water-splitting are generally in the laboratory-scale testing phase and significant materials corrosion problems must be overcome to establish industrial scale components with long operational lifetimes.

Nuclear energy also has a potential to support production of chemical energy. The production of crude oil will decrease and its quality will degrade in the long run. Steam and hydrogen from nuclear reactors can support the recovery of unconventional heavy oil in Canada, Venezuela and other countries or to improve the quality through the hydro-cracking technique as illustrated in the figure below.

Figure 1.Hydrogen from nuclear energy to support chemical energy

The main outputs of NPTDS’s Project on “Nuclear Production of Hydrogen” during 2006 and 2007 will be a TECDOC on design and safety approaches for the coupling of hydrogen production systems with nuclear reactors and the Proceedings of a Symposium on Non-electric Applications of Nuclear Power: Seawater Desalination, Hydrogen Production and other Industrial Applications.

Contributions from John Cleveland, J.Cleveland@iaea.org and Atam Rao, A.Rao@iaea.org.

The 1st Joint IAEA-EPRI Workshop on Modernization of Instrumentation and Control Systems in Nuclear Power Plants

The 1st Joint IAEA-EPRI Workshop on Modernization of Instrumentation and Control (I&C) Systems in Nuclear Power Plants will be held on 3-6 Oct. 2006, Vienna, Austria.

The purpose of the workshop is (1) to provide an opportunity for I&C, control room, and human factors experts representing the various stakeholders in the nuclear power industry to get together and learn state-of-the-art approaches to modernization of I&C systems and components, control rooms, measurement and information systems; (2) to share nuclear power plant modernization experiences and lessons learned; and (3) to provide a forum for interactions and discussions between experts on modernization challenges and opportunities. Design, engineering, implementation, and project management issues are to be discussed.

This workshop will be of interest to I&C engineers, decision makers, experts, and skilled practitioners who are or will be involved in replacing, upgrading, or adding instrumentation, control and information systems and equipment in operating nuclear power plants or other nuclear facilities. Participants from nuclear utilities, nuclear vendors, equipment suppliers, third party integrators, consultants, regulatory agencies, universities, and research organizations will benefit from this workshop. This workshop will bring professionals together to share expertise and experiences in order to more effectively modernize instrumentation and control systems, control rooms, measurement and information systems in operating nuclear power plants.

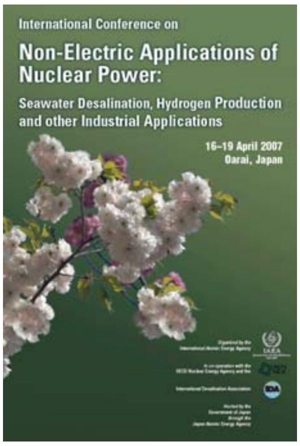
The workshop will include EPRI and IAEA international experts giving presentations on I&C modernization of nuclear power plant. Participants from NPPs will be asked to make short presentations on their experience and lessons learned. Open discussions with all attendees will take place at the end of the day.

For more information, visit the IAEA conference web page http://www.iaea.org/OurWork/ST/NE/NENP/NPES/Downloads/WS_IC_ERPI_2006/ic_erpi_ws_2006.pdf or contact O.Glockler@iaea.org.

International Conference on Non-Electric Applications of Nuclear Power Oarai, Japan (April 16-19, 2007)

Email Synopsis to: C.Czipin@iaea.org – Deadline: Nov. 1, 2006

An International Conference on Non-Electric Applications of Nuclear Power will be held in Oarai, Japan (April 16-19, 2007). Rising fossil fuel prices, environmental concerns and uncertainty about the adequacy of future supplies is sparking interest in hydrogen as an alternative to fossil fuel for the transportation sector. Similarly, many parts of the world, especially developing countries, are either anticipating or already experiencing acute shortages of clean potable water. In both applications as well as many others ranging from district heating to coal gasification, tar sand and heavy oil recovery, nuclear power is poised to play a significant role, improving thermal utilization and providing a competitive, efficient and clean energy source. The conference will update the status of technologies, economics, as well as the potential and challenges of nuclear power non-electric applications.



For more information, visit the IAEA conference web page http://www-pub.iaea.org/MTCD/Meetings/Announcements.asp?ConfID=152 or contact M.Methnani@iaea.org.

Nuclear Power on the Net:

http://www.iaea.org/OurWork/ST/NE/NENP

IAEA International Atomic Energy Agency

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