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Nuclear Power Newsletter

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Contents

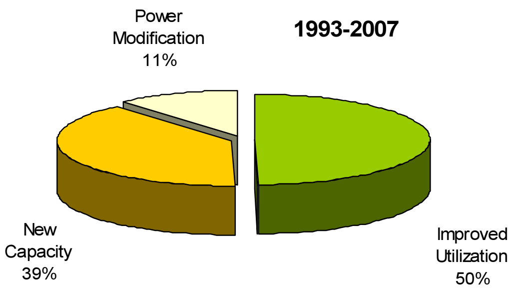
Division of Nuclear Power
Department of Nuclear Energy
IAEA
P.O. Box 100
Wagramer Strasse 5,
A-1400 Vienna, Austria
Tel : +43 1 2600 22751

Women in the Division of Nuclear Power

The Division of Nuclear Power has a talented group of Professional Staff, of which an important segment are women. They come from different countries, backgrounds, institutions and cultures, but all have considerable expertise in nuclear energy/nuclear power.

Read more on page 2

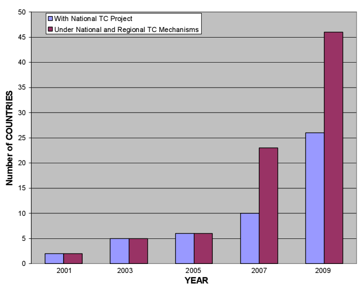
Nuclear Power Overview



Nuclear energy is an important part of the global energy mix. In 2007 nuclear power supplied about 14.2% of the world's electricity and expansion of nuclear energy is a key to meeting growing energy demands while reducing pollution and greenhouse gases.

Read more on page 3

Strengthening Nuclear Power Infrastructure



Renewed interest in nuclear power has resulted in a dramatic increase in demand for IAEA assistance. For the upcoming 2009-11 period, 46 IAEA Member States have asked for Technical Co-operation assistance in considering the introduction of nuclear power.

Read more on page 9

Fast Reactors and Accelerator Driven Systems

For obvious sustainability reasons, spent fuel utilization and breeding are returning to centre stage, and with this the fast reactor as the necessary linchpin. In this rapidly evolving environment, in which renewed interest in nuclear energy is driven by the need to develop carbon free energy sources, demographics and development in emerging economies, as well as by security of supply concerns, fast reactor deployment is likely to be accelerated.

Read more on page 15

Women in the Division of Nuclear Power

The Division of Nuclear Power has a talented group of Professional Staff, of which an important segment are women. They come from different countries, backgrounds, institutions and cultures, but all have considerable expertise in nuclear energy/nuclear power. They like the challenge of working at the IAEA and having the opportunity to observe and participate in the many different jobs and tasks related to nuclear energy and nuclear power. They find that the working style of the Division – including mentoring and coaching – helps to create an interactive, participative and dynamic environment. Working at the IAEA is also a good experience for them and their families, given its diverse work/life balance policies that foster a family-friendly working place. The Professional staff represented in the Division are varied and made up of many skill sets and backgrounds.

Women professional staff in the division: Xiaoping LI, Anne Katrine STARZ, Kerstin DAHLGREN PERSSON, Sama BILBAO Y LEON, and Bitsit Fisseha TEKESTE from left

Sama Bilbao y León (Spain) is a Mechanical Engineer with an MS in Energy Technologies (Polytechnic University of Madrid), a PhD in Nuclear Engineering (University of Wisconsin-Madison, USA) and an MBA (Averett University). She chose to study nuclear engineering because she knew that the world would need energy to power economic development, and she hoped that this field would allow her to make a significant contribution. Sama recently took up duties as a Nuclear Power Engineer, working in the formulation, development and implementation of activities related to the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO). She is a project manager in activities covering technical aspects of design and technology development of innovative nuclear reactors, fuel cycles and other reactor concepts. Although moving to Vienna required some logistics, including bringing her two medium size dogs, she enjoys the opportunity of participating in projects that truly have an impact and result into meaningful decisions.

For Xiaoping Li (China), a Power Engineer/Economist with a bachelor of engineering in Energy and Power from Xi'an Jiaotong University, working at the IAEA is a global experience in a comfortable and family-friendly working environment. Xiaoping also has an MSE in nuclear engineering and radiological science (University of Michigan, Ann Arbor). She decided to apply for a post at the IAEA after watching a television interview to the Director General, while she was working in a nuclear power plant in China. She works on infrastructure and planning issues for nuclear power plant economics, feasibility studies and project management, including technical cooperation activities. The fact that the work encompasses 149 countries makes it even more interesting and challenging.

Bitsit Fisseha Tekeste (Ethiopia) initially came to the IAEA for a 6-month internship as part of her Masters degree in Instrumentation, Information and System Sciences (Universite Claude Bernard Lyon I, France). Some months later she came back as a consultant to assist the Division in the implementation of the web-based international database on Digital I&C Products, Platforms, and Projects related to Nuclear Power Plant Instrumentation and Control (I&C) Modernization Projects and New Builds (the IDIP database). For Bitsit, this is a unique experience to acquire knowledge in different fields and from diverse sources.

Before joining the IAEA in 1997, **Kerstin Dahlgren Persson (Sweden)** was the Head of the Department of Man, Technology, Organization (MTO) at the Swedish Nuclear Power Inspectorate (SKI).Given her psychology degree (PhD in Industrial Psychology, University of Stockholm), Kerstin never thought of applying to the IAEA, but she was invited to work at the Division of Nuclear Installation Safety as a Safety Culture Specialist responsible for developing IAEA Safety Culture Services. She joined the Division of Nuclear Power in 2006 to work on the revision of and integration of safety culture into the IAEA Safety Standards on Management Systems and to develop guidance in the areas of management systems and culture, leadership, ethics, human performance, continual improvement and change management.

Anne-Isabelle Casset (France) came to the IAEA for a 6-month internship, because she was interested in some IAEA pilots on technical research projects related to nuclear power plant design and performance, which is a central part of her studies. She went back to her university in Karlsruhe at the end of July to finish her studies in mechanical and industrial engineering.

Anne Katrine Starz (USA) is a Cost Free Expert (CFE) from the US Department of Energy, assisting countries to introduce nuclear power. Her diplomatic, policy and international science and technology cooperation experience are put to good use in advising countries in the early stages of a nuclear power programme. She is a technical officer on technical cooperation projects related to national infrastructure development and also serves as the INPRO area coordinator for infrastructure. Before joining the IAEA, she was a science attaché for nuclear energy at the US Mission to the IAEA, and has previously managed international cooperative programs for the US Department of Energy. Anne has an MA in International Commerce and Policy (George Mason University).

Contact: S.Bilbao@iaea.org; X.Li@iaea.org; B.Takeste@iaea.org; K.E.Dahlgren@iaea.org; A.Starz@iaea.org; and L.Mereles.gonzalez@iaea.org.

Message from the Director

Welcome to the September issue of the Newsletter from IAEA's Division of Nuclear Power.

By following an established tradition, the September version of the newsletter is organized in a way to focus on review type articles overviewing specific areas of interest rather than sharing information on the results of recent meetings.

Because the expectation for the role of nuclear power is rising, and more countries begin to consider embarking on nuclear power programmes and ask the IAEA for assistance, the Division needs more staff members. The capacity and competence of the workforce in the Division is of paramount importance in delivering quality documents and services to the IAEA Member States. Therefore, we are paying strong attention to recruit competent professions, as are other companies and organizations in the nuclear power community. Although not so many women are working in the nuclear power community, we have been quite successful in recruiting excellent female professionals as is reported by the first article in this newsletter. As other positions in the Division of NP become vacant, I would like to encourage you to consider working for an international organization, which is quite rewarding in the context of working for those who need your expertise, for achieving equity in time (across generations) and space (special attention to the needs of developing countries) toward sustainable development, and for maximizing the benefits from the use of nuclear energy. IAEA vacancy notices are posted at http://recruitment.iaea.org/phf/p_vacancies.asp.

Contact: A.Omoto@iaea.org.

Nuclear Power Overview

Historical development of nuclear power

Nuclear reactors have provided electricity since 1954. Figure 1 shows that the most extensive development was in the 1970s in North America, in the 1980s in Europe and in the last decade in Asia.

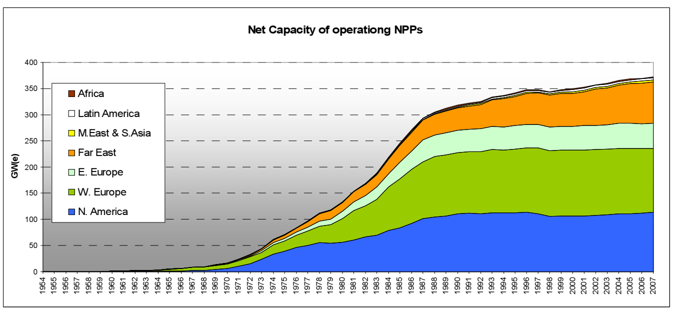


Figure 1. Development of nuclear power

Figure 2 provides an overview of power rector constructions by regions. The number of reactors under construction reached 233 reactors in 1979. From the 1980s on, this has reduced to around 30. Nowadays nuclear power construction is concentrated in Asia and Eastern Europe. Expansion in Asia can be illustrated by the fact that 20 of the 35 reactors under construction are in that region, and that over the last 8 years, 23 of the 31 grid connections were in that region.

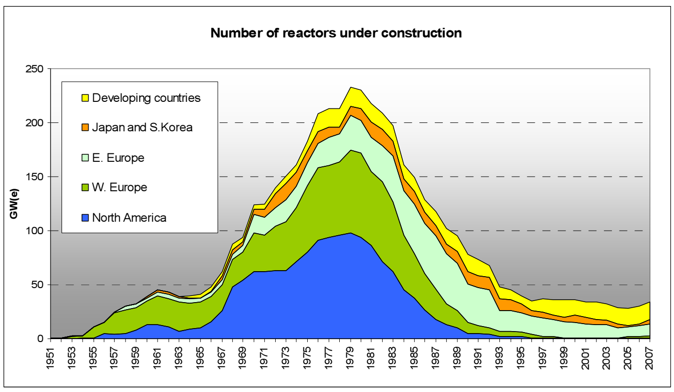


Figure 2. Construction of new reactors

Current status of nuclear power

As of the middle of 2008, worldwide there are 439 operational nuclear power plants (NPP) totaling 372 GW(e) of capacity. Nuclear energy industry is conscentrated in Europe, North America and in Asia as illustrated on Figure 3. In addition there are 5 operational units in long-term shutdown with a total net capacity 2.9 GW(e).

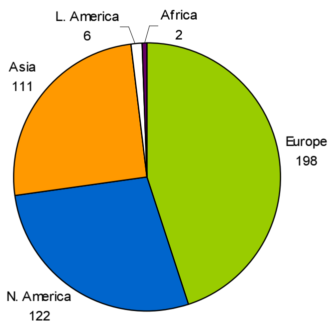


Figure 3. Number of reactors by region

Thirty-five reactor units with a total capacity 29.2 GW(e) are under construction. To date, 2008 has seen the construction start of two new units, viz.: Ningde 1 in China, and Novovoronezh 2-1 in Russia.

In the current fleet of operational power reactors the pressurized water reactor (PWR), which includes also the Russian PWR design (WWER), is the dominant reactor type as shown in Figure 4. PWR units represent 65.4% of installed nuclear capacity. Boiling water reactors (BWR), including the advanced boiling water reactor (ABWR), represent 22.9% of installed capacity. All other reactor types total only 11.7% of installed nuclear capacity.

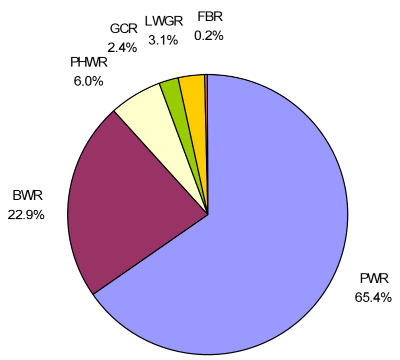


Figure 4. Nuclear capacity by reactor type

Capacity and production in 2007

Energy production of nuclear power plants is a result of an installed capacity and effectiveness of its utilization.

In 2007 there was no permanent shutdown, compared to eight in 2006, therefore the installed capacity was driven by investment into construction of new NPPs and into power uprating of existing reactor units. Three new reactors were connected to the grid and one long-term shutdown reactor was reconnected. The total installed capacity of the nuclear industry has risen from 369.8 to 372.2 GW(e) during 2007.

Utilization of installed capacity can be measured by the energy availability factor (EAF). It is the percentage of maximum energy generation the plant is ready to supply to the electrical grid to meet its demand.

In Figure 5 the yellow bars show the growth in installed capacity since 1990 (measured against the left scale) and red bars show the growth in global nuclear electricity production (measured against the right scale). The installed capacity is represented by values at the end of each particular year. This may cause a 'lagging effect' between capacity and production values in some years, especially with permanent shutdowns just at the end of a year.

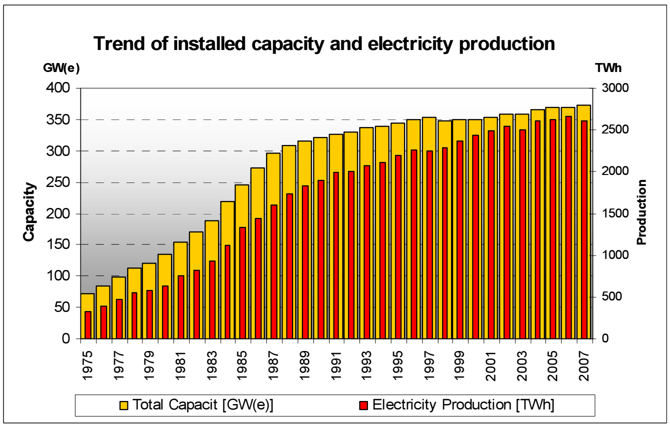


Figure 5. Nuclear energy production

In 2007, nuclear electricity production dropped to 2608 TW•h compared to 2661 TW•h in 2006 when the nuclear production reached the historical maximum.

In spite of the 'lagging effect' of permanent shutdowns at the end of 2006 the main reasons for decreased nuclear production in 2007 can be found in availability of nuclear reactors

The average worldwide EAF was 81% in 2007, the. Half of the nuclear reactors operated with EAF above 85% (worldwide median value). The top quarter of reactors reached EAF above 91%.

Figure 6 shows a trend of EAF since 1990. In the 1990s, the EAF increased continuously by an average of ~1% per year, reaching the value of 84% in 2002. Over the last years, this trend was halted, and the EAF dropped to 81%. In 2007, the EAF decreased by 2%. A consequence of this decrease can be illustrated by the following deduction: considering the number of operating reactors and their capacity this drop is equivalent to the shutdown of ~8 reactors.

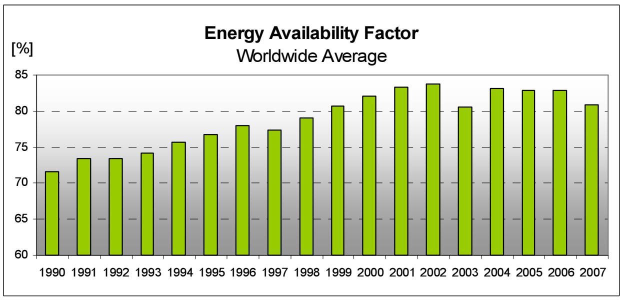


Figure 6. EAF trend

Breaking down the EAF by reactor type, the high availability of PWRs, PHWRs and BWRs is illustrated on Figure 7. Results for BWRs were affected by the TEPCO case in 2003, and by the July 2007 earthquake in north-western Japan and its effect on seven reactor units of the Kashiwazaki-Kariwa nuclear power station. Both those significant unusual outages contributed to the global nuclear production drop in 2003 and 2007 but looking on the trends of PWR, PHWR and especially GCR it is obvious that the problem is more general. Analysing EAF by region the 2007 results show a significant drop of availability in Far East Asia, Western Europe, Middle East Asia and Latin America.

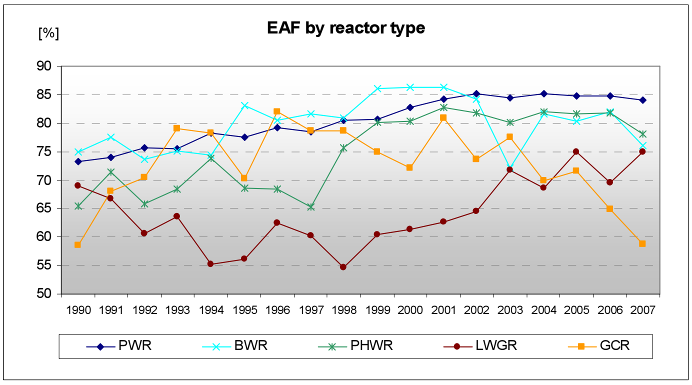


Figure 7. EAF for the most common reactor types

Figure 8 shows that the declining trend of NPP availability in last years results in drop of its contribution to production growth. Three years ago the analyses of factors contributing to increased nuclear electricity production in 15-years period 1990-2004 showed that improved plant utilization (energy availability) was the leading contributor, accounting for 57% of the production increase.

The same analysis was repeated for the period 1993-2007. In the updated analysis contribution of improved utilization dropped from 57% to 50%. New capacity as a result of NPP construction and permanent shutdowns contributed in this period by 39%. Contribution of power modification of existing reactor units (uprates, derates) has increased from 7% to 11%. .

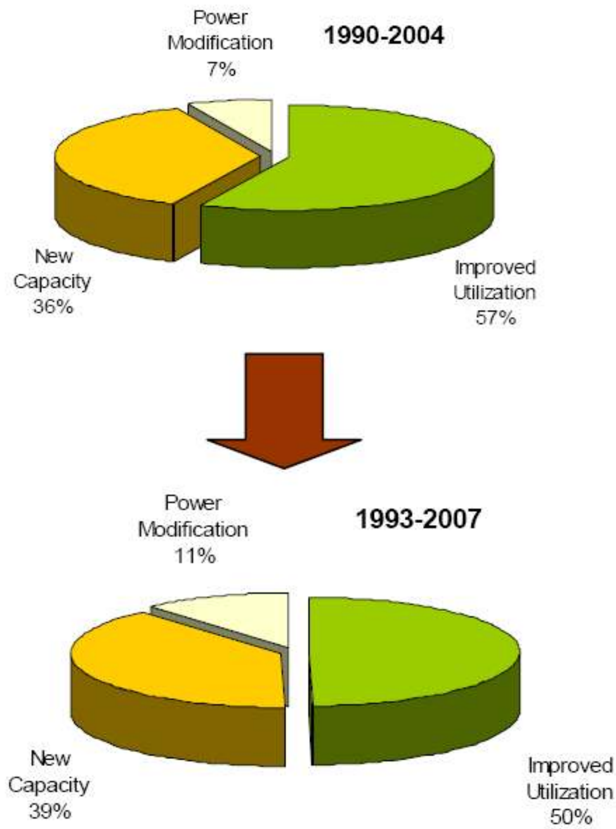


Figure 8 Contributions to nuclear production growth

The trend of plant availability in last years suggests that operating utilities should reinforce their programmes for more effective utilisation of the installed capacity.

Planned energy production losses related to maintenance activities and refuelling are generally the main contributor to plant unavailability. Frequency and organization of planned outages are determined in principle by reactor design but experience shows that for all reactor types there is space for improvement in planned outage management.

Contact: J.Mandula@iaea.org.

NPP Instrumentation and Control Technologies

Instrumentation and control (I&C) systems along with human-system interfaces (HSI) are complex technologies that enable NPP personnel to operate the plant effectively and safely. These systems perform protection, control, supervision and monitoring functions and are vital parts of normal, abnormal and emergency operations.

Obsolescence concerns and progress in electronics and information technology (IT) have created incentives to replace traditional analog I&C systems in nuclear power plants with digital I&C systems, i.e. systems based on computers and microprocessors. Digital systems offer higher reliability, better plant performance and additional diagnostic capabilities. Analog systems will gradually become obsolete in the general IT shift to digital technology. About 40% of the world's operating reactors have been modernized to include at least some digital I&C systems. Most newer plants also include digital I&C systems.

Digital I&C systems have posed new challenges for the industry and regulators, who have had to build up the methods, data and experience to assure themselves that the new systems meet all reliability and performance requirements. In general, countries with more new construction of nuclear reactors have had greater incentives and opportunities to develop the needed capabilities.

The importance of safety critical digital I&C and HSI applications in NPPs had led the IAEA to organize several technical meetings on these subjects:

- Lessons Learned in Large Modernization Projects in NPP I&C Systems
- Modernization Projects of NPP Instrumentation and Control Systems Related to Power Uprates and Licence Renewals Project
- Implementing and Licensing Digital I&C Systems and Equipment in NPPs
- Integration of Analog and Digital Instrumentation and Control Systems in Hybrid Main Control Rooms at Nuclear Power Plants
- Common-Cause Failures in Digital Instrumentation and Control Systems of Nuclear Power Plants
- Increasing Power Output and Performance of Nuclear Power Plants by Improved Instrumentation and Control Systems

In addition, the IAEA has initiated a new Coordinated Research Programme (CRP) on Advanced Surveillance, Diagnostics, and Prognostics (SDP) Techniques Used for Health Monitoring of Systems, Structures, and Components in Nuclear Power Plants. The project identifies research required in the fields of on-line monitoring, diagnostics, and performance prediction including data acquisition, processing and analysis techniques, integration, overall system operation and maintenance. Emphasis is given to (1) increased SDP needs in existing NPPs arising from power uprates and license renewals and (2) built-in SDP capabilities in new NPP designs.

A workshop on Neutron Fluctuations, Reactor Noise, and Their Applications in Nuclear Reactors will be held from 22 to 26 September 2008, at the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy. The purpose of the workshop is to provide the participants with the knowledge of fundamental theories, equations, relationships, and applications of stochastic processes taking place in nuclear reactors. Practical applications of signals noise analysis in nuclear power plants will also be discussed with an emphasis on instrumentation and control systems for surveillance, diagnostics, and prognostics. The workshop is intended for scientists, researchers, engineers, and university personnel interested in broadening their understanding of the subject.

A technical meeting titled Impact of Digital I&C on the Operation and Licensing of Nuclear Power Plants will be held in Beijing on 3-6 November 2008, hosted by the China Nuclear Power Engineering Company Ltd. The purpose of the meeting is to discuss the benefits and challenges of using digital technologies in the instrumentation, control, and information systems of nuclear power plants and to further develop a technical document on the topic. A two-day technical visit to the Tianwan NPP is planned after the meeting

Digital I&C systems are expected to continue as an area of rapid technological development. Future designs of NPPs will require new solutions both in sensing technologies and in digital control. Advanced sensors, detectors, transmitters, and data transmission lines are needed to meet the requirements imposed by the operating conditions of new designs (e.g. high temperatures and high flux) and the harsh environment of 'beyond design basis' conditions.

Additional meetings and workshops are planned to discuss the impact of digital technology on how NPP I&C systems and human-system interfaces are designed, implemented, licensed, operated, and maintained.

For more information please visit
http://www.iaea.org/NuclearPower/IandC/

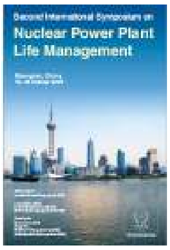
Contact: O.Glockler@iaea.org.

Integrated NPP Life Cycle Management

Recognizing the importance of this issue and in response to the requests of the Member States the IAEA Division of Nuclear Power implements the sub-programme on Engineering and Management Support for Competitive Nuclear Power. Three projects within this sub-programme deal with different aspects of the NPP life cycle management with the aim to increase the capabilities of interested Member States in implementing and maintenance of the competitive and sustainable nuclear power.

From the nuclear industry perspective, if nuclear power plant utility choose to pursue longer term operation beyond their initial licensing renewal term (i.e. beyond 60 years), there are no current regulatory prohibitions. However in keeping with the long established philosophies of ensuring public health and safety, nuclear industry would be required to demonstrate that such extended plant operations may continue to be conducted in a safe manner. The particular project deals with this specific issues to support longer term operation including aspects of ageing phenomena and their monitoring, issues of control and instrumentation, maintenance and operation issues, economic evaluation of plant life management (PLiM) including guidance on its earlier shut down and decommissioning.

Second International Symposium on Nuclear Power Plant Life Management



The Second International Symposium on Nuclear Power PLiM was held on 15−18 October 2007 at Shanghai, China in cooperation with China Atomic Energy Authority (CAEA) and China Nuclear National Corporation (CNNC). The objective of the symposium is to emphasize the role of PLiM programmes in assuring safe and reliable nuclear power plant operation.

The IAEA is in a position to be one of the global focal points and drivers of PLiM for long term operation (LTO) programme in Member States. In the 2nd PLiM symposium, about 300 participants from 35 Member States and 3 international organizations participated and 175 papers were submitted to present in keynotes, oral and poster sessions. The symposium programme contained 10 keynote speakers, 18 technical sessions, a panel session, a poster session as well as exhibitions on destructive examination, investigation on material degradation, pressurized heavy reactor and software demonstration forums.

These documents are available through the ENTRAC database (http://entrac.iaea.org/Default.aspx).

Master Curve Approach to Monitor Fracture Toughness of Reactor Pressure Vessels in Nuclear Power Plants Vessel in Nuclear Power Plants (CRP results)

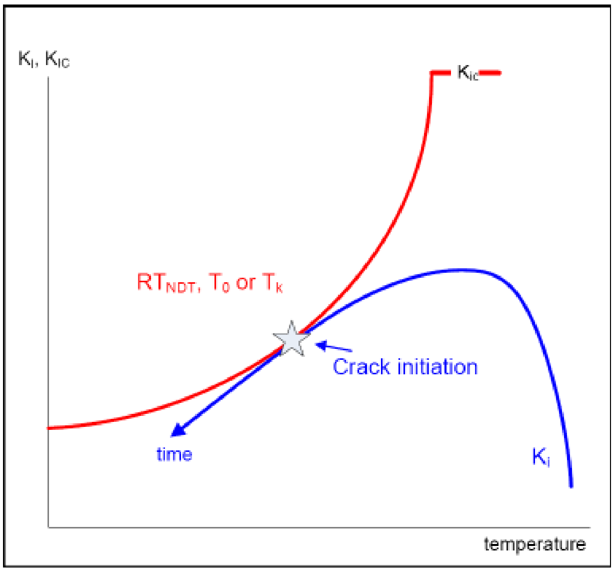
The coordinated research project (CRP) is a continuation of previous successful CRPs on resolving technical issues associated with application of the master curve (MC) approach to reactor pressure vessel (RPV) integrity assessment. Overall objectives of the CRP include:

- Better quantification of fracture toughness issues relative to testing surveillance specimens for application to RPV integrity assessment, and
- Development of approaches for addressing MC technical issues in integrity evaluation of operating RPVs.

In the final evaluation for the application of the master curve in RPV, three key areas were identified as needing further work by previous CRP. After polishing the draft technical document and collecting all of test data, the final technical document will be published in 2008.

Review and Benchmark of Calculation Methods for Structural Integrity Assessment of Reactor Pressure Vessels during Pressurized Thermal Shock (CRP results)

The Coordinated research programme (CRP) on review and benchmark of calculation methods for structural integrity assessment of reactor pressure vessels during pressurized thermal shock (PTS) event is to review the results of benchmark deterministic calculations of a typical PTS regime and to prepare technical report series. A total of ten experts from 8 Member States and JRC-IE participated in the CRP.



Determination of RT_{NDT}, T_O or T_k

The overall objective of this CRP was to perform benchmark deterministic calculations of a typical PTS regime with the aim of comparing effects of individual parameters on the final RPV integrity assessment, and then to recommend the best practices for their implementation in PTS procedures. This will allow better technical support to NPP operation safety and life management. After the 3rd research coordinated meeting to be planned on 25–29 August 2008 in Vienna, the final technical documents will be published in 2009.

Technical Indices of Ageing Degradation Mechanisms (International Generic Ageing Lessons Learned (GALL) /Knowledge base)

The objective if this project is to use the US GALL (Generic Ageing Lessons Learned) report (NUREG-1801) together with international ageing experience, in order to produce an international equivalent to the GALL report which addresses WWERs, CANDUs, and Western BWRs/PWRs.

The objective mainly has the following two aspects:

- to cover potential ageing degradation mechanisms for SSCs of LWRs and CANDUs major Member Sates are taking into account;
- to cover good ageing management programmes major Member Sates are taking into account are implementing or planning for the above mentioned ageing degradation mechanisms.

Structure of international GALL

Since this activity needs certain amount of work and continues at least two years, the meeting will be followed by two to three CS meetings and one technical meeting. The final technical documents will be published in 2010.

Guidelines and Experience on Power Uprating and Side Effects in Nuclear Power Plant

The process of increasing the licensed power level of a commercial nuclear power plants (NPPs) is called a ‘power uprate’. Power uprates are generally categorized based on the magnitude of the power increase and the methods used to achieve the increase.

Currently a significant number of the nuclear power plants have plans for power uprate by larger or smaller amounts. In most cases this is an economic way of producing more electricity in a nuclear power plant, and which has attracted interest due to increased electricity prices; a situation that is expected to remain. The increase in the electricity produced in a nuclear power plant can be achieved in two ways.

One way of increasing the thermal output from a reactor is to increase the amount of fissile material in use. Optimization of the reactor core can also be done. The amount of fissile material is increased either by increasing the degree of enrichment, or by increasing the density of the fuel. Optimization of the fuel reload aims at increasing the output from the fuel bundles with less power without affecting the high power bundles. This calls for the management of extra fuel bundles on every refuelling. It is also possible to increase the core power by increasing the performance of the high power bundles.

Safety margins can be maintained by either using fuels with a higher performance, or through the use of improved methods of analysis to demonstrate that the required margins are retained even at the higher power levels. The technical document will be published in 2008.

Heavy Components Replacement in Nuclear Power Plants: Procedure and Experience

The replacement of heavy components is the result of widespread stress corrosion of Inconel 600 (and alloys 82/182) in the primary system. Following the corrosion of steam generator tubes, which led to the first steam generator replacement (SGR) operations, work has begun on reactor vessel head replacements (RVHR) and pressurizer replacements, pending treatment of the dissimilar butt welds (DBW).

A view of steam generator replacement: steam generator rigging inside a containment

Utilities are looking for ways to optimize plant lifetime, and must therefore prevent stress corrosion in primary components, while combating other phenomena, such as thermal fatigue or certain metallurgical weaknesses. Since the early 2000s, the driving factors for main component replacements are more complex and interconnected. In respect of the regulatory safety issues, Operators have developed economic models that help them make their decision on main components replacements and fix the optimum dates.

Component replacement is often the most feasible solution to solve the problems associated with primary water stress corrosion cracking (PWSCC) of Alloy 600. Even if mitigation and /or repair were a local solution, replacement offers many advantages when addressing the assortment of potential susceptible parts contained in a major component. The replacement of heavy components is the result of widespread stress corrosion of Alloy 600 (and alloys 82/182) in the primary system. Following the IAEA's efforts addressing corrosion of steam generator tubes, which led to the first steam generator replacement (SGR) projects, the IAEA has begun work to share information on reactor vessel head replacements (RVHR) and pressurizer replacements.

Contact: M.Kearney@iaea.org, K.Kang@iaea.org.

Management Systems

The recently published IAEA Safety Standards No. GS-R-3: The Management System for Facilities and Activities and Safety Guide No. GS-G-3.1: Application of the Management System for Facilities and Activities reflect the principles of integrated management systems, the key characteristics of a strong safety culture and the broad agreement that has emerged on the relationship between management systems and safety culture. The last safety guide from the set of management system safety standards is DS349 (The Management System for Nuclear Installations) which provides recommendations how to meet the requirements for management systems that are established in GS-R-3 and supplements GS-G-3.1 providing guidance specifically for nuclear installations. It supersedes Safety Guides Q8–Q14 of Safety Series No. 50-C/SG. DS349 is submitted to the Commission of Safety Standards for final approval and it is expected top be published early 2009. With the publication of DS349 the set of management system safety standards will be complete.

GS-R-3 and the associated safety guides are widely used in the Member States. This is reflected in GC51 where the GC commended the IAEA's efforts in the area of management systems, recognizes the importance of strong leadership and effective management for safe and reliable performance of nuclear facilities.

The standards were promoted in a number of workshops and meetings. For the European region a workshop was held in Vienna, November 2007 and for Latin America in Bariloche April 2008. The workshops recognized that the IAEA's safety standards are very beneficial for Member States and the integrated approach to management systems results in an increased focus on safety and safety culture.

The workshops concluded that there is a need for additional guidance from the IAEA on the transition to an integrated system, the management of large projects such as the construction of new NPPs, the introduction of strong safety culture in countries embarking on nuclear power, and on the assessment by regulators of integrated management systems.

The IAEA is encouraged to continue providing guidance and services to Member States on integrated management systems with a view to enhancing safety and safety culture.

The Nuclear Power Engineering Section provides support to Member States in enhancing and continually improving their management system, including safety culture. This support is based on the IAEA Safety Standards for Management Systems. This CIMS (Continual Improvement of Management Systems) service is focused on assisting nuclear organizations in how to perform self-assessments as a basis for identifying areas for improvement and provide advice on international best practices in how to enhance and continually improve their management system and safety culture.

The successful application of management systems and the development of a strong safety culture rely heavily on the leadership of the organization. The IAEA is developing guidance on how to develop proper nuclear leaders with a focus on the specific challenges facing nuclear organizations. Included in these efforts will be the provision of forums in order for nuclear leaders to share experiences and learn from each other.

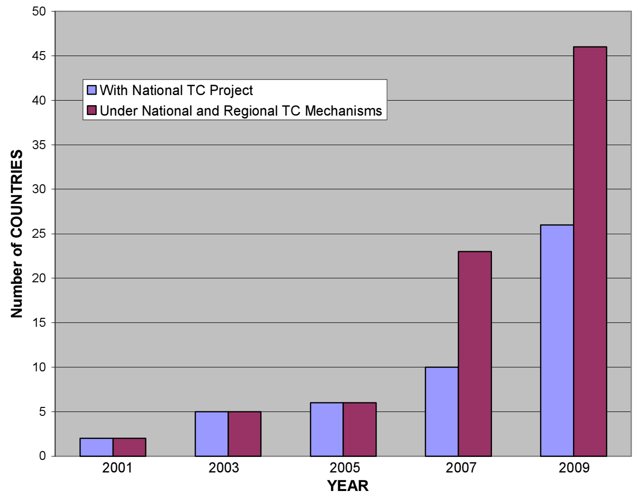
In order to properly monitor the effectiveness of the application of the management system and the developmental stages of the safety culture nuclear organizations need to have a proper set of indicators. The IAEA is developing indicators for management systems and safety culture that are proactive in nature i.e. so called leading indicators, which aim at tracing at an early stage degradations in activities known to have a strong impact of the successful application of the management system and the development of a strong safety culture.

Contact: k.dahlgren@iaea.org, p.vincze@iaea.org.

Strengthening Nuclear Power Infrastructure

Member States that are considering the introduction of nuclear power face the challenge of building the necessary national nuclear infrastructure for the first NPP. The IAEA response to this demand is provided through increased technical assistance, missions and workshops, and with new and updated technical publications.

The figure that follows shows that renewed interest in nuclear power has resulted in a dramatic increase in demand for IAEA assistance. For the upcoming 2009-2011 period, 46 IAEA Member States have asked for Technical Co-operation assistance in considering the introduction of nuclear power (26 through national projects, and a total of 46 when considering both national and regional projects). For the current (2007-2008) period, there was also a significant increase from the preceding period; with 10 national and 2 regional Technical Cooperation projects providing support to a total of 23 Member States.



Countries Requesting IAEA Assistance

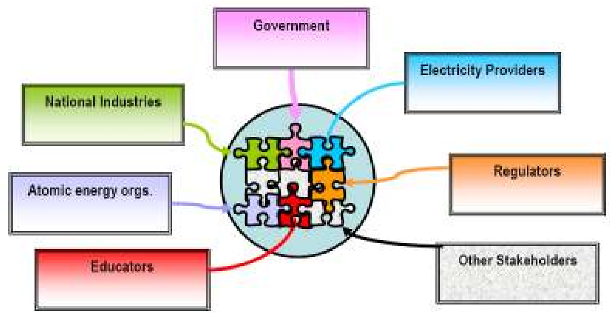
The following paragraph provides information regarding upcoming meetings and documents related to nuclear power infrastructure.

A workshop on Evaluation Methodology for Nuclear Power Infrastructure Development is planned from 10-12 December 2008 in Vienna, with co-sponsorship by the Governments of Canada, China, France, India, Japan, Republic of Korea, Russian Federation and United States of America. This is a continuation of the workshops on nuclear power infrastructure development held in December 2006 and November 2007. The 2008 workshop on evaluation of infrastructure development will also include special sessions on the NEPIO (Nuclear Energy Programme Implementing Organization) which is the organizations created by a government to study the introduction of nuclear power.

Regarding technical publications, a new NE Series Technical Report on Evaluation of National Nuclear Infrastructure Development Status is planned to be issued in September 2008. It provides an evaluation approach based upon the guidance laid out in the publication NG-G-3.1 Milestones in the Development of a National Infrastructure for Nuclear Power.

The following NE Series Technical Reports are in advanced development and are planned to be finalized during 2008:

- Competencies of the Owner-Operator
- Issues Improving Prospects for Financing Nuclear Power Projects
- Responsibilities and Competencies of a Nuclear Energy Programme Implementing Organization (NEPIO)



Nuclear Energy Programme Implementing Organization (NEPIO)

involves many organizations in planning for a Nuclear Power Programme

Work is going on in the preparation of the following NE Series Technical Reports planned to be finalized during 2009:

- Technology Assessment of NPPs
- Evaluation of Bids for Nuclear Power Plants
- Managing Sitting Activities for Nuclear Installations
- Work Force Planning for New Nuclear Power Programmes

Regarding future technical guidance, there are additional aspects of nuclear infrastructure — beyond those covered in the documents described above — where existing IAEA publications need updating. The target audience is those countries considering the introduction of nuclear power. In addition to the planned new or revised publications for 2009 and beyond will cover the following:

- industrial capacity and availability in light of the expected growth in nuclear energy,
- infrastructure issues related to alternative contracting and ownership policies.

Considering the number of Member States that plan to order their NPPs in the near future, special focus will also be given to increasing advice on infrastructure preparation needs during the phase following the agreement of a contract for the first NPP. Specific guidance based upon recent international experience will be developed to help effective management and implementation of the NPP construction and commissioning phase.

Contacts: T.Mazour@iaea.org, I.Facer@iaea.org, X.Li@iaea.org, V.Nkong-Njock@iaea.org, A.Starz@iaea.org, N.Pieroni@iaea.org.

Human Resource Development

A reliable supply of competent personnel is one of the biggest challenges for the entire nuclear power industry. Availability of human resources impacts on the mature industries (operating nuclear facilities, decommissioning, phasing-out or expanding); and those that are establishing nuclear power programmes. We monitor the human resource development needs of Member States in the nuclear field. Some important trends and challenges, and the IAEA responses, are presented in the table below:

Trend / Challenge	Relevant Activities of Division of Nuclear Power of IAEA
Effective management of human resources, integrated into management systems, for a broad spectrum of nuclear facilities for their entire life cycles	• A new Nuclear Energy Series Guide on Managing Human Resources in the Field of Nuclear Energy is being prepared for publication in 2008. • The Technical Working Group (TWG) on Training and Qualification of NPP Personnel has been transformed into a TWG on Managing Human Resources in the Field of Nuclear Energy. • Training courses and workshops on integrated management of human resources are regularly provided (on a regional basis and for individual countries and nuclear facilities). • Support to industry decision-makers and managers in establishing long-term strategic visions for development of human resources is provided through assistance in the development of strategic documents, conducting meetings, and advisory services by the IAEA's staff and international experts.
Ageing workforce	• IAEA-TECDOC-1510 The nuclear power industrys ageing workforce: Transfer of knowledge to the next generation and other related documents published. • Training courses and workshops performed. • Technical cooperation activities on knowledge preservation and transfer and assist visits conducted.
Expanding nuclear power sectors and the need for guidance regarding commissioning	• A Nuclear Energy Series report NG-T-2.2 Commissioning of Nuclear Power Plants: Training and Human Resource Considerations published in 2008. • Technical cooperation projects address human resource development and training for commissioning.
The need for competent human resources for increasing number of decommissioning projects all over the world	• A Nuclear Energy Series report NG-T-2.3 Decommissioning of Nuclear Facilities: Training and Human Resource Considerations published in 2008. • Technical and management training for decommissioning is performed within technical cooperation projects. • Support to nuclear facilities in development of strategic long-term vision for human resources for the decommissioning of nuclear facilities.
Human resources is a critical element for establishment of infrastructure for new nuclear power programmes; the lack of expertise of 'newcomers' in this area.	• Nuclear Energy Series Guide NG-G-3.1 Milestones in the Development of a National Infrastructure for Nuclear Power published in 2007 addresses Human Resource Development in detail. • A Nuclear Energy Series report Workforce planning for new nuclear power programmes is being prepared for publication. • Assist missions to Member States are performed. • Numerous technical cooperation projects to assist 'newcomers' in all regions are planned for the 2009-11 cycle.
Adequate professional ethics is one of the most important factors for nuclear power industry to survive, to avoid accidents and to cultivate the appropriate organizational culture.	• A Nuclear Energy Series report NG-T-1.2 Establishing a code of ethics for nuclear operating organizations published in 2007. • Professional ethics is addressed in nearly all training courses and workshops that have been conducted recently.
Competence of nuclear facility managers is a critical issue.	• Training courses and workshops for nuclear industry managers are performed on regional and national levels. • Technical cooperation activities include projects to train and develop managers for various phases (commissioning, operation, decommissioning).
The need for effective multi-purpose training tools.	• Meetings to share experience in this area are regularly conducted. • Advanced training tools (e-learning, simulators) are supplied to Member States through IAEA. • Training workshops on advanced simulator technologies for personnel training and engineering purposes performed. • IAEA-TECDOC-1500 Guidelines for Upgrade and Modernization of Nuclear Power Plant (NPP) Training Simulators published in 2006 and actively used. • A new Nuclear Energy report on training systems and training tools is planned for the 2010-11 cycle.
A systematic approach to training (SAT) is an effective and main tool for quality and efficient training, although support to introduce SAT is required.	• SAT methodology is addressed in the training courses for managers, staff and instructors. • Technical cooperation projects include support to SAT introduction in many countries. • IAEA continually and regularly publishes documents in support of SAT implementation; the guidance in these documents is used in Member States.

Trend / Challenge	Relevant Activities of Division of Nuclear Power of IAEA
Authorization and re-qualification of Control Rom personnel is the issue in many countries, including mature nuclear power industries.	• IAEA-TECDOC-1502 Authorization of nuclear power plant control room personnel: methods and practices with emphases on the use of simulators published in 2006 is actively used in Member States.
Maintenance personnel performance and training, as well as contractors competence is an issue for nearly all NPPs.	• Technical meetings and workshops for managers and staff are being performed, and attract due attention of the industry. • Support to establish quality maintenance programmes and effective training facilities is provided. • A new Nuclear Energy Series report Achieving excellence in maintenance personnel performance through training and other management initiatives is prepared for publication in 2008-2009 cycle.
Adequate use of Human Performance Improvement (HPI) techniques is one of the key prerequisites for ensuring safety and efficiency of nuclear facilities.	• HPI is addressed at all training courses and workshops performed recently in various regions and countries for managers and staff. • A new Nuclear Energy Series report Improving Human Performance in Nuclear Facilities is being prepared for publication in the 2008-2009 cycle.

Visit ENTRAC : http://entrac.iaea.org.

Contact A.Kazennov@iaea.org, T.Mazour@iaea.org.

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

INPRO was established in 2001 in response to a resolution by the IAEA General Conference, in order;to help to ensure that nuclear energy is available to contribute, in a sustainable manner, to the energy needs in the 21st century; and to bring together technology holders and users to consider jointly the international and national actions required for achieving desired innovations in nuclear reactors and fuel cycles.

Membership in INPRO (2008)

As of August 2008, INPRO has 28 members.

Members of INPRO in 2008. (in green colour)

What is INPRO doing in Phase 2?

After developing a methodology usable for assessment of Innovative Nuclear System (INS) in the context of safety, economics, proliferation-resistance, security and others, INPRO, in summer 2006, moved to Phase 2 which includes the following ongoing activities.

Using the INPRO methodology to assess nuclear systems

The IAEA assists Member States in the use of the INPRO methodology for assessing and selecting innovative nuclear systems. The INPRO methodology has been applied in national assessment studies performed by Argentina, Armenia, Brazil, China, India and Ukraine, as well as the Republic of Korea. It has also been used in a joint assessment study of closed fuel cycles with fast reactors by Canada, China, France, India, Japan, Republic of Korea, Russian Federation and Ukraine.

The INPRO methodology is suitable to be used by both mature nuclear countries wishing to assess future innovative solutions and systems and by new countries wishing to embark on new nuclear programmes for assessing possible future nuclear systems in a holistic manner. In particular for the latter, the IAEA offers support in the application of the methodology, but also – beyond the framework of INPRO – a wide range of energy planning tools and nuclear programme planning support.

Vision on opportunities and challenges of nuclear energy development

INPRO is developing a vision on opportunities and challenges of nuclear energy systems to contribute to sustainable development in the medium and long term. INPRO supports its members' capacity building in scenario/vision analysis and provides reference cases of global and regional long-term development of INS.

Infrastructure and institutional innovation

INPRO is trying to address issues such as a regional approach to smooth deployment of innovative nuclear systems, and also studying legal and institutional aspect of non-stationary small sized reactors.

Common user considerations

In 2007, INPRO embarked on a new activity on common user considerations, aimed at identifying common considerations in prospective new user countries regarding nuclear systems.

Through the CUC activity, INPRO reached out to a total of twenty-six countries that are not members of INPRO itself. A report summarizing the considerations of developing countries regarding future nuclear energy systems to be deployed by those countries was compiled in 2008.

Collaborative projects

Collaborative Projects deal with technological issues that need to be addressed for improved economics, safety, proliferation-resistance and other topics under INPRO members' initiatives. , Four projects have started since September 2007: Investigations of the 233Uranium/Thorium Fuel Cycle (ThFC), Proliferation Resistance: Acquisition/Diversion Pathway Analysis (PRADA), Decay Heat Removal for Liquid Metal Cooled Reactors (DHR), and Global Architecture of Innovative Nuclear Systems based on Thermal and Fast Reactors including closed Fuel Cycles (GAINS).

An additional eight INPRO Collaborative Projects have been prepared and are open for Member States to join. These deal with various topics, such as removal of heat by liquid metal and molten salt coolants, fuel cycles for innovative systems, passive systems and components, environmental impact benchmarking, use of nuclear power in smaller countries, safety aspects of nuclear hydrogen production, availability assessment of raw materials and advanced water cooled reactors.

Coordination with GIF

INPRO and the IAEA work together with the Generation IV International Forum (GIF) in order to create synergy and to avoid overlap;

- by sending experts to the GIF Policy Group and to GIF working groups (Risk and Safety, Proliferation Resistance & Physical Protection, Evaluation Modelling);
- by reviewing each others document such as the evaluation methodologies as appropriate; and
- by organizing regular coordination meetings.

The differences between the two are:

1) Mission and activities: GIF is primarily focused on research and development of nuclear technology to meet global needs. INPRO has a broad variety of missions and activities, including providing a forum for experts on necessary innovation in nuclear energy, developing methodology to assess innovative nuclear systems, providing common user considerations for the deployment of nuclear power in developing countries, and facilitating inter-national cooperation on technological issues.

2) Membership: GIF membership is limited to those countries that can bring substantial resources and expertise to its R&D programs, whereas INPRO members include both developed and developing countries. INPRO is open to all IAEA Member States. Currently, all members of GIF are also members of INPRO.

Contact: P.Gowin@iaea.org.

Addressing technologies for achieving competitive economics for new water-cooled nuclear power plants

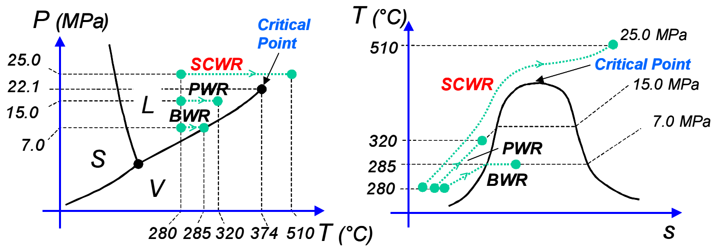
The IAEA's Major Programme on Nuclear Energy includes a Project on technologies for improving economics of advanced water cooled NPPs. nuclear power plants. Activities are conducted on the advice of experts from those Member States involved in advanced reactor development.

Achieving competitive costs presents a significant challenge. Proven means (such as standardization and series construction, multiple unit construction at a site, and others) are being incorporated for new plants, and new approaches are being pursued. New approaches include improvement of the technology base (i.e. more accurate databases of thermo-hydraulic relationships and thermo-physical properties, better neutronic and thermo-hydraulic codes, and further code validation); incorporation of passive safety systems for cases in which the safety function can be met more cheaply than with active systems; and development of systems with higher thermal efficiency (for example, the super-critical water cooled reactor - SCWR).

The Nuclear Power Technology Development Section (NPTDS) is carrying out activities addressing each of these new approaches:

Super-Critical Water Cooled Reactors (SCWRs)

SCWRs, operating thermodynamically above the critical point of water, promise to achieve improved economics through higher thermal efficiency and compact systems. The IAEA is conducting a CRP on Heat Transfer Behaviour and Testing of Thermo-hydraulic Codes for SCWRs. This CRP promotes international collaboration among IAEA Member States for the development of super-critical water-cooled reactors in the areas of heat transfer behaviour and testing of thermo-hydraulic computer methods.



Thermodynamic cycle of super-critical water-cooled reactors, compared to current day PWRs and BWRs

Organizations participating in the CRP include VTT (Finland), the University of Wisconsin (USA) KAERI (Rep. of Korea), Shanghai Jiao Tong University and the China Institute of Atomic Energy (China), Atomic Energy of Canada, Ltd (Canada), Bhabha Atomic Research Centre (India), the University of Pisa (Italy), Gidropress and the Institute of Physics and Power Engineering (Russian Federation), and the University of Manchester (United Kingdom). The CRP is being carried out in cooperation with the OECD-NEA.

Participants in the 1st Coordination Meeting for the CRP on SCWRs, 22-25 July 2008, Vienna Austria

Technology for Passive Safety Systems

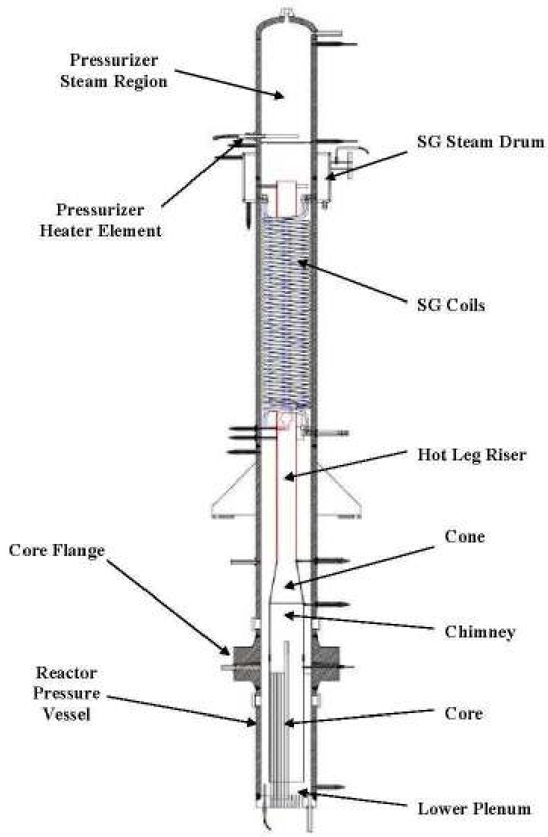
The IAEA is addressing passive safety system technology through its CRP on Natural Circulation Phenomena, Modelling and Reliability of Passive Systems that Use Natural Circulation. The CRP involves intense sharing of experimental data and analyses, and is enhancing understanding of natural circulation phenomena and models in water-cooled reactors. The organizations participating include CNEA (Argentina), CEA (France), FZ Rossendorf (Germany), Univ. of Pisa, (Italy), BARC (India), JAEA (Japan), KAERI (Rep. of Korea), Gidropress (Russian Federation), Paul Scherrer Institute (Switzerland), ENEA (Italy), IVS (Slovakia), the JRC Institute for Energy of the European Commission, Purdue University, Idaho State University and Oregon State University (USA), the University of Valencia (Spain), and AECL (Canada). The final RCM will be convened in November, 2008.

Courses on Natural Circulation in Water-Cooled Nuclear Power Plants

Building on the collective expertise in the above CRP on Natural Circulation, the IAEA presents a course on Natural Circulation in Water Cooled NPPs. During 2008 the course has been hosted by the Idaho National Laboratory (USA) in May, and by the International Centre for Theoretical Physics, Italy, in June.

Workshop participants 23-27 June 2008, Trieste Italy

Natural Circulation Stability and Accident Behaviour in Integral PWR



OSU MASLWR Test Facility: Reactor Pressure Vessel Key Areas

A new IAEA ICSP (International Collaborative Standard Problem) on Integral PWR Design Natural Circulation Flow Stability and Thermo-hydraulic Coupling of Primary System and Containment during Accidents has been prepared as a follow-up to the CRP on Natural Circulation Phenomena, Modelling and Reliability of Passive Systems that Use Natural Circulation. Oregon

State University has offered their experimental facility, and several organizations have indicated their interest in this ICSP. The scope includes two types of experiments: 1) single and two phase natural circulation flow stability test with stepwise reduction of primary inventory, and 2) loss of feedwater transient with subsequent ADS blowdown and long term cooling by primary-containment coupling. The series of experiments are scheduled to start in 2009 at Oregon State University. Participating organizations will perform blind and open simulation for experiments with their own computer codes.

HWR Thermal-hydraulic Computer Code Validation with SBLOCA Experimental Data

An ICSP on HWR code predictions with SB-LOCA experimental data was launched with the objectives of improving the understanding of important phenomena expected to occur in SB-LOCA transients, evaluating code capabilities to predict these important phenomena, their practicality and efficiency, by simulating an integrated experiment, and suggesting necessary code improvements or new experiments to reduce uncertainties. AECL volunteered to host this ICSP and will provide experimental data collected from RD-14M experiment for SBLOCA scenario. The organizations participating in the ICSP include CNEA (Argentina), AECL (Canada), Tsinghua Univ. (China), BARC and NPCIL (India), KAERI and KINS (Rep. of Korea), and SNN (Romania).

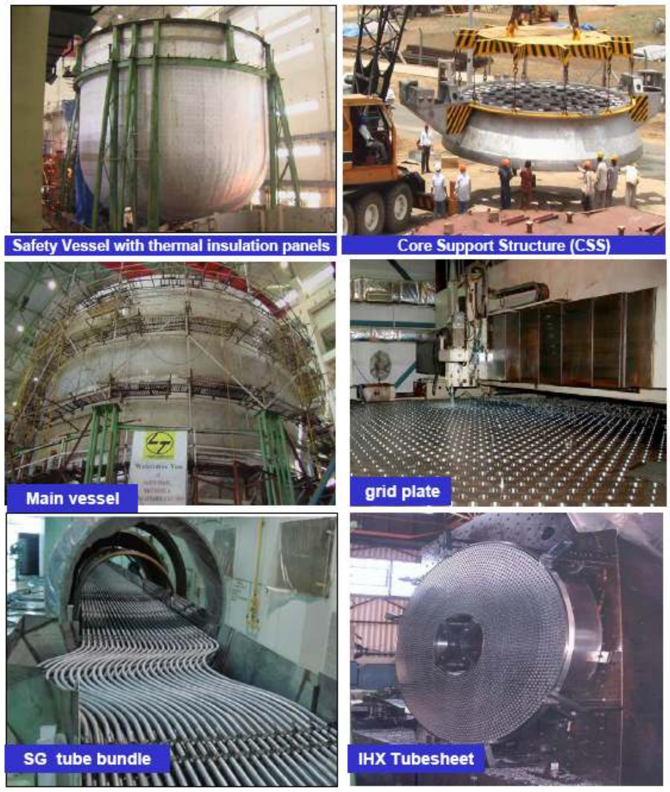
Benchmarking Severe Accident Computer Codes for HWR Applications

A new CRP on Benchmarking Severe Accident Computer Codes for HWR Applications has begun, and the first coordination meeting is planned early in 2009. This CRP will promote international collaboration among IAEA Member States through the benchmarking exercise to improve severe accident analysis capability for heavy water reactors (HWRs). The CRP scope includes defining the severe accident sequence and conducting benchmark analyses for HWRs, simulating phenomenological experiments(s) relevant to severe accidents and comparing the results with experimental data, and evaluating the capabilities of existing computer codes to predict important severe accident phenomena and suggesting necessary code improvements and/or new experiments to reduce uncertainties. The CRP has been planned on the advice and with the support of the IAEA Nuclear Energy Department's Technical Working Groups on Advanced Technologies for HWRs (the TWG-HWR). The CRP will be conducted by IAEA's Nuclear Power Technology Development Section, in cooperation with the Division of Nuclear Installation Safety.

Contact: J.Cleveland@iaea.org, J.H.Choi@iaea.org.

Technology Advances in Fast Reactors and Accelerator Driven Systems

For obvious sustainability reasons, spent fuel utilization and breeding are returning to centre stage, and with this the fast reactor as the necessary linchpin. In this rapidly evolving environment, in which renewed interest in nuclear energy is driven by the need to develop carbon free energy sources, demographics and development in emerging economies, as well as by security of supply concerns, fast reactor deployment is likely to be accelerated.



Progress made with component manufacturing for India's Prototype Fast Breeder Reactor (PFBR) under construction at Kalpakkam [courtesy of Indira Gandhi Center for Atomic Research (IGCAR) and Bharitiya Nabhikiya Vidyut Nigam Ltd (BHAVINI)]

There are indications that deployment of advanced prototype fast power reactors in both traditional fast reactor technology holders and new ones will materialize at the time horizon ~2020. This will be followed by a transition phase to commercial fast reactors and eventually by further innovation steps opening up the full potential of the fast neutron system and closed fuel cycle technologies with regard to both efficient utilization of the fissile resources and waste management. The necessary condition for successful deployment in the near and midterm is the understanding and assessment of technological and design options (based on both past knowledge and experience, as well as on research and technology development efforts).

The IAEA assists Member State activities in view of short and mid term fast reactor deployment by providing an umbrella for knowledge preservation, information exchange and collaborative R&D to pool resources and expertise.

On the other hand, to achieve the full potential of the fast neutron system and closed fuel cycle technologies with regard to both efficient utilization of the fissile resources and waste management, continued advances in research and technology development are necessary to ensure improving economics and maintaining high safety levels with increased simplification of fast reactor designs. The trend observed now shows that the group of Member States having fast reactor development programs is rapidly increasing, with emerging economies joining the traditional fast reactor technology holders and pursuing important fast reactor research and technology activities. The IAEA is the unique collaboration framework for all these players to work together to ensure that innovative fast reactor technology development stays focused on meeting aforementioned objectives.

Areas of collaboration are identified by Member States through participation in the IAEA Nuclear Energy Department's Technical Working Group on Fast Reactors (TWG-FR). The TWG-FR assists in defining and carrying out the IAEA's activities in the field of nuclear power technology development for fast neutron systems. It promotes the exchange of information on national and multi-national programs and new developments and experience, with the goal of identifying and reviewing problems of importance and stimulating and facilitating cooperation, development and practical application of fast neutron systems.

Major ongoing and planned (over the next 4 – 6 years) activities of this IAEA project include various Coordinated Research Projects (CRPs).

Recently, work on the CRP Studies of Advanced Reactor Technology Options for Effective Incineration of Radioactive Waste was completed. The participants had studied the transient behavior of various transmutation systems. The comparative investigations covered burner reactors and transmuters both containing fertile and fertile-free, so-called dedicated fuels. Results were presented in various external publications, and the draft final report is completed and will be submitted for publication as IAEA technical document.

Noteworthy is an ongoing CRP focusing on the preservation of the feedback from commissioning, operation, and decommissioning experience of experimental and power sodium cooled fast reactors. This CRP will produce lessons-learned/synthesis reports from the commissioning, operation, and decommissioning of experimental and power sodium cooled fast reactors. In its first stage, the CRP is focusing on operational feedback in three areas, viz. 'steam generators', 'fuel and blanket subassemblies', and 'structural materials'.

Work on the CRP on Analytical and Experimental Benchmark Analyses of Accelerator Driven System is also ongoing. The specific objective of this CRP 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. The participants in the CRP are performing computational and experimental benchmark analyses using integrated calculation schemes. To-date, the CRP has produced various external publications. It will be completed by the end of 2009.

Two new CRPs whose scopes include experimental research at two prototype fast reactors, viz. MONJU in Japan and PHENIX in France, were launched in September 2008. The former CRP, titled Benchmark Analyses of Sodium Natural Convection in the Upper Plenum of the MONJU Reactor Vessel addresses the natural convection behavior of the coolant in the reactor vessel of a sodium cooled fast reactor. The CRP participants will perform benchmark calculations focusing, in a first stage, on the numerical simulation of the sodium stratification measurements performed in the MONJU reactor vessel during the original start-up experiments. The latter CRP is centered on experiments planned before the final shutdown of PHENIX foreseen in early 2009. At this occasion, the French Commissariat à l'Énergie Atomique (CEA) is planning to implement a PHENIX end-of-life tests program. CEA, recognizing the unique opportunity offered by this tests program, is ready to open it for international collaboration within the framework, inter alia, of this CRP. The CRP will contribute towards enhancing participating Member States' analytical tools in the fields of neutronics, thermal hydraulics and mechanics. The CRP participants will perform blind pre-test, as well as post-experiment analyses of two tests, viz. the Control Rod Withdrawal Test and the Sodium Natural Circulation Test.

Looking ahead at the Programme and Budget Cycle for 2010–2011, IAEA projects on innovative fast neutron systems will continue to focus on issues addressing fast reactor economics, enhanced safety characteristics, sustainability, and public acceptance. CRPs in response to expressed Member States' needs, e.g. on topics like Source Term for Radioactivity Release Under Fast

Reactor Core Disruptive Accident Situations, Optimum Plant Parameters for Metallic and MOX Fuelled Fast Reactors, and Thermal-hydraulics, Code Benchmarking and Handling of Liquid Metal and Molten Salt Coolants at High and Very High Temperatures are planned. Last but not least, the IAEA projects on fast neutron systems technology development will continue fostering the exchange of technical information (by providing up-to-date status reports on fast neutron systems technology developments and convening topical technical meetings, workshops, symposia and conferences), maintaining scientific and technical databases relevant to fast neutron systems technology, viz. the 'Fast Reactor Database' and the 'Accelerator Driven Systems Database', as well as contributing jointly with the other advanced reactor technology development projects in IAEA's Nuclear Power Division to a WWW-based report on advanced NPP designs.

Visit: http://www.iaea.org/inisnkm/nkm/aws/fnss/index.html.

Contact: A.Stanculescu@iaea.org.

Common Technologies and Issues for Small and Medium Sized Reactors

There is continuing interest in Member States in the development and application of small and medium sized reactors (SMRs). 'Small' reactors are defined as those with an equivalent electric power less than 300 MW(e). 'Medium sized' reactors are those with an equivalent electric power between 300 and 700 MW(e). It is important that small or medium sized reactor does not necessarily mean small or medium sized nuclear power plant. Like any nuclear power plants, those with SMRs can be built several-at-a-site, or as twin units. In addition to this, innovative SMR concepts provide for power plant configurations with 2, 4, or more reactor modules. The units or modules could then be added incrementally in time taking benefits of the effects of learning, timing, construction schedule, and creating an attractive investment profile with minimum capital-at-risk, see Figure 1.

In the near term, deployment potential of the SMRs is based largely on their ability to fill niches where larger plants do not fit in, or to offer economic advantages related to incremental capacity increase. The applications could be industrial sites or population centres in remote off-grid locations, countries or country areas with small and medium electricity grids, investment and human resource conditions that benefit from incremental capacity addition, or non-electrical applications that require proximity of a nuclear energy source to the process heat application plant.

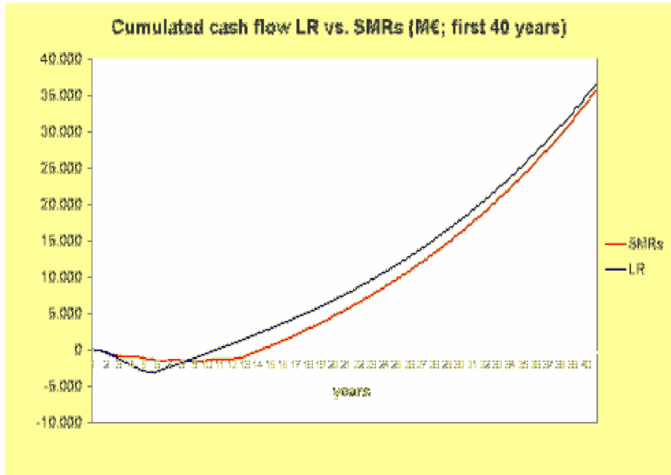


Fig.1. Time dependent cumulative cash flows (Euro million) for the construction and operation of a large reactor versus incremental build and operation of several SMRs of the same equivalent electric capacity

For the longer term, there is interest in innovative designs that promise improvements in safety, security, proliferation resistance, waste management, resource utilization, economics, product variety (e.g. desalinated seawater, process heat, district heat and hydrogen) and flexibility in siting and fuel cycles. Many innovative reactor designs have been proposed in the small-to-medium sized range, in many cases providing for multi-module plant configurations to achieve larger, often flexible, overall power station capacity.

Many of the niche advantages of SMRs are expected to be particularly attractive to some of the approximately 40 countries that have recently expressed interest in starting nuclear power programmes, for example, low investment increments and suitability for small grids. On the other hand, vendors in Argentina, China, India, Japan, the Republic of Korea, the Russian Federation, South Africa, and the USA are actively developing and promoting new SMR designs.

For about a dozen of innovative SMR designs, current progress in developing the technology and finalizing the design suggests possible deployment within the next decade. Construction began in June 2006 in the Russian Federation on a pilot floating cogeneration plant of 300 MW(th)/70 MW(e) with two water cooled KLT-40S reactors, see Fig. 2. Deployment is scheduled for 2010. In July 2006, the Russian Federation and Kazakhstan created a joint venture to complete design development for a 350 MW(e) VBER-350 reactor (basically a scaled-up version of the KLT-40S) for use in land-based co-generation plants. The first-of-a-kind plant deployment is targeted in 2015 at the former BN-350 site in Kazakhstan. Five integral PWR designs are in advanced design stages and commercialization could start around 2015: the 335 MW(e) IRIS design developed by International consortium led by Westinghouse, USA (currently co-owned by Toshiba Corp. of Japan); the 330 MW(th)

SMART design developed in the Republic of Korea for a co-generation plant; the prototype 27 MW(e) CAREM-25 developed in Argentina, for which construction in planned to be complete by 2011, and which is expected to further into commercial designs of 150 and 300 MW(e); the 200 MW(th) NHR-200 developed in China for district heating and other applications, both electrical and non-electrical; and the MASLWR of 45 MW(e) per module, developed in the USA, for multi-purpose applications and multi-modular plants of up to 540 MW(e). The 165 MW(e) PBMR, a high temperature gas cooled reactor with pebble bed fuel and direct gas turbine Brayton cycle, developed in South Africa, is-scheduled for demonstration at full size by 2012. Future configurations of this reactor will include 4 and 8-module plants. The 200 MW(e) per module HTR-PM, a high temperature gas cooled reactor with pebble bed fuel and indirect supercritical steam energy conversion cycle developed in China, is planned for a full size demonstration in 2013. Two-module plant configuration is foreseen for the commercial version of this reactor. The advanced heavy water reactor of 300 MW(e), developed in India for co-generation plants, is considered to be built early in the next decade. The reactor is being designed for operation with 233U-Pu-Th fuel and uses boiling light water coolant and heavy water moderator. All mentioned above SMRs provide for or do not exclude co-generation option with non-electric energy products being produced as well as the electricity.

Fig. 2. Artist's view of a floating nuclear cogeneration plant with two KLT-40S reactors (Russian Federation)

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. Several of such designs have a potential of being deployed as first-of-a-kind or prototype plants within the next decade. These include the ABV of 11 MW(e) and 8-year refuelling interval, which is an integral design PWR backed by marine reactor experience, and a couple of non water cooled reactors, which are the sodium cooled 4S reactor of 10-50 MW(e) and 10-30 year refuelling interval, developed in Japan, and the lead-bismuth cooled SVBR-75/100 reactor of 101.5 MW(e) and 6-9 year refuelling interval developed in the Russian Federation. The latter design is backed by operating experience of the Russian submarine reactors.

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 the key enabling technologies and in the resolution of the enabling infrastructure issues common to SMRs of various types. Within this project, the IAEA periodically produces and updates Status Reports and other publications on design and technology development for such reactors (the latest publication produced is IAEA-TECDOC-1536 (January 2007); they are downloadable free-of-charge from: http://www-pub.iaea.org/MTCD/publications/series1.asp).

The activities also include coordinated research projects (CRP) on important topics of design and technology development and assessment of various SMR options. A CRP Small Reactors without On-site Refuelling is in its last, fourth year with 16 participating institutions from 9 member states. The research topics include source term calculations to justify reduced off-site emergency planning for innovative SMRs, benchmarking for whole core depletion models of lead-bismuth cooled reactors, benchmarking for cells and fuel assemblies of light water reactors with coated particle based fuel, data and information exchange regarding fuel and coolant properties and progress in design development for the SMR concepts addressed, and inter-regional and intra-regional scenario studies for energy systems with small reactors without on-site refuelling. Upon an arrangement with the NEA OECD, several participants of this CRP from non-OECD countries participate in a benchmarking exercise for natural circulation of lead-bismuth coolant based on the tests performed in the HELIOS loop at the Seoul National University (Republic of Korea). The final research coordination meeting for this CRP will be convened on 3-6 November 2008, in Vienna. A Web page of the CRP is at: http://www.iaea.org/NuclearPower/SMR/CRP1/.

A new CRP entitled Development of Methodologies for the Assessment of Passive Safety System Performance in Advanced Reactors (2008-2012) has been approved and is collecting the applications for research agreements and research contracts. This project has the objective to determine a common analysis-and-test based method for reliability assessment of passive safety system performance. Such a method would facilitate application of risk-informed approaches in design optimization and safety qualification of the future advanced reactors, contributing to their enhanced safety levels and improved economics. The CRP will be conducted in cooperation with the Technical Working Groups on Advanced Light Water Reactors and Fast Reactors of the Department of Nuclear Energy and the Safety Assessment Section of the IAEA's Department of Nuclear Safety and Security. By August 2008, six applications have been received from Argentina, France, India, Italy, and the Russian Federation, and discussions are in progress with several other targeted participants. The first research coordination meeting would be held in 2008. More details on this CRP and application procedures is at: http://cra.iaea.org.

A new Nuclear Energy Series report on Passive Safety Design Options for SMRs is under final stages of internal review. The objectives of this report are, inter alia, to assist potential users of innovative SMRs in their evaluation of the overall technical potential of SMRs with passive safety design features, including their possible impacts in areas other than safety and to present the approaches for implementation of the defence in depth strategy in such reactors in line with the definitions and recommendations of the IAEA safety standard NS-R-1. Structured descriptions of safety concepts/features for 11 advanced SMR concepts, representing 5 reactor lines, have been collected from 8 Member States, and the report has been prepared and endorsed for publication by the Document Coordination Team of the Department of Nuclear Energy. The preparation of this report was mentioned with satisfaction in the IAEA General Conference resolution GC(51)/RES/14/B2(k) of September 2007.

A new Nuclear Energy Series Report Approaches to Assess SMR Competitiveness is under preparation, which has the objectives to assist potential customers in their assessment of technical and economical performance of SMRs and to provide a framework to assist potential stakeholders in the definition of a competitive strategy regarding design and deployment of SMRs. The report, which is prepared in cooperation with the IAEA's Planning and Economic Studies Section is to be submitted for publication in 2008.

A series of case studies to address competitiveness considerations for SMRs in different applications is ongoing, addressing the development and application of models to assist decision making of public and private investors regarding SMRs and including a generic study with an approach taking into account all economic factors affecting present value capital costs of SMRs in their concentrated deployment. A dedicated technical meeting was convened in Vienna on 1-4 July 2008 to coordinate case studies, see Fig. 3. The materials of the meeting are available on a CD, upon a request from the responsible officer.

Fig. 3. Participants of IAEA technical meeting on Coordination of Case Studies on Competitiveness of SMRs in Different Applications, 1-4 July 2008, VIC, Vienna

Future plans of the project include compilation of an updateable electronic database with innovative SMR descriptions, updating the status reports with a focus on the designs that have a potential to be deployed before 2020, consolidation of software tools for competitiveness assessment of SMRs in different applications, addressing the options to incorporate intrinsic proliferation resistance and security features, and addressing the options to enhance energy supply security with NPPs based on SMRs.

Contact: v.v.kuznetsov@iaea.org.

Technology advances for gas cooled reactors (GCRs)

The interest in GCRs continues to increase as the deployment of a commercial GCR plant in the near term is becoming a reality. This is particularly true for GCR systems with cogeneration capabilities because of the rising interest in hydrogen production worldwide. This makes the GCR the preferred heat source due to its high outlet temperatures.

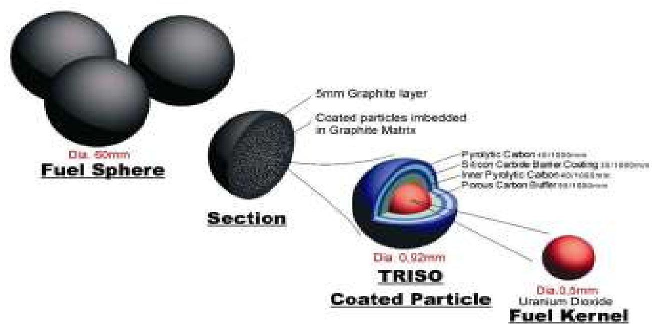
Progress is being made towards planning, licensing and construction of new GCRs with passive safety features. Some countries are almost at the stage where the licensing process has begun whilst others are busy with the conceptual design phase. Top level R&D consortia have been formed under the auspices of GIF (VHTR) and the European Commission (RAPHAEL), all with the objective of seeing a successful deployment of a plant in the near future.

Technology development activities within the Nuclear Power Technology Development Section (NPTDS) are overseen by the Technical Working Group on Gas-Cooled Reactors (TWG-GCR) The TWG-GCR provides a forum from which to review national and international gas cooled reactor (GCR) programmes and advise the IAEA on GCR related activities. Through different collaborative activities, a review of proven technologies as well as an improvement on them is gradually yielding gainful benefits on safety and economics of GCRs to all Member States.

A number of activities are currently underway or planned within the Nuclear Power Technology Development Section (NPTDS) to address technological challenges as well as economics for gas-cooled reactors (GCRs):

Advances in HTGR Fuel Technology

A great deal of experience has been accumulated over the past half century in the production and testing of coated particle fuels in support of High Temperature Gas Cooled Reactor (HTGR) technology development. The state of the art for PyC/SiC TRISO coated UO2 particles is well advanced, and sufficient to support modular HTGR development and deployment projects in the near term, but additional development is needed to expand the capabilities of HTGRs. Potential gains can arise from advanced fuel design and production technology, which could enhance the economics and range of applicability of HTGRs. Examples of current interest include the development of advanced coatings, fabrication methods and quality control, and the use of HTGRs for burning stockpiles of Plutonium.



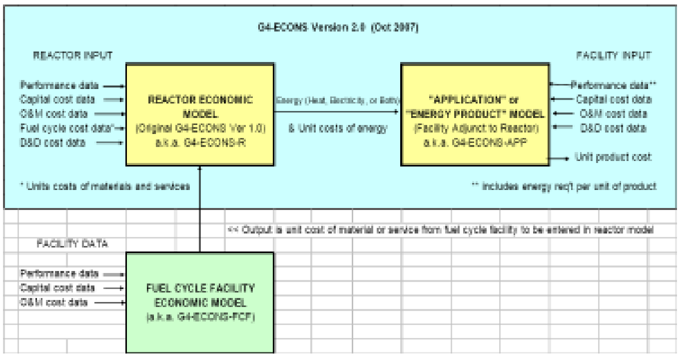
HTGR pebble-bed type fuel

Another issue warranting further investigation is the behaviour of HTGR fuel under high burnup. The data currently available for high performance UO2 fuel covers burnup up to 10-14% FIMA and plans are in place to investigate the range to 20% FIMA in future irradiation programs. Plans are underway for development and testing of UCO prismatic block fuel intended to achieve 26% FIMA. There is also a desire to qualify HTGR fuel integrity above the temperature safety limit currently set at ~1600ºC, possibly using a ZrC coating. Fuel performance model development work is proceeding in parallel to predict the behaviour of HTGR fuel under normal and abnormal operation. Validating the resulting analytical models with experimental data is necessary before use in plant licensing analysis. The IAEA CRP 6 on HTGR Fuel Technology is on-going and focuses on coated fuel particle characterization techniques, irradiation testing, accident testing, benchmarking fuel performance and fission product behaviour models under normal and accident conditions and advanced fuel designs

Institutes from China, Germany, Japan, the Republic of Korea, the Russian Federation, the USA, South Africa, France, Japan and the European Commission participate in the CRP. The next RCM for this CRP is scheduled for December 2008.

HTGR Economics Modelling

The first meeting on HTGR Economic Analysis was held in Vienna, Austria on 10-12 December 2007. At this meeting, the Generation IV International Forum (GIF) Cost Estimating Guidelines for Gen IV Nuclear Energy Systems were discussed with a view of understanding how these models can be applied to HTGRs. It was agreed that when the GIF software, G4ECONS is finally released, another Technical Meeting in the form of a training workshop must be convened to get an orientation on the software. The Workshop was subsequently convened at the VIC on 8-11 July 2008.



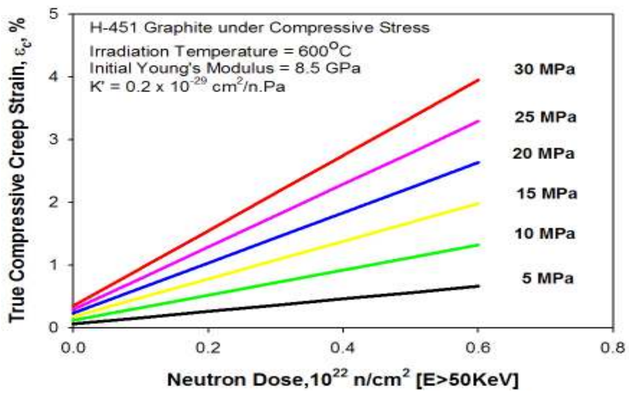
Overall G4-ECONS Modeling System

The organizations who participated in the workshop include PBMR (South Africa), AREVA (France), Tsinghua Univ. (China), INL and ORNL (USA). The participants concluded that G4-ECONS was a very valuable tool for Member States interested in Generation IV systems and with further improvements; it can be used as a tool for design/costs optimization. They expressed their interest in participating in future activities on this subject and to use G4-ECONS in their respective projects and provide feedback to both the IAEA and GIF EMWG. The next Technical Meeting on HTGR Economics Modelling is scheduled to take place in Washington D.C., USA on 2 – 3 October 2008 in conjunction with the International Conference on High Temperature Reactors (HTR2008) and an invitation has been extended to GIF EMWG Members and the GNEP AFCI project team members.

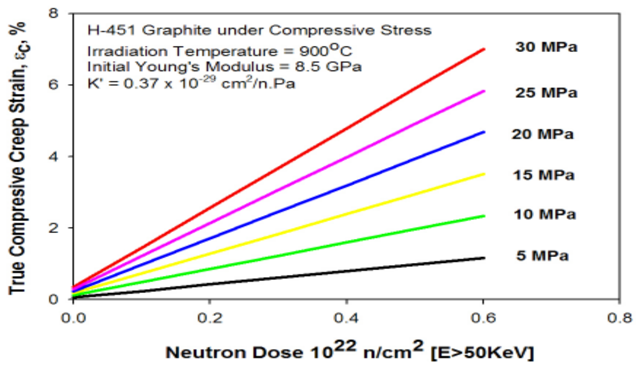
Irradiation Creep Behaviour of Nuclear Graphite

Isotropic and near-isotropic nuclear grade graphites are used as the nuclear moderator and major structural components of numerous existing power reactors as well as the Gen. IV Very High Temperature Reactors

(VHTR), such as the Next Generation Nuclear Plant (NGNP) and the Pebble Bed Modular Reactor (PBMR). During reactor operation graphite core components and core support structures are subjected to complex stresses such as combined loading from neutron irradiation induced dimensional change and thermal gradients. Moreover, static and seismic stresses act on the core components. Stresses in the graphite core are relaxed by irradiation induced creep, and thus it is important to be able to confidently predict the irradiation induced creep strain in a component as a function of dose, temperature, and stress.



Graphite compressive creep strain at 600 degrees Celcius



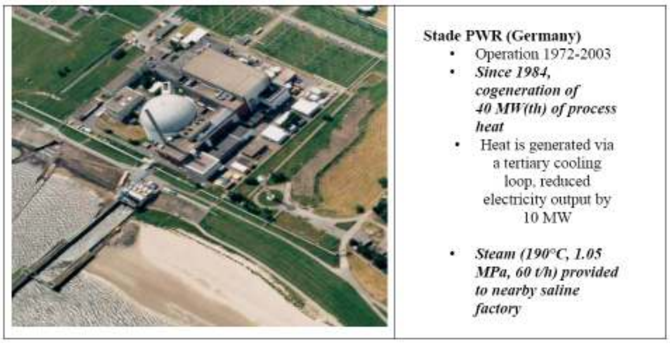
Graphite compressive creep strain at 900 degrees Celcius

The current understanding of graphite irradiation induced creep is based on experimental data from the 1980s and earlier, that only extends to moderate dose and temperature. However, with currently operating reactors reaching high doses, and proposed reactor designs anticipating high neutron doses and temperatures, the need for new creep experiments has become apparent. Furthermore, new graphites have been developed for Gen. IV reactors currently being designed.

In response to these needs and at the request of several Member States, a new CRP is being initiated to assist in coordinating the efforts of Member States planning new irradiation creep experiments to extend the existing database or gather data on the new graphites being used for Gen. IV reactors. The CRP will bring together scientists and engineers from numerous Member States, all of whom are involved in graphite core assessment, creep experiment designs, or modelling irradiation induced creep in graphite, and will enable comparisons of the relative merits of the various creep models and provide valuable input to the design of future creep experiments. Organizations who have expressed interest to participate in the CRP include, INET (China), CEA and AREVA (France), FZJ (Germany), HTR-TN (EU), JAEA (Japan), NRG, JRC (Netherlands), MINATOM and Kurchatov Institute (Russian Federation), PBMR (South Africa), BNG, Nexia Solutions, British Energy and University of Manchester (UK), and ORNL, INL and GA (USA). An experts' meeting to finalize the research plan for the CRP is scheduled to take place in December 2008 and the first RCM will take place early 2010.

Contact: b.m.tyobeka@iaea.org.

Non Electric Applications of Nuclear Power



An example of non electric applications of nuclear energy

Nuclear power is the only large-scale carbon-free energy source that, in the near and medium term, has the potential to replace crude oil and reduce greenhouse gas emissions. To do this, however, nuclear power must move beyond its historical role (as solely a producer of electricity) to other non-electric applications. Among these applications are seawater desalination, hydrogen production, district heating, and industrial processes applications. Such applications have tremendous potential in future ensuring worldwide energy and water security for a sustainable development. With its past experience in the heat and steam market in the low temperature range i.e. in the areas of desalination, district heating, and tertiary oil recovery, nuclear power can make the extension easily towards the short and medium terms.

The use of nuclear energy for the production of freshwater from seawater (nuclear desalination) is of broad interest in Member States due to acute water shortage issues in many arid and semi-arid zones. The desalination of seawater using nuclear energy (low temperature heat or electricity) is a demonstrated option, which could help meet the growing demand for potable water.

Evaporators at Aktau, Kazakhstan

Operating plant: Ohi, Japan

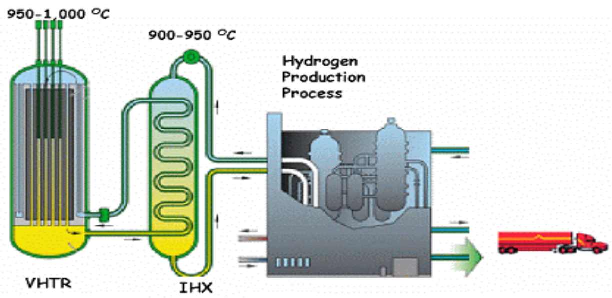
Hybrid (MSF+RO) plant, Kalpakkam, India

SWRO Plant at KANUPP, Pakistan

Floating Nuclear Power and Desalination Complex, Severodvinsk, Russia

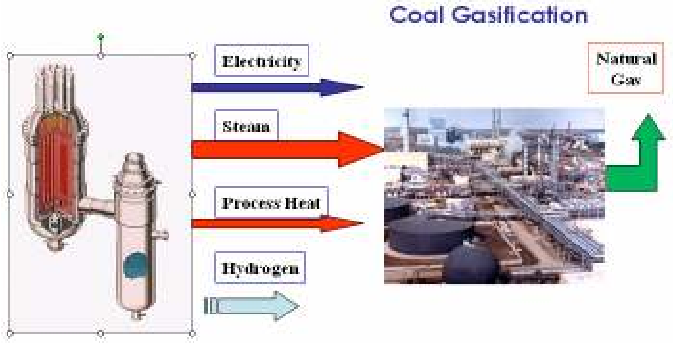
The demonstrated and proven application of nuclear power on nuclear desalination

In the higher-temperature heat/steam range, a significant potential for the applications of nuclear energy exists in areas of hydrogen production and the petro-chemical industries including the production of liquid fuels for the transportation sector. Nuclear energy can be used for hydrogen production 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. Hydrogen is used, for example, to sweeten crude oil to produce fuel for transportation, and in the longer term could become a fuel for fuel cell vehicles. 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.



Nuclear Hydrogen production

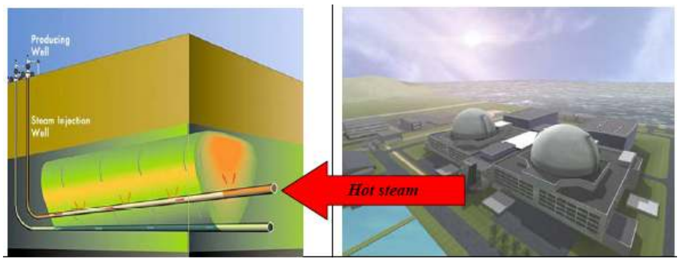
As a relatively cleaner fossil fuel source, coal gasification/liquefaction is an area of interest to nuclear energy. Production of synfuels and other hydrocarbons using nuclear heat is an area of greater promise. CO_2 can be used as feedstock together with water, nuclear heat and electricity for producing synthetic hydrocarbons, which may be better energy carrier than hydrogen. Preliminary estimates indicate that synfuels could be produced at prices comparable or even lower than fossil fuels. Further work on integrated nuclear-chemical complex is desirable to gain vital experience in this area.



Coal gasification using nuclear energy

Although nuclear industrial process heat applications have significant potential, it has not been realized to a large extent. One of the potential future applications of nuclear energy (in form of process heat) is for oil sand open-pit mining and deep-deposit extraction. In Canada, Alberta's oil sand deposits are the second largest oil reserves in the world, and have emerged as the fastest growing, soon to be dominant, source of crude oil in Canada. Other such industrial applications have been applied in Switzerland and in India.

Economic studies generally indicate that district heating costs from nuclear power are in the same range as costs associated with fossil-fuelled plants. In the past, the low prices of fossil fuels have stunted the introduction of single-purpose nuclear district heating plants. Although many concepts of small-scale heat-producing nuclear plants have been presented during the years, very few have been built. However, as environmental concerns mount over the use of fossil fuels, nuclear-based district heating systems have potential.



Oil shale production using nuclear energy

The IAEA project on non electric applications is gearing up on the short and medium term promising applications. Several technical meetings have been held on: Integrated

Nuclear Desalination Systems which is intended to provide an opportunity for the participants from Member States to exchange information and share experience on nuclear desalination activities in their respective countries which are actively involved in the nuclear desalination activities or considering the introduction of nuclear desalination, the coordinated research project on the Advances in Nuclear Power for Process Heat Applications which aims to evaluate the potential of advanced reactor designs in some process heat applications, such as hydrogen production and seawater desalination, *DEEP Users' Group* which aimed at re-examining all thermal and RO plant models in DEEP, correcting any necessary formula or panel related to DEEP code, and discussing preliminary draft of quality assurance document for DEEP development, and on Status of Hydrogen Production using Nuclear Energy which aimed at exchanging information among MS actively involved in the development of hydrogen production processes.

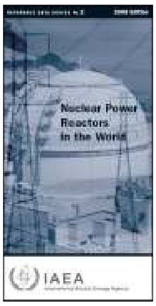
The International Nuclear Desalination Advisory Group (INDAG), which the IAEA established in 1996, continued its active role and has contributed to promotion and stimulation of nuclear desalination activities including, and provided a forum for Member States to exchange information on the technological developments, operations, and demonstration of integrated nuclear desalination systems. INDAG met in Jan 2008 and reviewed the IAEA's current and future activities and made several recommendations. To enhance its functions, the IAEA is currently planning to reforms INDAG into a Technical Working Group on Nuclear Desalination (TWG-ND).

The IAEA future activities on non electric applications of nuclear energy will expand further to include the nuclear industrial process heat applications which is expected to have significant potential such as the use of nuclear process heat for oil sand and synfuel applications. Simultaneously, the IAEA will continue other activities such as the Coordinated Research Programme (CRP) on Advances in Nuclear Power Process Heat Applications , the launching of new CRP on Advances in Nuclear Desalination Technology which aims at investigating various technical means to improve the safety and economics of product water, the upgrading of the IAEA Desalination Economic Evaluation Programme (DEEP), the development of Hydrogen Economic Evaluation Programme (HEEP), the publications of technical reports on major applications of non electric applications of nuclear energy such as nuclear desalination and nuclear hydrogen production, and various technical meetings with wide objective focusing on information exchange among Member States on such non electric applications of nuclear energy.

Among future IAEA activities are the scheduled technical meeting on non electric applications to be held in Rep. of Korea 3-6 March 2009, and the Training Workshop on Technology and Performance of Desalination Systems to be held at the International Centre for Theoretical Physics (ICTP), Trieste, Italy during 11-15 May 2009.

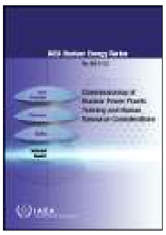
Contact: I.Khamis@iaea.org.

Recent Publications and Meetings



Nuclear Power Reactors in the World, 2008 Edition

This is the twenty-eighth edition of Reference Data Series No. 2, which presents the most recent reactor data available in the Power Reactor Information System (PRIS). It contains information as of the end of 2007 on power reactors status and operating performance in the IAEA Member States.

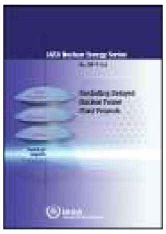


Commissioning of Nuclear Power Plants: Training and Human Resource Considerations

IAEA NES No. NG-T-2.2

For many Member States with operating nuclear power plants, it has been some years since a nuclear power plants (NPP) has been commissioned, and most of the staff with experience in commissioning has since retired. Additionally, in a number of Member States, serious consideration is being given to initiating a new nuclear power programme. This document is intended to provide useful information for both situations. It is expected that Member State organizations will use this information to improve their training programmes and other aspects of human resource management for commissioning of NPPs in areas such as: staffing plans for commissioning, commissioning training plan development and implementation, content and methods for commissioning training, training materials for commissioning, control room simulator training to support commissioning and the organization of training for commissioning.

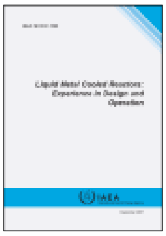
Restarting Delayed Nuclear Power Plant Projects



IAEA NES No. NP-T-3.4

The restarting of nuclear power plant projects with delays of several years in respect of the original scheduled commercial operation date presents particular management issues. These are beyond the normal management tasks for projects implemented within original planned schedules. Some practical experience from restarted delayed projects were reviewed and included in the present publication, which addresses specific management issues to be considered for a delayed project in the period after the decision for restarting is adopted. The publication covers those management issues not considered within the normal processes described in other IAEA publications. The practical experience collected from delayed projects that were successfully restarted, completed and brought to commercial operation can provide useful assistance to the management of similar projects considering resumption of work. Intended users are senior managers and engineers of nuclear utilities, and suppliers of equipment, services and technical support for construction and commissioning.

Application of Reliability Centred Maintenance to Optimize Operation and Maintenance in Nuclear Power Plants



IAEA-TECDOC No. 1590

This IAEA-TECDOC describes the concept of Reliability Centred Maintenance (RCM) which is the term used to describe a systematic approach to the evaluation, design and development of cost effective maintenance programmes for plant and equipment. The concept has been in existence for over 25 years originating in the civil aviation sector. This IAEA-TECDOC supplements previous IAEA publications on the subject and seeks to reflect members experience in the application of the principles involved.

Liquid Metal Cooled Reactors: Experience in Design and Operation

IAEA-TECDOC No. 1569

This publication presents a survey of worldwide experience gained with fast breeder reactor design, development and operation. It is focused on the following subjects: state of the art of liquid metal fast reactor (LMFR) development; design features and operating experience of demonstration and commercial sized nuclear power plants with sodium cooled fast reactors; lead–bismuth cooled (LBC) ship reactor operation experience and LBC fast power reactor development; treatment and disposal of spent sodium; decontamination after shutdown of the typical loop type LMFR; and an analysis of advantages and disadvantages of sodium as a coolant, giving due consideration to advances in the technology and design of sodium components.

Strategy for Assessment of WWER Steam Generator Tube Integrity

IAEA-TECDOC No. 1577

In countries operating WWER-440/1000 nuclear power plants (NPPs), there are significant differences in the eddy current inspection strategy and practice as well as in the approach to steam generator heat exchanger tube structural integrity assessment. The IAEA initiated a Coordinated Research Project (CRP) with the overall objective to improve structural integrity assessment of steam generators of WWER-440/1000 NPPs. This publication describes the main achievements of the CRP, specifically, a proven approach to steam generator integrity assessment which consists of three critical elements: degradation assessment, condition monitoring and operational assessment. This approach can provide assurance that the steam generators will continue to satisfy the appropriate performance criteria.

Workshop on Modernization Projects of NPP Instrumentation and Control Systems Related to Power Uprates and License Renewals

An IAEA regional workshop on Modernization Projects of NPP Instrumentation and Control Systems Related to Power Uprates and License Renewals was held in Portoroz, Slovenia on 14-18 April 2008. The objective of the workshop was to exchange information on I&C modernization projects related to power uprate, license renewal, and refurbishment activities in nuclear power plants. Lessons learned from completed or planned I&C projects were presented and discussed in detail.

Workshop participants, 14-18 April 2008, Portoroz, Slovenia

The workshop was attended by 33 participants from Armenia, Bulgaria, Canada, Croatia, Germany, Hungary, Lithuania, Romania, Russian Federation, Slovakia, Slovenia, Ukraine, and the USA. The participants were engineers and mid-level managers from nuclear utilities, regulators, and technical support organizations. Their expertise included modernization projects, design, implementation, licensing, practical applications, and operational aspects of I&C maintenance and modernization.

A CD-proceedings was prepared and distributed after the workshop. The CD contains all presentation materials and other supporting documents. It has been also uploaded to the IAEA NPP I&C website at http://entrac.iaea.org/I-and-C/WS_PORTOROZ_2008_04/Start.htm.

Contact: O.Glockler@iaea.org.

Consultants meeting on developments of the Power Reactor Information System (PRIS)

A Consultants meeting on developments of the Power Reactor Information System (PRIS) was held from 30 June – 2 July, 2008 in IAEA Headquarters. Consultants were invited from France, Slovakia, Sweden and USA.

The objective of the meeting was to discuss in details a working version of PRIS-Statistics application. The main focus of the meeting was on a new feature for reactor grouping and on new report structure.

PRIS contains wide range of information about nuclear power plant status and performance. To assist in nuclear power performance analyses and benchmarking the outputs from PRIS have to be easy achievable in predefined structures, forms and reports.

Contact: J.Mandula@iaea.org.

The National Workshop on Integrated Maintenance Management System

The National Workshop on Integrated Maintenance Management System was conducted at the Bushehr Nuclear Power Plant (BNPP) from 20 to 23 July, 2008 to support the selection of an IT system for maintenance management.

The objective of the workshop was to provide lessons on maintenance strategy and integrated IT system supporting maintenance management and to exchange experience with its implementation.

The workshop, which was organised within the Technical Cooperation project IRA/4/03: Strengthening Owner's Capabilities for Commissioning and Start-up of Bushehr Nuclear Power Plant, was attended by 24 participants from different BNPP/NPPD departments.

Contact: J.Mandula@iaea.org.

Peer Review Service on SALTO for Dukovany NPP

A peer review mission on safe long term operation (SALTO) was provided on 20–25 April 2008 at Dukovany Nuclear Power Plant (NPP) in the Czech Republic. The review covered the areas of basic principles, long term operation (LTO) feasibility including time limited ageing analyses, scoping and screening processes, preconditions for LTO, ageing management and other LTO related activities for mechanical components, electrical and I&C components including equipment qualification and civil structures, and radiological environment impact assessment.

Taking into account of the above mentioned points, the team recognized that the plant approaches and initial preparation work for safe long term operation are in line with international practices. Lessons learned from this mission will be reflected on finalizing the SALTO review guideline.

Contact: M.Kearnay@iaea.org.

Workshop on Power Uprating for Laguna Verde Nuclear Power Plant, 9–12 June 2008, Veracruz, Mexico

Workshop participants, 9–12 June 2008, Veracruz, Mexico

Currently a significant number of the nuclear power plants have plans for power uprate by larger or smaller amounts. In most cases this is an economic way of producing more electricity in a nuclear power plant, and which has attracted interest due to increased electricity prices; a situation that is expected to remain. Power uprates are categorized based on the magnitude of the power increase and the methods used to achieve the increase of core power.

Contact: L.Kupca@iaea.org.

Expert Mission Service on Preservation of Stored Components and Equipment for Atucha II NPP

An expert mission at Atucha II focused on preservation of stored components and equipment took place at the plant site on 23–27 October 2006. The mission objective was to analyse the state of preservation of the Atucha II installed and stored equipment and components regarding their adequacy for further use in the conditions of project restart after a period of more than 10 years delay.

The follow-up mission took place at plant site on 14–17 July 2008. The objective of this follow-up mission was to review the progress on the assessment of the long term preserved and stored mechanical, electrical, I&C and civil components and equipment, as well as the measures which were taken, based on findings and recommendations of the first mission.

Contact: L.Kupca@iaea.org.

Technical Meeting on Improving Prospects for Financing Nuclear Power Projects

A Technical Meeting was held to review the draft of NE-Series-Report Improving Prospects for Financing Nuclear Power Projects on July 23-25, 2008. The Report aims at providing guidance and understanding across the range of issues involved in the establishment and financing of nuclear power plants. It identifies the key influencing factors which impact on financing NPP, the potential risks and risk mitigation strategies, options for improving prospects of financing NPP. Some possible financing models are presented and explained. The target users are Member States introducing nuclear power reactors for the first time and others who are either seeking a significant increase from a small base or initiating the restart of a dormant nuclear programme. It is planned to finalize the report for publication in the last quarter of 2008.

Meeting participants, July 23-25, 2008, Vienna Austria

Contact: X.Li@iaea.org.

Consultants meeting on Invitation and Evaluation of Bids for Nuclear Power Plants

A new NE-Series-Report on Invitation and Evaluation of Bids for Nuclear Power Plants was initiated. The objective is to provide integrated and updated practical guidance on invitation and evaluation of bids for nuclear power plants with the state of the art information. A Consultants Meeting was organized on May 14-16, 2008 to prepare the outline. The first draft is scheduled by end of October 2008. The scope of this Report will address the bid invitation specification, and the technical and economic evaluation of bids. Target users are decision makers, advisers, senior managers and staff involved in bidding process in the governmental, utilities and industrial organizations in countries initiating or extending nuclear power programmes.

Contact: X.Li@iaea.org.

Site Selection for Building NP Infrastructure

Within the framework of the Technical Cooperation Project ALG/0/013 - Sustainable Energy Development and Preparation for Nuclear Power, a workshop on site survey and evaluation was held from 6 to 10 July 2008 at Alger, Algeria. The objective of this workshop was to provide advice and guidance that will help to (i) identify key issues that might affect decisions on the suitability of a site for new nuclear installations, (ii) establish appropriate organization and management structure for siting activities, and (iii) establish the basis for the control and verification of activities affecting quality of the survey and the selection of nuclear power infrastructure sites in Algeria.

Workshop participants in Algiers, Algeria, 06-10 July 2008

This activity was found as one of the siting events leading to address all siting related areas in an integrated manner through addressing siting issues (i) that are concerned with the technical and socio-economic feasibility and minimizing the cost, (ii) related to the environmental impact and the potential risks on the population, and (iii) that are more political and/or subjective and need to be address such as public opinion, land-use, legal aspects etc.

Along the line, the increased demand for assistance on site survey and evaluation and the need to further provide improved materials and documentation to Member States, have urged the IAEA to initiate the development of a guidance document on managing siting activities. The above publication will address activities related to feasibility and infrastructure development on siting. In this connection, actions that aim to finalize a NE Series document on *Managing* Siting Activities for Nuclear Power Plants in 2009, are underway.

Contacts: V.Nkong-Njock@iaea.org.

New Staff in the Division of Nuclear Power

AOKI, Masahiro

Mr. Aoki (Japan) has recently taken up duties in the Nuclear Power Engineering Section as a nuclear engineer. He will assist in the planning, coordination and implementation of the activities of NE's infrastructure project team. Mr. Aoki has over 20 years of experience working for the Japanese Government in various areas relating to nuclear energy such as the management/planning of programs for electric demand and supply, enforcement programs for export control of sensitive civilian goods for possible use for Weapons of Mass Destruction and lately in the area of nuclear safety, radiation protection and emergency preparedness.

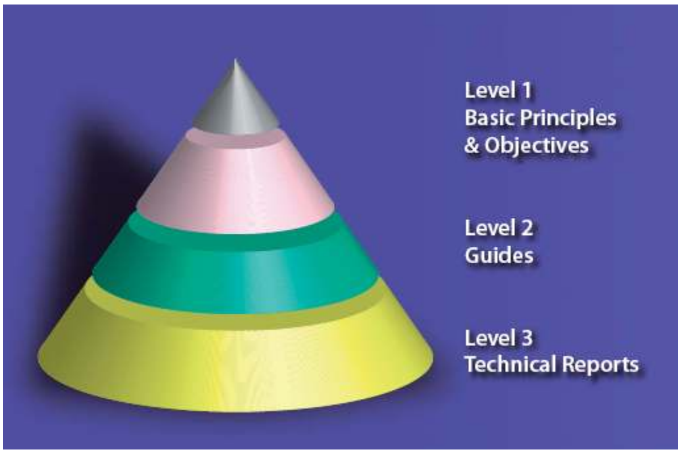
Contact: M.Aoki@iaea.org.

Vacancy Notice for Professional Posts

New vacancy notices will be available on the IAEA webpage addressing https://personnel.iaea.org/apps/phflink/p_vacancies.asp.

Applications from qualified women and candidates from developing countries are encouraged.

Nuclear Energy Series Enhances Credibility and Provides Clear Structure



Visit the website:
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The IAEA's Nuclear Energy Series (NES), continues to increase the consistency, coordination and recognition of key Nuclear Energy publications through an organized, user-friendly structure. It supports the diverse needs of Member States by clearly defining Nuclear Energy principles, objectives, areas and topics and by providing continuity of publications through a formalized preparation and review process.

Through the efforts of the Document Coordination Team (DCT), involving members of every section and division of the Department of Nuclear Energy, publications are submitted for discussion and review ensuring better collaboration among colleagues and supporting the overall integrity of the NES. This carefully established review process also allows systematic analysis of existing publications and helps to identify gaps and areas not covered by the Series. Based on analysis, some of the many existing publications (IAEA-TECDOCs, Technical Report Series, etc.) are revised, updated and integrated into the NES and others are listed as supporting documents providing important background information in each area.

Currently, there are nearly one hundred NES manuscripts in different stages of DCT review. These include four Objectives, four Guides and eighty technical Reports covering a wide range of topics and areas. To date, one Guide and six Reports have been published under the Series and twelve more publications have been approved by the Publications Committee and will be available in the coming months. (See inset for several examples). In addition to publications, a Nuclear Energy Series Glossary is under development which defines specialized terms and provides increased consistency within the Series.

Over one thousand publications, both under the new NES and previously existing supporting documents, are accessible on the IAEA website and their full texts (in PDF format) can be downloaded from the Department's clickable map: http://www.iaea.org/OurWork/ST/NE/NESeries/ClickableMap/. The map is structured in accordance with the three levels, four subject areas and specific, identified topics in the NES and includes a search engine allowing users to find existing publications by title, identification code or keyword.

For a more detailed description of the Series, a new brochure entitled Introducing the Nuclear Energy Series is available at the General Conference.

Contact: p.vincze@iaea.org, L.Stern@iaea.org.

International Conference on Opportunities and Challenges for Water Cooled Reactors in the 21st Century October 27−30 2009 Vienna

Water Cooled Reactors have been the keystone of the nuclear industry in the 20th century. As we move into the 21st century and face new challenges, such as the threat of climate change and the large growth in world energy demand, nuclear energy has been singled out as one of the sources that could substantially and sustainably contribute to power the world. As the nuclear community worldwide looks into the future with the development of advanced and innovative reactor designs and fuel cycles, it becomes important to explore the role Water Cooled Reactors will play in this future.

The objectives of the International Conference on Opportunities and Challenges for Water Cooled Reactors in the 21st century are to:

- Explore the status and trends in the development of advanced water cooled reactor designs, both for electrical and non-electrical applications.
- Provide a forum for the exchange of information among those interested in the introduction or expansion of nuclear power programmes in the 21st century, taking into account the desire to build capacity in terms of human resources, energy planning, regulatory capabilities and other infrastructure.
- Discuss the trends in nuclear design and safety and their anticipated impact on the required capabilities of operating, regulatory and technical support organizations, as well as in safety, reliability and performance improvements.
- Examine the role of operation and maintenance optimization programmes in assuring safe and reliable nuclear power plant operations;
- Explore the future role of water cooled reactors, by themselves and as a bridge towards the use of innovative nuclear reactors designs and fuel cycles.

The conference is geared to senior policy-makers and government officials, decision-makers in climate change policy, energy planning and finance, managers and technical experts from nuclear design and research organizations, as well as operating organizations.

The conference will include technical sessions where contributed papers will present the current state of knowledge in a large variety of topics. Experts from all over the world are encouraged to submit papers in the following topics

- Topic 1: Lessons Learned from the Safety and Performance Achievement in Existing Water Cooled Reactors
- Topic 2: Design and Construction of Advanced Water Cooled Reactors
- Topic 3: Innovative and Advanced Applications of Water Cooled Reactors
- Topic 4: Challenges and Opportunities to Launch New Nuclear Power Programmes

Key deadlines:

- 14 April 2009 : Submission of Extended Synopsis (Electronic Version – 800 words)
- 15 July 2009 : Notification of paper acceptance
- 14 August 2009 : Submission of Full papers

Conference Web Page:

All the most up-to-date information about the conference will be posted in the conference web site:

http://wwwpub.iaea.org/MTCD/Meetings/Announcements.asp?ConfID=164

Contact: S.Bilbao@iaea.org, O.Glockler@iaea.org, K.Kang@iaea.org.

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Wagramer Strasse 5, P.O. Box 100, A-1400 Vienna, Austria

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