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Nuclear Power Newsletter

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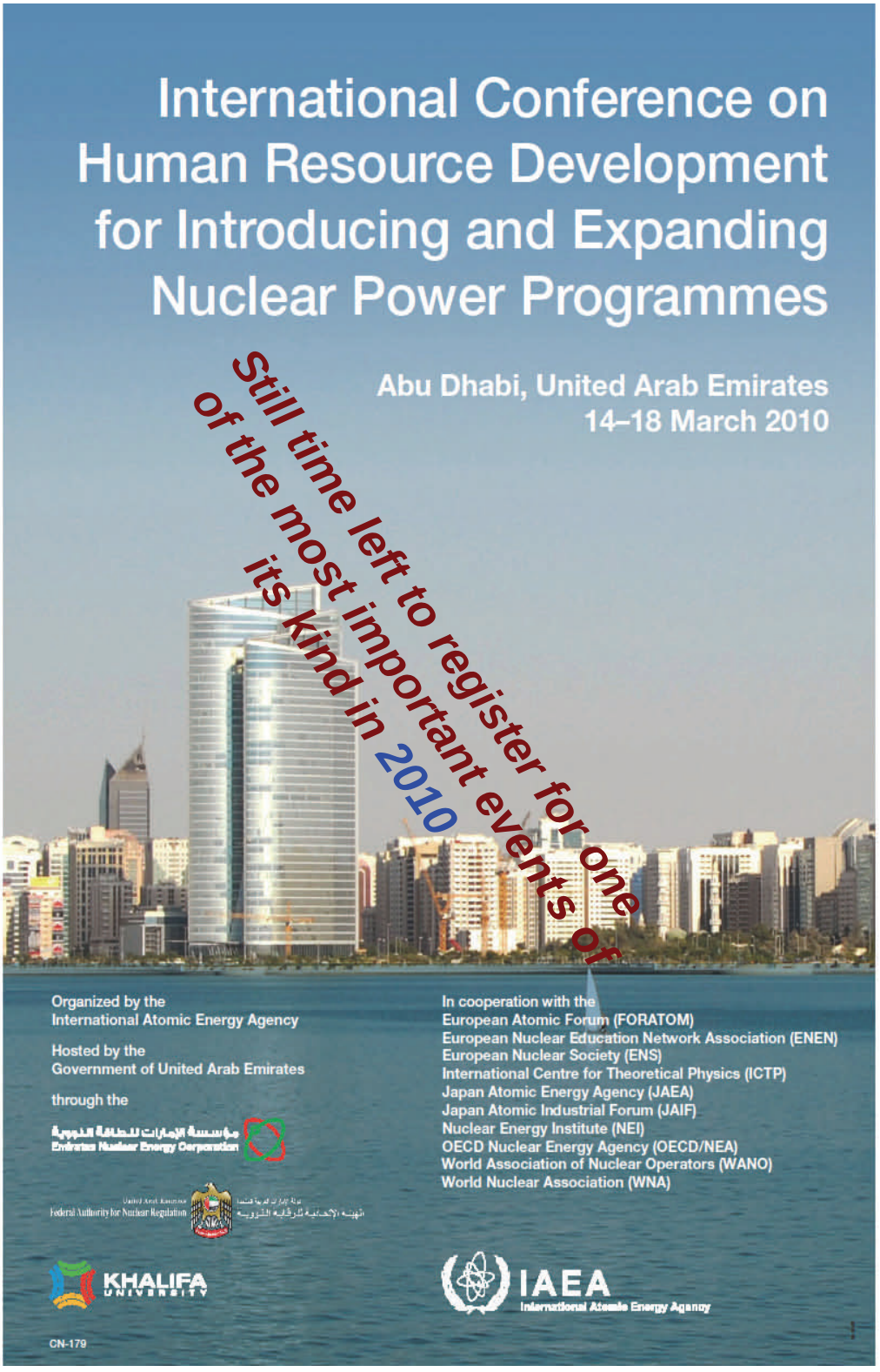
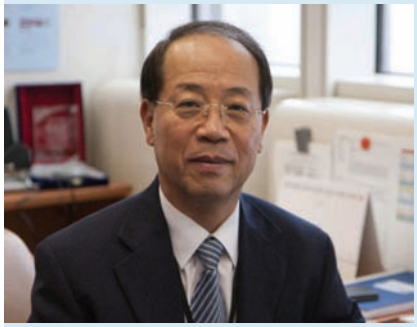


Message from the Director

Hello, everyone! Welcome to the December 2009 Newsletter of the Division of Nuclear Power. It is a great honour for me to have a chance to serve the Member States as one of the IAEA staff members.



During the past 3 months, as I joined the IAEA in October this year, I have the privilege to take part of the role of the IAEA in accelerating the applications of atomic energy to peace, health, and prosperity throughout the world. Furthermore, I have been struck by the breadth of the activities covered within the NENP, their valuable outcomes, and the professionalism of the staff and external experts/consultants involved, and hope that such activities will be enhanced further in the future.

Rising expectations of the role of nuclear power to respond to the increased number of newcomers and global environmental considerations over fossil fuel have led the IAEA to continue to provide support to Member States in all required areas such as support to operating nuclear power plants, nuclear infrastructure building for newcomers, and assessment of different technology options of reactor designs, innovative technologies and their applications.

I am happy to report that the 2010 regular budget of NENP has been increased about 15% compared to 2009 to include 5 new professional posts in 2010.

Mr. Akira Omoto, the former Director of the NENP, left the IAEA after serving the Agency over 5 years. Many of you that are recipients of this newsletter have had the pleasure to work with Akira. He returned back to Japan where he would teach the students at the university.

By taking this opportunity, I would like to thank Akira for his great contribution to the Agency and the Member States. We wish Akira all the best.

On the occasion of the December issue and the 2010 New Year, I would like to wish joys, health, and prosperity to our readers, collaborating experts and consultants, colleagues and staff.

Happy new year!

J.K. Park
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Powering the Future

Opportunities and Challenges for Nuclear Power in the 21st Century

The theme of the *International Conference on Opportunities and Challenges for Water Cooled Reactors in the 21st Century*, which was held in Vienna on October 2009, was on the future of nuclear power and the role of water cooled reactors will play in this future. As the world moves into the 21st Century and faces new challenges, including the growth in world energy demand or the threat of global climate change, nuclear energy is seen as one of the sources that could substantially and sustainably contribute to powering the world. "The problem in coming decades is the need to secure environmentally-benign energy. This cannot be done without nuclear," said Adrian Collings, Director of Policy Development at the World Nuclear Association (WNA), in his opening remarks. “Both challenges and opportunities lie ahead for nuclear power. Like the poles of a magnet, they do not exist separately," said Yury Sokolov, IAEA Deputy Director General for Nuclear Energy. "What some perceive as an opportunity may be a challenge for others, and a challenge today will probably become an opportunity tomorrow. All these complexities are fully applicable to the nuclear industry and its future," he added.

The four-day event focused on the role of water cooled reactors in the 21st century nuclear sector. "Water Cooled Reactors will play an important role in the future and through this conference we will be able to contribute to the worldwide exchange of lessons learned from our operational and regulatory experiences in ensuring the success of future nuclear power development around the world," Mr. Sokolov explained. As the cornerstone of the nuclear industry in the 20th Century, water cooled reactors comprise the majority of the existing nuclear power reactor fleet. A broad range of topics from current nuclear power outlook to advanced applications of water cooled reactors. More than 260 participants representing 54 Member States and four international organizations attended.

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Leadership and Management of Nuclear Power Programmes

With the support of the US Department of Energy (US DoE), the IAEA organized an Interregional Training Course on Leadership and Management of Nuclear Power Programmes in emerging nuclear power states at the Argonne National laboratory (ANL), USA, October 2009. Jointly prepared by NE and NS, the training course aimed to help decision makers and those responsible for developing and implementing nuclear power programmes in emerging nuclear power states obtain knowledge and develop the skills and abilities needed to achieve the different milestones of such an undertaking.

IAEA/Argonne
Regional Training Course on
Nuclear Power Infrastructure Programmes and Related Projects in Emerging Nuclear States

The training course was supported by the IAEA Technical Co-operation Programme, attended by 28 participants were at the decision-making-level from 20 Member States from the four regions (Africa, Asia, Europe and Latin America), and revolved around three major inter-related objectives (ii) providing knowledge connected to the 19 issues a state has to consider when establishing a nuclear power programme (iii) sensitizing participants to the specific processes, organization and management systems related to the nuclear power business, and (iii) further strengthening the networking among emerging nuclear power countries and sharing international experience on the subject matter. The course provided an opportunity to review the status and prospects of nuclear power and to discuss the necessary actions to carry forward the positive momentum that nuclear power has witnessed in recent years, a good forum for exchanging information and sharing experience on good practices and therefore, and an excellent mechanism for networking among the participating countries.

Participants' feedback included suggestions for future improvements to the course as they found the course extremely useful and informative. They reported that the course included new information and represented new knowledge and the training and guidance provided during the course will increase their ability to conduct the preparations needed to develop and implement a nuclear power programme. It was the first time they had received such a comprehensive picture and understanding of what establishing a nuclear power programme. As a result of the course and in view of the fact the they intend to use that knowledge back home, the participants will be better able to develop the knowledge and management processes and to establish the organization needed to manage nuclear power programmes in their newcomer countries. The IAEA and the ANL were encouraged to repeat or organize similar course in the future and were requested to ensure that all relevant IAEA Member States were informed of the course.

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Extended Country Nuclear Power Profiles

The Country Nuclear Power Profiles (CNPP) compiles background information on the status and development of nuclear power programs in Member States. It consists of organizational and industrial aspects of nuclear power programs and provides information about the relevant legislative, regulatory, and international framework in each country. Its descriptive and statistical overview of the overall economic, energy, and electricity situation in each country, and its nuclear power framework is intended to serve as an integrated source of key background information about nuclear power programs in the world.

The CNPP project, which was initiated in 1990s, was updated during the Technical Meeting held in June 2009 to make it more applicable for countries newly considering nuclear power projects. The CNPP report structure was revised to include additional information on the nuclear power infrastructure development and to present factors related to effective planning, decision making and implementation of future projects. The new extended structure of the CNPP was approved at the Technical Meeting. In July 2009, the IAEA has also organized assistance for countries ready to apply the new CNPP structure in preparation of the CNPP reports. The draft CNPP reports prepared by the participants were reviewed by the experts and necessary changes and modifications were advised.

Based on an extensive effort on CNPP report revision, updating and new report preparation the 2009 edition consists of 44 profiles: 30 from countries operating nuclear power plants and 14 from countries having past or planned nuclear power programmes (Bangladesh, Egypt, Ghana, Indonesia, the Islamic Republic of Iran, Italy, Kazakhstan, Nigeria, Philippines, Poland, Thailand, Tunisia, Turkey and Vietnam). From last edition 21 profiles have been updated and 5 new profiles reports have been added. For the other countries, the IAEA updated the profile statistical tables on nuclear power, energy development, and economic indicators based on information from IAEA and World Bank databases. The new 2009 edition of CNPP is available on CD-ROM and on the web: *www-pub.iaea.org/MTCD/publications/PDF/cnpp2009.*

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IAEA and KHNP Collaborate to Support Nuclear Newcomers

Yury Sokolov, IAEA Deputy Director General for Nuclear Energy (left) and Jong Shin Kim, KHNP President & CEO (right) signed a *Practical Arrangement* supporting nuclear power development and strengthening capabilities for nuclear power plant safety, performance and service life in IAEA Member States.

The IAEA and the Korea Hydro & Nuclear Power Company LTD (KHNP) are increasing their ongoing collaboration. Through the recently signed *Practical Arrangement*, both organizations have agreed to cooperate to support nuclear power development and strengthen IAEA Member States´ capabilities in nuclear power plant safety, performance and service life. "This practical arrangement will provide the foundation to share the Rep. of Korea´s rich experience in nuclear power with IAEA Member States, both newcomer and operating nuclear power countries," stated Yury Sokolov, IAEA Deputy Director General for Nuclear Energy.

Cooperation will be bolstered in three areas: developing the infrastructure required to establish a nuclear power programme; strengthening capabilities in safety, performance and service life; and exchanging information and material relevant to nuclear power programmes. In particular, countries considering whether to embark on a new nuclear power programme will receive support. Collaboration could result in jointly organized technical meetings, publishing joint documents and implementing IAEA technical cooperation or review missions.

Under this agreement, the Department of Nuclear Energy intends to develop additional mentoring programmes for infrastructure preparation and construction management for expanding nuclear power plants. Through these programs, Rep. of Korea´s technical competence and experience will be shared with other IAEA Member States.

"I remember the early stages of the nuclear power construction program in my country," stated Jong Shin Kim, President and CEO of KHNP. "Now it is our turn to help the newcomers in the nuclear industry. We are ready and willing to help, hand in hand with the IAEA." The *Practical Arrangement* was signed on 28 October 2009 by IAEA Deputy Director General Yury Sokolov and KHNP President & CEO Jong Shin Kim.

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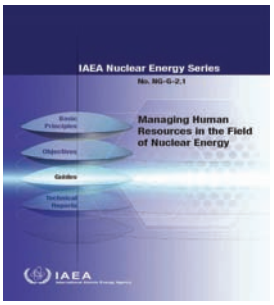
Human Resources: Key to Success

A new Nuclear Energy Series Guide

The role of adequate human resources for achieving the objectives in the field of peaceful use of nuclear energy cannot be overestimated. A new Nuclear Energy Series guide 'Managing Human Resources in the Field of Nuclear Energy' was published in September 2009, and serves to communicate a message to all stakeholders on the importance of adequate human resources for safe and efficient operation of the nuclear industry, and on the essential activities to be undertaken in order to reliably supply the competent workforce.

Support in human resource development

One effective way to assist Member States embarking on nuclear power in HR development and becoming an 'intelligent customer' are the NENP workshops and expert missions. Two comprehensive workshops (in Belarus and in Ghana) on strategic issues of HR development were performed in October 2009. The success of those workshops resulted heavily from involvement of specialists possessing 'hands-on' broad experience in carrying out nuclear programmes, including experts working in senior positions at nuclear power plants, regulatory bodies and technical support organizations.



Management competence – a decisive factor

Competence of managers is a crucial factor for successful implementation of a nuclear programme and for any phase of a nuclear power plant life cycle. A consultants' meeting to discuss and obtain advice from the nuclear power senior managers and training specialists on the management competencies required for construction, commissioning and operating phases was held on 23-25 September 2009 in Obninsk. The nineteen senior and middle managers and specialists from eight countries (Belarus, Brazil, Canada, China, Germany, Republic of Korea, the Russian Federation and Ukraine), and from WANO and IAEA, exchanged their experiences regarding organizational factors impacting on success of the new NPP projects and proactive ways to select, train and develop management staff. It is remarkable that the participants of the meeting have reached – using the IAEA recommendations and publications – a consensus on required management competencies that may serve as a basis for the national activities in acquiring competent managers for the nuclear power industry.

Assistance in comprehensive evaluation of NPP training systems

Our division is assisting Member States in evaluating and improving NPP training systems, using proven methodology, job aids and experts. The latest example is assistance to the Armenian NPP in 2009 in the framework of a technical cooperation project on Raising levels of operational safety at the ANPP. Based on results of evaluation and using the IAEA recommendations, our Armenian colleagues developed a comprehensive programme for improvement of NPP training. That programme was discussed in October 2009 at the IAEA meeting attended by the ANPP senior and training managers, representatives of WANO, US DOE, an organization providing on-site assistance through the EC support and IAEA.

Advanced Training Tools and Technologies

It was not surprising that a technical meeting on Simulators, Advanced Training Tools and Technologies for the Nuclear Industry held at the IAEA on 2-5 June 2009 attracted more than one hundred ten participants from thirty-six countries and the IAEA. Representatives from nuclear facilities, operating organizations, government agencies, regulatory bodies, universities, academia, training and technical support organizations, R&D institutions and suppliers of training tools not only shared their experience and conducted bright presentations but also demonstrated a wide range of advanced computerized tools and technologies for the nuclear industry. A special session was devoted to the development of training systems for newcomers. A full set of the meeting material may be found on ENTRAC http://entrac.iaea.org

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Topical Issues in Infrastructure Development: Managing the Development of a National Infrastructure for Nuclear Power

A workshop is being planned for February 2010 as a continuation of the broad-ranging infrastructure workshops conducted in the past few years. This workshop will focus on the national strategy for the nuclear power programme as the starting point for institution-building and human resource development. As with previous workshops in the series, the agenda will provide breakout sessions for exchange of experience, lessons learned, and discussion among countries introducing nuclear power, those with experienced nuclear power programmes and potential suppliers. An announcement will be posted on the IAEA website in the near future when the details are finalized.

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Nuclear Power Newcomers and International Cooperative Actions: Newcomers Describe Main Issues Faced in Developing Their Nuclear Power Programs

A joint workshop organized by the Nuclear Energy Department and the Nuclear Safety and Security Department with the support of the Technical Cooperation Department attracted more than 120 participants from 49 Member States and WANO. Open discussions among the participants on the primary issues that newcomers are currently facing in introducing nuclear power programmes (NPP) in safe and sustainable ways, elicited six common problems:

- Getting strong national commitments and efforts following a robust political decision to introduce nuclear power within the country.
- Reaching political and economic stability, and keeping some continuity within the country to be able to develop a sustainable NPP with long-term safety.
- Human resource development and keeping qualified and trained staff (avoiding brain drain) within the newcomer country.
- Establishing or consolidating the national newcomer's legal and regulatory framework;
- Transparency, openness and involvement of the public and stakeholders in the development of a NPP.
- Preparing for future participation of national skills, industries and services to the NPP (i.e. localization).

The Chairmen concluded and explained that:

- Newcomers might be expecting too much from foreign assistance. Newcomers need to be intelligent customers, by understanding the technology, the process to embark on nuclear power, and being able to internally coordinate all international assistance programmes.
- Sharing information amongst newcomers is very useful and should be developed.
- Newcomers should request peer review services (e.g.: INIR and Tailored IRRS).

Based on the points raised during the workshop, the IAEA will prioritize efforts for newcomers especially in the following areas:

- Developing IAEA guidance documents on establishing the necessary newcomer's infrastructure to introduce nuclear power, providing assistance, and organizing peer reviews based on these documents.
- Facilitating newcomers' efforts to coordinate all assistance programmes and information sharing coming from foreign countries, EU and international organizations.
- Organizing more workshops which can give time devoted to newcomers by including discussions with breakout sessions and/or regional workshops.

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Invitation and Evaluation of Bids for Nuclear Power Plants

Specifying, obtaining and evaluating NPP bids is the most important and most concise project related activity during the preparatory phase of the nuclear power programme. A consultant meeting was held from 28-30 October 2009 in Vienna to review the Nuclear Energy Series Report draft on Invitation and Evaluation of Bids for Nuclear Power Plants (NPP).

This NES report is intended to provide integrated and up-to-date practical guidance on the complete process of NPP bidding for countries initiating or expanding nuclear power programmes. In addition, taking into account the current status of the global NPP market, in some countries, the NPP bidding process could be replaced by the direct communication between the supplier and owner, or only one supplier might participate in the NPP bidding process. Under this situation, this NES report could be used to check the compatibility of the information provided by supplier and owner, to implement the technical and economic evaluation of the supplier's proposal, and to negotiate the contract.

The NPP bidding process can be divided into the following main phases:

- Preparation of the Bid Invitation Specification (BIS); (owner).
- Preparation of bids; (bidders).
- Evaluation of bids; (owner).
- Contract negotiations; (owner and preferably two bidders).
- Finishing and signature of the contract. (owner and supplier).

The schedule is to publish this report in early 2010.

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Safety Assurance of NPP with WWER

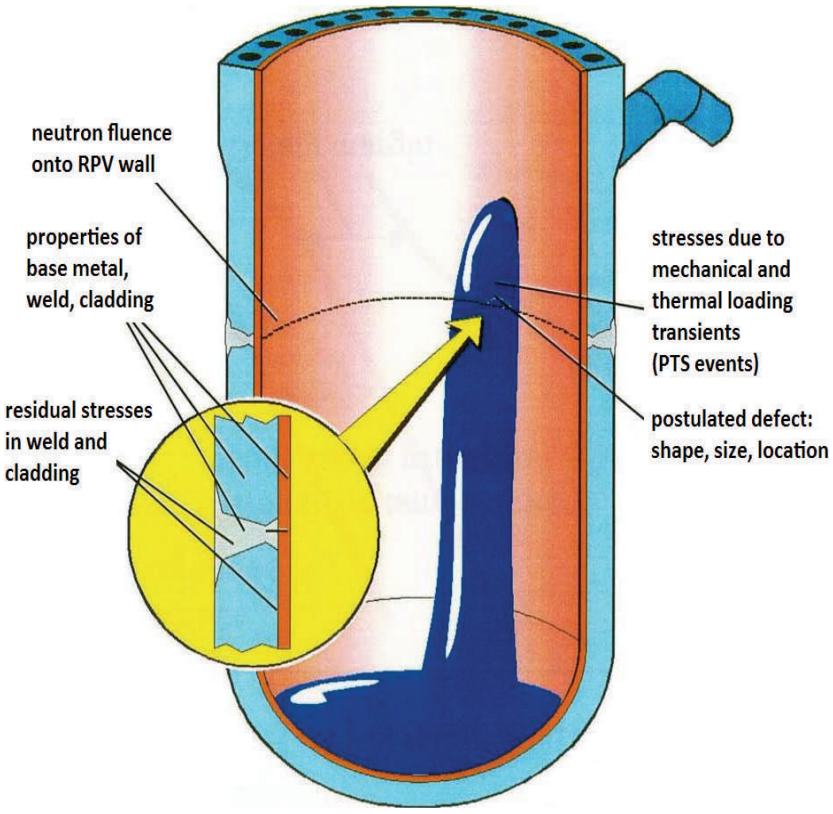
The IAEA will continue supporting MSs in the area of safety assurance of NPP having WWER reactors as was done in Conference held in Podolsk, Russian Federation on May 2009. The conference was attended by 235 specialists from 13 states, 62 Russian and 21 foreign organizations. The actual main activities and future major challenges in WWER fleet are:

- new reactors and development of structural materials for NPP components with planned 60 years design lifetime;
- power uprate in operated units in the range 4–10%;
- preparation of natural circulation concept in the primary circuit of WWER-1000/1200 units on the power level up to 30% without main coolant pump for the case of beyond design accidents; and others.

Future demands are: long term operation, power uprate, development of new WWER units with the power in the range of 300–1600 MW, innovations in design of reactors with supercritical water parameters, preparation of new standards for existing and developing NPPs, and implementation of activities in the field of nuclear knowledge and preservation.

Systems, Structures and Components Integrity

Another area of IAEA continuing support is on the integrity of main systems, structures, and components (SSCs). The IAEA has already held a workshop June 2009 where experts presented their lectures on 1) integrity assessment of reactor pressure vessels and other safety relevant SSCs, 2) tools used in the assessment and the latest research (advanced fracture mechanics, leak-before-break concept, modeling of irradiation embrittlement on substructural level), 3) examples of life extension programme in Germany, Rep. of Korea and the United States of America.



Key elements of RPV structural integrity

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INPRO

International Project on Innovative Nuclear Reactors and Fuel Cycles

Looking Back and Moving Forward: INPRO fosters sustainable nuclear energy development

The year 2009 was the year in which INPRO, the International Project on Innovative Nuclear Reactors and Fuel Cycles, made a major leap forward in fulfilling its vision of fostering innovation so that nuclear energy can make a significant contribution to meeting global energy demand in a sustainable manner. Established in 2000 by a resolution of the IAEA General Conference, which reconfirmed support for INPRO in subsequent years and most recently at the 53rd GC Meeting, the project will celebrate its 10th anniversary in 2010.

The INPRO Action Plan for the next biennium, first drafted and discussed at the 14th meeting of the INPRO Steering Committee (SC) in February 2009 (see Newsletter Vol. 6, No. 2), was finalized and approved at the 15th Meeting of the INPRO SC in November 2009. The plan charts the way forward for INPRO through a focused reorganization of the project structure (in 2008), and ongoing and new activities that are grouped into five major areas:

- Nuclear Energy System Assessments using the INPRO Methodology;
- Global Vision, Scenarios and Pathways to Sustainable Nuclear Development;
- Innovations in Nuclear Technology;
- Innovations in Institutional Arrangements;
- the INPRO Dialogue Forum on Nuclear Energy Innovations.

A sixth area ensures effective policy coordination and management of the project, as well as targeted communication with INPRO's stakeholders. A membership-based and multilateral project, INPRO benefits from contributions of at present 30 IAEA Member States and the European Commission and all relevant Agency programmes; it also works in synergy with other international initiatives such as the Generation IV International Forum (GIF).

INPRO is mainly supported by extra-budgetary funds. The results of its activities are made available to all IAEA Member States.

This article highlights the project's vision and plans for 2010-2011 and also reports on some of the lessons learned, progress made and results achieved to date.

A. Nuclear Energy System Assessments using the INPRO Methodology

A Nuclear Energy System Assessment (NESA) is a holistic approach using an internationally validated tool, the INPRO methodology, to support long-term planning and strategic decision making in Member States that are planning to expand existing nuclear energy programmes or establish a new one. More specifically, a NESA evaluates:

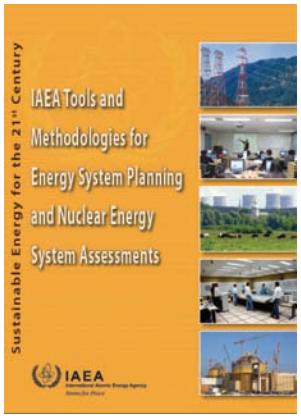
- All nuclear facilities in a given nuclear energy system, from mining thought to final end states for all wastes and permanent disposal of high level waste, and all related institutional measures such as a legal framework, regulatory bodies, etc.
- The complete lifecycle of the facility ('cradle to grave'), i.e. design, construction, operation and decommissioning,
- All assessment areas defined in the INPRO methodology, i.e. economics, infrastructure, waste management, proliferation resistance, physical protection, environment and safety.

A NESA can be used both by countries with established nuclear programmes, e.g. to assess the transition from a

current fleet of reactors to a nuclear energy system with innovative technologies, and by 'newcomers', wishing to embark on new nuclear programmes. The assessment allows them to consider possible future nuclear systems in a holistic and comprehensive manner to determine whether or not they would meet a country's sustainable development.

Following earlier assessment studies in a number of Member States, recently **Belarus** has initiated an assessment of its planned nuclear energy system, and several other countries have indicated their interest to do the same. Two new activities in 2010 and 2011 will support such initiatives, i.e. **the development and publication of a comprehensive full-scope NESA** and **NESA Support Packages** targeted to the individual needs of countries wishing to perform an assessment of their existing or planned nuclear energy system.

In early 2009, the INPRO methodology was published in a nine volume manual *Guidance for the Application of an Assessment Methodology for Innovative Nuclear Energy Systems* (IAEA-TECDOC-1575 Rev.1). Prepared jointly with the IAEA's Planning and Economic Studies Section (PESS), an booklet on *IAEA Tools and Methodologies for Energy System Planning and Nuclear Energy System Assessments* presented IAEA computer models devoted to energy system analysis and planning, indicators for sustainable energy development, and the INPRO methodology as a tool for NESAs.



This publication served as a background document in **a Workshop on 'IAEA Tools for Nuclear Energy System Assessment for Long Term Planning and Development'**, jointly organized by the INPRO Group and PESS with support from the Department of Technical Cooperation and held in July 2009. The workshop brought together participants from 40 IAEA Member States, and was one of the key elements of an IAEA interregional project to promote technology development and the application of future nuclear energy systems developing countries. Their representatives, especially those who are not INPRO members, were able to familiarize themselves with the large range of aspects that have to be taken into account when establishing modern nuclear energy systems. The approach of coupling the assessments for an optimal energy mix and evaluating a planned nuclear energy system was considered to be very useful.

INPRO Collaborative Projects (CPs) are another mechanism for meeting INPRO's objective of fostering innovation and sustainable nuclear energy development They enable groups of Member States to collaborate closely on topics of joint interest. One such project within Programme Area A was recently launched in cooperation with the IAEA Laboratories in Seibersdorf: **Environmental impact benchmarking applicable for nuclear energy system under normal operation.** The CP, which will run until 2011, was initiated by France and has attracted participants from 12 Member States so far. The project will consider environmental stressors and types of release of such stressors, e.g. through the atmosphere or water and investigate the type of contamination, which could occur, e.g. through inhalation or through the food chain (ingestion). Expected results include a benchmark of assessment methodologies to rank radionuclides concerning their impact on human health; a comparison of the most important radionuclides and their environmental impacts when the source is a nuclear power plant or reprocessing facility; and feedback on the practical application of the INPRO methodology in the assessment area 'Environment'.

B. Global Vision, Scenarios and Pathways to Sustainable Nuclear Development

INRPO can fill a unique niche in contributing to the development of a vision and possible scenarios for global and regional nuclear power development, Mr. Yury Sokolov, IAEA Deputy Director General, Department of Nuclear Energy, and INPRO Project Manager pointed out at the 15th INPRO Steering Committee Meeting.

Sharpening the focus on how nuclear energy can contribute to long-term sustainable development is the aim of an INPRO study **Global Scenarios and Regional Trends of Nuclear Energy Development in the 21st Century,** which has been a key activity in 2009. Using scientific-technical pathway analysis to develop global and regional nuclear energy scenarios and identify role of technological innovations in reactors and fuel cycle methods, the study illustrates interregional links in industrial capacity and resources including uranium, flows of nuclear fuel and other nuclear materials between regions to support the global growth of nuclear energy. Sixteen experts from nine INPRO Member States have contributed to the study which will be concluded at the end of 2009.

Four ongoing collaborative projects will continue through 2010 or 2011, respectively:

- Global Architecture of Innovative Nuclear Systems based on Thermal and Fast Reactors including Closed Fuel Cycles (GAINS)
- Fuel Cycles for Innovative Nuclear Systems through Integration of Technologies (FINITE)
- Investigation of the 233U/Th Fuel Cycle (ThFC) and
- Meeting Energy Needs in the Period of Raw Materials Insufficiency during the 21st Century (RMI).

Three new activities are included in the biennial Action Plan and will:

- Integrate results from the above four CPs and the global vision and scenarios study into a single activity, with a publication in 2012 on **the INPRO vision on sustainable nuclear energy development scenarios in the 21st century**;
- Investigate options for sustainable supply of fuel including thorium; and
- Explore how to consider macroeconomic and socio-economic factors to support Member States in strategic nuclear energy planning.

The results of these new activities will be documented in IAEA publications.

C. Innovations in Nuclear Technology

This covers collaboration among INPRO Members in the area of innovative technologies, developed to support the deployment of innovative nuclear systems in Member States and under other international collaborative mechanisms such as GIF. Two of the five CPs in this programme area are highlighted here.

INPRO CP COOL: Next generation reactors, to be used for hydrogen production and other applications, will need to incorporate innovative approaches to further enhance their reliability and safety for large scale deployment in different regions of the world. An important feature of these reactors will be the use of coolants at temperatures that are much higher than those in current generation reactors. This involves addressing a wide range of issues concering design and safety of these reactors.

An INPRO CP, termed COOL, investigates the technological challenges of cooling reactor cores that operate at temperatures up to 1000 degrees C in advanced fast rectors, high temperature reactors and accelerator driven systems, by using liquid metals and molten salts as a coolant. The CP was initiated by the Czech Republic and India, and five other countries have joined since, i.e. Brazil, China, Germany, Hungary, Italy and the Republic of Korea. Each participating country has ongoing research activities related to liquid metals and molten salts and will contribute with its particular expertise. It is foreseen that the results of the investigation will be published in 2011.

INPRO CP PGAP: A Performance Assessment of **P**assive **GA**seous **P**rovisions aims at proposing an internationally accepted definition for the reliability of thermal-hydraulics passive systems and a methodology to assess their reliability. The new methodology will build from existing methodologies developed in Europe and India, and will use the results of a benchmark exercise, modeling decay heat removal transients for the CEA gas cooled fast reactor (GFR) design. The benchmark will comprise two phases – deterministic calculations and reliability calculations. For each phase, two transients will be simulated to asses the performance of the decay heat removal system.

The initially six partners in the CP, France, Belarus, Belgium, Czech Republic, Germany and India, were joined by Algeria last year, when the country expressed the wish to become a member of INPRO. The CP includes active participants, performing the benchmark exercise, and observers. Integrating Algeria successfully as a new partner during the project has demonstrated the potential for INPRO to collaborate well with new INPRO Members. Coordination is also ensured with the IAEA Coordinated Research Project on 'Development of Methodologies for the Assessment of Passive Safety System Performance in Advanced Reactors'. The CP will continue in 2010, and results will be published at the end of the study.

D. Innovations in Institutional Arrangements

Innovative institutional arrangements and new infrastructure concepts for the deployment of nuclear energy remain an important challenge to be addressed in most future nuclear scenarios. INPRO has undertaken related work in the past. Many of the associated issues to be investigated are relatively new and pose complex challenges.

One new activity in this area will be a **CP on Innovative Institutional Approaches**, e.g. multinational fuel cycle approaches, fuel leasing options, multinational nuclear fuel cycle (MNNFC) participation, infrastructure options and others. This three-year CP will be initiated in 2010 in cooperation with NPES, Nuclear Safety and coordinated with the Division of Nuclear Fuel Cycle and Waste Technology.

In 2009, a key study in this area has addressed **legal and institutional issues of Transportable Nuclear Power Plants (TNPP)**. A TNPP is a non-stationary nuclear energy unit capable of producing final energy products. It includes the nuclear reactor, balance of plant, e.g. steam generator or turbine, and if necessary, fuel storage facilities. The complete TNPP is factory-fabricated and then moved to its location by rail, truck or ship. Fuel is either already included in the reactor core or transported separately and the loaded at the site. All TNPP reference cases in the INPRO study are not designed for, and do not enable, operation during transport. TNPPs are of particular interest for areas with limited infrastructure,

countries with small electrical grids, and remote or isolated islands. No operating TNPP exists in the world today, although in several countries new technologies are being designed or TNPPs constructed. TNPPs require innovative approaches to institutional and legal arrangements. Seven Member States are participating in this study which also benefits from cooperation of the IAEA Office of Legal Affairs. Special emphasis has been placed on:

- Technical, logistic and hard infrastructure implications for the use of a TNPP as a battery reactor
- A minimum technological level required in the recipient country to deploy a TNPP
- Quality assurance and control to meet licensing requirements in the supplier/recipient countries.

The main objective is to help developers learn about technologies that could simplify legal and infrastructure issues, technical design scenarios, and options for operation and ownership. The study results will be published in 2010.

E. INPRO Dialogue Forum on Nuclear Energy Innovations

This Dialogue Forum will be implemented in 2010 and 2011 through a variety of meetings, the first being held on 1-4 February 2010. It offers a platform for stakeholders including representatives of governments, national and international organizations, regulators, vendors, operators and nuclear researchers to discuss and share information, but not necessarily reach consensus or adopt joint policies. The aim is to bring together technology users and holders from all interested Member States and facilitate a dialogue so that holders and users can better understand concerns, possibilities and limitations associated with the development and deployment of innovative nuclear energy systems. The main outcome of the Dialogue Forum will be proceedings that document positions, questions, and progress in discussions.

F. Policy Coordination, Communication and INPRO Management

In October 2009, Mr. Jong Kyun Park assumed the position of the Director of the Division of Nuclear Power and **Policy Coordinator of INPRO**. A new activity in 2010 is the organization of **an international event**, in conjunction with the 54th Meeting of IAEA General Conference, **to mark the 10th anniversary of INPRO.**

The approved INPRO Action Plan 2010-2011 reinforces INPRO´s role as a multilateral body that is discussing nuclear energy innovation through a comprehensive scientific and technological understanding of the institutional, legal, sociological, environmental and economic factors that will determine the success of nuclear energy development.

For further details Visit also the new INPRO Website at www.iaea.org/INPRO.

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Technology Development for Water Cooled Reactors

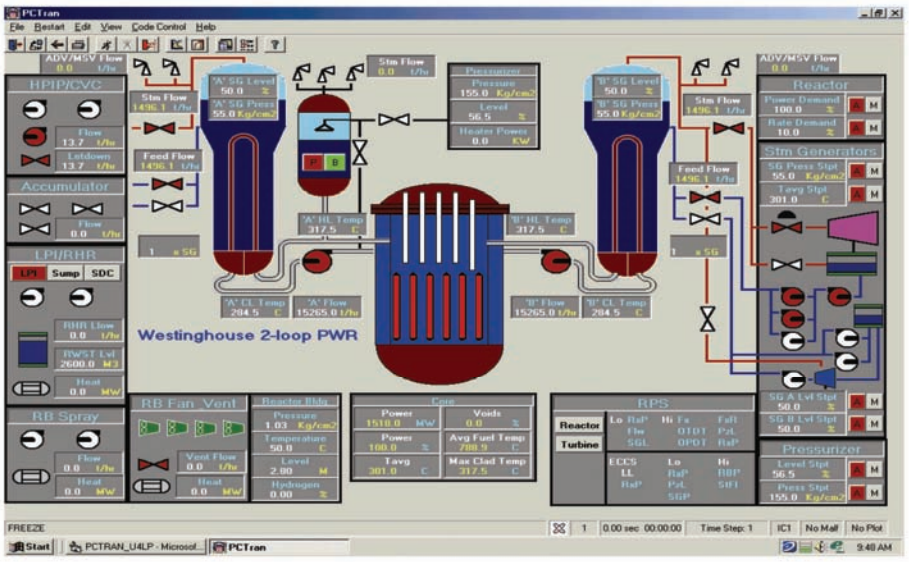
Water cooled reactors (WCRs) have been the keystone of the nuclear industry in the 20th century. As we move into the 21st century and the nuclear community worldwide looks into the future with the development of advanced and innovative reactor designs and fuel cycles, it becomes important to explore the role WCRs will play in this future. In this context, the recent meetings of the **Technical Working Groups on Advanced Technologies for Light Water Reactors and Heavy Water Reactors (the TWG-LWR and the TWG-HWR)** emphasized putting the highest priority in developing, finalizing and solidifying a long term strategic plan that focuses the role and future activities of the IAEA Water Cooled Reactors Technology Development Group.

In keeping with one of the key roles of the Agency, which consists in being an up-to-date and unbiased source of information on available nuclear technology, the Technology Development Section will complete in 2010 an ambitious effort to compile and categorize the **current status of the various reactor designs in the form of a web accessible database** that will be available in the IAEA public website.

Passive safety systems are becoming an important component in advanced water cooled reactor designs. This has led to an international interest in sharing best practices and experiences in the design and validation of passive safety systems and in the optimum use of active and passive systems. A survey of various passive systems, evaluated within the framework of the IAEA coordinated research project (CRP) on Natural Circulation Phenomena, Modeling, and Reliability of Passive Systems That Utilize Natural Circulation, was published in 2009 as an **IAEA-TECDOC-1624** entitled Passive Safety Systems and Natural Circulation in Water Cooled Nuclear Power Plants. The final document summarizing the main results of this CRP is under preparation and is expected to be issued in 2010. As a follow-up to this CRP, **a new** IAEA 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 using experimental facilities at the

at Oregon State University and the first workshop is planned for March 2010. The next session of the IAEA training course on Natural Circulation in water cooled NPPs will be held at ICTP, Trieste, Italy, May 2010.

Another area where there are substantial international efforts is the development and effective use of computational tools in support of experimental work. The Agency is gathering the state of the art knowledge with regard to the development of computer models, including CFD codes, that accurately represent the behaviour of advanced nuclear systems. These activities include the benchmarking of computer codes against available integral and separate effects test data, or against other suitable analytical tools. This is the goal of the CRP on Benchmarking Severe Accident Computer Codes for HWR Applications the Agency started in 2009 and whose second research coordination meeting is scheduled at NPCIL, in Mumbai, India in February 2010. The IAEA ICSP on HWR Small Break LOCA (SBLOCA) aims to improve the understanding of important phenomena expected to occur in SBLOCA transients and to evaluate code capabilities to predict these important phenomena is currently underway.



The compilation and maintenance of peer-reviewed databases for Member State use is also an important endeavour of the IAEA. The IAEA and the IAEA Designated Center for Nuclear Materials Properties Data Base Management (CNMD) located at Hanyang University in Rep. of Korea are currently involved in a major overhaul of the hardware and software that supports the web-based IAEA THERPRO database of thermophysical properties data of materials for water cooled reactors. It is expected that the upgraded database, which currently includes more than 13,000 thermophysical properties data tables of more than 1,300 materials will be completed by early 2010. In this sense, the IAEA CRP on Heat Transfer Behaviour and Thermohydraulics Code Testing for Supercritical Water Cooled Reactors is currently pursuing the establishment of a base of accurate data for heat transfer, pressure drop, blow down, natural circulation and stability for conditions relevant to supercritical fluids. This CRP is contributing to the international efforts in the development of supercritical water cooled reactor concept by testing analysis methods for SCWR thermo-hydraulic behaviour, and identify code development needs. The IAEA is making an effort in identifying Member States' needs and supporting them. One of the areas countries have indicated a desire in receiving guidance is the process of evaluating different nuclear technology options. As a consequence, a document on

Nuclear Reactor Technology Assessment for Near Term Deployment is currently under development based on the best practices and lessons learned from recent experiences and on the feedback from the two very successful workshops on Technology Assessment organized by IAEA in 2007 and 2008. Because achieving a short and efficient construction schedule for future NPP construction projects is also a priority for Member States, the IAEA is finalizing a report titled Construction Technologies for New Nuclear Power Plants, which assimilates global experience from a variety of recent large construction projects and includes comprehensive descriptions of all construction methods including their advantages and disadvantages, and a discussion of best practices and lessons learned.

Technology Training in the area of advanced WCRs is also a main concern for the IAEA. For the last few years the Agency has compiled a collection of PC-based simulators designed to provide insight and hands-on experience in the key design and operational characteristics and the response to perturbations and off-normal situations for a variety of water cooled reactor types. The collection currently has seven simulators: BWR, CANDU, PWR, WWER, Passive BWR, Passive PWR and Advanced CANDU. The expansion of this collection to include additional reactor types, the enhancement of the existing simulators, manuals and training materials, as well as the organization of periodic workshops for in-depth understanding of the simulators continues to be a priority for 2010. New technology training courses/workshops are under development to be deployed within 2010.

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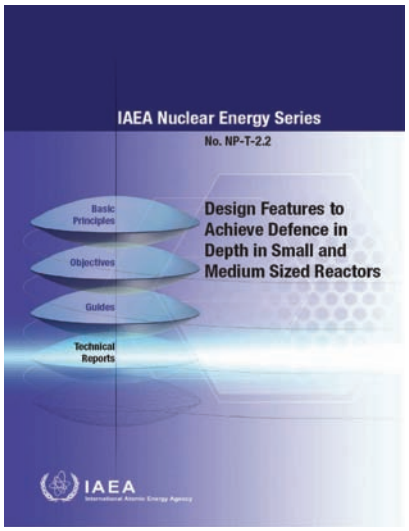
Technology Development for SMRs Reactors

Common Technologies and Issues for small and medium sized reactors (SMRs)



The IAEA General Conference resolution GC(53)/RES/13/B.3 of September 2009 encouraged the secretariat to continue the activities of the Regular Budget project Common technologies and issues for SMRs on both the development of key enabling technologies and the resolution of key infrastructure issues for innovative SMRs of various types, which is complementary to the extrabudgetary International Project on Innovative Nuclear Reactors and Fuel Cycle (INPRO).

Following this recommendation, in 2010 the project will continue the activities aimed at justification of reduced emergency planning zone requirements for SMRs. Specifically, the final report of a coordinated research project (CRP) on small reactors without on-site refuelling will be published as IAEA-TECDOC, presenting a methodology for such justification and an example of its application. In line with the recommendations of the IAEA Nuclear Energy Series Report NP-T-2.2 on Design Features to Achieve Defence in Depth in SMRs published in July 2009 (see Fig. 1), a CRP on Development of Advanced Methodologies for the Assessment of Passive Safety System Performance in Advanced Reactors (CRPI31018) will be continued, and the second research coordination meeting for the CRP will be convened in March 2010.

To support finding a competitive strategy in SMR design and deployment, a new Nuclear Energy Series report titled Approaches to Assess Competitiveness of SMRs will be produced and software tools for the assessment of SMR competitiveness in different applications will be consolidated and verified. National case studies on SMR competitive applications will be completed, and a report summarizing the outputs of these studies will be prepared.

Following the publication of status reports on advanced SMR designs (IAEA-TECDOC-1485 in 2006 and IAEA-TECDOC-1536 in 2007), the updated design descriptions of SMRs will be included in the newly developed electronic database of advanced reactor designs. The preparation of a new status report on advanced SMR designs with a potential of deployment before 2020 will be started.

The activities on preparation of a new IAEA Nuclear Energy Series report on Options to Enhance Proliferation Resistance and Physical Protection of NPPs with Innovative SMRs will be continued, and a technical meeting would be convened. The specific objective of this report would be to define a framework for the use of different approaches to incorporation of the intrinsic proliferation resistance and physical protection features in the designs of advanced SMRs and associated fuel cycles, starting from early design stages. This activity foresees broad cooperation with the IAEA's INPRO project.

As in 2008-2009, support to the preparation of a new Nuclear Energy Series report on Legal and Institutional Issues for Transportable Nuclear Power Plants will be provided, with INPRO taking a lead.

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Technology Development for Gas Cooled Reactors

The TWG-GCR meeting of February 2009 approved the following activities for implementation in 2010.

- A Technical Meeting culminating into a NE Series Document on Licensing experiences for past HTGRs and challenges for future HTGR Nuclear Power Plants (NPPs). This will be pursued in collaboration with the NSNI section in the Safety Department.
- Development of a NE Series document on HTGR Economic Assessment.
- Finalization and publication of the second TECDOC on the CRP5 on HTGR Performance.
- Finalization and publication of the TECDOC on the CRP6 (Advances in HTGR Fuel).
- Publication of the NE Series Document on Construction Methods for Nuclear Power Plants.
- First Consultancy Meeting for the proposed CRP on HTGR Reactor Physics, Thermal Hydraulics and Depletion Uncertainty Analysis.

A new CRP on Graphite Irradiation Creep was approved for implementation by the Technical Working Group on Gas-Cooled Reactor at its meeting in February 2009.

The CRP's main objective is to enhance an understanding of the creep phenomenon in nuclear graphite through a set of experiments as well as irradiation creep model development and testing. To date, 7 institutes and companies have joined the CRP namely, British Energy and University of Manchester from the UK, NRG (The Netherlands), KAERI (Rep. of Korea), PBMR and the University of Pretoria (South Africa), INET (China) JAEA and Toyo Tanso (Japan). The first RCM finalized the work plan and established working groups with a view of addressing common and synergistic activities of interest. The CRP will run for a period of 4 years and will end in December 2013.

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Technology Development for Fast Reactors and Accelerator Driven Systems

Fast reactors have been under development for many years in several countries, primarily as breeders. Fast reactors can also contribute to reducing plutonium stockpiles, and to reducing the required isolation time for high-level radioactive waste by utilizing transuranic radioisotopes and transmuting some long-lived fission products.

The design and operation of sodium-cooled fast reactors, such as the small size Prototype Fast Reactor in the United Kingdom, the prototype Phénix in France, the BN-350 in Kazakstan (part of its thermal energy was used for sea-water desalination), the demonstration BN-600 in Russia, Monju in Japan, and the commercial size Superphénix in France, have provided an experience base of more than 400 reactor-years. In addition, there is a considerable base of experience with lead-bismuth eutectic cooled propulsion (submarine) reactors operated in Russian Federation. Currently, there are two experimental fast reactors in operation (BOR-60 and FBTR in Russian Federation and India, respectively) and one under commissioning (CEFR in China); one power fast reactor in operation (BN-600 in Russian Federation), one under re-start preparation (Monju in Japan), one in the stage of end-of-life tests (Phénix in France), and two under construction (PFBR and BN-800 in India and Russian Federation, respectively).

The areas of collaboration between Member States within the framework of IAEA's Project on Technology Advances in Fast Reactors and Accelerator Driven Systems are identified by the Member States through participation in the IAEA Nuclear Energy Department's Technical Working Group on Fast Reactors (TWG-FR). In 2009, the Project can look back at notable achievements, e.g.:

- Providing opportunity for in depth information exchange among IAEA Member States in the field of accelerator applications including nuclear material research, Accelerator Driven Systems (ADS) for utilization and transmutation of minor actinides and some long-lived fission products, and accelerator technology [see International Topical Meeting on Nuclear Research Applications and Utilization of Accelerators, organized in cooperation with the American Nuclear Society by the IAEA Division on Nuclear Power, the Division of Physical and Chemical Sciences, and the Division of Nuclear Fuel Cycle and Waste Technology, Vienna, 2009].
- Implementation of two Coordinated Research Projects (CRPs) aiming at validation and qualification of reactor physics data and codes based on experimental benchmarks
- Planning and organization of the first large international conference in almost twenty years dedicated to fast reactors and their fuel cycles, the International Conference on Fast Reactors and Related Fuel Cycles: Challenges and Opportunity (FR09), Japan, December 2009.
- Release of various technical publications, e.g. IAEA-TECDOC-1623, IAEA-TECDOC-1633, and IAEA-TECDOC-1626.

Looking ahead to the next IAEA Programme and Budget cycle 2010 – 2011 and beyond, and in view of enhancing the role of the TWG-FR in meeting the needs of interested Member States, the Project will continue to organize regular meetings to exchange information, carry out CRPs of common interest to the TWG-FR Member States, be pro-active in the organization of large conferences on different aspects of fast reactor research and technology, and last but not least sustain the excellent platform for the fast reactor specialists to share the experience related to design, development, construction and operation of nuclear power plants with fast reactors.

The TWG-FR will also increase its efforts towards establishing a forum for broad exchanges on technical requirements for 4th generation fast reactor systems. It will offer its services towards creating an international collaboration framework for studies towards the development and realization of a fast spectrum experimental reactor. More emphasis will be put on benchmark studies on modeling and simulation of various phenomena related to fast reactors, efforts to secure training and education in the field of Fast Neutron System Physics, Technology and Applications will be increased and respective Schools/Workshops held on a regular basis, and, last but not least, in collaboration with the Nuclear Safety Department, the task of preparing Safety Guides on Fast Reactors will be initiated and vigorously pursued. For more information see www.iaea.org/inisnkm/nkm/aws/fnss/index.html

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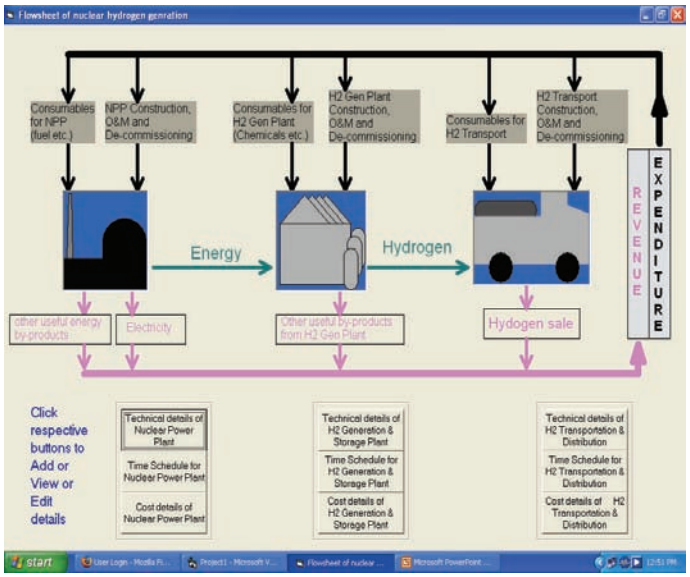
Non Electrical Applications of Nuclear Power

To meet the global growing interest in non electric applications especially for seawater desalination and hydrogen production, the IAEA has already implemented several activities such as the development of Desalination Economic Evaluation Programme (DEEP) and the publications of several technical report.

In 2009, these activities have been enhanced further by the release of updated version of DEEP, the release of

the beta-version of the IAEA toolkit on nuclear desalination (above), and the release of new version of the IAEA Hydrogen Economic Evaluation Programme (HEEP), and technical reports on the environmental impact of nuclear desalination and on water management for the efficient use and consumption of water in new nuclear water reactors.



HEEP Flowsheet of Nuclear Hydrogen Generation

In 2010, previous activities will be enhanced further as they have received the support of the TWG-ND (previously known as INDAG) which held its first meeting in June 2009, and the support of participants to the technical meeting held in Oct 2009 in Mumbai, India on the status of hydrogen production using nuclear energy. The new activities will focus on the release of new Version of DEEP having several improvements to respond to the need of making scoping analysis and economic comparisons of various envisioned desalination systems using nuclear and conventional energy sources. In addition to finalizing the above mentioned technical documents, other technical documents will be completed including the compilation of a guideline on how to conduct the environmental impact of nuclear desalination, technical report on preparing feasibility studies for seawater desalination using nuclear energy and aspects of cogeneration (i.e. electricity, desalination, and hydrogen).

Other activities will include capacity building through various forms of information production with focus on near term processes, and industrial applications using nuclear energy. It is hoped that during 2010 a new CRP will be launched on HEEP benchmarking, and the works will continue on the CRP concerning the new technologies for seawater desalination using nuclear energy.

Contact: Ibrahim Khamis I.Khamis@iaea.org

Publications: *in Print*

Passive Safety Systems and Natural Circulation in Water Cooled Nuclear Power Plants, IAEA-TECDOC-1624.

BN-600 Hybrid Core Benchmark Analyses. Results from a Coordinated Research Project on Updated Codes and Methods to Reduce the Calculational Uncertainties of the LMFR Reactivity Effects, IAEA-TECDOC-1623.

Advanced Reactor Technology Options for Utilization and Transmutation of Actinides in Spent Nuclear Fuel, IAEA-TECDOC-1626.

Decommissioning of Fast Reactors After Sodium Draining, IAEA-TECDOC-1633.

Recent Publications

2009

Nuclear Power Objectives: Achieving the Nuclear Energy Basic Principles. NP-O, August 2009.

Managing Human Resources in the Field of Nuclear Energy. NG-G-2.1, September 2009.

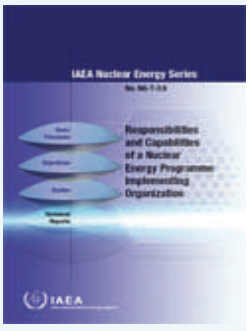
Proceedings of an International Conference on Non-Electric Applications of Nuclear Power: Seawater Desalination, Hydrogen Production and other Industrial Applications, 16-19 April 2007, Oarai, Japan, Vienna, P-1354, 2009.

Thermophysical Properties of Materials for Nuclear Engineering: A Tutorial and Collection of Data, IAEA-THPH, Feb 2009.

Design Features to Achieve Defence in Depth in Small and Medium Sized Reactors" IAEA Nuclear Energy Series Report, NP-T-2.2 STI/PUB/1399, July 2009.

Intercomparison of Techniques for Inspection and Diagnostics of Heavy Water Reactor Pressure Tubes: Determination of Hydrogen Concentration and Blister Characterization, IAEA-TECDOC-1609, March 2009.

Responsibilities and Capabilities of a Nuclear Energy Programme Implementing Organization. NG-T-3.6, October 2009.



Initiating Nuclear Power Programmes: Responsibilities and Capabilities of Owners and Operators. NG-T-3.1, October 2009.

Issues to Improve the Prospects of Financing Nuclear Power Programmes. NG-T-4.1, October 2009.

Integrity of Reactor Pressure Vessels in Nuclear Power Plants: Assessment of Irradiation Embrittlement Effects in Reactor Pressure Vessel Steels, NP-T-3.11, 2009.

Implementing Digital Instrumentation and Control Systems in the Modernization of Nuclear Power Plants, NP-T-1.4, 2009.

2008

Nuclear Energy Basic Principles, NE-BP.

Evaluation of the Status of National Nuclear Infrastructure Development, NG-T-3.2.

Advanced Applications of Water Cooled Nuclear Power Plants, IAEA-TECDOC-1584.

Accident Analysis for Nuclear Power Plants with Modular High Temperature Gas-Cooled Reactors, Safety Reports Series no. 56.

International Status and Prospects of Nuclear Power, Booklet.

Heavy Component Replacement in Nuclear Power Plants: Experience and Guidelines, NP-T-3.2 .

The Role of Instrumentation and Control Systems in Power Uprating Projects for Nuclear Power Plants, NP-T-1.3.

On-line Monitoring for Improving Performance of Nuclear Power Plants Part 2: Process and Component Condition Monitoring and Diagnostics, NP-T-1.2 .

On-line Monitoring for Improving Performance of Nuclear Power Plants Part 1: Instrument Channel Monitoring , NP-T-1.1.

Safe Long Term Operation of Nuclear Power Plants, SRS-57 .

Application of Reliability Centred Maintenance to Optimize Operation and Maintenance in Nuclear Power Plants, IAEA-TECDOC-1590.

Establishing a Code of Ethics for Nuclear Operating Organizations, NG-T-1.2.

Strategy for Assessment of WWER Steam Generator Tube Integrity, IAEA-TECDOC-1577.

2007

Milestones in the Development of a National Infrastructure for Nuclear Power, NG-G-3.1, 2007.

Liquid Metal Cooled Reactors: Experience in Design and Operation, IAEA-TECDOC-1569.

Status of Small Reactor Designs without On-site Refuelling , IAEA-TECDOC-1536 .

Economics of Nuclear Desalination: New Developments and Site Specific Studies, IAEA-TECDOC-1561.

Upcoming Events

Date	Contact	Title	Loca-	Country
01-04 Feb-10	H.Khartabil@iaea.org	INPRO Dialogue Forum on Nuclear Energy Innovations (Technical Meeting/Workshop)	Vienna	Austria
22-26 Feb-10	a.stanculescu@iaea.org	4th RCM of the CRP on Analytical and Experimental Benchmark Analyses of Accelerator Driven Systems	Mumbai	India
23-26 Feb-10	J.H. Choi@iaea.org	TM on Benchmarking Severe Accident Computer Codes for Heavy Water Reactor Applications	Mumbai	India
15-19 March	V.kuznetsov@iaea.org	Development of Advanced Methodologies for the Assessment of Passive Safety System Performance in Advanced Reactors	Vienna	Austria
16-19 Mar-10	J.H.Choi@iaea.org	CT on ICSP on Integral PWR Design Natural Circulation Flow Stability and Thermo-Hydraulic Coupling of Containment and Primary System during Accidents	Corvallis, Oregon	USA
17-21 May-10	J.H.Choi@iaea.org	Training Course on Natural Circulation Phenomena and Passive Safety Systems in Advanced Water Cooled Reactors	Trieste	Italy
17-21 May-10	a.stanculescu@iaea.org	43rd Technical Working Group on Fast Reactors TWG-FR	Brussels/ Mol	Belgium
17-19 May-10	i.khamis@iaea.org	TM Hydrogen production using low & medium temperature electrolysis	Vienna	Austria
25-27 May-10	R.Beatty@iaea.org	16th INPRO Steering Committee Meeting	Vienna	Austria
14-18 Jun-10	F.Depisch@iaea.org	Workshop on Nuclear Energy Systems Assessment (NESA) using the INPRO Methodology	Vienna	Austria
15-17 June-10	a.kazennov@iaea.org	Biennial Meeting of the IAEA Technical Working Group on Managing Human Resources in the Field of Nuclear Energy	Vienna	Austria
8-11 June-10	o.glockler@iaea.org	RCM of the CRP on Advanced surveillance, diagnostics, and prognostics techniques used for health monitoring of systems, structures, and components in NPPs.	Richland, WA	USA
27 June-1 July10	s.bilbao@iaea.org	Joint Meeting of the Technical Working Group on Advanced Technologies for LWR and HWR	Vienna	Austria

For more information on IAEA Meetings,

please visit:http://www-pub.iaea.org/MTCD/Meetings/PDFplus/current.pdf

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