



News from the Division of Nuclear Power  
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**Record attendance of more than 620 at the international conference on**

## **Fast Reactors and Related Fuel Cycles: Challenges and Opportunities**

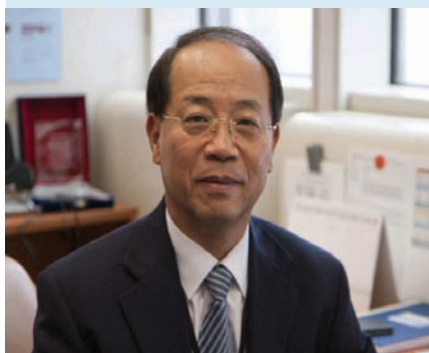
In response to a strong demand by Member States, the IAEA (Division of Nuclear Power and Division of Nuclear Fuel Cycle and Waste Technology) organized this international conference which was hosted by the Japan Atomic Energy Agency with participation of 622 experts from 20 countries and 3 international organizations. One hundred-fifty oral presentations, 154 displayed posters, as well as interventions and discussions at two panels and the Young Generation Event underlined the timeliness of FR09 and substantiated the claim that fast reactor and associated fuel cycle research and technology development is, in many countries, back on the agenda of research and industrial organizations, as well as academia.

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*Read more on page 13*

## Message from the Director

Welcome to the March 2010 Newsletter of the Division of Nuclear Power. I hope every reader of this Newsletter stayed in good health over the holiday and New Year season. It is the time to prepare for the coming summer since the spring has just arrived. It is also the time for us to prepare for the nuclear renaissance which is nearby with us.



The 2010 – 2011 program cycle in the Agency has just begun. Among many other activities of the NENP, supporting the Member States (MSs) with operating nuclear power plants (NPPs) for safe and effective operation is very important since a lot of the operating NPPs are over 20 years and they are getting old every year. This is also important to the MSs considering the introduction of the first NPP for better public acceptance on nuclear power. The NENP, in coordination with other departments in the Agency, will try its best to support existing fleet for the safe and improved performance as was done in previous years.

The NENP will keep focusing on the development of advanced/innovative nuclear power technologies for the preparation of the future needs for sustainable development. The NENP will continue focusing on the timely sharing of scientific and technical information related to advances in nuclear power technology and its various applications including non electric applications such as seawater desalination, hydrogen production and other industrial applications. Major activities in 2010 will focus on the issues for the near term technologies of various types and sizes of nuclear reactors with major focus on water cooled reactors. There will be a series of meeting/workshops and CRP's, to address the issues for the development and applications of water cooled reactors through the 21<sup>st</sup> century including economics and sustainability. Similarly, the Agency will continue to play a major role in the technology sharing and development related to fast reactors through CRP's and meetings related to both the startup and shut-down of major fast reactor projects globally.

With the adoption of the INPRO Action Plan for 2010–2011 by the INPRO Steering Committee, INPRO is starting into the biennium with activities in four substantive and two cross-cutting Programme Areas. A) Member States are being offered support for their long-range strategic nuclear programme planning through Nuclear Energy Systems Assessments (NESA) using the INPRO methodology; B) Scientific-technical studies on global nuclear development scenarios, including the transition to future nuclear fleets; C) Innovations in Nuclear Technology and D) Innovations in Institutional Arrangements. A new, cross-cutting area is the INPRO Dialogue Forum, effectively connecting today's technology holders with tomorrow's technology users.

Supporting MSs considering their first nuclear power plant is one of the major activities of the NENP since over 60 MSs have expressed their interests in introducing nuclear power programme. In 2009, three Integrated Nuclear Infrastructure Review INIR missions, in coordination with all the departments in the Agency, were carried out for Jordan, Indonesia, and Vietnam in order to assist their successful preparations for the introduction of the nuclear power programme. Many activities supporting newcomers are currently on going, and 4–5 more INIR missions are planned to be performed in 2010, and maybe more in 2011.

High turnovers of the senior staff in the Department of Nuclear Energy are expected to happen in 2010 and 2011. This would cause some problems in preserving the knowledge and competency of the Agency and also consistency of the service to the MSs. Thus, all the staff members of the NENP will be working closely with neighboring colleagues to ensure competencies, knowledge and institutional memory are maintained in the Division.

Two days of (NENP) Divisional retreat for sub-programme leaders was held in mid January. Twelve staff participated in the retreat was held to further promote good internal coordination of all services and activities provided by the Division to Member States. It was agreed "More We, Less Me".

Mr. Vladimir Kuznetsov who has been working on small and medium sized reactors is leaving us at the end of April 2010 after long years of good services. I would like to thank Mr. Kuznetsov for his great contribution to the Agency and the Member States. I wish Vladimir all the best.

I would like to try my best to improve the communications and cooperation with all the Member States, colleagues, friends, and the staff members for the fruitful and memorable year of 2010.

See you all in June 2010 Newsletter.

Jong Kyun Park

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## Support to Expanding Nuclear Power Plants (NPPs)

### NPPs Construction Management

Construction schedules of NPPs, from the first placement of structural concrete to grid connections, have ranged from less than five to more than twelve years. Achieving accurately predicted and shorter construction schedule is critical to the financial success of any new power plant project. This is one of the major challenges facing the nuclear industry. Recent experience in construction shows, that other challenge are the complexity of the vendor-customer relationship, length of the supply



chain, and the globalization of the nuclear industry. The IAEA is preparing a publication on nuclear power plant construction management to address all relevant issues related to construction management including interfacing with existing nuclear power plants. The first consultants meeting will be held 16-19 February 2010 in Vienna and the second technical meeting 28-30 June at Shanghai Nuclear Engineering Research & Design Institute (SNERDI), Shanghai, China.

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### NE Series Draft Report on Construction Methods for NPPs

Since October 2008, the Nuclear Power Technology Development Section (NPTDS) has embarked on an activity to develop a report on construction methods for nuclear power plants. The document is intended to document best practices from recent and past nuclear construction projects, with emphasis on methods used and how they impact the project schedule, cost and quality. Experts from Member States currently involved in or planning to start Nuclear Construction Projects such as China, Republic of Korea, Japan, India, the USA, South Africa, Canada and the United Arab Emirates participated in a series of Consultants Meetings and contributed towards the development of the document. The final consultants meeting was held in December 2009 to review and finalize the document.

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## Management for Efficient Water Use & Consumption in Water Cooled Reactors

As water requirements for electricity production must compete with other demands for water, reducing water use and consumption in nuclear power plants is more likely to help Member States introducing nuclear power in their energy supply mix even in areas affected by water shortages. NPTDS is also about to complete in 2010 a comprehensive first-of-a-kind technical draft report on water management in NPPs. The main objectives of this report are to present the current water requirements in NPPs, the technology behind it, best practices and strategies for lowering water withdrawal rates, as well as to present the trends that are likely to be of interest in the future.

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### Project Management for New Nuclear Power Projects

The IAEA will organize an interregional workshop on Project Management for New Nuclear Power Projects. The workshop will be held during 10 -15 May 2010 at the Korea Nuclear Education and Training Center (KNETC) in Ulsan, Republic of Korea.



Topics in the workshop will include: 1) Considerations for reactor technology assessment; 2) Nuclear power plant construction management; and 3) Nuclear power plant construction technology. The workshop will provide practical information on technology-neutral approach for the evaluation of available reactor technologies, an overview of technologies involved in the construction of a new NPP, construction infrastructure assessment and construction management. For these topics, the workshop will present concepts and issues, yet it will include case studies and lessons learned from participant countries. The workshop will also include a scientific visit to a construction site of nuclear power plants and radwaste disposal facility.

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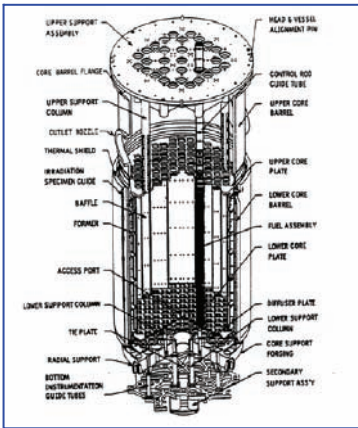
## Support to Operating Nuclear Power Plants (NPPs)

### Plant Life Management for Long Term Operation

Many plants that are reaching the end of their planned life are achieving high economic returns, because their capital costs have mostly been recovered, and the output is often as high as at any time during the plant life. A great incentive to utilities is to demonstrate that the plant will continue to operate. This requires not only a safety justification but also a demonstration that there are no life limiting features approaching and that the plant could be operated economically. A workshop on the above subject was held at the Institute of Nuclear Technology (INETEC) from 4 to 6 November 2009 in Zagreb, Croatia. A total of eighteen engineers from Armenia, Bulgaria, Croatia, Hungary, Romania, Russian Federation, Slovenia, Slovakia and Ukraine participated to share their practical applications of plant life management (PLiM) programme experiences and practices.

### Reactor Core Internals Behaviour and Technology for Repair and Replacement

The extension of Nuclear Power Plant life is becoming an attractive option for utilities to continue to supply electricity. The reactor pressure vessel internals (RPVI) are of the high priority key components which are necessary for the long term operation of NPPs. A workshop was held from 24 to 27 November 2009 in Mexico City, Mexico, and focused on reactor pressure vessel internals integrity requirements and assessment



methods for life management programmes, damage mechanisms, inspection and surveillance methods and their application. Furthermore, structural analysis and integrity assessment of RPVI, as well as mitigation and repair/replacement methods, were addressed.

### Launching a New CRP on Continued Operations Beyond 60 Years in NPPs

Faced with the competing threats of global warming and a looming energy shortfall, Member States are contemplating whether a 2<sup>nd</sup> term life extension service

can be squeezed out of their ageing nuclear power plants without compromising safety. This CRP will contribute to the establishment of the quantitative evaluation methodology for continued water cooled reactor's operations beyond 60 years. The results of the CRP will be used in assessing the long term reliability of systems structure and components, management of age-related degradation issues and application of new technologies for monitoring, diagnostics, and performance prediction. The CRP's goals are: 1) Identifying broadly defined research areas that address long-term challenges to plant operations, 2) Identifying prioritized research areas, 3) Identifying cross-cutting topics of relevancy, and 4) Establishing stakeholder roles and responsibilities. The first consultants meeting will be held from 3 to 5 March at Seoul, Republic of Korea.

### Equipment Qualification

The IAEA is preparing a report on equipment qualification on operational nuclear power plants. A consultants meeting was held from 8 to 10 March 2010, in Daejeon, Republic of Korea. The purposes of this meeting were to build on the technical framework needed for equipment qualification on operational nuclear power plants, and to address all relevant issues related to equipment qualification and interface with nuclear power plants.

### Significance of PTS for RPV Integrity

The IAEA will host a consultants meeting from 22 to 24 March 2010 in Vienna to discuss the production of a publication on significance of pressurized thermal shock (PTS) for reactor pressure vessel (RPV) integrity. The purpose of this meeting is to finalize the extended draft. The publication on PTS is expected to be published in 2010.

For all previous articles

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### Support for Long Term Operation of NPPs in Ukraine

The goal of the TC UKR 4/014 Project is to provide technical support to the utility and regulatory authority of Ukraine in their plans for long term operation (LTO) of nuclear power plants (NPPs) in Ukraine. A review and planning meeting which was held from 14 to 15 December 2009 in Vienna has set up the following activities to be implemented in 2010:

- Expert mission and workshop on review of safety factor ageing management, developed for periodic safety review of Rivne NPP.
- Expert mission on equipment qualification developed for Rivne NPP.
- Workshop on Reactor Pressure Vessel (RPV)

Surveillance Specimens Programme, with respect to planned annealing of Rivne Unit 1 RPV in 2011.

### **Ageing Management of Steam Generator**

The IAEA is preparing a publication on ageing management of steam generators. A second consultants meeting was held from 1 to 4 December 2009, where a team of consultants reviewed the current IAEA-TECDOC-981 Assessment and Management of Ageing of Major Nuclear Power Plant Components Important to Safety (published in 1997). The team discussed suggestions on revision of the current content and layout of the new report. The next meeting will be held from 16 to 18 June 2010, after which the report on management of SG ageing should be finalized and published in 2011.

### **RPV Irradiation Embrittlement**

The reactor pressure vessel (RPV) is the life limiting component of a nuclear power plant. The last decade has seen remarkable progress in developing a mechanistic understanding of irradiation embrittlement, which is the most severe degradation mechanism of every RPV. This understanding has been used in formulating robust, physically-guided and statistically-calibrated models transition-temperature shifts. This workshop was held at the International Centre for Theoretical Physics (ICTP) from 23 to 27 November 2009 in Trieste, Italy. A total twenty eight (28) young engineers, students and professionals from Argentina, Czech Republic, Egypt, Ethiopia, Finland, Indonesia, Malaysia, Nigeria, Pakistan, Philippines, Republic of Korea, Russian Federation, Slovakia, Turkey, Ukraine and the Territories under the Jurisdiction of the Palestinian Authority participated and learned from lectures given by international experts.

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### **I&C Modernization Projects**

Consultant meetings were held in Vienna in November and December 2009 focusing on two subjects that are important to I&C projects: modernizing operating NPPs and designing new builds. The first meeting covered current challenges and resolutions in designing, implementing, testing, licensing, and operating modern I&C systems in NPPs. The second meeting was on qualification of digital commercial off-the-shelf equipment for use in the safety systems of NPPs.

### **Network of Excellence Launched**

A new initiative titled Network of Excellence for Supporting the Use of I&C Technologies for the Safe and Effective Operation of NPPs (NE-ICT) was launched in December 2009. Two hundred experts from 35 Member States were contacted and many signed up for the

NE-ICT, bringing in new ideas and opportunities for a forum-like interaction that can support our NPP I&C related programs. Software tools and various modes of interactions are now being considered for the network operation.

### **Assessing and Managing Cable Ageing in NPPs**

The IAEA was represented at the 8th Working Group Meeting of the OECD/NEA SCAP Cable Ageing Project, which was held at the OECD Conference Centre in Paris, France in January 2010. The workshop was followed by an IAEA consultants meeting aimed at further developing an IAEA publication on assessing and managing cable ageing in NPPs. An IAEA Technical Meeting on the subject is scheduled for September 2010 to be held in Halden, Norway.

### **Supporting Country-Specific Technical Areas**

Two workshops were held to support country-specific activities in specified technical areas: (1) presenting good international practices in I&C modernization projects in support of the Atucha NPP Unit 2 restart project in Argentina in November 2009, and (2) presenting and comparing I&C codes and standards used in NPPs to a representative audience of the NPP industry in China in December 2009.

### **Coordinated Research Programme (CRP) on Surveillance, Diagnostics, and Prognostics in NPPs**

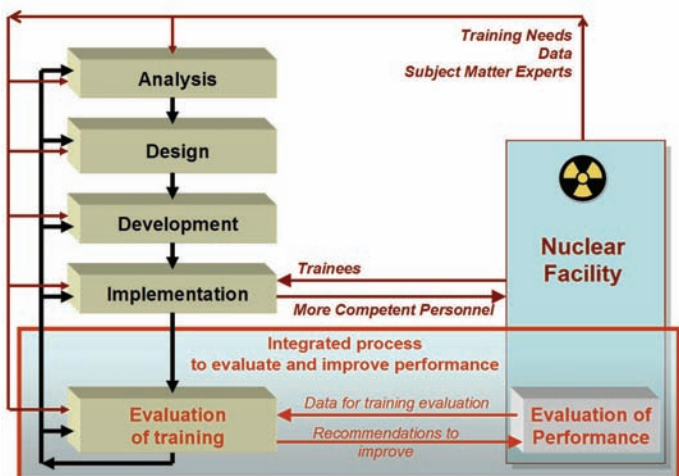
The 2<sup>nd</sup> research co-ordination meeting on the CRP titled Advanced Surveillance, Diagnostics, and Prognostics Techniques used for Health Monitoring of Systems, Structures, and Components in NPPs was held in Daejeon, Republic of Korea, hosted by KAERI. A consultants meeting to perform benchmark analysis and to further develop the CRP Report was held in February 2010 in Dunaujvaros, Hungary.

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### **Nuclear Facility Personnel Training**

Training is one of important measures to achieve and maintain the required competence of various categories of nuclear facility personnel, including nuclear power plants, and one of important activities in the framework of overall Management System to improve organizational and human performance of a nuclear facility. It is vitally important to have proven and effective training methodology based on actual experience. The IAEA



Technical Reports Series No. 380 Nuclear Power Plant Personnel and its Evaluation. A Guidebook was published in 1996. Since then the nuclear industry has accumulated valuable experience in the field of personnel training. The Agency updates Technical Reports Series No. 380 incorporating recent experiences and recommendations, in particular, expanding the scope to include other nuclear facilities in addition to NPPs. A new report on nuclear facility personnel training is being prepared currently and will supersede Technical Reports Series No. 380.

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## Infrastructure for Newcomer Countries

### Lessons Learned from Integrated Nuclear Infrastructure Review Missions

A consultants meeting was held 3-5 February in Vienna, focusing on lessons learned from previous INIR missions. Senior experts on nuclear power infrastructure devised a plan for the improvement of future INIR missions, based on the lessons learned from three INIR missions already completed in Jordan, Indonesia and Vietnam. This plan reconfirms the importance of INIR missions for the sound development of nuclear infrastructure. The plan covers a broad range of issues that are key to a successful INIR mission: preparation needed before the mission, concrete steps for conducting the mission including templates and interview methodologies, as well as the format of the final report to maximize the benefits for the recipient country.

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## IAEA Integrated Nuclear Infrastructure Review Missions to Indonesia and Vietnam

The IAEA conducted two Integrated Nuclear Infrastructure Review (INIR) missions in December, to review Indonesia's and Vietnam's preparations to date for introducing nuclear power. The INIR missions are used to evaluate a country's nuclear infrastructure status and to identify areas where further work is needed. The missions are comprehensive in scope and assess the status of all 19 elements included in the Milestones document.

Indonesia and Vietnam have been working with the IAEA on various elements of their respective nuclear



power programmes. The IAEA team and the representatives from the recipient states conducted the discussions in a positive manner. The IAEA team identified the gaps that need to be addressed, and made suggestions to enhance the action plan and coordinate international assistance.

The guidelines for conducting INIR missions were published in March 2009, and the first INIR mission was conducted in Jordan in August 2009.

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### Integration of NPPs into Electric Grids

A consultants meeting (held in Vienna, December 2009) and a national training course (held in Hanoi, Vietnam November 2009) were focusing on integrating NPPs into the electric grid. The meeting was on Establishing a Review Mission to Assess Member States' Readiness to Integrate NPPs into Electric Grids, while the training course was on Electric Grid Reliability and Interface with NPPs. An IAEA Technical Meeting on the subject is scheduled for August 2010 in Vienna.

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## IAEA Education and Training Support Group

The IAEA is authorized by its Statute to foster the exchange of scientific and technical information on the peaceful uses of atomic energy; and to encourage the exchange and training of scientists and experts in the field of peaceful uses of atomic energy. While education and training are fundamentally the responsibility of Member States, the Agency has been playing an important role in assisting them to establish and maintain competent and sustainable human resources required for safe, secure and efficient peaceful use of atomic energy. In support to coordination of these activities, an Agency-wide Education and Training Support Group (ETSG) was established in 2007, and the staff representing many Agency's departments and offices constituted that group. The ultimate goal is to assist Member States to build and maintain competent and sustainable human resources and institutional capacity matched to their current and future needs related to the peaceful use of atomic energy. Alexey Kazennov of the Division of Nuclear Power was recently appointed as the next chairperson of the ETSG.

For recommendations on improvements of the IAEA education and training activities, please

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## INPRO

### International Project on Innovative Nuclear Reactors and Fuel Cycles

#### INPRO Dialogue Forum on Nuclear Energy Innovations

The INPRO Dialogue Forum is a continuation of a two-year INPRO activity that resulted in the development of so called common user considerations (CUC) to identify expectations of developing countries considering the introduction of nuclear power. The work was documented in an IAEA publication: *Common User Considerations (CUC) by Developing Countries for Future Nuclear Energy Systems: Report of Stage 1* (IAEA Nuclear Energy Series No. NP-T-2.1, STI/PUB/1380). The 'common considerations' referred to issues such as economics, financing, infrastructure, environment, resources, waste management, nuclear safety, proliferation resistance, physical protection and technical requirements. The study showed that technology holders and technology users can benefit from an

expanded dialogue so that both sides would have a better appreciation for the challenges and expectations as-



sociated with the introduction of nuclear energy with an emphasis on required innovations needed to ensure the sustainability of nuclear energy in the long term.

The main value of the INPRO Dialogue Forum lies in the opportunity to discuss and share information without necessarily reaching consensus or adopting joint policies. Correspondingly, the main product of the INPRO Dialogue Forum will be proceedings that document positions, questions and progress in discussions. Several workshops will take place in the next years to address the multitude of topics that were proposed by stakeholders from the CUC activity as well as in other INPRO events and meetings, including a special session on the Dialogue Forum at the 15th meeting of the INPRO Steering Committee in November 2009. The central theme is "deploying innovation" and covers areas that range from future innovative nuclear systems to innovative institutional arrangements that are needed to support the sustainable long term deployment of innovative nuclear systems.

The first workshop of the Dialogue Forum, held on 1-4 February 2010 at the IAEA, was attended by 47 participants from 31 countries. It was organized through the IAEA Technical Cooperation Programme (INT/4/142) and conducted in cooperation with the Planning and Economic Studies Section (PESS) of the Department of Nuclear Energy, and the Division of Nuclear Installation Safety (NSNI) of the Department of Nuclear Safety and Security. Three topics were selected for this first workshop:

1. Socio- and macroeconomic factors that influence decisions regarding deployment of nuclear systems;
2. Proven technology as related to innovative nuclear energy systems;
3. Safety approaches for innovative nuclear energy systems.

The workshop format consisted of panel discussions where experts in each of the above topical areas made presentations. Sufficient time for discussion and dialogue was incorporated into the program during the presentation sessions and through breakout groups where a more focused dialogue took place on each of the topics. The participants in each breakout session prepared summaries that included main conclusions as well recommendations for future discussions and actions.

Some of the social factors that were discussed included public perception, social equity, and environmental impact. In the macroeconomic area, factors such as economic policy, financing, and balance of payments were discussed. These and other factors are important for decisions regarding nuclear deployment and an important recommendation was to expand the dialogue to facilitate the integration of these factors into the policy settings of different countries.

In the area of proven technology, the discussion was focused on innovative nuclear energy systems and the processes used by technology holders to determine the maturity of a given design, as well as the expectations from user countries. An important conclusion was the need for further action, and possibly development of a methodology, to evaluate the maturity or technology readiness level of innovative nuclear systems.

In the area of safety, harmonization was recognized as an important issue that, while getting sufficient attention from technology holders, there is a need to engage technology users as well in ongoing activities and discussions. An important recommendation was to extend the discussion of harmonization to waste management and transportation of nuclear materials.

All presentations are available at the meeting webpage at <http://www.iaea.org/INPRO/2010-Feb-DF-WS.html>. The next INPRO Dialogue Forum workshop will be held in early October 2010.

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## Results from the INPRO Collaborative Project GAINS

A coherent vision for the evolution of a global nuclear energy system requires unification of a methodological platform — including assumptions, boundary conditions, tools — and validation of the simulation results through sample analyses of transition strategies from the present to future nuclear power systems with reduced financial, environmental, and proliferation risks. Performance of these tasks is in the focus of the INPRO Collaborative Project on **Global Architecture** of

Innovative Nuclear Systems based on Thermal and Fast Reactors including Closed Fuel Cycles (**GAINS**), implemented by Argentina, Belgium, Canada, China, the Czech Republic, France, India, Italy, Japan, the Republic of Korea, the Russian Federation, Slovakia, Ukraine, USA and the European Commission. Within the IAEA, the Division of Nuclear Fuel Cycle and Waste Technology (NEFW) and the Planning and Economic Studies Section (PESS) are contributing to this collaborative project.

One of the key features of the analyses in GAINS is to apply a non-geographical heterogeneous model, in addition to a conventional homogeneous model, to examine the synergy between groups of countries (NG1: recycling group, NG2: once-through fuel cycle group, NG3: minimal fuel cycle infrastructure).

In 2009, nuclear energy systems of three types were analyzed:

- Business as usual based on PWR (94%) and HWR (6%) operated in a once-through fuel cycle (BAU)
- BAU plus advanced PWR (BAU+)
- A system based on current and advanced PWR, HWR including fast reactors (FR) and a closed nuclear fuel cycle (BAU+FR).

Figure 1 illustrates the potential of fast reactor deployment in two cases. The synergistic case shows that the fleet of fast reactors could be doubled. Also, a larger fleet of fast reactors will decrease cumulative consumption of natural uranium. Both would considerably en-

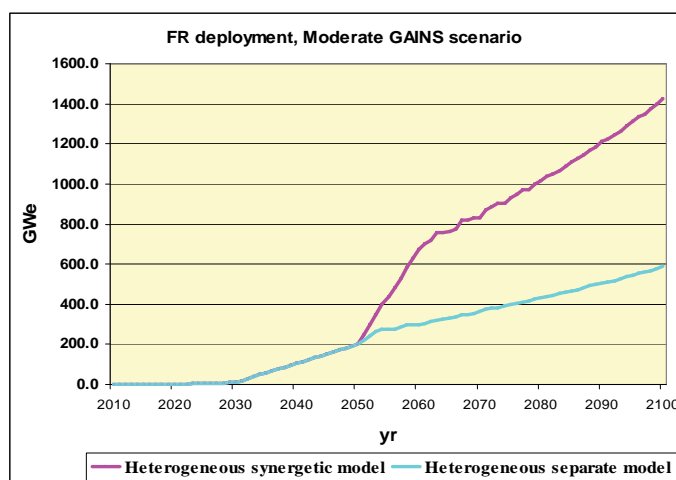


Fig. 1. Potential for fast reactor deployment in GAINS separate and synergistic cases

hance the sustainability of the global nuclear energy systems. In the BAU+ option, the relatively cheap uranium (<130 \$/kg) will be exhausted by around 2070 in the high nuclear demand scenario (1500 GW(e) in 2050; 5000 GW(e) in 2100), and by 2090 in the



moderate demand scenario (1000 GW(e); 2500 GW(e)). Introducing fast reactors with a break-even conversion ratio (CR ~1) into NG1 and full utilization of plutonium from thermal reactors of this group could save about 20% of the uranium necessary to realize the BAU+ option.

A synergistic approach would about double the uranium savings. Fast reactors with higher breeding ratios (BR>1) can make the total uranium savings even more significant. Assurances of nuclear fuel supply services through multilateral nuclear approaches (MNA) could result in synergies that would be crucial in addressing issues in the areas of waste management and proliferation resistance. Figure 2 shows that in the high nuclear demand scenario, the global accumulation of plutonium in spent fuel inventories can be decreased drastically by using fast reactors in NG1 (red curve) compared to the BAU once-through option (blue curve).

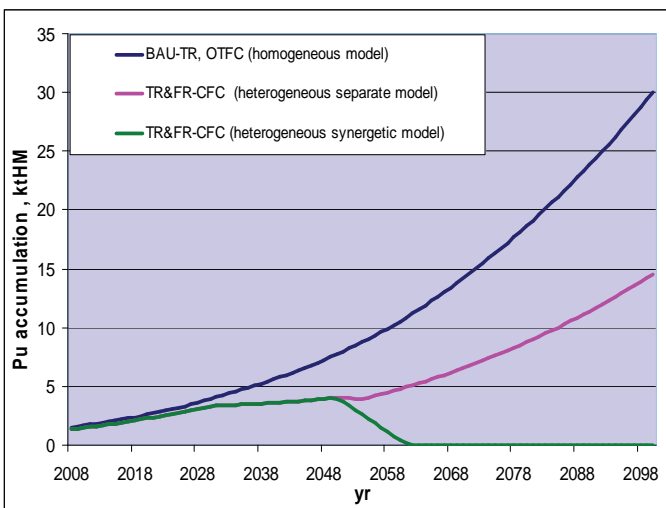


Fig.2. Potential for plutonium accumulation in GAINS separate and synergistic cases

In a synergistic case (green curve) the accumulation of plutonium is expected to further decrease to meet minimum operation needs. The synergistic approach substantially decreases waste management requirements in NG3. The MNA presents an option for a global nuclear architecture that would provide for more secure and manageable growth of nuclear power. However, other factors with their benefits and challenges, such as transportation and demand for fuel cycle services in other groups need to be further assessed.

In 2010, GAINS is focusing on further development of a framework for analysing global architectures and conducting sample analyses to illustrate the usefulness of the framework in assessing the benefits and challenges of the potential fuel cycle system. Additional innovative nuclear energy system options such as accelerator driven systems (ADS), molten salt reactor (MSR) systems and thorium fuel cycles may also be explored in

conjunction with developing the framework.

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## Proliferation Resistance of Innovative Nuclear Energy Systems

To assess the multiplicity and robustness of barriers against proliferation, an INPRO Collaborative Project (CP) is studying methods and processes to identify and analyze plausible pathways for the acquisition or diversion of weapons usable material. The results of the study on **Proliferation Resistance: Acquisition/Diversion Pathway Analysis (PRADA)** will contribute to further developing and strengthening the assessment area of 'proliferation resistance' of the INPRO Methodology. The overall objective is to provide guidance on enhancing proliferation resistance of innovative nuclear energy systems.

A basic principle is that intrinsic features and extrinsic measures of proliferation resistance shall be implemented throughout the full life cycle of an innovative nuclear energy system to help ensure that the system will continue to be an unattractive means for acquiring fissile material for a nuclear weapons programme. A key user requirement of the INPRO methodology also demands that innovative nuclear systems should incorporate multiple proliferation resistance features and measures.

The Republic of Korea has taken the lead in the PRADA project, in which Canada, China, the USA and the European Commission are also participating. Within the IAEA, the PRADA project benefits from a close cooperation with the Department of Safeguards.

Stage 2 of the PRADA project was completed at the end of 2009 and focused on determining plausible acquisition paths using the DUPIC (direct use of spent PWR fuel in CANDU reactors) fuel cycle, as a demonstration study for appropriate methods and processes. During stage 3 of the project, which started at the beginning of 2010, the multiplicity and robustness of barriers to prevent the diversion of fissile material in the sample reactor are investigated.

It is also planned to harmonize the results of the PRADA study with an assessment methodology for Proliferation Resistance and Physical Protection (PRPP) developed by an expert group of the Generation IV International Forum (GIF) for Gen IV nuclear energy systems. Making nuclear energy more proliferation resistant is crucial for sustainable nuclear development and one of the goals of both the INPRO and GIF methodologies in this area.

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## Membership in INPRO – Benefits and Process

IAEA Member States and recognized international organizations can become members of INPRO. As of February 2010, INPRO has 31 members.



In addition to participating in INPRO activities, INPRO members are also members of the INPRO Steering Committee, which guides INPRO's activities. The Steering Committee meets regularly to review progress and provide guidance on future activities. Every two years the Committee endorses the INPRO Action Plan, which defines detailed task areas and priorities for implementing INPRO activities.

A condition for membership is to make contributions to INPRO, which can be in the form of any of the following:

- providing extrabudgetary funds;
- providing cost free experts to INPRO;
- performing a *Nuclear Energy System Assessment* using the INPRO methodology; or
- participating in INPRO Collaborative Projects.

Member States wishing to become a member of INPRO should address a letter expressing this intention to the INPRO Project Manager, Deputy Director General Y. Sokolov, Head of the Department of Nuclear Energy. After that, a consultative process will be established to determine details and practical steps.

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## Technology Development for Water Cooled Reactors

### Heat Transfer, Thermal-Hydraulics and System Design for Supercritical Pressure Water Cooled Reactors

There is high interest internationally in both developing and industrialized countries in the design of innovative supercritical water cooled reactors (SCWRs). This interest arises from the high thermal efficiencies (44-45%) and improved economic competitiveness promised by this concept, which utilizes and builds upon the recent developments of highly efficient fossil power plants. The SCWR is one of the six concepts included in the Generation-IV International Forum (GIF).

During the 2nd Research Coordination Meeting for the IAEA CRP on Heat Transfer Behaviour and Thermo-hydraulics Codes Testing for SCWRs held in Vienna in August 24-27, 2009, Member States expressed an interest in organizing a technical meeting in which specialists in the areas of heat transfer and thermal-hydraulics, thermodynamics and systems design for supercritical water cooled reactors would have the opportunity of participating in extended technical discussions on the details associated to the science and engineering of supercritical water cooled reactor concepts. The University of Pisa kindly offered to host such a technical meeting.

The purpose of the meeting is to provide a platform for detailed presentations and technical discussions leading, to exchange of results, fostering world-wide collaboration in research activities, improving the communication between industry (utilities, vendors etc.), regulatory organizations and research organizations, and the provision an up-to-date review of the science and engineering of supercritical pressure water cooled reactor concepts.

The meeting will have the following main objectives (with an emphasis on application and design issues) to:

- Review progress in the development of correlations, equations and methods to describe the heat transfer behaviour with fluids under supercritical pressure conditions.
- Evaluate comparisons of analyses and numerical predictions of thermal-hydraulics codes against theoretical estimates and experimental data.
- Review the status of core design and neutronics studies for current SCWR concepts.
- Review the status of current SCWR concepts, system design and approach to safety.

As usual in this type of meeting, the programme will include a discussion session to enable participants to contribute to the summary and highlights of the meeting and to make recommendations to the IAEA on future work in this field.

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## Advanced Fuel Pellet Materials and Fuel Rod Designs for Water Cooled Reactors

NENP and NEFW joined forces to organize a technical meeting on Advanced Fuel Pellet Materials and Fuel Rod Designs for Water Cooled Reactors on November 23-26, 2009. The meeting was hosted by the Paul Scherrer Institute (PSI) in Villigen, Switzerland, and counted with the participation of 45 specialists representing fuel vendors, nuclear utilities, R&D institutions and regulatory authorities from 20 Member States. The 17 technical papers submitted to the meeting were grouped in three sessions: Fabrication and Design, Advanced Fuels and Innovative Fuel Designs. The meeting also included a round-table discussion session on Regulatory Aspects of Fuel Quality Assurance. During the



last day of the meeting, PSI hosted a well organized and informative technical tour of some of their research facilities (including the synchrotron source SLS and the continuous spallation neutron source SINQ). The tour facilitated additional in-depth discussions of advanced fuel characterization techniques and modern materials research capabilities, and highlighted the importance of international cooperation in fields so scientifically intensive such as materials science.

The meeting covered the current state of nuclear fuel technologies, the challenges and the opportunities, as well as new perspectives and upcoming innovations. Meeting participants also compiled recommendations for future activities, some of which can be incorporated

into existing and future IAEA programs. For example, the issue of the 5% enrichment limit was identified as a new subject of common interest; this topic was the focus of a number of technical papers and the subject of very lively round-table discussions.

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## NPP Simulators for Education

The joint IAEA/ICTP Workshop on Nuclear Power Plant Simulators for Education was held October 2009 at the International Centre for Theoretical Physics (ICTP) in Trieste, Italy. Twenty-two participants from 21 countries were provided with practical information on the application of the IAEA PC-based NPP simulators for educational and training purposes. Five instructors from Canada, Russian Federation, Switzerland and the United States of America also participated in the workshop. The workshop consisted of a combination of lectures followed by exercises using the simulators.

It covered the demonstration and use of eight simulators: a WWER-1000, a PWR with active safety systems and a PWR with passive safety systems, a BWR with active safety systems and a BWR with passive safety systems, a CANDU-9, an Advanced CANDU (ACR700), and a TRIGA research reactor. By using the simulators, in combination with the training material, participants investigated and developed an understanding of the operational response characteristics of the various reactor types. The workshop was special in the sense that many of the participants were representatives of educational institutions, regulatory bodies, research and plants. The workshop was therefore interactive in nature, with considerable discussion and feedback from the participants themselves.

The IAEA PC-based Simulators for Education simulate the response, to normal operation and accident conditions, of a number of water-cooled reactor types. The Simulators are designed to provide insight and understanding of the general design and operational characteristics of various power reactor systems, and are used in many educational institutions.



Feedback received from the participants at the last day of the workshop has shown that there were several constructive suggestions to improve the workshop and the IAEA simulators themselves, the content and the value of the workshop were praised by the participants.

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## Technology Development for SMRs Reactors

### Common Technologies and Issues

On 3-6 November 2009, an IAEA technical meeting on Options to Enhance Proliferation Resistance and Security of NPPs with Innovative SMRs was convened at IAEA Headquarters with 13 participants from 9 IAEA Member States. The meeting had the objectives to present and discuss design approaches of innovative SMRs and associated fuel cycles with a potential to contribute to enhanced level of the proliferation resistance and security features, with a link to targeted application conditions of such reactors and an explanation of how such features could simplify and make effective and efficient the implementation of necessary verification and security measures. The meeting concluded that proliferation resistance and physical protection (security) features of innovative SMRs and associated fuel cycles should be introduced in the design and evaluated starting from the early stages of design and continue as the designs mature.

Last year was the final year for a coordinated research project on Small Reactors without On-site Refuelling conducted with 18 participating institutions from 11 Member States. The project has, *inter alia*, developed a risk-informed methodology for performance-based definition of the emergency planning zone radius, complete with its trial application. It also included energy park growth scenarios studies. The studies addressed attainable growth under constraints on internally generated

and external fissile mass availability, on internally-generated and external capital financing availability, on mix of reactor types in the nuclear park, and on timing considerations for closing the fuel cycle. One of the conclusions was that capitalization for financing of an aggressive growth is much more confining than is fissile mass availability. Final draft of the CRP report has been developed and is under review by the project participants.

On 16-19 March 2010, the second RCM of a coordinated research project on Development of Methodologies for the Assessment of Passive Safety System Performance in Advanced Reactors will be convened in IAEA Headquarters, in Vienna. Further details of the activities are available from Mr. V. Kuznetsov: [v.v.kuznetsov@iaea.org](mailto:v.v.kuznetsov@iaea.org)

### End of Service Summary

by Vladimir Kuznetsov (NENP/NPTDS)



I've taken the position of a Nuclear Engineer (P-4) in the Nuclear Power Technology Development Section on 01 May 2003, being responsible for small and medium sized reactors and partly INPRO.

For the biennium of 2006-2007, a dedicated Agency's regular budget project on Common Technologies and Issues for SMRs was justified.

The project had eventually got a recurrent status with broad support from the resolutions of the IAEA General Conferences: <http://www.iaea.org/NuclearPower/SMR/>. Through the efforts undertaken in 2003-2006, two status reports of advanced SMR designs were produced, IAEA-TECDOC-1485 and IAEA-TECDOC-1536 highlighting the design features and design development status for nearly all (60) advanced SMR design concepts developed in the world at the time. Other produced publications include IAEA-TECDOCs-1451, 1487 and the IAEA Nuclear Energy Series report NP-T-2.2. All these and other publications are downloadable from the indicated link.

In 2004-2009 a coordinated research project on small reactors without on-site refuelling was conducted with 18 participating institutions from 11 Member States. The project has developed a risk-informed methodology for performance-based definition of the emergency planning zone radius, complete with its trial application. Final draft of the CRP report has been prepared which is

currently under review by the project participants. Over the period of my service notable progress for several advanced SMR designs was observed. Two of them the KLT-40S and the HTR-PM - are under construction, for several others licensing process or pre-licensing negotiations have been started. I believe SMRs will play an important role in future energy systems, especially if we remember that small reactor does not necessarily mean a small capacity power station.

In the end of my service term, I would like to express my acknowledgement and deep personal appreciation to IAEA staff members who provided valuable guidance and support of my activities: Mr. T. Shea (SG), Mr. J. Cleveland, Mr. A. Stanculescu, Mr. M. Methnani, and Ms. Yaela Gomez Nuñez (all from NPTDS), Mr. M. Gladyshev (NENP), Mr. P. Contri and Mr. M. Gasparini (NSNI), and Mr. C. Ganguly (NEFW).

I wish NPTDS a productive work and further success!  
Vladimir Kuznetsov

## Technology Development for Fast Reactors and Accelerator Driven Systems

The end of the year 2009 witnessed a busy schedule for the IAEA's Project on Technology Advances in Fast Reactors and Accelerator Driven Systems, with the undisputed highlight being the International Conference on Fast Reactors and Related Fuel Cycles - Challenges and Opportunities (FR09), organized by the IAEA (collaborative effort of the Division of Nuclear Power and of the Division of Nuclear Fuel Cycle and Waste Technology), and hosted by the Japan Atomic Energy Agency (JAEA), in Kyoto from 7 – 11 December 2009.

After a hiatus of 18 years, FR09 was organized by the IAEA in response to strong Member States' demand, and the expectations were accordingly high. Arguably, these expectations were met by this large gathering of 622 experts from 20 countries and 3 international organizations. One hundred-fifty oral presentations, 154 displayed posters, as well as interventions and discussions at two panels and the Young Generation Event underlined the timeliness of FR09 and substantiated the claim that fast reactor and associated fuel cycle research



and technology development is, in many countries, back on the agenda of research and industrial organizations, as well as academia.

The FR09 scope included the key scientific and technological areas (e.g. fuels and materials development, safety, advanced simulation, component and system design, coolant technology, etc) in which innovation is pursued to ensure that next generation's fast reactor and fuel cycle achieve their potential. While reported results are encouraging, remaining open issues were also identified, and planned R&D programs to resolve them outlined. The importance of international collaboration in this was highlighted, as a means to pool resources, avoid duplication, and make best use of synergies.

The way forward is tied to clear objectives, leading to the commissioning of experimental fast reactors (CEFR in China in 2010), the restart of the industrial prototype Monju in Japan in 2010, the commissioning, at the time horizon 2011 – 2013, of power fast reactors in India and the Russian Federation (PFBR and BN-800, respectively), the planned construction of the French prototype fast reactor ASTRID, and further construction projects in India, Russian Federation, Japan, and the Republic of Korea.

For these ambitious programs, aforementioned international collaboration is a must, as are continuous efforts to harmonize concepts, in order to avoid duplications and aim for complementarities. The importance of establishing international fast reactor safety standards was also highlighted.

As done for the last 40+ years, the IAEA Nuclear Energy Department's Technical Working Group on Fast Reactors offers the unique framework for collaboration among Member States pursuing research, technology development, and deployment of fast reactors.

Finally, a clear indication of interest to establish the FR International Conference as a series has emerged. First discussions indicate that a three-year interval is deemed to be appropriate. In the next months, the IAEA will follow up on this and consider the possibility of organizing the next FR International Conference, possibly in 2012.

Looking ahead to 2010, the Project will continue the implementation of its 3 Coordinated Research Projects, sustain, within the framework of the TWG-FR, the excellent platform for the Member States' experts to share the experience related to design, development, construction and operation of nuclear power plants with fast reactors, increase the efforts towards establishing a forum for broad exchanges on technical requirements for 4<sup>th</sup> generation fast reactor systems, and, last but not least, collaborate with the colleagues in the Nuclear Safety Department on the preparation of Fast Reactor Safety Guides.

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## Non-Electric Applications of Nuclear Power

### Hitting a moving target

With many countries expanding the environmental legislation, nuclear power must abandon the business as usual principle and take into consideration many factors. Among others, these include the increasingly stringent regulations on water withdrawal, thermal and chemical discharge, and cumulative impacts.

Many environmental challenges may hinder the potential for revival of nuclear power. In spite of the urgency of the matter, lack of publications addressing such important challenges in a more profound manner remains.

Regulations on environment, taking into account the cumulative impact, created a situation where achieving an acceptable environmental performance is similar to hitting a moving target. Even if the facility itself is in compliance with the environmental standards, according to these regulations, impacts of the facilities in the vicinity of the nuclear site have to be taken into consideration, lowering the margin for acceptable adverse impacts. In effect, this increases the demand for best practices and solutions that will allow nuclear power to “do more with less”.



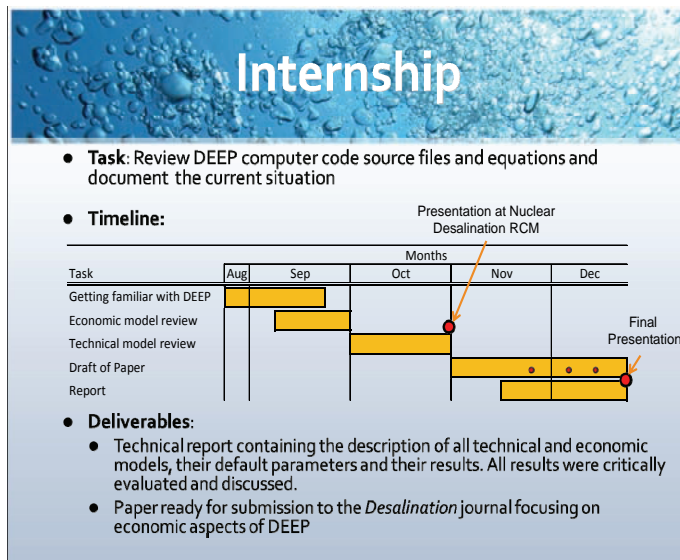
Recognizing this crucial issue for nuclear power, the IAEA is focusing on all concepts that have the potential to improve its environmental performance. Non-electrical applications of nuclear power present feasible measures for alleviating the related adverse environmental impacts. However, other solutions, technical as well as managerial, should be sought after if nuclear power is to answer thoroughly the challenges posed.

Currently, as a part of its continued support to non-electric applications of nuclear energy, the IAEA is about to produce technical reports on (i) Comprehensive Assessment of the Environmental Impacts of Nuclear Desalination; (ii) Efficient Management for Water Use/Consumption in Nuclear Power Plants.

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Vladimir Anastasov [V.Anastasov@iaea.org](mailto:V.Anastasov@iaea.org)

## Distinguished Internship on DEEP

K.C. Kavvadias, a young PhD Candidate (from Greece) has just completed his 4-months internship on nuclear desalination in the NENP/NPTDS. His focus was to review the overall economic models and parameters used in the IAEA Desalination Economic Evaluation Programme DEEP, and evaluate the validity and reliability of DEEP through comparative results.



“I have mixed feelings; happy that I am returning home, and sad that I am leaving such nice people and friends behind. Still, I would also like to express once more my gratefulness to my supervisor, for his confidence in me and for giving me this opportunity to work on such an interesting subject.”, said Mr. Kavvadias.

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## Launching a New CRP on HEEP Benchmarking

The IAEA is planning to launch a new Coordinated Research programme CRP to examine the economics of nuclear hydrogen production and at same time perform benchmark analysis using the IAEA Hydrogen Economic Evaluation Programme HEEP software.

HEEP is a newly developed and released software and could be downloaded by Member States free of charge. During this CRP, HEEP will be used extensively for the benchmarking studies including various scenarios of hydrogen production using nuclear energy. The analysis is expected to include comparison study among various options and processes for hydrogen production at large scales, as well as include distribution models and co-generation or stand alone options of nuclear power plant.

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## NENP Management Retreat: Further Improving Our Services to Member States

With the participation of Director of Nuclear Power Division, Sections Heads, and invited senior staff, a retreat was held at the outskirts of Vienna to discuss vision of Nuclear Power Division beyond 2010. The one-and-half day retreat included several meetings, discussions, and brain storming on how best to improve our services to Member States. The meeting proved to be a very successful activity not only on the social side where everyone got to know his/her colleagues in a more friendly way, but also with respect to the many fruitful discussions and ideas to improve outcomes through efficient team working and team building approaches.

*The main theme of the retreat was: More we, less me*



The division has set, as internal management objective, to further promote good internal coordination of all services and activities provided by the division to Member States in 2010 and beyond. The ultimate goal of the Nuclear Power Division is that all activities and projects are being carried out with a high degree of efficiency within the division, eventually contributing to improving the services provided to Member States in 2010 and beyond.

The guiding theme of the retreat was the divisional vision beyond 2010 and till year 2016, including objectives and scope of the programmatic activities, efficient programme implementation, communication internally and with Member States, technical issues and priorities, maintaining competencies, institutional memory and knowledge and our interactions with other Departments of the IAEA.

A total of 40 individual action items have been agreed upon, which will now serve as our internal guidance to further improve in our daily work. This wonderful and very fruitful activity which was initiated by the Director of the Nuclear Power Division Mr. Park was highly appreciated by participants to the retreat whom recommended a follow up similar activity with other staff in the Nuclear Power Division .

### Vacancy Notice for Professional Posts

In addition to the current open positions that have been posted, the NENP Division will have more openings in the next 12 months. These open positions will include 5 new P-Staff and 1 new G-Staff positions that were added to the division to address the increased activities in the coming years.

Additional opening will be posted as positions become vacant as part of the normal rotation policy of the Agency.

New vacancy notices will be available on the IAEA webpage addressing  
[https://personnel.iaea.org/apps/phflink/p\\_vacancies.asp](https://personnel.iaea.org/apps/phflink/p_vacancies.asp).

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

# Upcoming Events

Date	Contact	Title	Venue	Country
01-03 Mar-10	<a href="mailto:H.Khartabil@iaea.org">H.Khartabil@iaea.org</a>	4 <sup>th</sup> GIF-INPRO Interface Meeting	Vienna	Austria
03-07 May-10	<a href="mailto:b.m.tyobeka@iaea.org">b.m.tyobeka@iaea.org</a>	RCM of the CRP on Conservation and Application of HTGR Technology - Advances in HTGR Fuel Technology Development	Vienna	Austria
10-14 May-10	<a href="mailto:K.S.Kang@iaea.org">K.S.Kang@iaea.org</a> <a href="mailto:s.bilbao@iaea.org">s.bilbao@iaea.org</a>	TC Workshop: Project Management for New Nuclear Power Projects	Ulsan	Rep. of Korea
1-3 June-10	<a href="mailto:b.m.tyobeka@iaea.org">b.m.tyobeka@iaea.org</a>	TM on Performance of past and present HTGR Test Reactors and critical Facilities - 1-3 June 2010	Vienna	Austria
5-8 July 10	<a href="mailto:s.bilbao@iaea.org">s.bilbao@iaea.org</a>	Technical Meeting on Heat transfer, thermal-hydraulics and system design for supercritical pressure water cooled reactors	Pisa	Italy
5-8 July 10	<a href="mailto:V.Nkong-Njock@iaea.org">V.Nkong-Njock@iaea.org</a>	TM on Common challenges in Nuclear Power Programme	Vienna	Austria
06-09 July 10	<a href="mailto:A.Starz@iaea.org">A.Starz@iaea.org</a>	TM on regional approaches and infrastructure	Vienna	Austria
14-18 June-10	<a href="mailto:F.Depisch@iaea.org">F.Depisch@iaea.org</a>	TC Workshop: Long-range Nuclear Programme Planning and Strategy Development	Vienna	Austria
28-29 June-10	<a href="mailto:i.khamis@iaea.org">i.khamis@iaea.org</a>	CM on Benchmarking of the Hydrogen Economic Evaluation Programme HEEP	Vienna	Austria
24-28 Aug 10	<a href="mailto:s.bilbao@iaea.org">s.bilbao@iaea.org</a>	RCM of the CRP on Heat Transfer Behaviour and Thermo-hydraulics Code Testing for Super-critical Water Cooled Reactors (SCWRs)	Obninsk	Russian Fed.
06-09 Sept 10	<a href="mailto:V.Nkong-Njock@iaea.org">V.Nkong-Njock@iaea.org</a>	TM on planning for industrial involvement and technology transfer in NPP projects	Vienna	Austria
21— Sept 10	<a href="mailto:R.Beatty@iaea.org">R.Beatty@iaea.org</a>	10 <sup>th</sup> Anniversary of INPRO	Vienna	Austria
28 Sept– 01 Oct	<a href="mailto:a.kazennov@iaea.org">a.kazennov@iaea.org</a>	TM on Training and Educational systems for Nuclear Industry		Sweden
4-8 Oct 10	<a href="mailto:H.Khartabil@iaea.org">H.Khartabil@iaea.org</a>	INPRO Dialogue Forum Technical Meeting/ Workshop	Vienna	Austria
4-8 Oct 10	<a href="mailto:J.Mandula@iaea.org">J.Mandula@iaea.org</a>	TM on the maintenance and operation of PRIS Database	Vienna	Austria
27-28 Oct 10	<a href="mailto:i.khamis@iaea.org">i.khamis@iaea.org</a>	TM Technical Working Group on Nuclear Desalination	Vienna	Austria

**For information on IAEA Meetings,  
please visit:**<http://www-pub.iaea.org/MTCD/Meetings/PDFplus/current.pdf>

## Impressum

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