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## Contents

• International Ministerial Conference on Nuclear Power in the 21st Century	1
• Briefing GC Delegates on Nuclear Power Issues	2
• Supporting Nuclear Infrastructure Development	4
• Nuclear Power Engineering	6
• Nuclear Power Technology Development	8
• INPRO	10
• Recently Published	12
• Technical Meetings October–December 2013	12

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IAEA Director General Yukiya Amano addressing the Ministerial Conference. (Photo: IAEA)

## Nuclear Power in the 21st Century

*International Ministerial Conference concludes that nuclear power remains an important energy option for many countries.*

Nuclear power remains an important option for many countries to improve energy security, provide energy for development and fight climate change. Nuclear safety has been strengthened worldwide in the wake of the Fukushima Daiichi accident, and high levels of nuclear safety remain a necessary prerequisite for future growth of nuclear power.

These were some of the major conclusions of the **International Ministerial Conference on Nuclear Power in the 21st Century**. Thirty-eight ministers were among the 500 participants from more than 80 countries and international organizations who gathered in St Petersburg, Russian Federation, from 27–29 June 2013.

The Conference was organized by the IAEA in cooperation with the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD), and hosted by the Government of the Russian Federation through the State Atomic Energy Corporation ROSATOM.

The main event of the conference was the 50 national statements made by IAEA Member States on the prospects of nuclear power development. In addition, four panels of high-level experts addressed four key issues on nuclear power development:

*Continued on p. 3*

## Message from the Director



One of the most important events for nuclear power, the *International Ministerial Conference on Nuclear Power in the 21st Century*, was successfully held in St. Petersburg, Russian Federation, in late June 2013. The Conference reconfirmed that nuclear power is an important option for many countries. It was a turning point from the tragic accident in Fukushima towards an optimistic future for nuclear power with strengthened safety.

The Division of Nuclear Power is organizing three side events during the 57th IAEA General Conference about our many activities. The programme of events can be seen below. In addition, we will also co-organize, with the Nuclear Knowledge Management Section, a side event on *Networks for Collaboration in Nuclear Education on 18 September (15:30-17:00h)* and present the new e-learning modules for nuclear newcomers, available on the Division's website.

Technical Working Groups (TWG) reflect a global network of excellence and expertise. They are groups of experts who provide advice and support in the implementation of the programme of the Division. Several such TWG meetings were held over the past few months. In addition, we continue to implement the projects related to the IAEA Action Plan on Nuclear Safety and provide assistance to Member States who are actively developing infrastructure for new nuclear power programmes.

Most of our readers will have received a survey on newsletters from the Department of Nuclear Energy and I thank all who have participated. The decision whether to produce a single newsletter on nuclear energy issues or continue with individual ones, including the Nuclear Power newsletter, is still pending and we will inform you about the outcome in due course. In the meantime, I invite you to visit our divisional website at <http://www.iaea.org/NuclearPower/> and connect with us through [Twitter @IAEANE](https://twitter.com/IAEANE).

We have to say good-bye to several colleagues and thank them for their work, including Fanny Bazile (INIG), Elisabeth Dyck (INPRO), Jaana Isotalo (NPES) and Bismark Tyobeka (NPTDS), who has been appointed as Chief Executive Officer of the National Nuclear Regulator of South Africa. We welcome cost-free experts Mr Hidayatulla and Mr Susyadi from Indonesia and Benoît Lepoussé from France.

I extend my best wishes to all readers of this newsletter.

Jong Kyun Park, [J.Park@iaea.org](mailto:J.Park@iaea.org)

## Briefing GC Delegates on Nuclear Power Issues

*Member States' representatives and IAEA staff will speak at the following side events on nuclear power issues during the 57th IAEA General Conference (16–20 September 2013).*

### Support to New Nuclear Power Programmes: INIR Missions and IAEA Assistance

**18 September 2013, 9:30–11:00**

This side event will highlight the IAEA's Integrated Nuclear Infrastructure Review (INIR) missions by providing feedback from Member States who have hosted recent INIR missions. Member States will share their views on how the results of INIRs were used in developing national nuclear power programmes, and how to prioritize assistance. South Africa, a country with an operating nuclear power programme, will report its experience with the INIR mission. Lastly, the concept for INIR missions for countries in Phase 3 of the IAEA Milestones approach will be presented, as well as other developments in the nuclear infrastructure development programme.

### Third Nuclear Operator Organizations Cooperation Forum

**19 September 2013, 10:00–12:00**

The purpose of this side event is to identify and share the owner and operator's perspectives, recent experiences,

relevant factors and approaches influencing the safety and performance improvements, as well as long-term strategies emerging after the Fukushima accident. This Forum was previously organized during the IAEA General Conferences in 2011 and 2012.

### Energy Planning and Nuclear Energy System Sustainability Assessment — Services of the Department of Nuclear Energy

**19 September 2013, 13:30–15:00**

The briefing, jointly organized by the Planning and Economic Studies Section and the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) will present an integrated view of the services provided by the Department of Nuclear Energy to IAEA Member States, including training, assistance and tool sets for energy planning, nuclear energy system sustainability assessments (NESAs), modelling in support of strategic nuclear energy planning and an overview of macroeconomics and social impacts on nuclear energy systems planning. The briefing will also present specific outcomes and findings from INPRO's four major projects.



*Continued from p. 1*

- Energy and the Environment;
- Nuclear Safety and Reliability through International Cooperation;
- Infrastructure, Technology and Institutional Development — The Way Forward;
- Drivers for Deployment of Sustainable and Innovative Technology.

All presentations and statements are available at:

<http://www-pub.iaea.org/iaemeetings/cn206documentation.aspx>.

Many countries participating in the Conference—mostly in the developing world—expressed their interest in launching nuclear power programmes, and several countries intend to expand their use of nuclear power. After 27 years, the first construction of a nuclear power plant has started in a newcomer country, the United Arab Emirates.

"The Conference has achieved its main goal: to confirm that nuclear energy is an important part of the world's energy mix", said Sergei Kirienko, Director General of the State Atomic Energy Corporation ROSATOM and President of the Conference. "The innovative character of this type of energy provides us with sustainable development in the future. The closed nuclear fuel cycle and fusion may open for humanity absolutely new horizons", he added.

"I believe we can look ahead with confidence and optimism to the future of nuclear power in the 21st century", said IAEA Director General Yukiya Amano, after stressing that "effective steps have been taken to make nuclear power plants safer everywhere", following the accident at the Fukushima Daiichi Nuclear Power Plant in Japan in March 2011. "Nuclear power will make a significant and growing contribution to sustainable development in the coming decades. The IAEA is committed to ensuring that the expansion of nuclear power takes place in a way which results in maximum safety, reliability and efficiency, and guards against the proliferation of nuclear weapons".

In a message, OECD Secretary-General Angel Gurría stated: "We are far from achieving our environmental goal of limiting increases in average world temperature. Bolder and more innovative efforts are required, and nuclear energy can and must be part of the solution. But it is essential to do so in a safe and economically competitive manner".



Alexander Bychkov, IAEA Deputy Director General for Nuclear Energy spoke at a side event on IAEA support for national nuclear programmes on 28 June 2013. (Photo: Evrensel/IAEA)

**Concluding Statement**

The conference concluded with a **Statement by the Conference President**. The concluding statement said nuclear power, as a stable base-load source of electricity complements other energy sources including renewables, and many states look to it to reduce the impact of volatile fossil fuel prices and mitigate climate change. At the same time, participants emphasized the need for high levels of nuclear safety. "It is fully recognized that nuclear accidents have no borders and nuclear safety must be robust, effective and transparent", the statement said, adding that global nuclear safety had been strengthened through comprehensive safety reassessments by IAEA Member States, and through additional measures to improve plant safety, regulatory oversight, emergency preparedness and international collaboration.

Participants reaffirmed their commitment to the IAEA Action Plan on Nuclear Safety to strengthen the global nuclear safety framework, and emphasized the IAEA's central role in international cooperation on nuclear safety and the peaceful use of nuclear energy, including the generation of electricity. The significant contribution of the OECD/NEA to safety and economic analyses of nuclear power was also recognized.

The Conference Statement is available at:

<http://www-pub.iaea.org/iaemeetings/cn206p/Concluding-StatementBythePresident.pdf>

The Conference concluded that for many countries nuclear power is a proven, clean, safe, and economical technology that will play an increasingly important role in achieving energy security and sustainable development goals in the 21st century. The goal of the Conference was achieved, and participants looked forward to the next ministerial nuclear power conference in four years' time.

The St. Petersburg Ministerial Conference followed those held in Beijing in 2009 and in Paris in 2005.

The IAEA Scientific Secretariat included Anne Starz, Masahiro Yagi and Fanny Bazile, all from the IAEA Division of Nuclear Power, as well as Paul Woodhouse from the Department of Nuclear Safety and Security.

*This article is based on IAEA press releases and news stories prepared by the Division of Public Information.*

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The Boris Yeltsin Presidential Library offered a splendid setting for the Ministerial Conference. (Photo: Calma/IAEA)

# Supporting Nuclear Infrastructure Development

## Integrated Nuclear Infrastructure Group (INIG)

### TWG on Nuclear Power Infrastructure Development

The Technical Working Group on Nuclear Power Infrastructure (TWG-NPI) is a group of international experts from experienced nuclear countries and those considering or embarking on a new nuclear power programme. It provides advice on, and support for, the implementation of the IAEA's nuclear power infrastructure development programme. Currently the TWG-NPI is chaired by Mr Franklin Erepamo Osaisai, Chairman of the Nigeria Atomic Energy Commission.

At the **fourth meeting of the TWG-NPI**, held at the IAEA in May 2013, experts from 17 Member States discussed challenges faced by newcomer countries, assistance provided by experienced nuclear countries to those embarking on a nuclear power programme, and the role of the IAEA in support of nuclear power infrastructure development.



*Closing Session of the TWG-NPI Meeting (from left): A. Starz, INIG Group Head, J.K. Park, Director, NENP, DDG-NE A. Bychkov, Chair F.E. Osaisai, and Scientific Secretary M. Aoki. (Photo: IAEA)*

They addressed key issues such as capacity building, communicating with the public in Member States, cooperation on training between embarking and experienced countries, and IAEA peer review services and countries' self-evaluation on the status of their nuclear power programme. The meeting also provided an opportunity to learn about the latest developments in individual countries by examining case studies, key challenges and good practices.

"The TWG members have provided invaluable suggestions and recommendations to the Agency on many aspects of our nuclear power infrastructure development programme", said Masahiro Aoki from INIG, who was the Scientific Secretary of the meeting. In particular, the participants encouraged the IAEA to continue providing assistance to embarking countries in the areas of strategic human resource development, public communication, and becoming 'knowledgeable customers'.

In closing the meeting, Alexander Bychkov, IAEA Deputy Director General for Nuclear Energy highlighted recent developments in several Member States: "The United States

started the construction of two nuclear power plants this March, which is the first time in the country in over 30 years", he said. "Belarus concluded a general contract with the Russian supplier, and Poland completed transboundary consultations". This was the last meeting of the first three year term of TWG-NPI members.

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### Effective Training in Support of Nuclear Power Programmes

#### Cooperation for Human Resource Development among Embarking and Experienced Countries

Experts engaged in nuclear training met at the IAEA to discuss current training related issues and share views to improve training courses in order to develop and maintain the nuclear workforce at national and organizational levels.

The **Technical Meeting on the Cooperation for Human Resources Development among Embarking and Experienced Countries**, held on 4–6 June 2013, served as a forum for sharing experience and knowledge on the development and implementation of training courses for embarking countries through cooperation with experienced countries. The participants, who were all training experts in the nuclear field, were from Member States that are considering embarking on a nuclear power programme and from experienced countries that are running well-established training programmes in support of nuclear power development.

The meeting provided an opportunity to get acquainted with training programmes in different experienced countries, the EU and the IAEA. It also allowed participants to broaden their knowledge on training opportunities to ensure a qualified workforce for their future nuclear power programme. For example, an aging workforce is an emerging challenge that many embarking countries are facing due to postponed decision on their nuclear power programme. Utilizing experts from other sectors is one of way to address it. The UK experience shows that a skills certificate is useful to facilitate transfer of an experienced workforce from sectors such as oil and gas to the nuclear industry.

Other challenges identified relate to brain drain and the inability to attract a younger generation. Also, the selection of participants, follow-up training programmes, balancing personal merit and organizational needs, and language barriers are issues that need to be considered.

The Technical Meeting also covered establishing new training courses for specific areas in the nuclear sector. The participants agreed that training topics such as public acceptance, a systematic approach to training and the assessment of human resource development address the challenges that embarking countries face. Suggestions and feedback from the meeting will be taken into account when planning future IAEA training programmes.

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## Interregional Training Courses

Supported by funds of the [Peaceful Uses Initiatives](#) (PUI), the IAEA organized several interregional training events under the IAEA Technical Cooperation programme (INT2013). These courses are aimed at building the relevant workforce in Member States embarking on or expanding nuclear power programmes, and include:

**A Master's degree programme in nuclear engineering**, organized at the KEPCO International Nuclear Graduate School (KINGS), with support of the Government of the Republic of Korea; the IAEA is supporting nine students from seven embarking countries to participate in this programme of studies. The two-year Master's programme aims at training future leadership-level professionals for the nuclear industry.

**A six-week Interregional Training Course on Nuclear Power Infrastructure Capacity Building**, also organized at KINGS, with Korean Government support; twenty participants from 14 countries in the African, Asian, Europe and Latin America regions were trained through this course (*see article on p. 6*).

**An Interregional Training Course on Leadership and Management of Nuclear Power Programmes**, organized at the Argonne National Laboratory (ANL) with US Government support; twenty participants in managerial positions from 15 countries embarking on or expanding the national infrastructure for nuclear power have attended the training.

The courses were extremely well organized by the US and Korean hosts. Further training events will take place in the fourth quarter of 2013.

These educational and training programmes intend to support decision makers and senior managers in developing expertise and knowledge required for nuclear power programmes. They also help technical staff to acquire knowledge and skills to actively participate in the development of a nuclear power programme, and thus to support the safe and responsible use of nuclear power worldwide.

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## Integrated Work Plans for UAE's and Vietnam's Nuclear Power Programmes

In early June 2013, representatives of the **United Arab Emirates (UAE)** and the IAEA endorsed and signed the Integrated Work Plan (IWP) developed during the first half of 2013.

"The Integrated Work Plan is an important document which sets the framework of the UAE's work with all departments of the Agency to the advancement of its national nuclear power programme in the next five years" said UAE Permanent Representative Ambassador Hamad Alkaabi. "The IWP defines an integrated framework for IAEA assistance to national nuclear power development activities, tailored to UAE needs and reflecting national plans as well as recommendations from the IAEA".

The UAE-IAEA Integrated Work Plan covers the period of 2013 up to 2017, which is the projected year of operation of the first nuclear power reactor in the country. Construction of the first unit began in 2012 and of the second one in 2013. By 2020, the UAE plans to deliver a total of 5600 MW of electricity through four nuclear power plants.

**Vietnam**, another country making progress in developing nuclear power, reviewed and updated its IWP in June 2013. A delegation of senior and executive managers of Vietnam's nuclear power programme, led by the Vietnamese Permanent Representative Ambassador Ngyen Thiep, discussed Vietnam's introduction of nuclear power with IAEA experts from the Departments of Nuclear Energy, Nuclear Safety and Security, Safeguards and Technical Cooperation (TC). The IWP for Vietnam provides an integrated view of planned events and activities to be carried out through the TC programme, as well as through national, bilateral and multilateral undertakings. Vietnam's IWP was first developed and adopted in 2011, and sets the course for activities up to 2015; it is reviewed annually.

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Construction Site of Unit 1, Barakah Nuclear Power Plant, UAE. (Photo: ENEC)

## E-learning for Nuclear Newcomers

<http://www.iaea.org/NuclearPower/Infrastructure/elearning/index.html>

The IAEA has launched a new e-learning series to help newcomer countries as well as those expanding their nuclear power programmes. The interactive modules will cover the 19 infrastructure issues of the IAEA Milestones approach, and bring decades of expertise to life.

**Module 1, Implementing a Nuclear Power Programme**, is an introduction and overview of nuclear power infrastructure development, while **Module 2, Developing a Human Resource Strategy**, focuses on human resources management, a crucial element of a nuclear power programme.

**Three new models have been developed: Module 3, Stakeholder Involvement**, has just been launched and emphasizes the importance of developing and implementing a stakeholder involvement strategy and plan in parallel with the establishment of the nuclear power programme.

**Module 4, Management of a Nuclear Power Programme** explains why strong management and leadership is needed for the programme and how to manage the nuclear power programme in an efficient way to ensure a safe, secure, peaceful and efficient operation of the nuclear power plant.

As **Construction Management** is a complex issue, the e-learning **Module 5** will highlight the different aspects of construction management over each phase of development.

To support users to navigate through the modules, we have also created an animated **User Guide**.

This e-learning project is supported by an extra budgetary contribution from the Republic of Korea under the [Peaceful Uses Initiative](#). It is implemented by the Integrated Nuclear Power Infrastructure Group (INIG) with support from the Nuclear Power Engineering Section (NPES) of the IAEA Division of Nuclear Power, Department of Nuclear Energy.

All modules are based on the IAEA Milestones approach (Nuclear Energy Series No. NG-G-3.1), other relevant IAEA publications, and current experiences from newcomer countries. The modules are available at the above web page.

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## Nuclear Power Engineering

### Capacity Building for New or Expanding Nuclear Power Programmes

Helping Member States in capacity building for introducing or expanding nuclear power programmes was the focus of an IAEA training course recently held in Ulsan, Republic of Korea. The six-week programme was organized in cooperation with the KEPKO International Nuclear Graduate School (KINGS) under an IAEA Technical Cooperation Project.

“This training course provided practical advice related to available nuclear technologies”, said Ki-Sig Kang from the Nuclear Power Engineering Section. “This includes bid evaluation, contract, site selection, pre-construction activities, and management for a new or expanding nuclear power project”.

Some 20 participants from 14 Member States participated in the training course. The focus was on gaining technical knowledge to take part in informed decision making necessary for launching or expanding a nuclear power programme. Also, experts from countries that are starting a new nuclear power programme shared their experience.

“A nuclear power programme is a major undertaking requiring careful planning, preparation and investment in time and

human resources”, Mr Kang said. “Countries need an increasing number of qualified staff with both technical and managerial skills to successfully establish a new programme or expand an existing one”.

Therefore, the IAEA is providing support to Member States with a confirmed interest in near-term deployment of a nuclear power programme and to those with expansion plans. This is done through the IAEA Interregional Technical Cooperation Project on “Supporting nuclear power infrastructure capacity building in Member States introducing and expanding nuclear power” (INT2013).

**The IAEA Interregional Training Course on Nuclear Power Infrastructure Capacity Building in Member States Introducing and Expanding Nuclear Power** was held from 10 June to 19 July 2013.

The host organization, KEPKO International Nuclear Graduate School (KINGS) in the Republic of Korea, is an education institute established to train leadership level professionals in planning, design, construction, operation and management of nuclear power plants.

The training course was supported by the IAEA Department of Technical Cooperation.

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*Interregional Training Course on Nuclear Power Infrastructure Capacity Building, 10 June to 19 July 2013, Ulsan, Republic of Korea. (Photo: Kang/IAEA)*

## TWG on Nuclear Power Plant Instrumentation and Control

The IAEA held the **24th biennial meeting of the Technical Working Group on Nuclear Power Plant Instrumentation and Control (TWG-NPPIC)** on 22–24 May 2013. Thirty-five representatives from 19 Member States and two international organizations attended the meeting.

The TWG is comprised of a group of experts from Member States who provide advice to the IAEA concerning all activities related to nuclear power plant instrumentation and control (NPP I&C). The meeting provided a forum for Member States to report on country activities, discuss current issues and commonly encountered difficulties, and share best practices or strategies used in the design and implementation of nuclear power plant I&C systems. It also included discussions on the needs of Member States and provided recommendations for IAEA programme planning and implementation in the areas of I&C and human-system interface (HSI) in nuclear power plants.

“This technical working group was established in 1970, and it has a long history of actively supporting the Agency’s I&C programmes” said Mr Bychkov in his opening speech.



*Control Panels in a Nuclear Power Plant. (Photo: J.Gabrowski)*

Extended operation of nuclear power plants needs modernization and upgrades, and I&C is one of the most relevant fields in this area, as I&C equipment normally becomes much faster obsolete than that of mechanical or civil structures.

As a result of the discussions, the recommendations emphasized technical areas which have been considered as topics for IAEA Technical Meetings, Coordinated Research Projects, Workshops/Training Courses, and for technical publications, including:

- Accident monitoring systems for nuclear power plants;
- Application of Field Programmable Gate Arrays in instrumentation and control systems;
- Wireless technologies;
- Instrumentation and control in advanced small modular reactors (SMRs);
- Software evaluation and dependability assessment;
- Aging management of electrical equipment and components;
- Support for new plants and newcomer countries;
- Human factors engineering;
- Engineering and design aspects of computer security in nuclear power plant I&C systems.

More detailed information at:

<http://www.iaea.org/NuclearPower/Meetings/2013/2013-05-22-05-24-TWG-NPE.html>

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## Accident monitoring systems for nuclear power plants

The lessons learned from the accident at the Fukushima Daiichi nuclear power plant point to the importance of accident management systems, including instrumentation systems that can monitor relevant plant parameters inside the reactor containment and potentially in the reactor core. Monitoring these parameters is essential to implement severe accident management guidelines.

The IAEA is preparing a new technical report on accident monitoring systems for nuclear power plants. It describes the basic principles of accident monitoring, the methodology for implementing accident monitoring instrumentation, criteria to be considered during the design of such instrumentation, and areas where new methodologies or technologies may be needed. This issue is included in the IAEA Action Plan on Nuclear Safety developed in response to the Fukushima Daiichi accident.

A **technical meeting** held in Hwaseong-si, Republic of Korea, provided an international forum for presentations and discussions **on accident monitoring systems in nuclear power plants**. The 50 international experts from 16 Member States also assisted the IAEA in defining future activities in accident monitoring systems and reviewed the draft of the technical report. This will be the first guidance document published by the IAEA that specifically addresses accident monitoring instrumentation in nuclear power plants. The report, to be published in the IAEA Nuclear Energy Series, intends to fill a gap for all stakeholders in the nuclear industry and is expected to be published in 2014.

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# Nuclear Power Technology Development

## Technical Working Group on Fast Reactors

Reflecting a global network of excellence and expertise, the members of the **IAEA Technical Working Group on Fast Reactors (TWG-FR)** held the **46th annual meeting** in late May 2013. Discussions on current activities in the development of fast reactors and accelerator-driven systems in IAEA Member States and on national and international programmes were on the agenda.

“In the last years, the fast reactor community has achieved very promising results in the field of Generation IV safety design criteria, prevention and mitigation of severe accidents, advanced structural materials and innovative fuels, and others”, said Alexander Bychkov, IAEA Deputy Director General for Nuclear Energy. “However we are also very well aware that many challenges are still to be tackled by the fast reactor community”.

Continued R&D and technology innovations are needed on fast reactor and related fuel cycle technologies. International cooperation remains a primary means by which progress can be achieved to make fast reactors an attractive option for electricity production in the near future. The meeting was briefed about recent IAEA achievements in the area, including the International Conference on Fast Reactors and Related Fuel Cycles (FR13) held in Paris in March 2013.

“We also held two workshops on fast reactors safety, a seminar on fast reactors technology in cooperation with Argentina, and made contributions to other IAEA education and training initiatives” said Stefano Monti, Scientific Secretary

of the TWG-FR and IAEA Team Leader for Fast Reactor Technology Development.

Several coordinated research projects (CRPs) with active participation of Member States are ongoing or planned. The CRP on ‘Benchmark Analysis of an EBR-II Shutdown Heat Removal Test’ held its first meeting in 2012. A CRP on ‘Sodium Properties and Safe Operation of Experimental Facilities in Support of the Development and Deployment of SFR’, proposed by France, will be established in 2013, and a CRP on ‘Source Term for Radioactivity Release under Fast Reactor Disruptive Accident (CDA) Conditions’, proposed by India, will be launched in 2014. During the meeting, China proposed a CRP on ‘Benchmark analyses of CEFR reactor physics based on a physical start-up experiment’ and Japan proposed a CRP on ‘Benchmark Analyses of Sodium Natural Convection in the Upper Plenum of then MONJU Reactor’.

“The experts confirmed the importance of international collaborations”, said Mr Monti. “This refers to key areas such as advanced simulation and modelling, technologies for fast reactors in-service inspections and fuel handling, core monitoring and inherent and passive safety features”.

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## I&C Systems for SMRs

One of the important technical areas associated with the design and operational and process characteristics of small modular reactors (SMRs), particularly the integral PWR-type SMR, is instrumentation and control (I&C) systems.

A **Technical Meeting on I&C for Advanced SMRs**, held at the IAEA in May 2013, served as a forum for discussing



*Construction Site of the BN-800 Fast Reactor at the Beloyarsk Nuclear Power Station, Russian Federation. (Photo: ROSATOM)*



current knowledge, practices, design and architecture, implementation, and operating experience with I&C systems in advanced SMRs. The challenges and issues that need to be resolved before advanced SMRs can be deployed were also discussed. Participants presented the global status of SMR design development and identified key cross-cutting issues associated with I&C systems that arise from the specific dynamic behaviour of SMR operational characteristics. The IAEA presented its activities on I&C system engineering that should be incorporated in advanced reactor and SMR technology development.

“Member States have recognized the need to identify the distinctive features of advanced SMRs through relevant IAEA programmes”, said Hadid Subki from the Nuclear Power Technology Section. I&C issues for advanced SMRs such as staffing, sensors, human factor engineering issues for multi-module SMRs with common control room, and cyber security in case of remote deployment of advanced SMRs, were discussed. As an outcome of the meeting, the IAEA will prepare an IAEA Nuclear Energy Series report on I&C systems for advanced SMRs.

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## Evaluating Maximum Operating Temperatures for HTR Fuel

Evaluating maximum operating temperatures and accident conditions is crucial for identifying the role of high temperature reactors (HTRs) in a future energy portfolio. HTRs are very likely to be used for combined heat and power generation or process heat applications, rather than solely for generating electricity. Higher operating temperatures allow wider uses, as well as higher efficiencies, in the regarded processes (e.g. hydrogen production with HTRs). Nevertheless, it has to be assured that fission releases from the fuel elements during accident conditions are kept to a reasonable minimum.

The **Technical Meeting on Re-evaluation of Maximum Operating Temperatures and Accident Conditions for High Temperature Reactor Fuel and Structural Materials**, held at the IAEA on 10–12 June 2013, provided a forum to discuss maximum allowable operating temperatures, and accident conditions for HTR fuel and structural materials, as well as future initiatives in these areas.

All participants agreed that the reliable, high performance HTR fuel that is needed to run HTRs on high operating temperatures, i.e. 950 °C outlet temperature, is available now. The fuel was tested independently in three variants and all proved to be of much better manufacturing quality than fuel produced in the 1990s.

“The results give us confidence that the maximum accident temperature, which is currently set at 1600 °C, can be pushed to higher limits”, said Bismark Tyobeka from the Nuclear Power Technology Section. “At the same time, it is possible to keep fission releases of the fuel at a constant level or even decrease them”.

Further analysis will be required concerning the possibility of increasing operating and accident temperatures in HTRs. Innovative thorium and uranium oxycarbide (UCO) fuel particles seem to have higher accident temperature margins than the currently used uranium dioxide (UO<sub>2</sub>) fuel particles.

Furthermore, diffusive release of caesium which has been a major concern in the past might be caused by manufacture defects or faults rather than by the actual fuel particles.

The results of this meeting and any further results will be used for a new coordinated research project (CRP) on this topic, which will start in October 2013.

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## Pressure Tube Creep Phenomena

Pressure tube (PT) deformation is a critical aging issue in operating Heavy Water Reactors (HWRs). Horizontal pressure tubes can have three kinds of deformation: diametric creep leading to flow bypass and the penalty to critical heat flux for fuel rods, longitudinal creep leading to the interference of feeder pipes and/or fuelling machine, and sagging leading to interference with in-core components and potential contact between the pressure tube and the calandria tube.

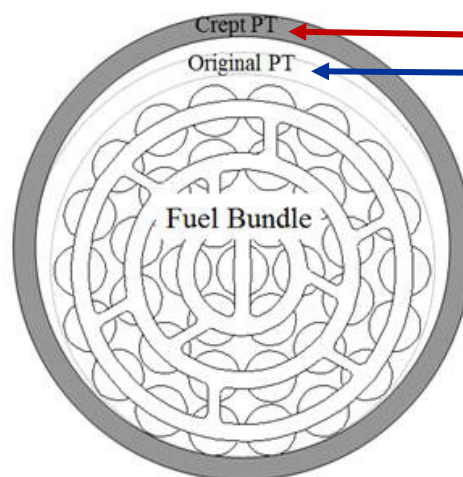
The National Atomic Energy National Commission of Argentina (CNEA), Atomic Energy of Canada, Ltd (AECL), the China Institute of Atomic Energy (CIAE), the Bhabha Atomic Research Centre (BARC) in India, the Korea Atomic Energy Research Institute (KAERI), and the Romanian Institute for Nuclear Research are participating in a new coordinated research project (CRP) that aims at improving understanding and prediction of pressure tube creep phenomena.

The CRP scope includes setting up a database on pressure tube deformation, microstructure characterization of pressure tube materials collected from HWRs currently operating in Member States and developing a prediction model for pressure tube deformation.

The experts participating in this CRP met at the IAEA on 2–4 July 2013 to develop the integrated research plan for the project and specify their individual contributions.

The expected outcomes from the CRP are: (1) improved understanding of pressure tube creep mechanisms by studying the effect of material response and operating conditions; (2) improvement of material characterization technology; (3) recommendation for manufacturing to achieve optimal pressure tube performance; (4) improvement in the prediction of pressure tube creep; and (5) improvement in aging management procedures.

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*Graphical Illustration of a Deformed Pressure Tube.*

# International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)

## INPRO Steering Committee Discusses Future Action Plan

The **INPRO Steering Committee** held its **20th Meeting** on 22–24 May 2013 at the IAEA. The 43 representatives from INPRO Members and international organizations, who attended the meeting, reviewed the draft INPRO Action Plan for 2014–2015, made recommendations for current and future activities and identified Member State priorities and support for individual INPRO activities. The meeting was chaired by Mr Pascal Anzieu (France); Mr Bhaskar Sur (Canada) and Mr Ferhat Aziz (Indonesia) served as rapporteurs.

“I am satisfied with the progress of the INPRO project”, said Alexander Bychkov, IAEA Deputy Director General for Nuclear Energy and INPRO Project Manager. He highlighted several achievements since the last meeting of the Steering Committee in 2012, including the successful completion of the Nuclear Energy System Assessment (NESA) by Belarus, and progress in ongoing NESAs in Indonesia, Romania and Ukraine, as well as the excellent cooperation with the Generation IV International Forum (GIF) and other international organizations and initiatives.

A major discussion item on the meeting’s agenda was the draft INPRO Action Plan for 2014–2015, presented by the INPRO Group. For the next biennium, several new activities are proposed in each of the four major projects of INPRO’s programme. This includes, e.g., a new collaborative project to develop key indicators for innovative nuclear energy systems under the ‘Global Nuclear Energy Scenarios’ theme, and two new collaborative projects, one on nuclear fuel and fuel cycle analysis for future nuclear energy systems and another one on waste from innovative types of reactors and fuel cycles, both within the ‘Innovations’ theme. Another proposal was a nuclear energy system planning service package, which is intended to properly capture the enduring value of INPRO as an ongoing service to Member States. Several topics were also proposed for future INPRO Dialogue Forums.

“We’ve selected most of the new activities proposed in the draft Action Plan”, said Mr Anzieu. “There was also strong interest from Member States in the Dialogue Forum which is a very successful activity”. The 2014-2015 Action Plan will be revised in line with the comments and recommendations from the Steering Committee and presented for endorsement at the 21st meeting on 18 November 2013 at the IAEA.

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*Participants in the 20th INPRO Steering Committee Meeting, held in May 2013 at the IAEA. (Photo: Gladyshev/IAEA)*

## Progress in SYNERGIES Project

The project on Synergistic Nuclear Energy Regional Group Interactions Evaluated for Sustainability (SYNERGIES) is one of the main activities within INPRO’s theme on ‘Global Nuclear Energy Scenarios’. This project has the largest number of participants and observers from INPRO Members, including 25 countries and the OECD’s Nuclear Energy Agency.

“The overall objective of the INPRO Collaborative Project on SYNERGIES is to identify and evaluate mutually beneficial collaborative architectures”, said Vladimir Kuznetsov from the INPRO Group, who is leading the project. “We also investigate the driving forces and impediments for achieving globally sustainable nuclear energy systems”.

### The third technical project meeting of the SYNERGIES collaborative project

was held on 3–7 June 2013 at the IAEA. Twenty three experts from 18 INPRO Member States and the UK (which participated as an observer) presented and discussed the progress achieved since the second SYNERGIES meeting in November 2012 and to update and approve work plans for the next period.

**Task 1** of the project, led by France, covers synergistic collaboration in nuclear fuel cycle back end. Several scenarios are being examined focusing on a) mono-recycling of uranium/plutonium (U/Pu) in thermal spectrum reactors; b) the introduction of fast reactors to support multi-recycling of Pu in light water reactors (LWR) and fast reactors (FR); c) FRs with reprocessing of fuel from thermal reactors to enable growth in fast reactor capacity; and d) transition of Th/<sup>233</sup>U fuel cycle via U/Pu HWR-LWR-FR phase and scenarios with alternative U/Pu/Th fuel cycles.

For Task 1 of the project, specific scenarios of the above mentioned scenarios (a-d) were elaborated and their drivers and impediments were identified on a preliminary basis. Good progress was observed in the Russian-Ukrainian study of the scenarios belonging to b) and c) above. Armenia joined this study during the meeting, and will host a dedicated SYNERGIES consultants’ meeting to be convened in Yerevan in November 2013. Also, preliminary results of Task 1 studies from Argentina, Italy and Romania were presented and discussed.

**Task 2** of the SYNERGIES project is evaluating additional nuclear energy system options with thermal and fast reactors. It is led by the Russian Federation. Five studies have already been completed, including those on alternative FR start-up



deployment strategies and on scenarios with spectrum-shift VVER and HTR. Several draft deliverables were prepared and are available on the SYNERGIES web page: <http://www.iaea.org/INPRO/CPs/SYNERGIES/index.html>.

**Task 3** is led by Belgium and evaluates options for minor actinide management. A highlight of the meeting was the presentation from France on technical and economic assessments of different options for minor actinide transmutation. Some results of this study will be included in the final report of the SYNERGIES project. Otherwise, systems for analysis and codes were identified by all participants in this task.

**Task 4**, led by India, is developing key indicators (KI) including economic assessment methods. Sets of KIs were selected for consideration in specific SYNERGIES tasks; detailed economic data on nuclear reactors and fuel cycle facilities and services have been collected. These data have been applied in a trial comparative analysis of selected synergistic and non-synergistic scenarios of the completed INPRO collaborative project on Global Architecture of Innovative Nuclear Systems based on Thermal and Fast Reactors including Closed Fuel Cycles (GAINS). Draft deliverables are available on the SYNERGIES web page.

A detailed work plan and a schedule of work for the period until the next SYNERGIES meeting, scheduled for 18–22 November 2013, have been elaborated.

The participants were also informed about a training course on dynamic modeling of complex collaborative scenarios for nuclear energy systems with the use of the MESSAGE code and were invited to participate in this event. The course will be conducted jointly by the Planning and Economic Studies Section (PESS) and the INPRO Group on 21 October–1 November 2013, with a distant pre-training taking place in September 2013.

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## INPRO Dialogue Forum on Licensing and Safety Issues for SMR

The INPRO Dialogue Forum is one IAEA mechanism for technology holders and users to discuss technological and institutional innovations. The **6th INPRO Dialogue Forum on ‘Licensing and Safety Issues for Small and Medium-sized Nuclear Power Reactors (SMRs)’** was held on 29 July to 2 August 2013 at the IAEA. The meeting was attended by some 120 experts and representatives from 37 Member States and four international organizations. The large number of international participation was proof of the topicality and high interest among Member States in these issues.

The meeting included panel discussions on challenges and issues for SMR deployment and licensing, lessons learned for SMRs from the Fukushima Daiichi accident, and international cooperation on SMR licensing and safety. Working groups addressed major issues regarding licensing and safety issues of SMRs: (1) considerations for SMR designs; (2) siting considerations of SMRs; (3) application of a graded approach to the regulatory and licensing process; (4) legal and regulatory framework of SMRs; and (5) public participation in the SMR licensing process. They produced reports on each of the five topics, including summaries of discussions, case studies and

the recommended path forward to resolve and address these key issues.

For those countries considering SMRs in their nuclear power development programme, the meeting provided licensing and regulatory knowledge and opportunities for discussions on common safety issues with technology holders. Participating Member States considering the use of SMR technology were able to develop and prioritise licensing and safety issues, develop an understanding of related work in other forums and the issues identified in the working groups.

This Dialogue Forum was organized in cooperation with the Nuclear Power Technology Development Section and the Regulatory Activities Section in the Department of Nuclear Safety and Security. More information on this and previous Forums is available at: <http://www.iaea.org/INPRO/DFs/index.html>

The 7th INPRO Dialogue Forum is scheduled for 18–22 November 2013 and will address the ‘Sustainability of Nuclear Energy Systems Based on Evolutionary Reactors’.

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## Collaborating on Globally Sustainable Nuclear Energy Systems

Effective collaboration in innovations and R&D offers many advantages and is recognized as essential, particularly in the area of developing innovative globally sustainable nuclear energy systems. The IAEA is in the unique position to collect and disseminate experiences and good practices that support Member States to use effective collaboration mechanisms in innovations. That is why the development of a new IAEA Nuclear Energy Series report on enhancing collaboration on innovations to support globally sustainable nuclear energy systems is viewed as a cross-cutting and important activity. The report is prepared by the INPRO Group in cooperation with IAEA Member States and other IAEA programmes. This activity was endorsed by the INPRO Steering Committee at its 20th meeting in May 2013.

*“We cannot solve problems by using the same kind of thinking we used when we created them.”*  
*Albert Einstein*

Examples and practices of establishing collaboration mechanisms will be provided and analysed including collaborative projects, networks, international research centres, centres of excellence and communities of practice. Different options and methods to enhance collaboration will be analysed.

The activity should be beneficial for many different users in Member States including all major stakeholders in the development and deployment of sustainable nuclear energy systems; decision-makers and senior managers responsible for organization of R&D and innovations; managers and professionals carrying out innovative projects and R&D in the nuclear field; managers and professionals from countries establishing nuclear power programmes; and managers and specialists involved in establishing or improving collaboration mechanisms, either nationally or through international initiatives.

### Interested in contributing to this activity? Contact:

Alexey Grigoriev, [A.Grigoriev@iaea.org](mailto:A.Grigoriev@iaea.org) or Alexey Kazennov, [A.Kazennov@iaea.org](mailto:A.Kazennov@iaea.org), in the INPRO Group.

## Recently Published



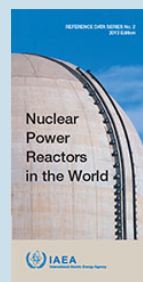
Nuclear Reactor Technology Assessment for Near Term Deployment  
[IAEA Nuclear Energy Series No NP-T-1.10](#),  
 STI/PUB/1597



Hydrogen Production Using Nuclear Energy  
[IAEA Nuclear Energy Series No NP-T-4.2](#),  
 STI/PUB/1577



Implementation of a Management System for Operating Organizations of Research Reactors  
[Safety Reports Series 75](#), STI/PUB/1584



**Nuclear Power Reactors in the World**  
[Reference Data Series No. 2](#),  
 2013 Edition

The most recent reactor data available to the IAEA as of the end of 2012, on power reactor operating, under construction and shut down, and performance data on reactors operating in the IAEA Member States.

Performance Assessment of Passive Gaseous Provisions (PGAP): *Report of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO)*  
[IAEA-TECDOC-1698](#)

Evaluation of High Temperature Gas Cooled Reactor Performance: Benchmark Analysis related to PBMR-400, PBMM, GT-MHR, HTR-10 and the ASTRA Critical Facility  
[IAEA-TECDOC-1694](#)

## Technical Meetings October–December 2013

All meetings organized by the Division of Nuclear Power at:  
[www.iaea.org/NuclearPower/Meetings/2013/](http://www.iaea.org/NuclearPower/Meetings/2013/)

Date	Title	Location	Contact
1–4 Oct	TM on Human Resources Roadmap and Capacity Building	IAEA, Vienna,	<a href="mailto:B.Molloy@iaea.org">B.Molloy@iaea.org</a>
2–3 Oct	TM on Assessment and Options to Improve Thermal Efficiency in Nuclear Power Plants	IAEA, Vienna	<a href="mailto:I.Khamis@iaea.org">I.Khamis@iaea.org</a>
21–25 Oct	TM on Becoming a Knowledgeable Customer	Moscow, Russia	<a href="mailto:Y.Troshchenko@iaea.org">Y.Troshchenko@iaea.org</a>
28–31 Oct	TM on Environmental Impact Assessment for SMRs Deployment in Newcomer Countries	IAEA, Vienna	<a href="mailto:H.Subki@iaea.org">H.Subki@iaea.org</a>
28 Oct–1 Nov	TM on Management of Nuclear Power Plant Projects	Hanoi, Vietnam	<a href="mailto:J.Boogaard@iaea.org">J.Boogaard@iaea.org</a>
4–8 Nov	TM on Strategic Supply Chain and National Industrial Involvement in Nuclear Power	Beaune/Monthieux, France	<a href="mailto:XP.Li@iaea.org">XP.Li@iaea.org</a> <a href="mailto:M.Yagi@iaea.org">M.Yagi@iaea.org</a>
5–8 Nov	TM on Degradation of Primary System Components of Water Cooled Nuclear Power Plants	IAEA, Vienna	<a href="mailto:K-S.Kang@iaea.org">K-S.Kang@iaea.org</a>
18–22 Nov	4th TM of the INPRO Collaborative Project on SYNERGIES	IAEA, Vienna	<a href="mailto:V.Kuznetsov@iaea.org">V.Kuznetsov@iaea.org</a>
19–22 Nov	7th INPRO Dialogue Forum: Sustainability of Nuclear Energy Systems based on Evolutionary Reactors	IAEA, Vienna	<a href="mailto:A.Korinny@iaea.org">A.Korinny@iaea.org</a>
27–28 Nov	TM on Establishing Networks for Countries Introducing Nuclear Power	IAEA, Vienna	<a href="mailto:M.Ferrari@iaea.org">M.Ferrari@iaea.org</a> <a href="mailto:B.Pagannonne@iaea.org">B.Pagannonne@iaea.org</a>
3–5 Dec	TM on Status of IAEA Fast Reactor Knowledge Preservation Initiative	IAEA, Vienna	<a href="mailto:S.Monti@iaea.org">S.Monti@iaea.org</a>

## Impressum

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