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THE IAEA INTERNATIONAL PROJECT ON INNOVATIVE NUCLEAR REACTORS AND FUEL CYCLES (INPRO): STATUS AND OUTLOOK

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ABSTRACT

Following a resolution of the General Conference of the IAEA in the year 2000 an International Project on Innovative Nuclear Reactors and Fuel Cycles, referred to as INPRO, was initiated.

Based on scenarios for the next fifty years and beyond, requirements in six different areas – economics, safety, waste management, proliferation resistance, environment, and infrastructure – to be met by innovative nuclear energy systems (INS) were identified. As well, a methodology has been developed to assess an INS. On the basis of this assessment, the need for innovations in existing nuclear technology, to be achieved via research, development and demonstration, can be identified.

A number of INPRO assessment studies are now underway, using the upgraded methodology. To guide such assessments draft manuals for carrying our assessments in each area of INPRO, economics, safety, etc., are being prepared and issued as working papers.

The next phase of INPRO will start in mid-2006. In this phase INPRO will undertake activities in three main areas, i.e. continuous improvement of the assessment methodology, infrastructure development, and facilitating, as requested by Member States, coordination for the planning of collaborative projects arising from the results from the assessment studies underway and planned.

INTRODUCTION

The Agency's International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) was established to help to ensure that nuclear energy is available to contribute, in a sustainable manner, to the energy needs in the 21st century. In 2005, its membership continued to grow, with Ukraine and United States of America becoming additional members, and total INPRO membership now stands at 24.

The main objectives of INPRO are to:

- Help to ensure that nuclear energy is available to contribute in fulfilling energy needs in the 21st century in a sustainable manner; and
- Bring together both technology holders and technology users to consider jointly the international and national actions required to achieve desired innovations in nuclear reactors and fuel cycles.

Based on scenarios for the next fifty years and beyond, requirements in six different areas – economics, safety, waste management, proliferation resistance, environment, and infrastructure – to be met by innovative nuclear energy systems (INS) were identified. As well, a methodology has been developed to assess an INS. On the basis of this assessment, the need for innovations in existing nuclear technology, to be achieved via research, development and demonstration, can be identified.

Thereafter, INPRO organized 14 case studies (8 by national teams and 6 by individuals) to test and validate the methodology. This validation exercise was completed at the end of 2004 with the publication of the IAEA report, TECDOC-1434 [1], setting out an improved assessment methodology, based on the recommendations feedback from the case studies.

STATUS OF MANUALS

In addition to the description of the INPRO methodology, documented in TECDOC-1434 [1], in all INPRO areas, such as safety, economics, environment, waste management, proliferation resistance and infrastructure, corresponding manuals have been prepared during 2005 and beginning of 2006 to guide applicants of the INPRO methodology how to perform an assessment of an INS. The manuals concentrate on the third level¹ of the INPRO hierarchy of requirements, called Criteria consisting of Indicators and Acceptance limits. They provide background of these Criteria and describe in detail how to determine the value of the Indicators and Acceptance Limits for a given INS.

In some of the manuals a quantitative example is given how to perform an INPRO assessment in the specific area. For example, in the area of safety of nuclear reactors, the concept of an advanced BWR is compared to an operating BWR, demonstrating the increased level of safety in the new design. Another example is provided for the INPRO area of economics. Here an economics study is shown for a country with a small grid and with a need of additional power supply, and that has to decide between the deployment of fossil power (gas) or two nuclear options (PWR and HWR). In the area of proliferation resistance and waste management, the DUPIC fuel cycle is being evaluated.

Based on a decision of the 8th INPRO steering committee the area of physical protection will also be included into the INPRO methodology.

The INPRO manuals have been sent out to the MS in draft form as working papers and are supposed to become part of the IINPRO documentation.

STATUS OF ASSESSMENT STUDIES

A number of INPRO assessment studies are underway, using the upgraded methodology of TECDOC-1434 and the INPRO manuals.

A joint study is performed by China, France, India, Korea, Russia, and Japan (as an observer) to assess an INS based on fast reactors with a closed fuel cycle. Recently Ukraine has announced that they will also participate in this study. In each participating country, the study will provide an overview of the current status of the fast reactor technology development and

conditions for future deployment. As a boundary condition for the INPRO assessment, it will develop a range of scenarios based on predicted growth of national demand of energy using codes such as MESSAGE and DESAE. As a global scenario the SRES scenario B2 will be used. Suitable fast reactor technologies, such as gas and metal cooled reactor and associated fuel cycles, based on e.g. oxide, carbide and metal fuel, will be evaluated.

A national study is performed by France, on the transition from their existing suite of LWRs to Generation IV reactors. The national scenario predicts a constant supply of nuclear power in the future, taking into account life extension of existing reactors, replacement by Generation 3+ type LWR reactors (EPR) and the introduction of Generation 4 fast reactors around 2030.

An assessment of the DUPIC fuel cycle is done by Korea, focussing on proliferation resistance issues. The study evaluates the complete cycle starting from fuel inserted into PWR, use of burned up PWR fuel for fabrication of fuel for HWR till the final depository.

Both China and India are planning to perform a study of an INS that includes high temperature reactors. The studies should explore the capabilities of such reactors, such as non-electrical applications, e.g. process heat, enhanced safety and high efficiency.

An assessment of different fuel cycle options, slight enriched uranium and low enriched uranium, for a 600 MWe PHWR and a 300 MWe PWR is performed by Argentina.

Armenia is assessing the possibility of additional nuclear power in a country with a small grid.

Several additional assessment studies have been announced recently by INPRO MS, including, studies by Brazil on two types of small reactors, Morocco on economic aspects of nuclear power, and Ukraine on its national nuclear program. The Czech Republic jointly with Bulgaria, Poland, Russia and Slovakia plans to assess energy needs in the 21st century and its satisfaction by several options of energy supply.

All the assessment studies performed will provide feedback how to improve the INPRO methodology further.

OTHER ONGOING ACTIVITIES

An interface meeting with Generation IV international forum (GIF) was held on September 2005. INPRO and GIF confirmed that both initiatives were complementary and agreed on the convenience to develop further co-operation. INPRO/IAEA experts are participating in GIF working groups on proliferation resistance and physical protection, safety, and in the economics modelling group.

¹ The first level is called Basic Principle, the second one User Requirement [1].

The great interest on INPRO by the international community was verified in the Scientific Forum organized during the 49th General Conference, attended by more than 70 representatives from different countries, and also in the international conferences and symposiums organized around the world where INPRO presentations have been made.

The progress of the project in 2005 was reported to the 8th INPRO steering committee meeting, held on December 2005 and it was agreed to proceed to the next phase of INPRO.

An INPRO information portal for INS assessment is being created based on recommendations from MS. This portal will consist primarily of a database containing information needed to perform an INPRO assessment, but also the results of such assessment studies. It will also provide the user with access to a variety of codes that can be used in such an assessment. Existing relevant databases in the IAEA will be linked to this portal.

As preparatory steps for future phases of INPRO several activities are performed such as the establishment of country profiles on R&D programs and facilities for INS and a report on status and trends of Innovative Nuclear Fuel Cycle Technologies.

CONCLUSION AND OUTLOOK

INPRO's mission is to provide a forum for discussion of experts and policy makers from industrialized and developing countries on all aspects of nuclear energy planning as well as on the development and deployment of innovative nuclear energy systems (INS) in the 21st century.

INPRO has provided to its MS a comprehensive description how to perform an assessment of INS on a national, regional and global basis. The ongoing assessment studies will provide feedback how to improve this methodology further, and should identify areas where R&D is needed to fulfil the INPRO requirements for a sustainable nuclear energy system.

The next phase of INPRO will start in mid-2006. In this phase INPRO will undertake activities in three main areas, i.e.

- Continuous improvement of the assessment methodology;
- Infrastructure development; including activities such as consideration of options for regional development of INS including fuel cycle centres, evaluation of fuel cycle strategies, harmonization of licensing and of industrial codes and standards; and
- Facilitation, as requested by MSs, of the coordination for planning of collaborative projects arising from the results from the assessment studies underway and planned.

NOMENCLATURE

EPR	European pressurized reactor
GIF	Generation IV international forum
HWR	Heavy water moderated reactor
INPRO	International Project on innovative nuclear reactors and fuel cycles
INS	Innovative Nuclear Energy System
LWR	Light water reactor
PHWR	Pressurized heavy water moderated reactor
R&D	Research and Development

REFERENCES

- [1] INTERNATIONAL ATOMIC AGENCY, Methodology for the assessment of innovative nuclear reactors and fuel cycles, Report of Phase 1B (first part) of INPRO, IAEA-TECDOC-1434, Vienna (2004).

