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

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History and Introduction
Motivation and Initial Goals

During the 90s

- **stagnation** in nuclear power development, recognition of its potential
- among others: *Three Agency Study, Millennium Summit*
- **long-range** and **holistic** planning are needed
- **innovations** are key for sustainable nuclear future
- **international cooperation** is an important way to success
INPRO

• Origins
  • Established in 2000/2001
  • Authorized by IAEA General Conference resolutions

• Characteristics
  • Membership based
  • Funded mainly from extrabudgetary contributions
  • Appr. 20 to 25 staff (mainly CFEs from Member States) at IAEA Headquarters
  • International Project inside IAEA
  • Cross-cutting with all relevant technical Departments involved
INPRO Objectives

- To help to ensure that nuclear energy is available to contribute, in a sustainable manner, to meeting the energy needs of the 21st century;

- To bring together technology holders and users so that they can consider jointly the international and national actions required for achieving desired innovations in nuclear reactors and fuel cycles.
INPRO on the Policy Level

- IAEA General Conference
  - Resolutions adopted & continuously reiterated since 2000
- G8 Summit
  - Global Energy Security, St. Petersburg, 2006
  - “The development of innovative nuclear power systems is considered an important element for efficient and safe nuclear energy development. In this respect, we acknowledge the efforts made in the complementary frameworks of the INPRO project and the Generation IV International Forum.”

INPRO (Gowin 2012)
INPRO Membership 2001-2012

INPRO Members 2001 - 2012

Number of Countries

2001: 10
- Argentina
- Canada
- China
- Germany
- India
- Netherlands
- Russian Federation
- Spain
- Turkey
- EC

2002: 13
- Brazil
- Korea, Rep.
- Switzerland

2003: 15
- Armenia
- China
- Czech Rep.
- Indonesia
- Morocco
- South Africa

2004: 22
- Armenia
- Chile
- France

2005: 24
- Ukraine

2006: 27
- Belarus
- Japan

2007: 28
- Belgium

2008: 28
- Algeria
- Italy
- Kazakhstan
- Poland

2009: 31
- Jordan

2010: 32
- Egypt

2011: 35
- Israel

2012: 38
- Romania
- Malaysia
- Vietnam
Becoming an INPRO member

- IAEA Member States and recognized international organizations can become members of INPRO.
- 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 work with the INPRO Group at the IAEA;
  - Performing agreed nuclear energy system assessment studies using the INPRO methodology;
  - Participating in INPRO Collaborative Projects.
Long-range nuclear energy strategies
Initial Considerations
Nuclear energy strategies

• **Strategy**
  • **Medium- to long term**
  • Beyond one single NPP
    • In technical terms: cover whole nuclear energy *system* (all facilities)
    • In planning terms: cover whole nuclear energy *programme* (all projects)
  • Structured *hierarchy* of national planning documents in some countries
    • Link to national sustainable development plan

• **Two components**
  • **Quantified** (typically up to 30 years)
  • **Descriptive** (all timeframes)
Why are long-term strategies important?

Because the characteristic times of drivers, technology, economy and society are also long-term
Why are long-term strategies important? (2)

- Because key drivers for nuclear are long-term
  - Climate change and environment (50 to 100 years plus)
  - Competitor fossil fuel / availability (20 to 100 years)
  - Objective of energy security
  - Population growth plus energy intensity (two generations, 50 years)

- Because technical lifetimes are long-term
  - One nuclear power plant (15+40/60+15 years)
  - Full nuclear energy programme (plus 40 years)
  - Including spent fuel and waste (centuries)
Why are long-term strategies important? (3)

- Because becoming a “welcome member of the nuclear family” takes time
  - Nuclear an sector with many issues to be considered
  - A soft factor, but most relevant
  - Trust, suppliers, governmental agreements, reputation ...
- Because national sustainable development plans are long-term
  - Education, urbanization, agriculture, industrialization, health... (50 years)
    - Note e.g. pensions (100 years)
  - Industrial and infrastructure development (15 to 30 years)
  - Building or transferring nuclear knowledge, HR, education (15 to 40 years)
Why are long-term strategies important? (4)

- **Because of the large investment volumes**
  - Note: consider whole nuclear energy system
  - Typical payback times (several decades)
  - High risk of stranded investments
    - Spreading the risk for host economy (several decades)
    - Note: macroeconomic considerations

- **Because innovations are to be considered**
  - Technical innovations, e.g. for GenIV (20 to 40 years)
  - Institutional innovations (15 to 40 years)
INPRO’s contribution

Understand the challenge

Studies and Analysis
Global nuclear energy sustainability in the 21st century

Develop options

Collaborative Projects
Technical innovation
Institutional innovation

Implement solutions

Assist Member States
Long-range strategies and plans
INPRO Dialogue Forum
INPRO Projects in 2012–2013
“Understand the Challenge”

Global Nuclear Energy Development Scenarios (INPRO Project 2)
Publication

- Nuclear Energy Development in the 21st Century: Global Scenarios and Regional Trends
  - IAEA Nuclear Energy Series No. NP-T-1.8, STI/PUB/1476 (2010)
Calculations / Example

- Interregional flows of uranium, fresh, spent and MOX fuel under ‘high’ scenario (2050)

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GAINS / SYNERGIES / ROADMAPS

- **GAINS** (completed 2011)
  - Modeling *transition scenarios* towards sustainable nuclear energy system
  - Closed fuel cycles and fast reactors

- **SYNERGIES** (started 2012)
  - Added value of *cooperation* among countries in that transition

- **ROADMAPS** (to start in 2013)
  - What has to be done, when and by whom, to make this happen?
• Global Architecture of Innovative Nuclear Energy Systems with Thermal and Fast Reactors and Closed Nuclear Fuel Cycle (GAINS)

• 16 Member States and International Organizations as participants and observers

• Duration: 2008–2011; Status: Completed

• Outputs:
  
  • A verified framework for the assessment of transition scenarios to future sustainable nuclear energy systems (approach, assumptions, scenarios, codes, data)
  
  • Simulation results for 8 reference base cases representing homogeneous and heterogeneous world models with an option of collaboration among groups of countries
  
  • Possible benefits and issues of collaboration outlined

• Synergistic Nuclear Energy Regional Group Interactions Evaluated for Sustainability

• **Duration:** 2011–2014

• **Objectives:**
  
  • To identify and evaluate mutually beneficial collaborative architectures and the driving forces and impediments for achieving globally sustainable nuclear energy systems
  
  • To identify short-term and medium-term collaborative actions capable to develop pathways to long term sustainability.

• **Deliverable:** IAEA report in 2014

• **IAEA-internal coordination:** INIG, NPTDS, NEFW, PESS, NS, TC as appropriate
Task 1 (Core Task)
Evaluation of Synergistic Collaborative Scenarios of Fuel Cycle Infrastructure Development

Task 4 (Cross-cutting Task). Elaboration of key indicators specific for synergistic collaboration, including economic assessment methods

Task 2 (Support Task). Evaluation of Additional Options for NES with Thermal and Fast Reactors

Task 3 (Support Task). Evaluation of Options for Minor Actinide Management
SYNERGIES Status

- Preparatory meeting: October 2011
- Kick-off technical meeting: June 2012
  - ToR signed by 27 participants from 17 Member States
- Next meeting: 12-16 November 2012, in Vienna
Roadmaps for a transition to globally sustainable nuclear energy systems (ROADMAPS)

- Roadmap – flowchart of structured sets of actions, scope of work and timeframes for particular stakeholders in a collaborative scenario of transition to sustainable NES

- Status: To start in 2014–2015
“Develop Options”

Technical and Institutional Innovations (INPRO Project 3)
Overview

- **Completed Collaborative Projects**
  - Investigation of Technological Challenges related to the Removal of Heat by Liquid Metal and Molten Salt Coolants from Reactor Cores Operating at High Temperatures (COOL)
  - Advanced Water Cooled Reactors (AWCR)
  - Performance Assessment of Passive Gaseous Provisions (PGAP)
  - Decay Heat Removal System for Liquid Metal Cooled Reactors (DHR)
  - Implementation Issues for the Use of Nuclear Power in Small Countries (SMALL)
Overview

- **Planned Activities**
  - Transportable Nuclear Power Plants II - Case Study on Factory Fuelled SMR
  - Investigation of options for a new international project on fast reactors, fuel cycles and materials R&D
- **INPRO Collaborative Projects in 2012-2013**
  - Review of Innovative Reactor Concepts for Prevention of Severe Accidents and Mitigation of their Consequences (RISC)
  - Load Following Capability in Innovative Designs (LOADCAPS)
“Implement Solutions”

National long-range nuclear energy strategies using the INPRO methodology (INPRO Project 3)
The INPRO methodology: **sustainability**

The INPRO Methodology is an internationally validated tool for assessing an existing or planned nuclear energy system in seven key areas which encompass the dimensions of sustainable development, from economics to proliferation resistance and the environment.
Introduction to the Use of the INPRO Methodology in a NESA

- IAEA Nuclear Energy Series No. NP-T-1.12, STI/PUB/1478

Several other publications available
Experience with NESAs

- 6 national assessments
  - Argentina, Brazil, India, Republic of Korea as technology developer.
  - Armenia, and Ukraine as technology user.
- 1 multinational assessment (“Joint Study”)
  - Canada, China, France, India, Japan, Republic of Korea, Russian Federation, and Ukraine.
  - Development of NES of sodium cooled FR with CNFC.
- Results documented
  - TECDOC-1636 and TECDOC-1639 and others
Current NESAs

- NESA in Belarus
  - Full scope assessment of all INPRO methodology areas
  - Simplified nuclear energy system consisting of power plant and waste management facilities
  - Completed in 2011

- Also on-going are NESAs in
  - Kazakhstan
  - Indonesia
  - Ukraine

- Planned
  - Jordan, Egypt, Italy, South Africa, ...
NESA Support Package

- Tailored assistance to Member States
  - Expert support
  - Data collection, evaluation, report

- Tools
  - E.g. e-NESA Software

- Training and capacity building
  - Workshops (TC assistance)
  - NESA Training Course for Students
“The INPRO Dialogue Forum”
(INPRO Project 4)
The INPRO Dialogue Forum

• INPRO Dialogue Forum on Global Nuclear Energy Sustainability

• Strategic dialogue
  • Between nuclear technology holders and users
  • On topics of joint interest
    • Nuclear energy innovations (2010–2011)
    • Broader: global nuclear energy sustainability (2012–2013)

• Objectives
  • Discuss, jointly deliberate, slowly develop common views or jointly identify issues to be addressed

• General Conference resolution GC(55)/RES/12.B.3
INPRO Dialogue Forum History

- Predecessor: CUC
  - Common User Considerations (CUC) by Developing Countries for Future Nuclear Energy Systems (Published in 2009)
  - Socio- and macroeconomic factors, Proven technology, Safety Approaches for Innovative Nuclear Systems
  - Multilateral Approaches to Sustainable Nuclear Energy Deployment - Institutional Challenges
- 3rd INPRO Dialogue Forum (2011)
  - Common user considerations for small and medium sized reactors
INPRO Dialogue Forum History

• 4th INPRO Dialogue Forum (2012 July/August)
  • At IAEA headquarters, Vienna, Austria
  • Drivers and Impediments for Regional Cooperation on the Way to Sustainable Nuclear Energy Systems
  • Related to SYNERGIES

• 5th INPRO Dialogue Forum (2012 August)
  • Hosted by Republic of Korea
  • Global nuclear energy prospects in the post-Fukushima era
“IAEA Action Plan for Nuclear Safety”

INPRO Contribution
INPRO Activities in 2012 - ... related to the Action Plan for NS

- New INPRO Collaborative Project **RISC**
  - Review of Innovative Reactor Concepts for Prevention of Severe Accidents and Mitigation of their Consequences
- Revision of **INPRO methodology** / chapters on nuclear safety
  - Incorporate lessons learned in all future assessments using the INPRO methodology
Coordination with other international initiatives
Cooperation

- With the **Generation IV International Forum (GIF)**
  - Participation in Policy Group as observer
  - Participation in Working Groups
  - Joint Action Plan in place (e.g. nuclear safety, economics)
  - Joint activities (e.g. workshops on SFRs)
- With the **European Sustainable Nuclear Energy Technology Platform (SNE-TP)**
- With the **OECD Nuclear Energy Agency (NEA)**
- With the **World Nuclear Association (WNA)**
- With the **International Science and Technology Centre (ISTC)**
Learn more?
INPRO Progress Reports

- Published annually
- Full record of
  - Activities
  - Results
- Links to individual project websites
- www.iaea.org/INPRO
Thank you for your attention

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