



IAEA

International Atomic Energy Agency

A new INPRO Service on Scenario Modelling and Analysis to Support Sustainable Development of Nuclear Energy

INPRO Services to Member States

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INPRO

International Project on
Innovative Nuclear Reactors
and Fuel Cycles

Introduction



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

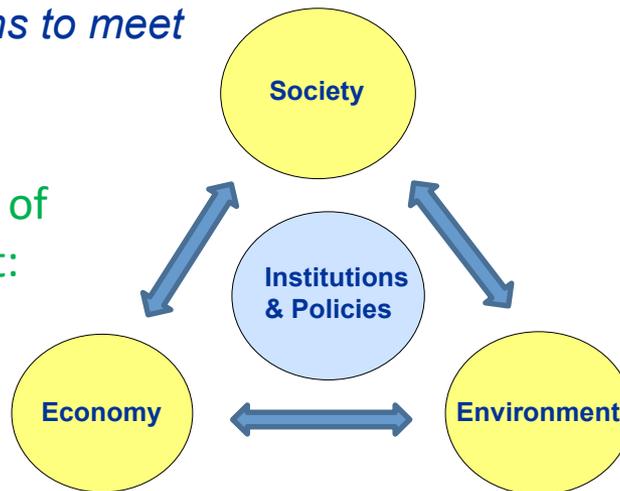
- The IAEA provides services that support the development of its Member States' national energy planning capacity – including tools used to perform studies to consider the future role of various energy technologies, including nuclear power.
- INPRO supports Member States in their long-term planning for development of *sustainable nuclear energy systems (NES)*.
- INPRO Member State participants developed NES system modelling and analysis tools and performed initial global and regional nuclear energy scenario studies, investigating specifically how collaboration/trade among different States and organizations can facilitate a transition to globally sustainable NES.
- Now INPRO is developing a new Service to Member States, based on tools developed over the past several years, to build further capacity in their infrastructure to model, analyse, road map and produce long-term plans in support of sustainable nuclear energy development.

Sustainable Development and Nuclear Energy

Top level definition of sustainable development according to the report of the Brundtland Commission – “Our Common Future”, Oxford University Press, Oxford (1987)

"Sustainable Development is the capacity to meet the needs of the present without compromising the ability of future generations to meet their own needs"

Three dimensions/pillars of sustainable development:



More recent developments:

2012 the Rio+20 conference on sustainable development

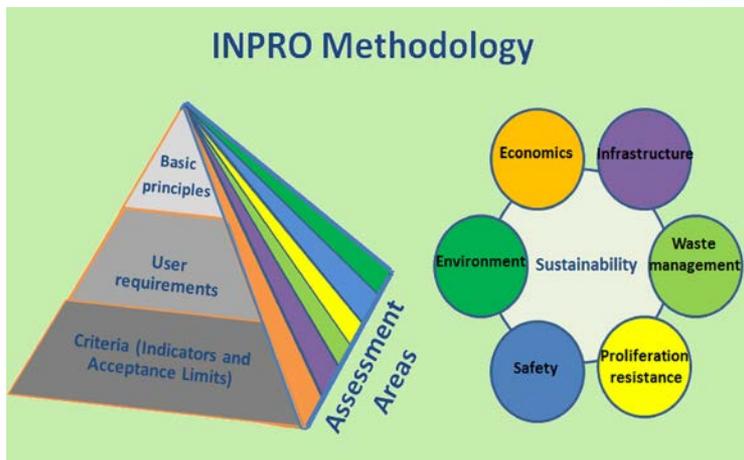
2015 High level Political Forum on Sustainable Development

Universal, integrated and transformative 2030 Agenda for Sustainable Development, produced a set of 17 UN Sustainable Development Goals (SDGs) with 169 associated targets

2016 Climate Change Conference (COP 22) – resulted in the Paris Agreement

Nuclear Energy potential: Affordable and clean energy (SDG 7) and Climate change mitigation (SDG 13)

INPRO Methodology for NES sustainability Assessment



Basic Principles: goals for development of a sustainable NES

User Requirements: what should be done by designer, operator, industry and/or State to meet the goal defined in the Basic Principle

Criteria:
Assessor's metric to check whether a User Requirement is being met

Concept and assessment tool for NES sustainability:

- Is the NES we have or what we target sustainable?
- What are the gaps?

- Developed by representatives of the IAEA Member States – INPRO Member nominated experts
- 7 Basic Principles, 30 User Requirements, more than 100 Criteria in assessment areas of Economics, Safety, Infrastructure, Environment, Proliferation Resistance and Waste Management
- INPRO methodology is primarily a tool to identify gaps in sustainability of a particular NES

INPRO Task Area “Global Scenarios”

- INPRO “Global scenarios” Task has been developing NES scenario modelling to understand certain broad issues of NES sustainability.
- Several Collaborative Projects have been implemented with active participation of Member States:
 - ✓ Global Architecture of Innovative Nuclear Energy Systems (**GAINS**) developed an analytical framework to model NES evolution scenarios involving cooperation/trade among countries
 - ✓ Synergetic Nuclear Energy Regional Group Interactions Evaluated for Sustainability (**SYNERGIES**) amended and applied the GAINS framework to national/regional case studies
 - ✓ Key Indicators for Innovative Nuclear Energy System Development (**KIND**) developed an approach for comparative evaluation of scenario options based on multi-criteria decision analysis (MCDA)
 - ✓ Roadmaps for a Transition to Globally Sustainable Nuclear Energy Systems (**ROADMAPS**) has developed a structured approach for road mapping development of sustainable NES ROADMAPS integrated the outputs of tools developed under GAINS, SYNERGIES and KIND.

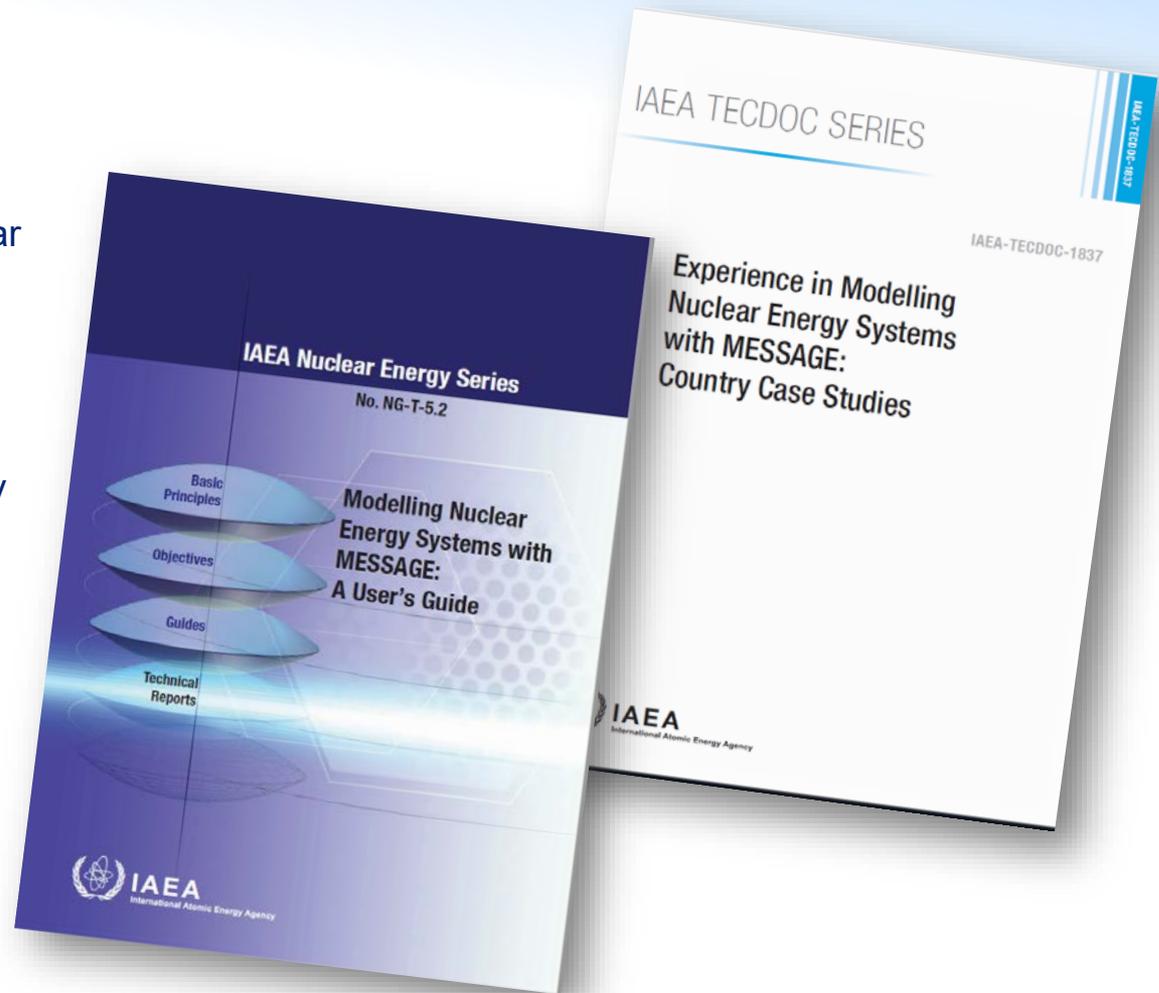
“Global scenarios” tools and a new INPRO service to Member States



- In all of the above-mentioned CPs valuable experience has accumulated and software tools were developed to support modelling, comparative analysis and planning.
- Sharing this experience with INPRO Members and providing them training on application of the software tools is being organized into a new INPRO Service to Member States.
- INPRO has already been providing a Service on nuclear energy system sustainability assessment using the INPRO Methodology (NESA).
- Given recommendations of the INPRO Steering Committee, feedback from individual INPRO Members, and Secretariat interest in capturing Task 1 “legacy value,” a New Service will be launched based on scenario analysis and decision support and road mapping tools.
- The basic objective is enhancement of capacity in Member States to perform long-term planning for sustainable development of nuclear energy systems.

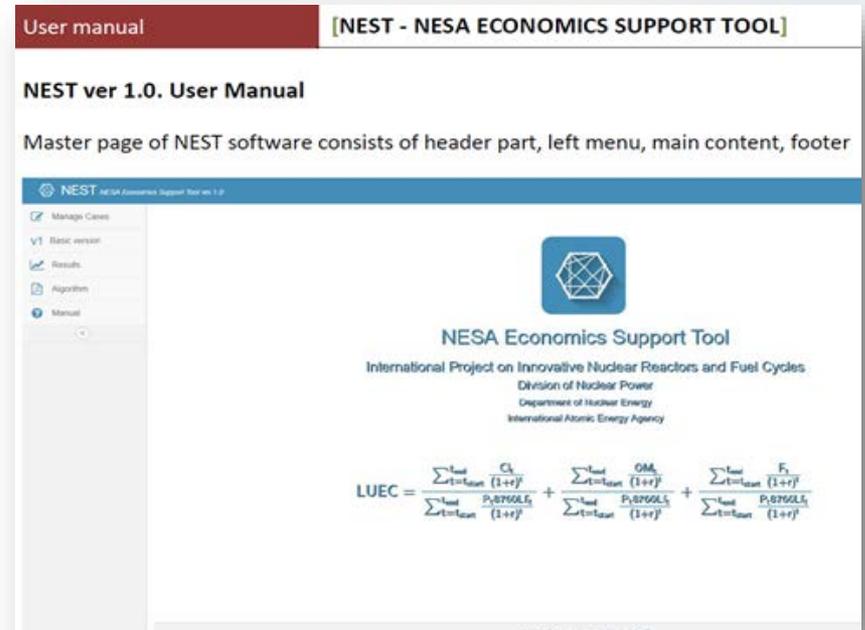
MESSAGE-NES TOOL (2016)

- MESSAGE-NES User's Guide provides step-by-step guidance to create models representing nuclear energy systems to a desired level of detail
- IAEA-TECDOC-1837 explores the experience gained in modelling national and global nuclear energy systems with MESSAGE-NES
- The targeted users for MESSAGE are engineers and economists working at nuclear energy departments, electric utilities, energy ministries and/or related R&D institutions



NESA Economics Support Tool (NEST)

- The NESA Economics Support Tool (NEST) was developed by INPRO to calculate *nuclear energy system economic metrics* for NESAs, e.g. Levelized Unit Electricity Cost (LUEC), Net Present Value (NPV), Internal Rate of Return (IRR) and Return of Investment (ROI), etc. However, these levelized cost model metrics are generic and not specific to sustainability assessment.
- The inputs need to be provided for each NES component, they include:
 - Capital Cost with details of overnight capital cost, capital investment schedule, interest during construction, back-fitting cost, decommissioning cost, etc.;
 - Operating cost with details of fixed and variable operation and maintenance cost, including wastes management cost, taxes, etc.;
 - Fuel cost with details of entire fuel cycle costs - natural uranium cost, conversion cost, enrichment cost, fuel fabrication cost; and back-end costs such as spent fuel storage, reprocessing, disposal, etc.



Approach for comparative evaluation of NES scenario Options

- INPRO Collaborative Project “Key indicators for innovative nuclear energy systems” (KIND) developed an approach and a tool for comparative evaluation of NES scenario options
- Approach is based on the application of a set of selected key indicators, reflecting certain topics of the INPRO Methodology, and a verified judgment aggregation/ uncertainty analysis method: Multi-Criteria Decision Analysis – MCDA
- Case studies of the KIND approach have shown its potential to support various decision-making problems, based on comparative evaluations of evolutionary and innovative NES
- The developed approach is recommended for supporting on-going evaluation and dialogue regarding sustainable energy development proposals with decision makers

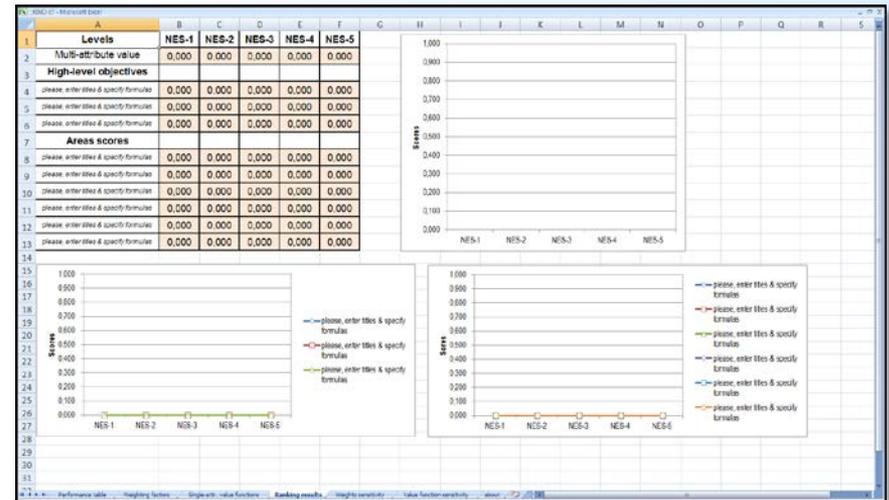
Approach for comparative evaluation of nuclear energy system/ scenario options:

- Compare different NES/scenario options based on selected set of key indicators and verified judgment aggregation/ uncertainty analysis method
- Establish productive dialogue with decision makers



KIND-ET tool to support NES scenario comparative evaluations

The KIND-ET decision support software tool was developed in the INPRO collaborative project KIND. KIND-ET is MAVT-based Excel-application that supports MCDA efforts.



KIND-ET can help identify advantages and disadvantages of various NES options/scenarios, compared under different circumstances. It can evaluate overall ranking, considering NES performance, as well as experts' and decision makers' judgments and preferences.

Roadmapping toward enhanced nuclear energy sustainability

The INPRO Collaborative Project “Roadmaps for a transition to globally sustainable nuclear energy systems” (ROADMAPS) developed:

- The *roadmap template* – a structured approach for achieving sustainable nuclear energy, through a framework for documenting actions, scope of work, and timeframes for specific efforts by particular stakeholders;
- An approach for bottom-up integration of national roadmaps to derive a regional or a global projection of a pathway toward enhanced nuclear energy sustainability;
- The ROADMAPS Excel Tool (ROADMAPS-ET) supporting practical application and analysis/visualization of the results;
- Examples of application of the roadmap template and the integration approach are detailed in a series of case studies performed by project participants;
- The training materials and consultants’ services provided by the INPRO Secretariat.

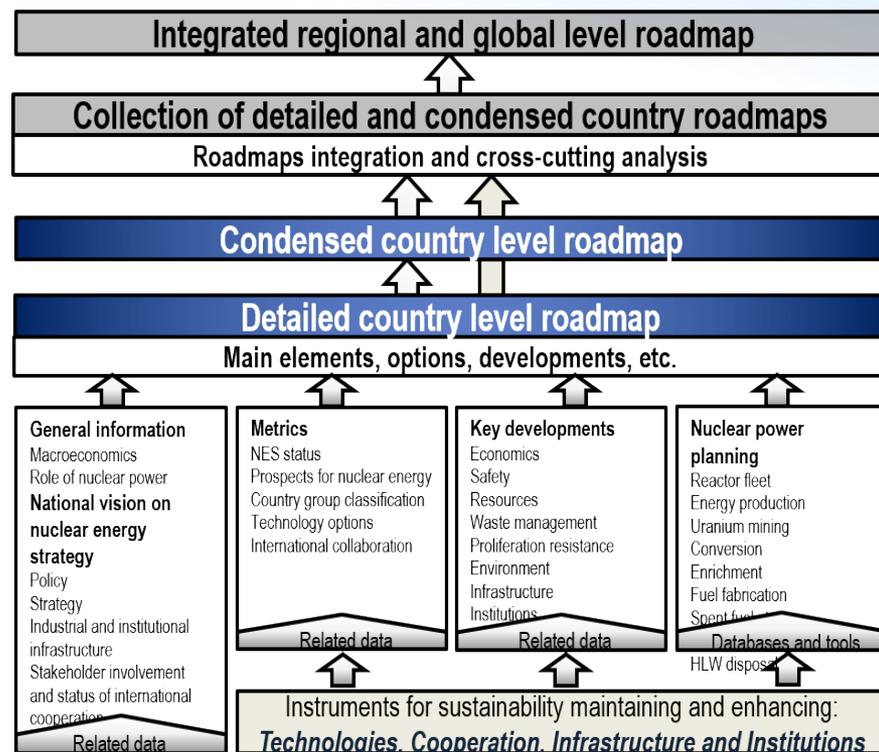


Roadmap template

The *roadmap template* includes several structural elements, including characterization of the current situation of the nuclear energy sector and of plans/projections for nuclear power development in the timeframe under consideration:

- General country information;
- National plans and perspectives on nuclear energy development;
- Metrics on nuclear energy status and development;
- Key tasks and developments;
- Reactor fleet and nuclear fuel cycle evolution;
- Integration and cross cutting analysis;
- Progress monitoring;
- Reactor database and informational sources;
- Nuclear power planning and scenario analysis tools.

The template is intended for a country-level roadmap; several such roadmaps can later be integrated.



Elements of Service package

Service Package - Scenario Analysis and Decision Support
for Development of NES with Enhanced Sustainability

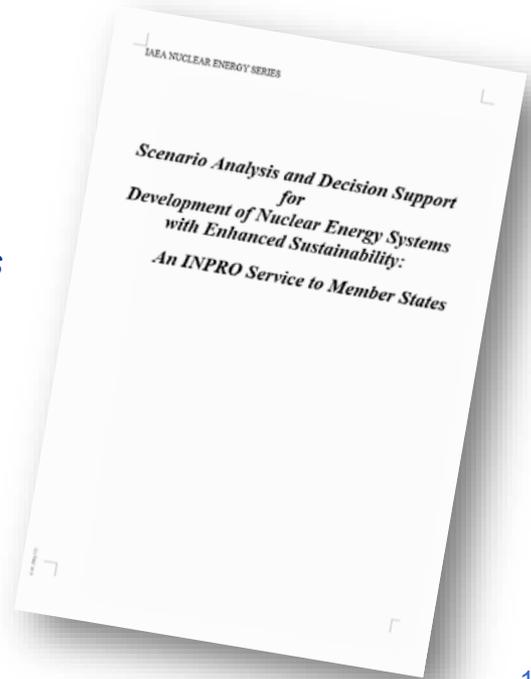
Capacity building to strengthen MS expertise (*customer tailored applications*), *training, national and regional workshops, Webex videoconferencing, E-Learning*

Technical guidance for conducting national studies
IAEA documents and software tools

Exchange of experience among experts and policy makers
IAEA technical and consultants meetings

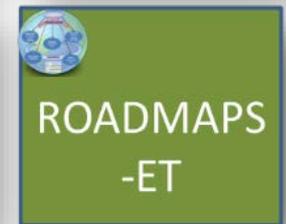
2019 Plans:

- **Regional Pilot Training and Review of the Course Materials:** Mexico City, Mexico, 7-11 October 2019
- **New Service Pilot Study:** FAST FORWARD: *Development and analysis of scenarios involving small numbers of fast reactors to support multi-recycling of plutonium in light water reactors and fast reactors*, IAEA, Vienna, 5-8 November 2019 – limited to technology holding countries
- **Regional Pilot Training and Review of the Course Materials:** Russian Technical Academy, Obninsk, Russia, 2-6 December 2019



Conclusion

- The objective of the new INPRO Service is to provide assistance, training and consultancy to Member States in regional and national long-term nuclear energy system analysis and strategic planning taking into account the potential of technical innovation and cooperation among countries.
- The possible mechanism of delivering INPRO services in this area could be either national, regional or coordinated services provided to a set of nuclear trade partners as a group – or self selecting potential partners.
- Distance training and on line consultations can be implemented efficiently upon request of Member States.
- This new service would join NESAs as an integrated service provided to Member States by the INPRO Section.





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Thank you!



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