IAEA 60 Years
Atoms for Peace and Development

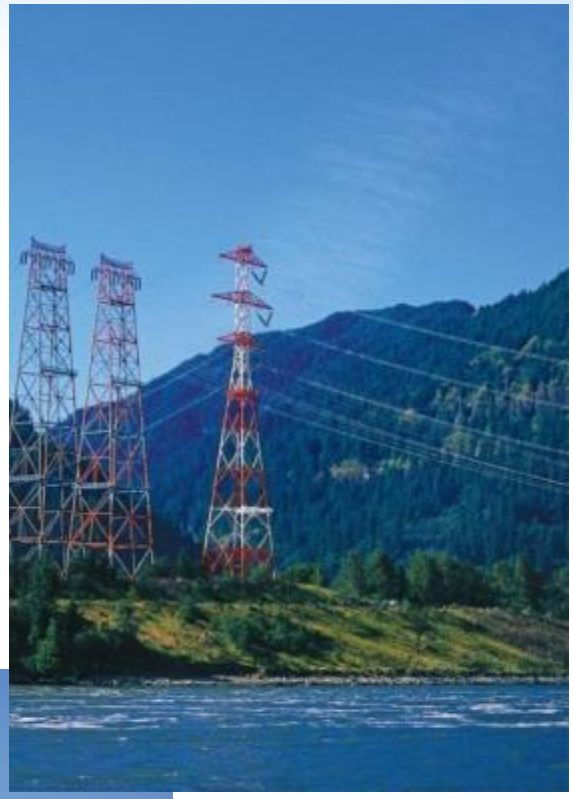
IAEA Assistance to Member States in development of nuclear energy

Presented by Mikhail Khoroshev
Nuclear Power Technology Development section
International Atomic Energy Agency

Joint ICTP/IAEA Workshop
“Research Reactors for Development of Materials and Fuels for Innovative Nuclear Energy Systems” 6-10 November 2017, ICTP, - Trieste, Italy

IAEA Statute

"…accelerate & enlarge contribution of atomic energy to peace, health and prosperity…"



IAEA & SDGs

IAEA 60 Years
Atoms for Peace and Development

IAEA: Main work areas

Nuclear Technology & Applications

Nuclear Safety & Security

Safeguards & Verification

Nuclear Energy

Nuclear Sciences & Applications

Technical Cooperation

Nuclear Safety & Security

Safeguards

NP Reactors

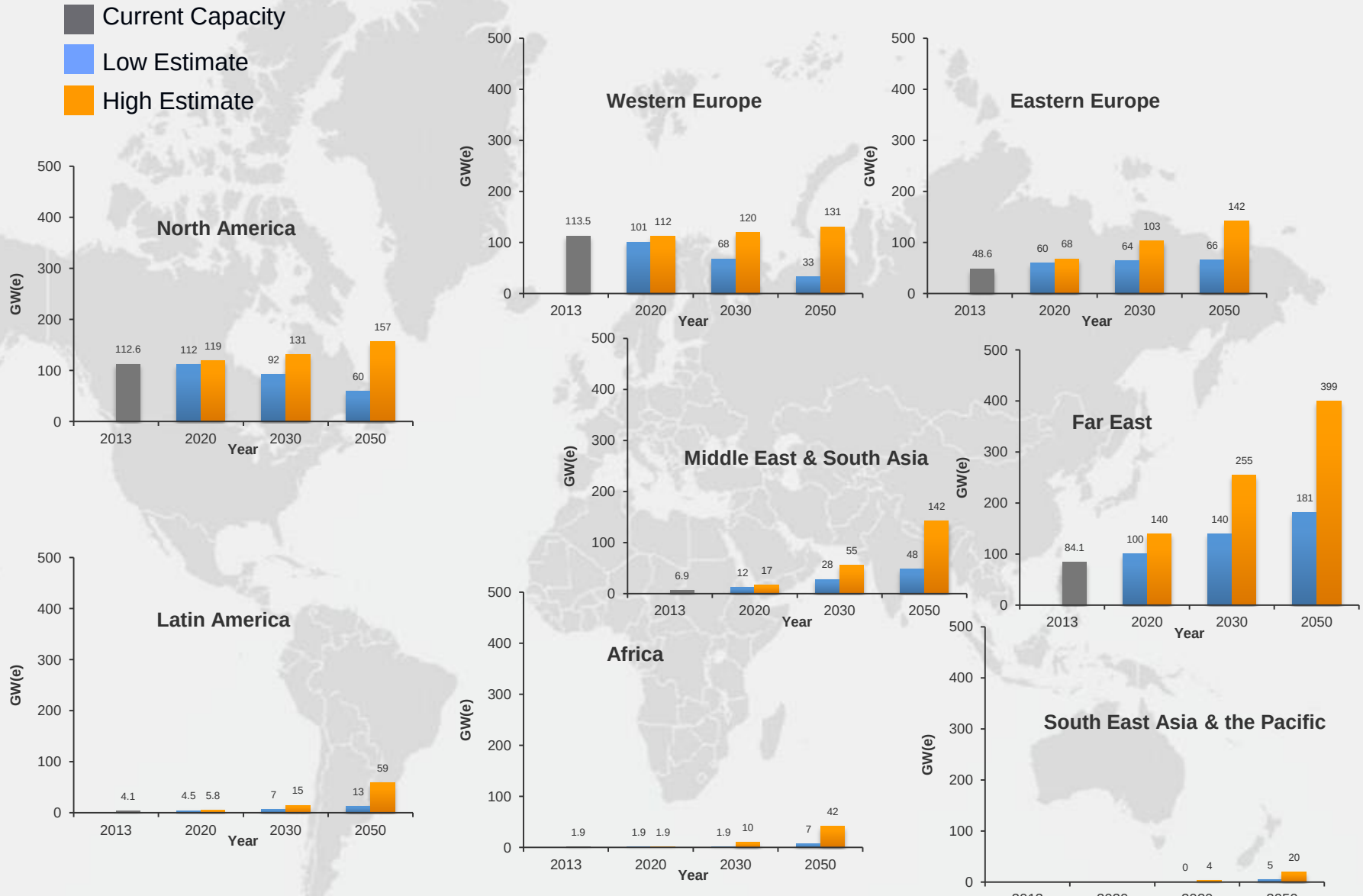
(as of 31 Dec 2017)

448 in operation

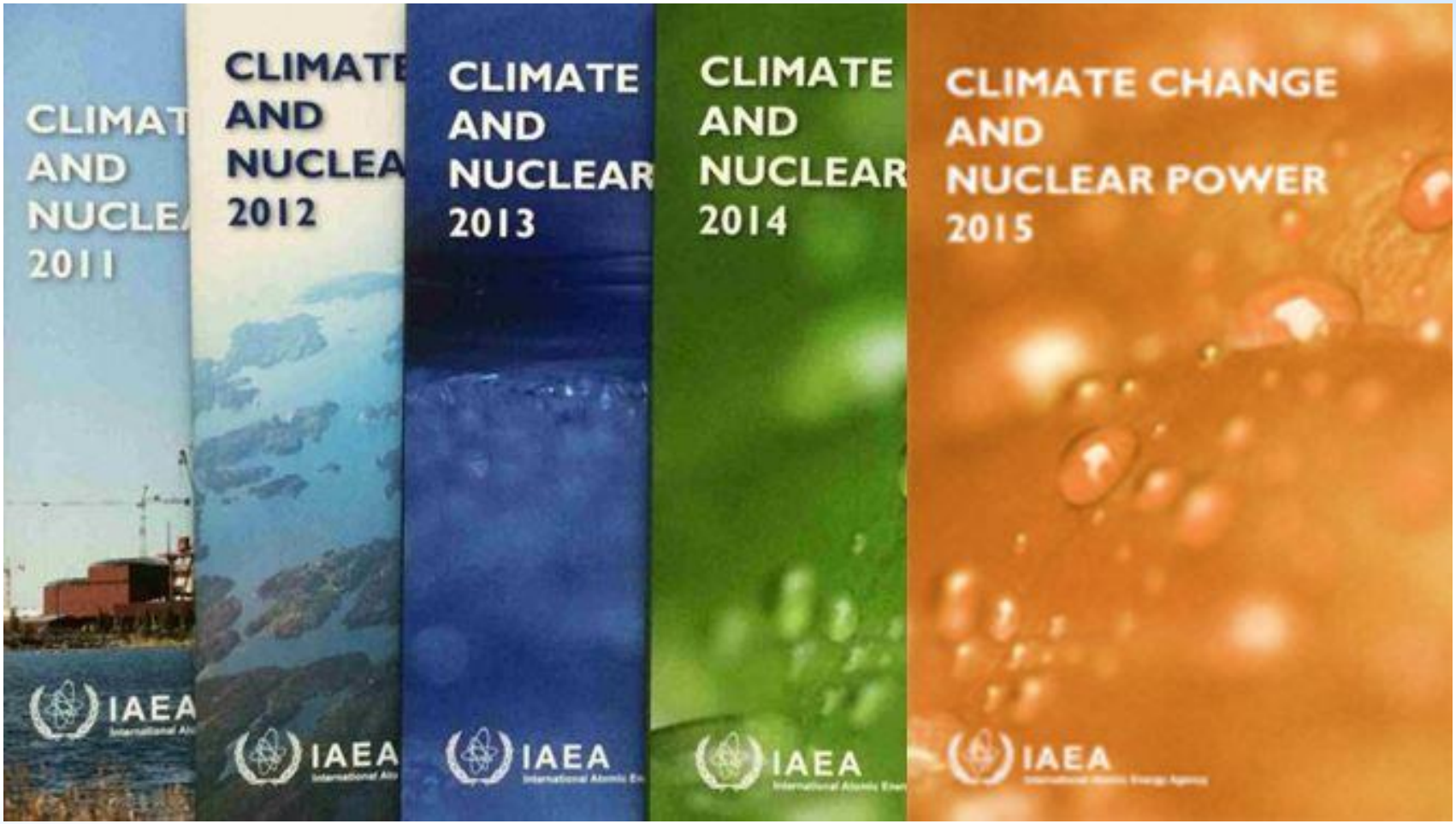
392 GW(e) Capacity

57 under construction (2/3 in Asia)

NP Development in Different Regions



Climate Change

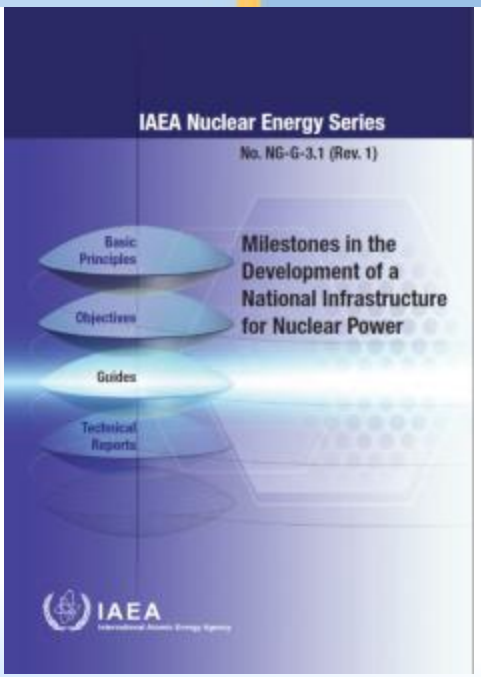


IAEA Assistance to Newcomers

MILESTONE 1
Ready to make a knowledgeable commitment to a nuclear power programme

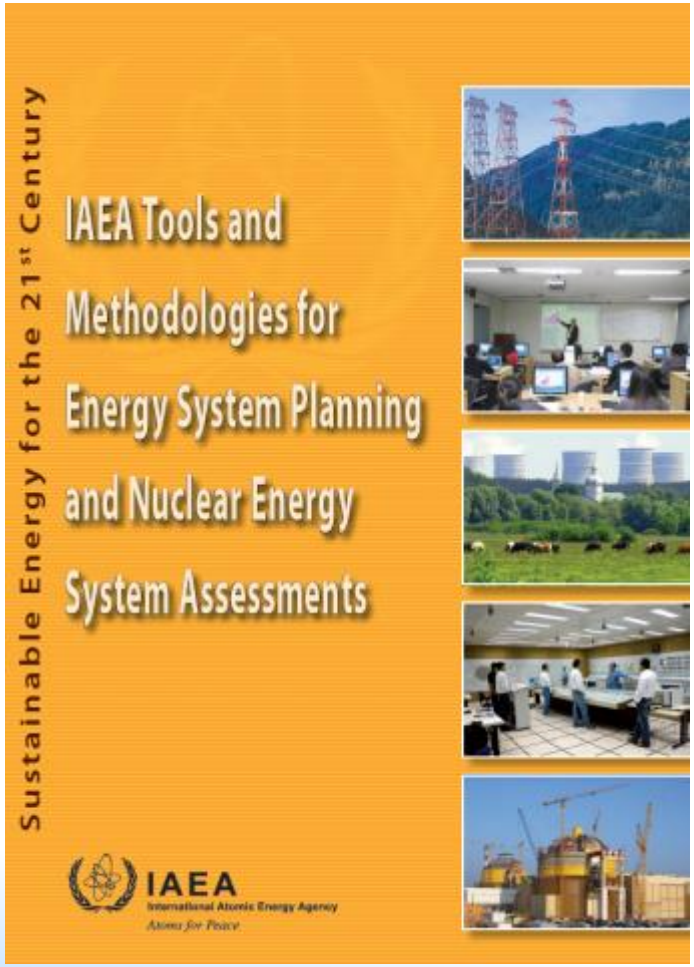
MILESTONE 2
Ready to invite bids/negotiate a contract for the first nuclear power plant

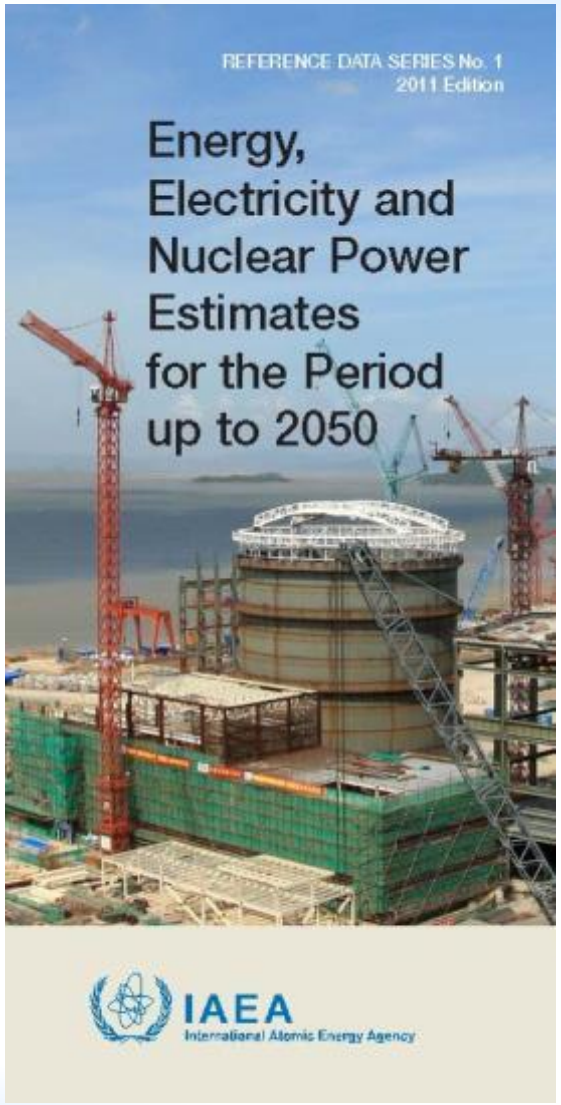
MILESTONE 3
Ready to commission and operate the first nuclear power plant



E-learning for Nuclear Newcomers

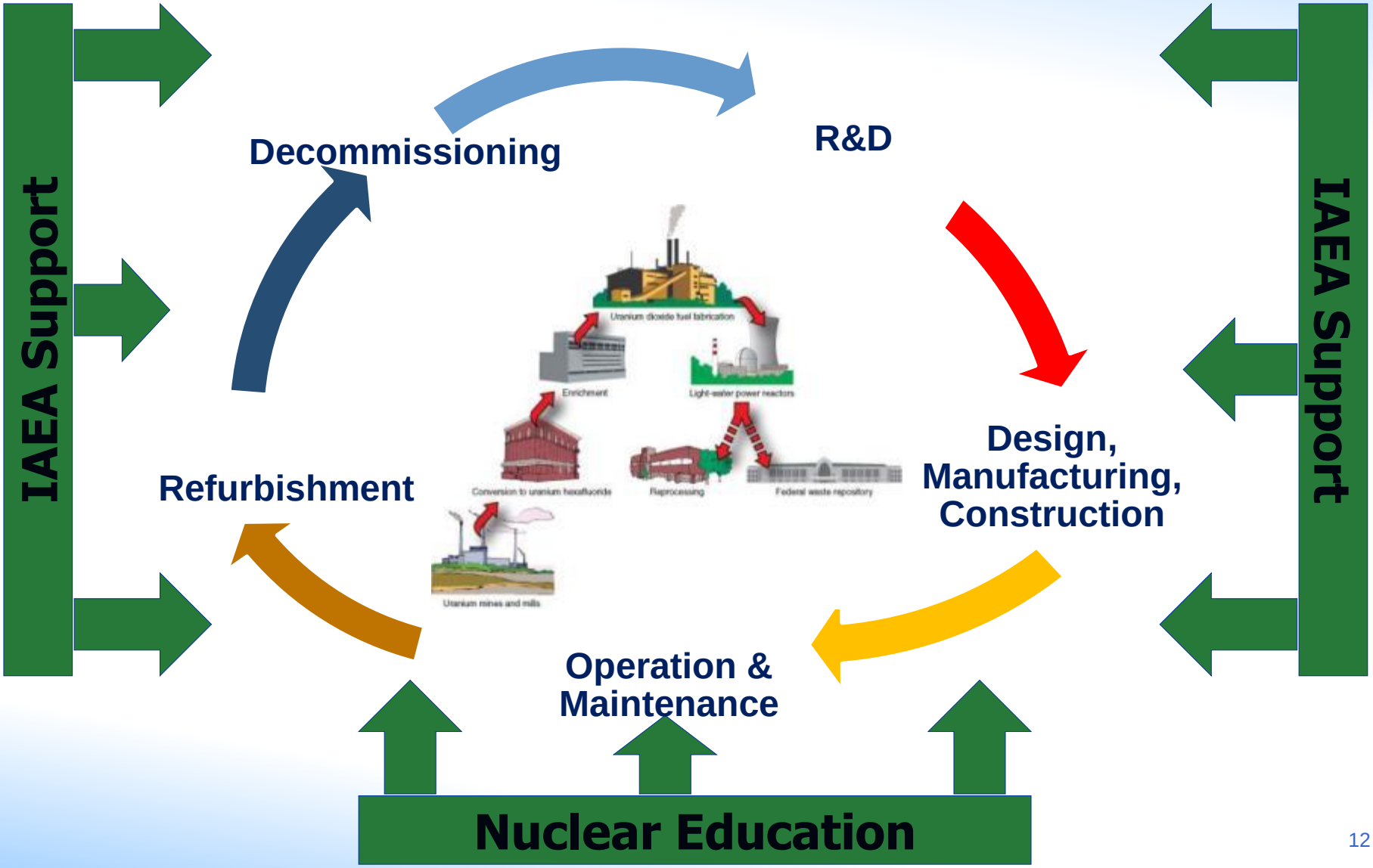
Analysis for Sustainable Energy Development





Energy Assessment

IAEA support in Nuclear Knowledge Management



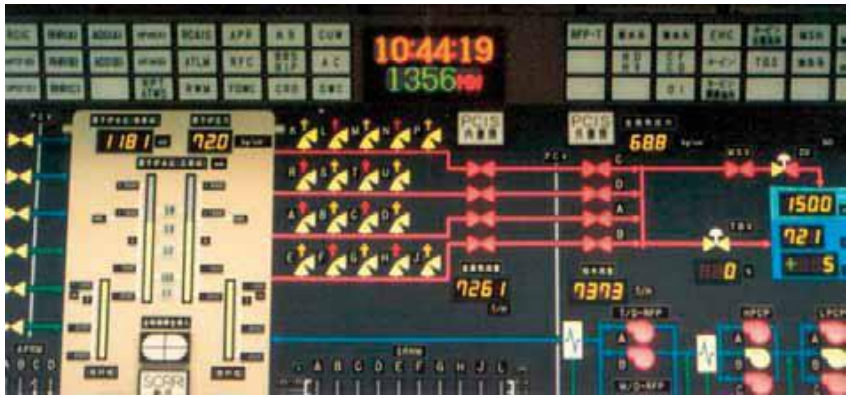
Regional Nuclear Education Networks

Cyber-Learning Platform

Nuclear Information

3.9 millions of bibliographical records

Support for operators

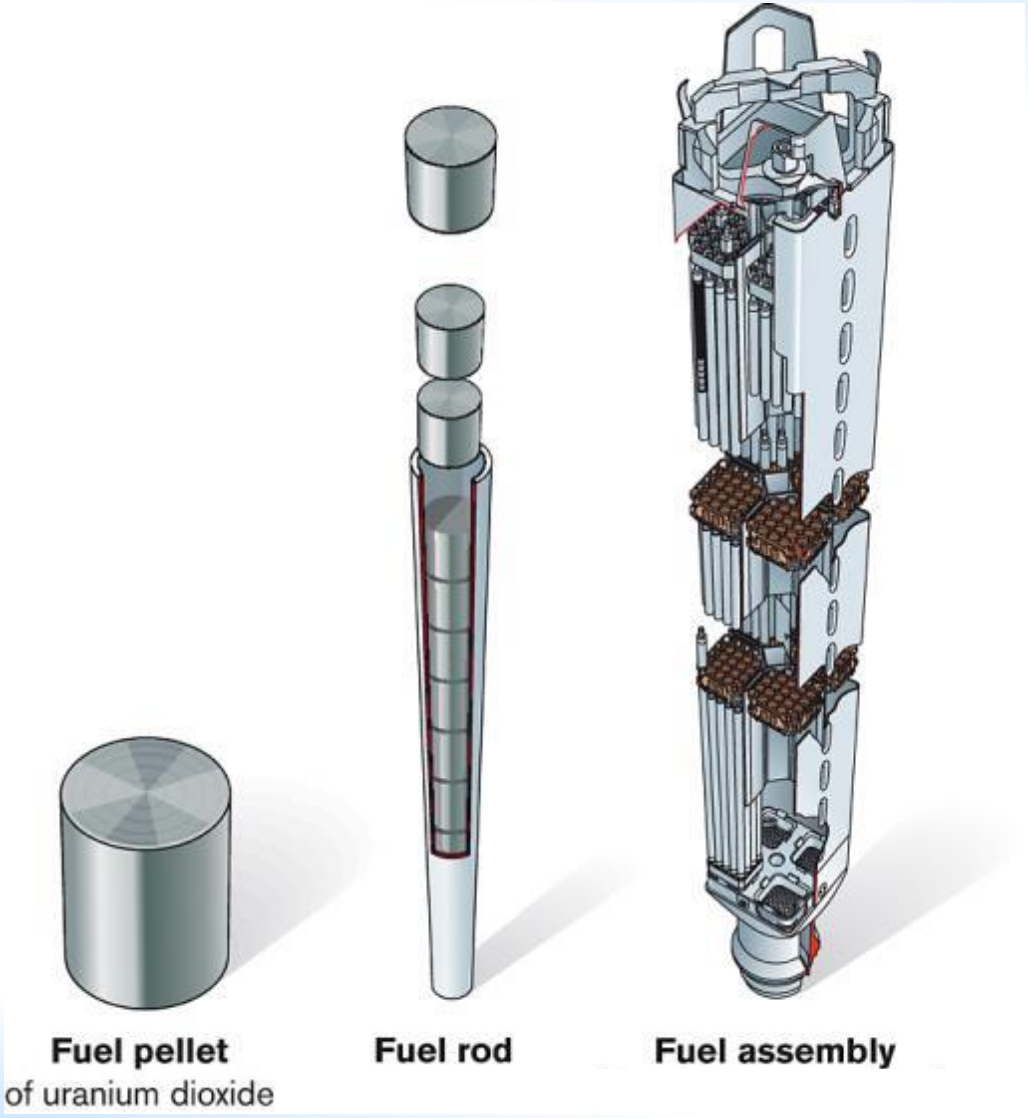


Instrumentation & control

Maintenance/
Outage management

Plant life management

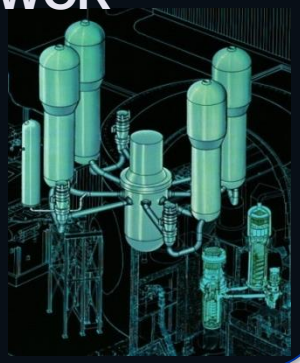
Nuclear fuel



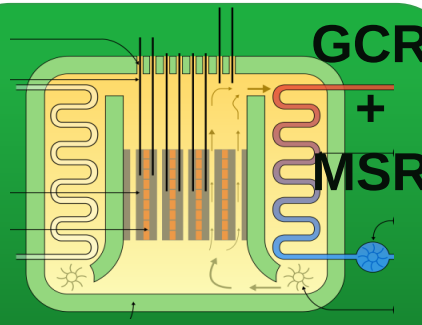
Nuclear Power Technology Development

60 Years
Atoms for Peace and Development

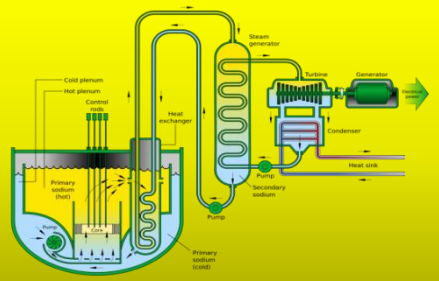
WCR



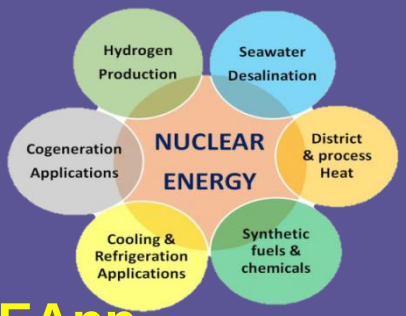
GCR
+
MSR



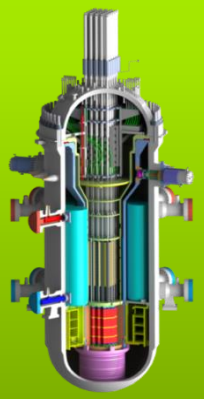
Fast Reactors



NEApp



SMR

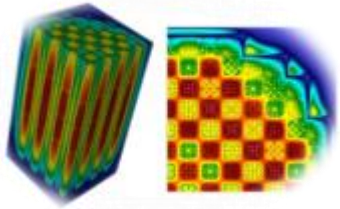


Technology Development for Advanced Reactor Lines

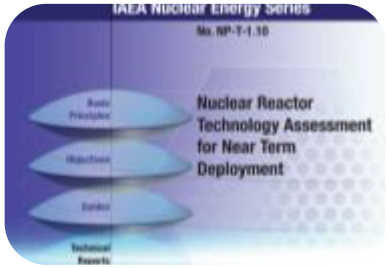
Macro Areas for Each Reactor Line and Non-Electric Applications

Assist MSs with national nuclear programmes; Support innovations in nuclear power deployment; Facilitate and assist international R&D collaborations

Information Exchange



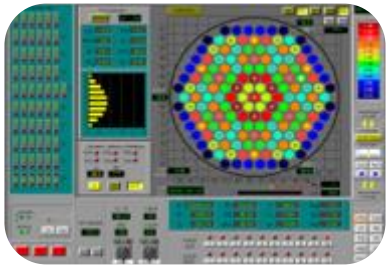
Modelling and Simulations



Development of Methodologies

Safety

Technology Support



Education and Training

Knowledge Preservation

ARIS Data Base https://aris.iaea.org/

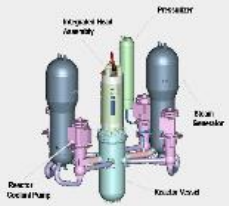
IAEA 60 Years Atoms for Peace and Development

IAEA | ARIS Advanced Reactors Information System

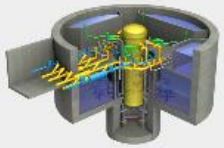
Technical Data | Characteristics | Publications | Glossary | About ARIS

ADVANCED REACTORS

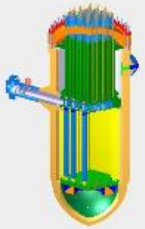
WATER COOLED TECHNOLOGY



PWR



BWR

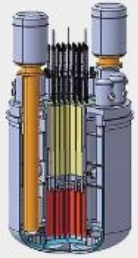


SCWR

GAS COOLED TECHNOLOGY

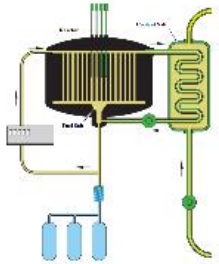
GCR

MOLTEN METAL COOLED TECHNOLOGY

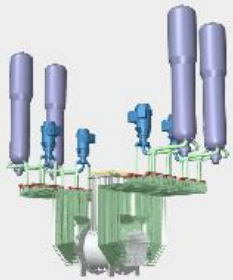


SFR

MOLTEN SALT COOLED TECHNOLOGY



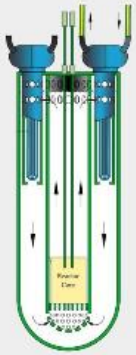
MSR



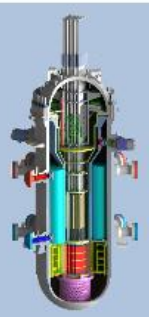
HWR

iPWR

GFR

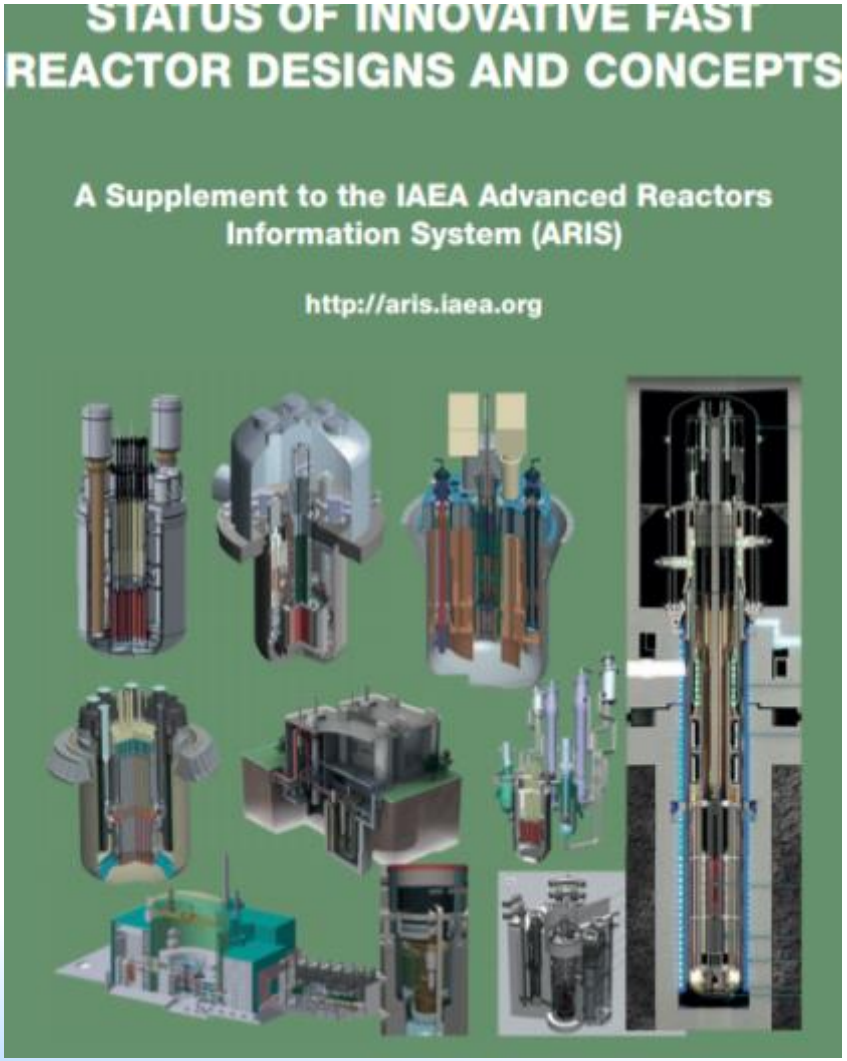


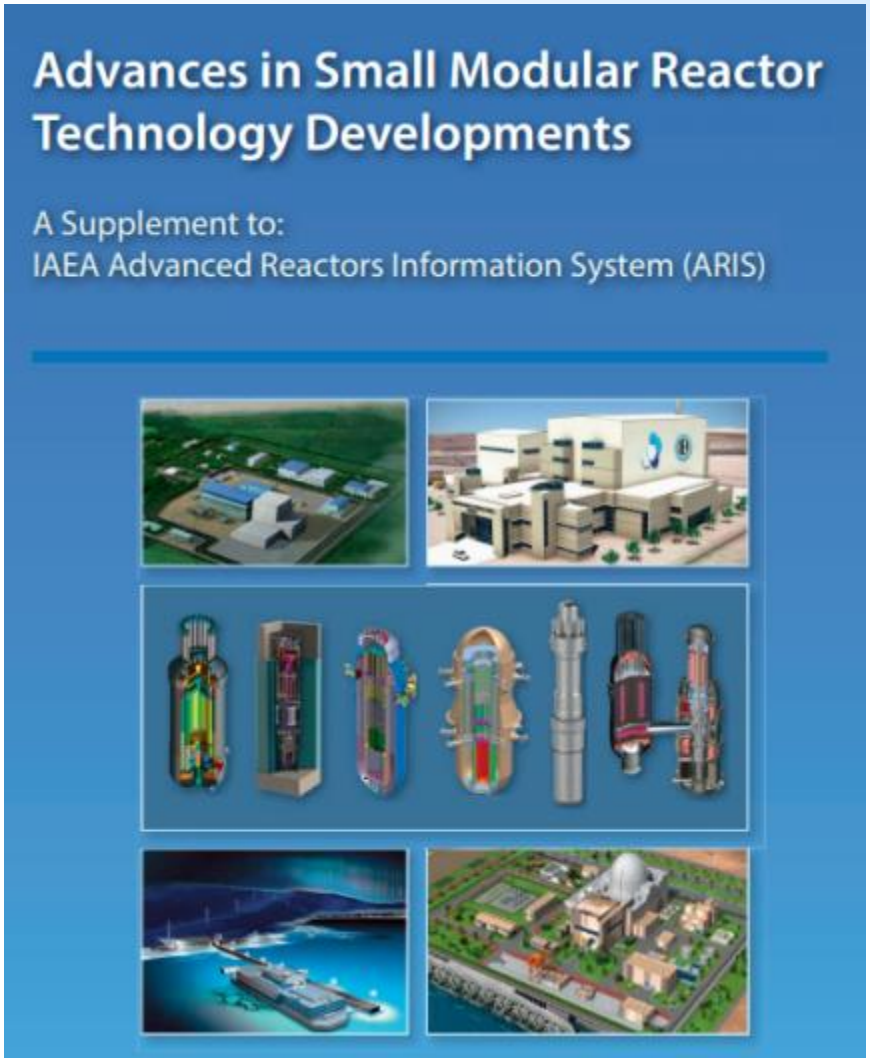
LFR



SMR

Innovation & Technology Development

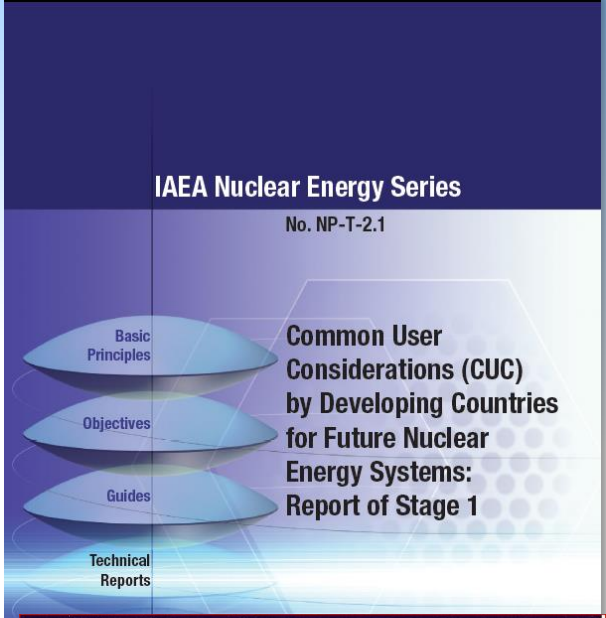


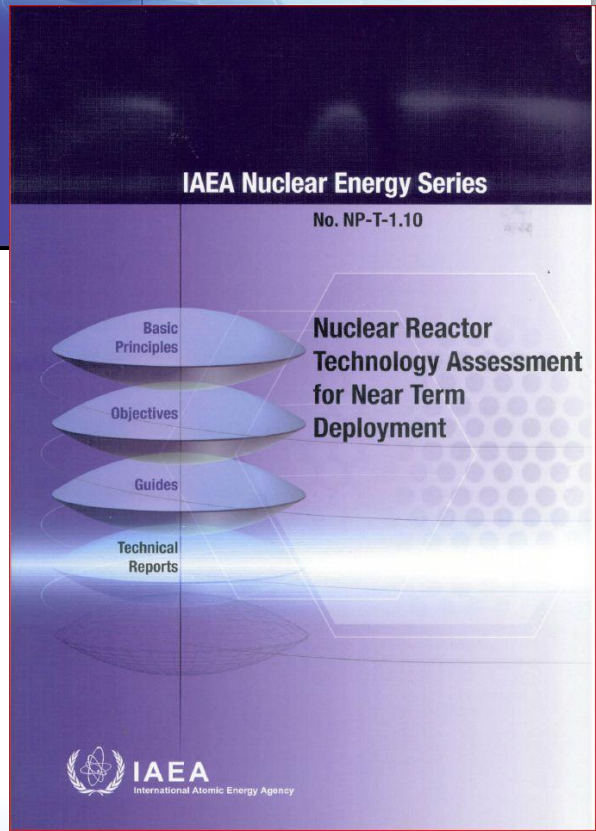


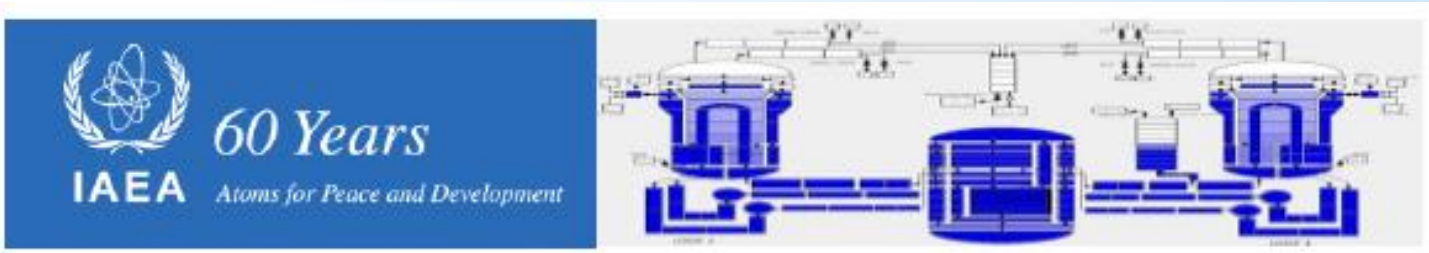
TRAINING COURSES
REACTOR TECHNOLOGY ASSESSMENT

Formal process of specifying key factors, based on country-specific protocols, assigning relative importance to each, and quantitatively evaluating technology design in a consistent manner using reliable and comparable data, e.g. from ARIS and vendors.

2014 – 2017





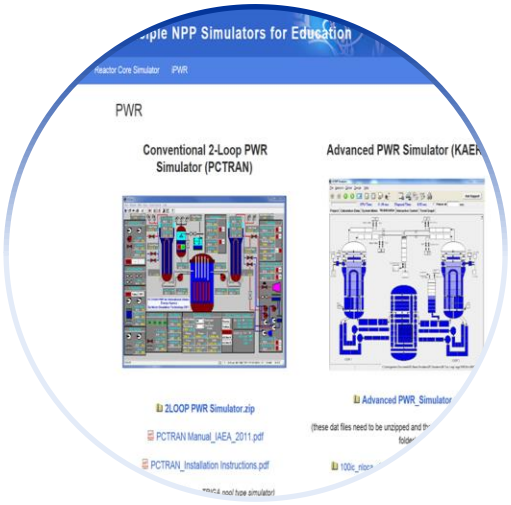


IAEA PC Based Basic Principle Nuclear Power Plants Simulators

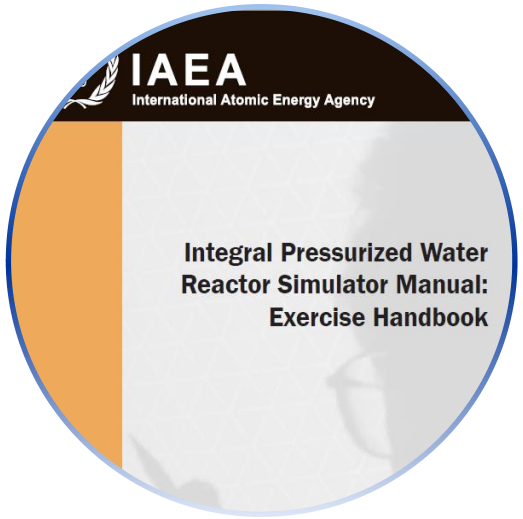
Learning-by-Doing Education and Training on Reactor Technologies in Support of Member States' Human Resource and Capacity Building

IAEA PC Based Basic Principle Nuclear Power Plants Simulators

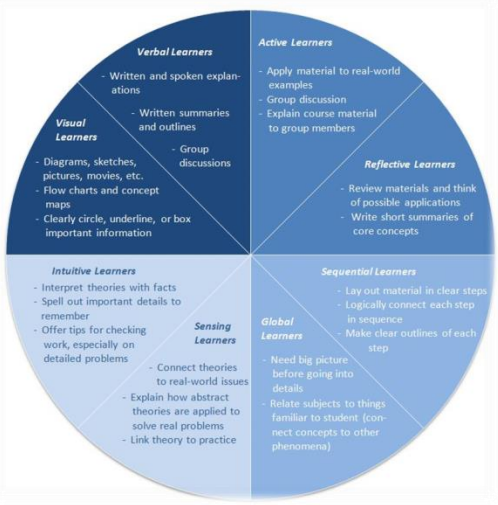
IAEA assist Member States in educating nuclear researchers, engineers, and regulators with effective learning-by-doing approach integrating the all 4 learning dimensions



10 PC based simulators



NEW: SMR Simulator



4 learning dimensions

IAEA arranges for:

- **Distribution of simulation software, and corresponding training materials**
- **Management of existing suite of simulators**
- **Development of new simulators**
- **Organization of training courses and workshops**

SMR booklet

- Published every two years
- 2016 edition includes:
  - 18 LWR designs
  - 7 marine based designs
  - 9 High temperature reactors
  - 6 fast reactors
  - 8 molten salt reactor designs

- Supplement to ARIS database
- https://aris.iaea.org/

CRP: HTGRs applications for energy neutral sustainable comprehensive extraction and mineral products development – till 2018

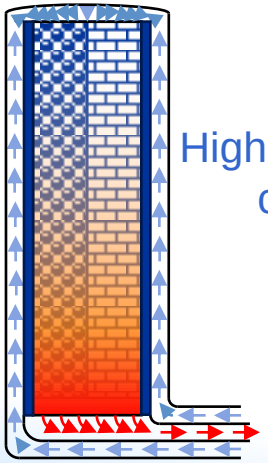
Use process heat to comprehensively extract mineral products

Phosphate rocks

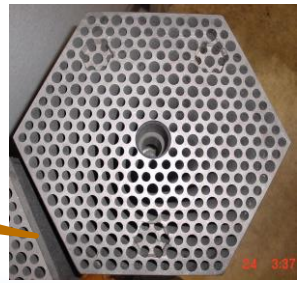
Process Heat for Phosphate conversion and U/Th recovery

Cleaner products and waste streams / reduced NORM

Uranium/Thorium



High Temperature Gas-cooled Reactor



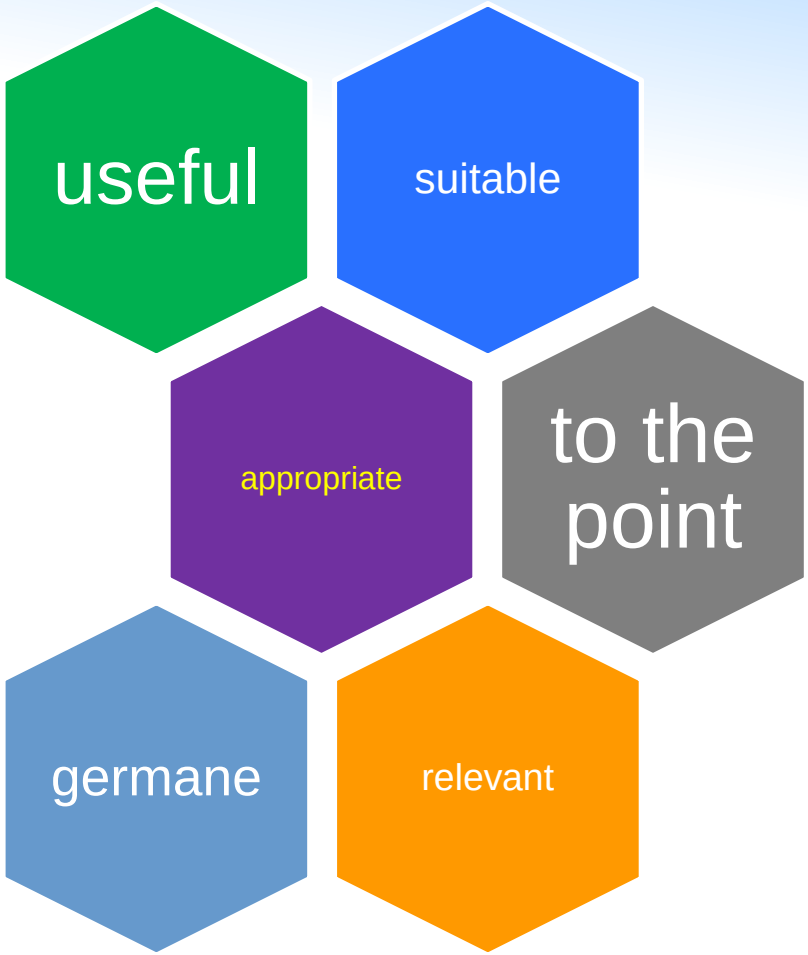
Nuclear Fuel Manufacturing

16 member states participating

CRP: Modular High Temperature Gas-cooled Reactor Safety Design

Propose safety design criteria based on the unique safety features of HTGRs

- clarifying the safety approach and safety evaluation criteria
- design and design extension conditions
- multiple reactor modules and co-generation considerations
- No cliff edge effects; no core melting
- 10 member states participating
- Project to finish in 2018



Safety analysis and Licensing is often singled out as one of the main challenges to the deployment of new advanced reactors.

IAEA Nuclear Graphite Knowledge Base

to support the preservation and sharing of expert knowledge and experience, across the international nuclear graphite community.

Databases

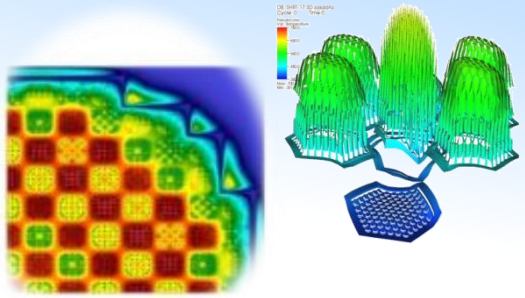
http://nucleus.iaea.org/sites/graphiteknowledgebase/

Fast Reactor Technology: Key Activities

IAEA 60 Years Atoms for Peace and Development

Modelling and Simulations

- Coordinated Research Projects (CRPs)
  - *EBR-II (Shutdown Heat Removal Tests)*
  - **NAPRO (Sodium properties)**
  - PSFR Source Term
  - CEFR Start-Up Tests
  - FFTF (ULOF Tests)



Knowledge Preservation

- Fast reactor knowledge preservation portal **(FRKP)**
- Liquid metal cooled fast neutron system database (**LMFNS**)

Education and Training

- **SFR Simulator** for Educational Purposes
- **ICTP-IAEA Workshop** on the Physics and Technology of **Innovative Nuclear Energy Systems**

Safety

- Joint **IAEA-GIF Technical Meeting** on Safety of SFR
- **Passive Shutdown Systems** for Fast Neutron Systems – NES Publication

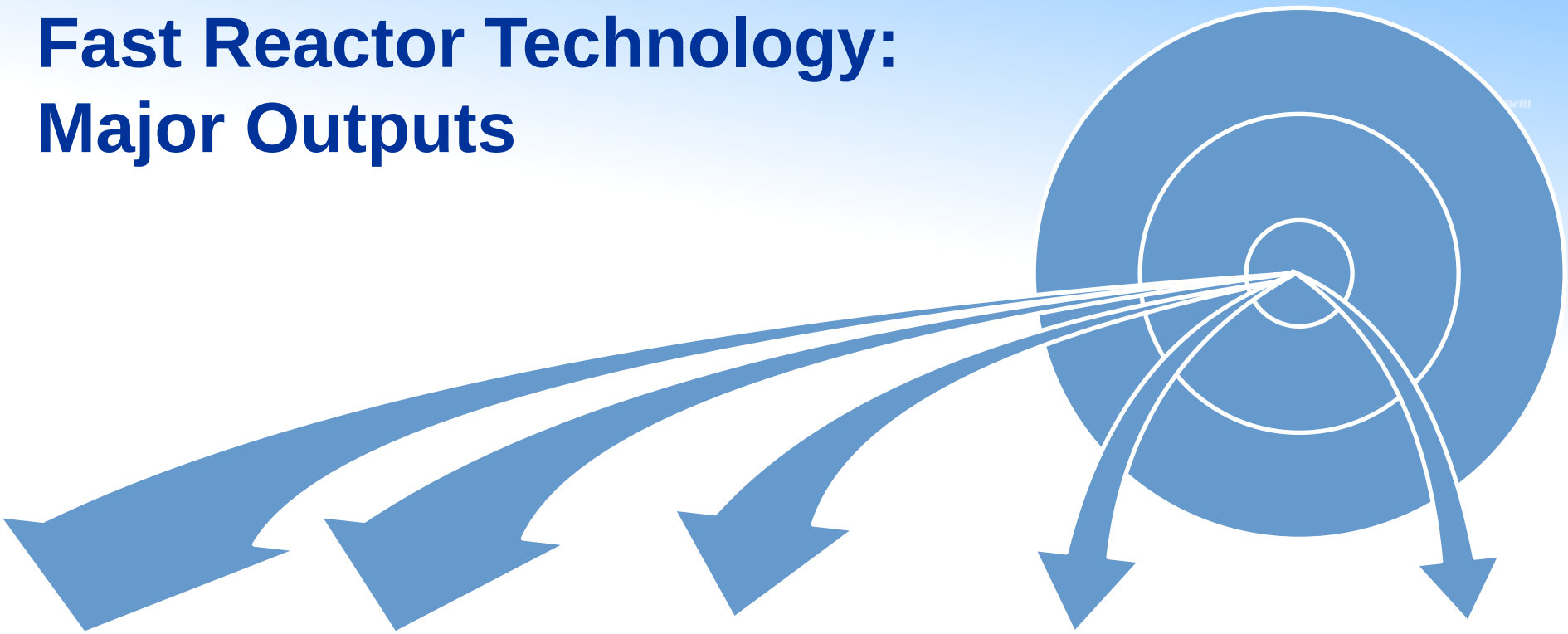
Technology Support

- **NAPRO:** CRP
- **LMFNS** Catalogue

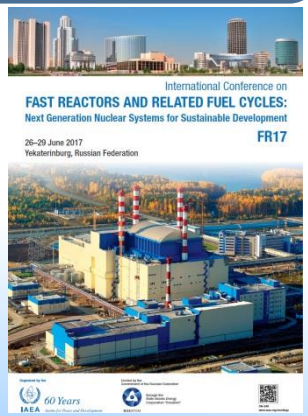
Information Exchange

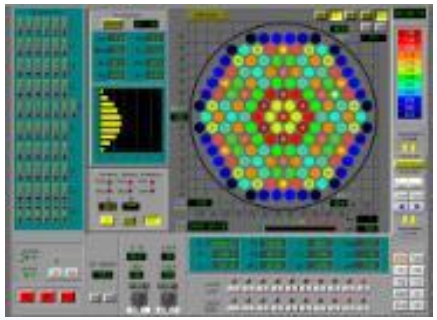
International Cooperation

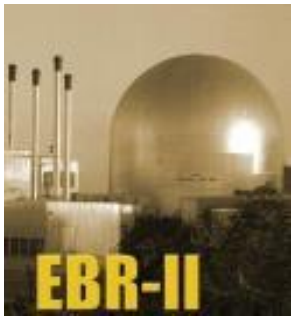
Fast Reactor Technology: Major Outputs



FR 17 Conference	FRKP portal	SFR Simulator	EBR- II Benchmark Results	Handbook on Sodium Properties





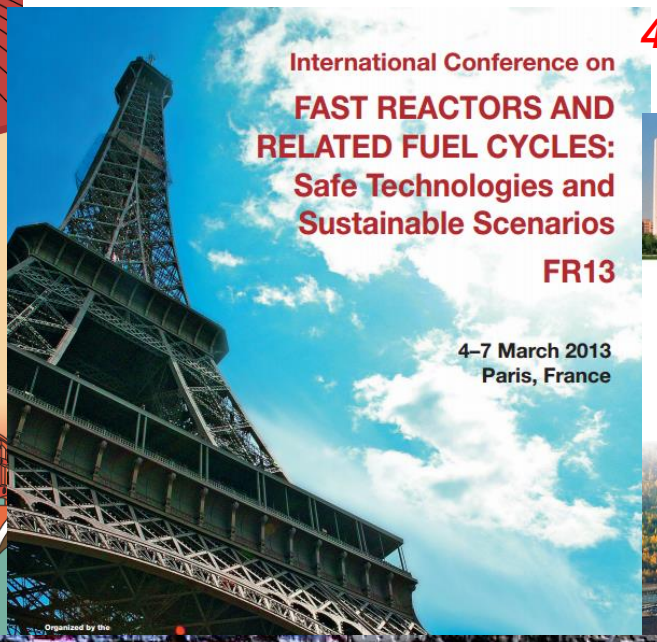


IAEA Conferences on Fast Reactors

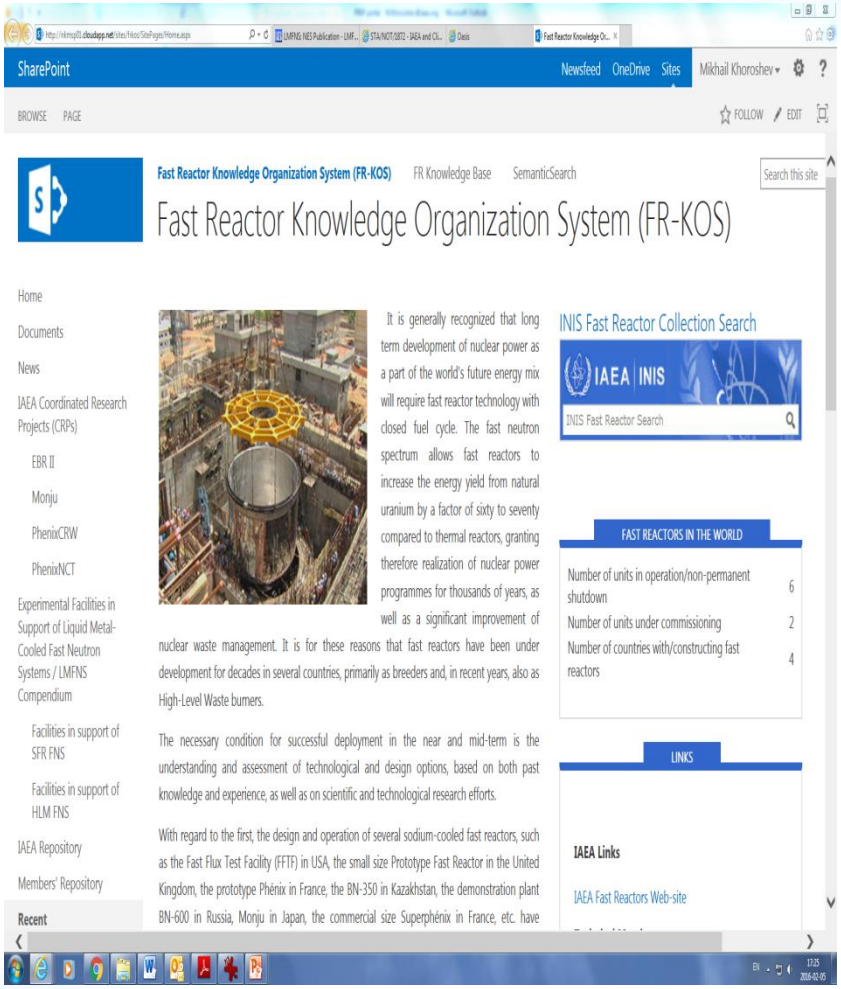
IAEA International Conference on *Fast Reactors and Related Fuel Cycles*

26- 29 June 2017, Yekaterinburg

***456 Papers** Presented*



Fast Reactor Knowledge Preservation: FRKP Portal



CRPs data uploaded: *(Designed and ready for use by projects' participants)*

1. **EBR-II** Shutdown Heat Removal Test Analysis
2. **Monju_UPNC:** Sodium Natural Convection in the Upper Plenum of the MONJU Reactor Vessel
3. **Phenix_CRW:** Control Rod Withdrawal Tests Performed During the PHENIX End-of-Life Experiments
4. **Phenix_NCT:** Sodium Natural Circulation Tests Performed During the PHENIX End-of-Life Experiments

- New CRP on **"Radioactive Release from the Prototype Fast Breeder Reactor (PFBR) under Severe Accident Conditions "**
- **Passive Shutdown Systems for Fast neutron reactors**

Available also on the web:

- **Experimental Facilities in support of Development and Deployment of Liquid Metal Cooled Fast Neutron Systems (LMFNS). LMFNS catalogue is a live database**
- **FR 17 conference**

FR Taxonomy was revised in 2016 and applied in the FRKP portal

LMFNS Experimental Facilities Database

Experimental Facilities in support of Development and Deployment of Liquid Metal cooled Fast Neutron Systems

- A comprehensive Catalogue providing detailed information on experimental facilities currently designed, under construction or operating
- Facilities Designed to support the development and deployment of innovative liquid metal-cooled (sodium, lead and lead-bismuth) fast neutron systems (LMFNS), both critical and subcritical
- Identifies existing or future operational experimental facilities able to support innovative LMFNS
- Expected to facilitate cooperation using existing and planned experimental facilities for LMFNS, and enhance their utilization by providing end-users with detailed information
- Encourages international collaborations

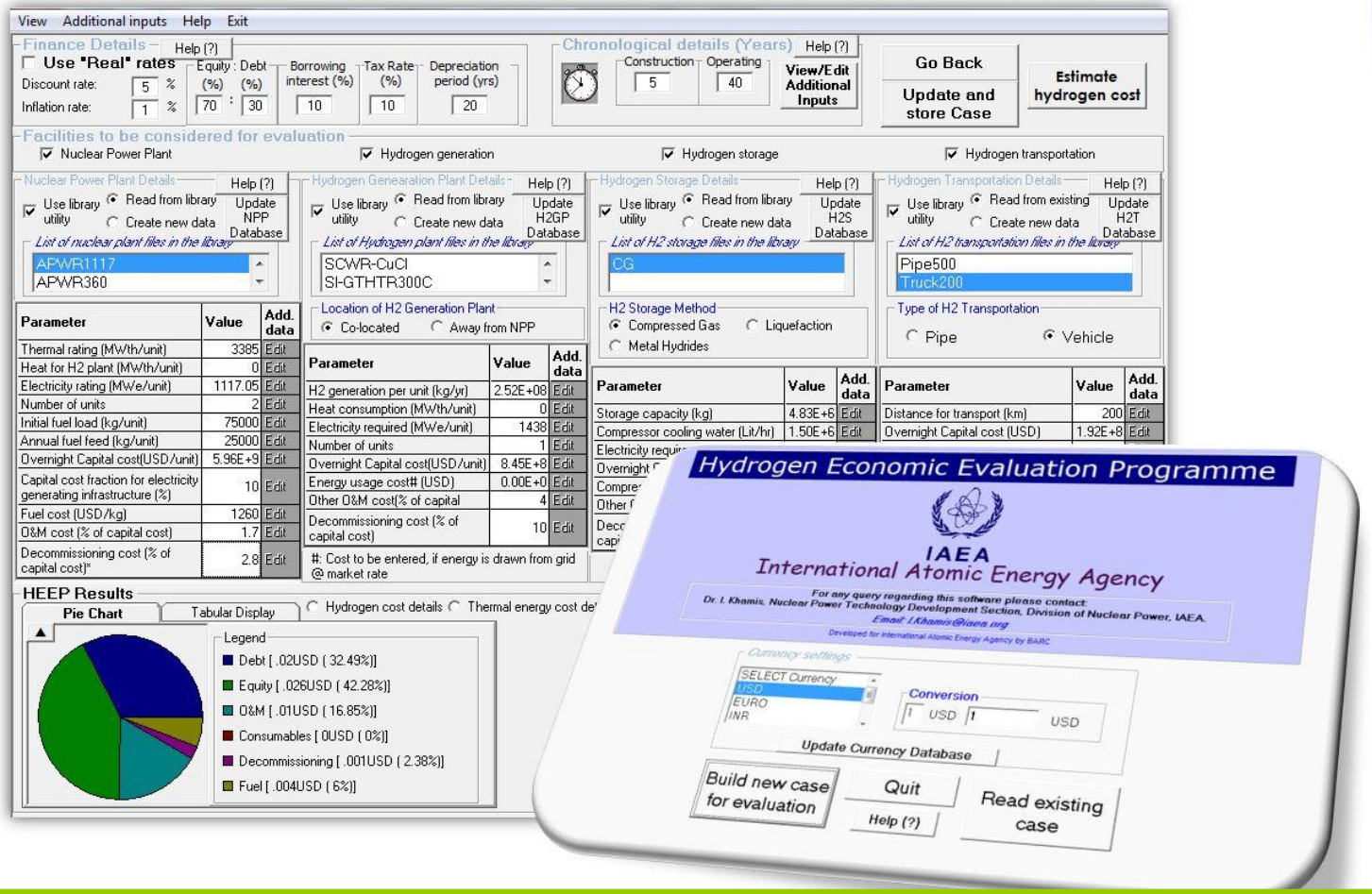
IAEA Workshops and Schools on Innovative Nuclear Energy Systems

- **Recent Course: *Joint ICTP-IAEA Workshop on the Physics and Technology of Innovative Nuclear Energy Systems for Sustainable Development*,** 29 Aug - 02 Sept 2016, Trieste, Italy
  - Imparted theoretical foundation of all aspects of innovative nuclear energy systems
  - Familiarized students with models and codes for design and safety analysis
  - Provided an active forum for sharing new ideas

"Preparing the next generation…"

HEEP

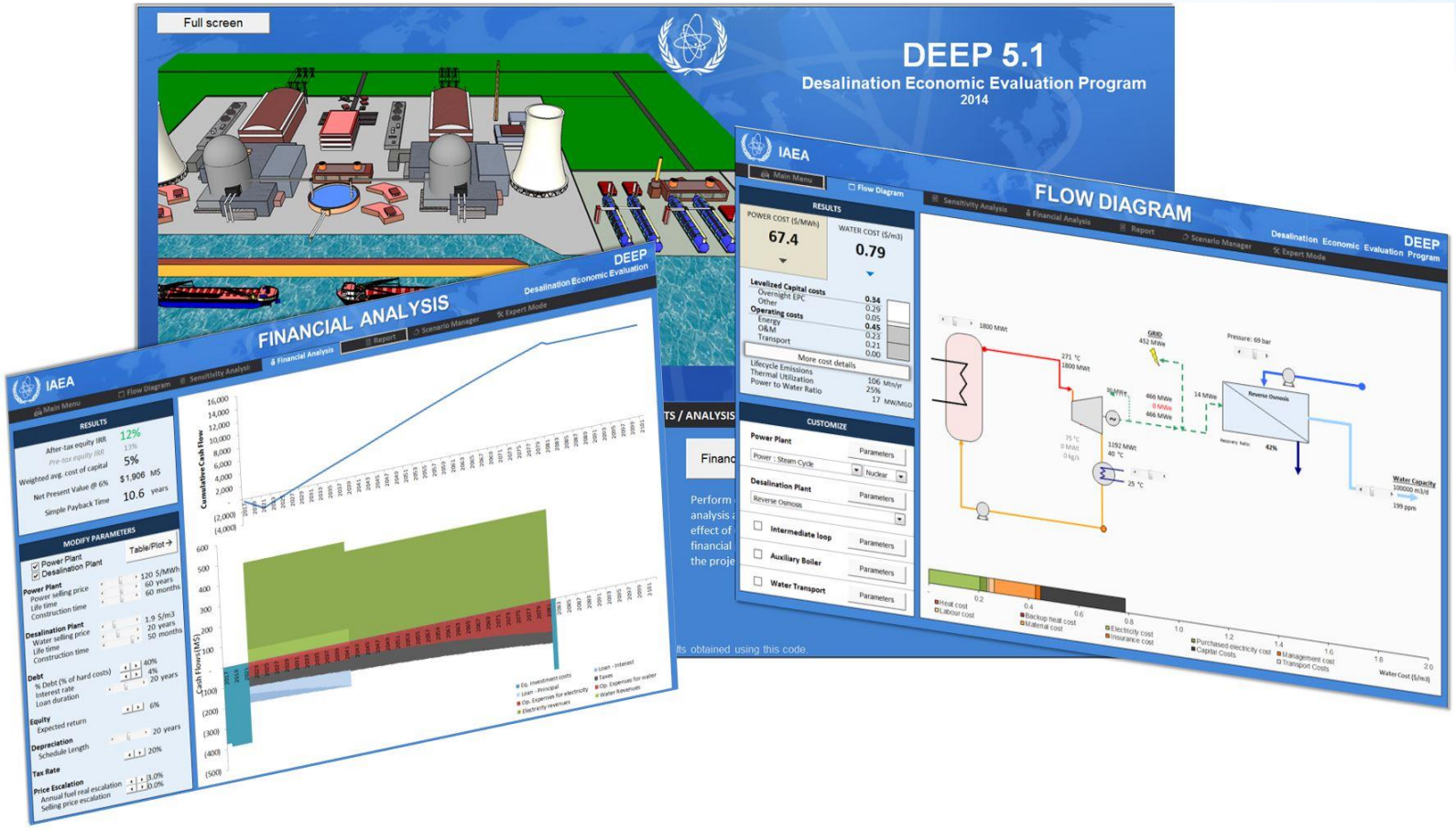
Evaluates the economics of the most promising processes for hydrogen production



Hydrogen Economic Evaluation Programme - NPTDS

DEEP

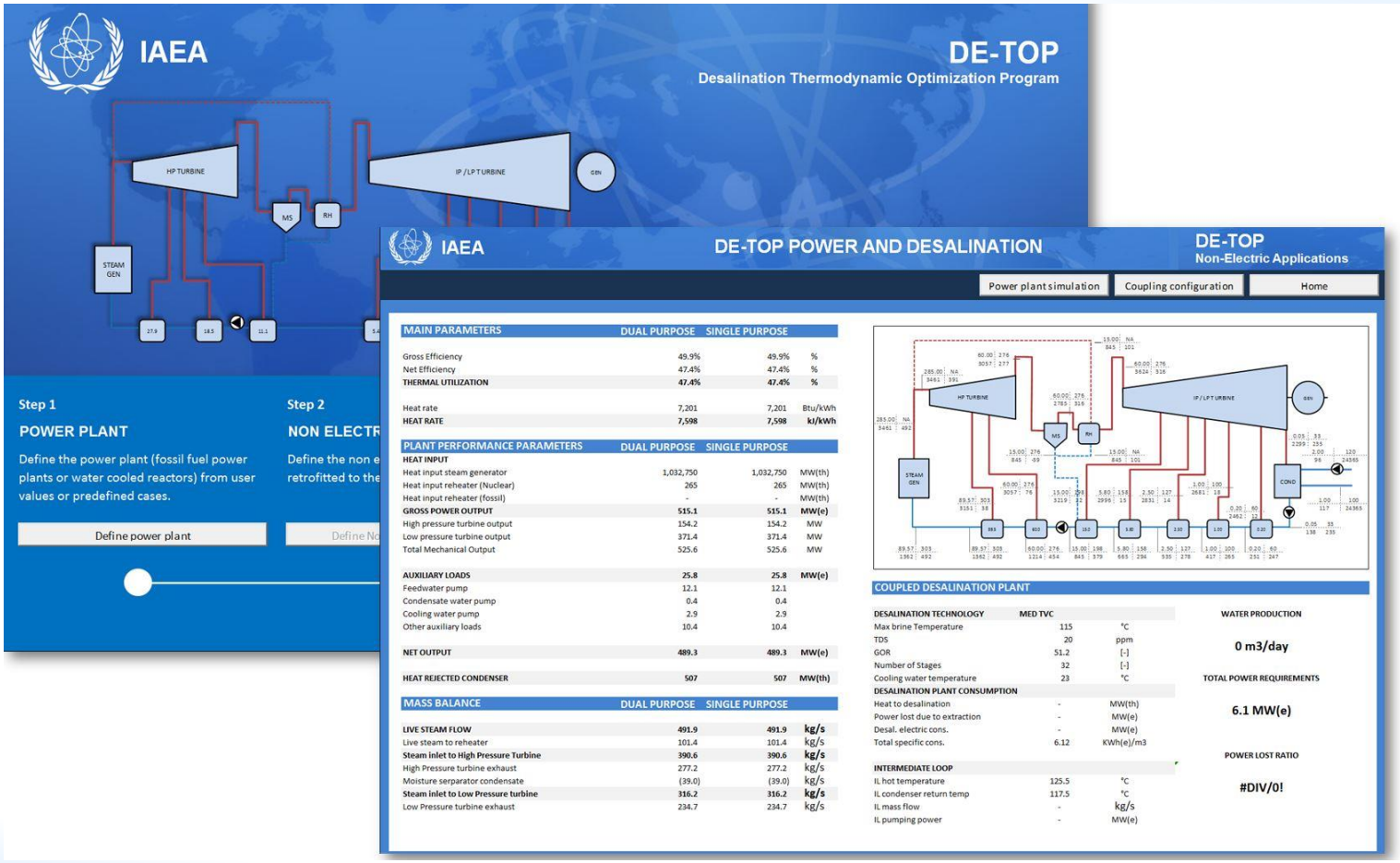
performance and cost evaluation of various power and seawater desalination cogeneration configurations.



Desalination Economic Evaluation Programme - NPTDS

DE-TOP

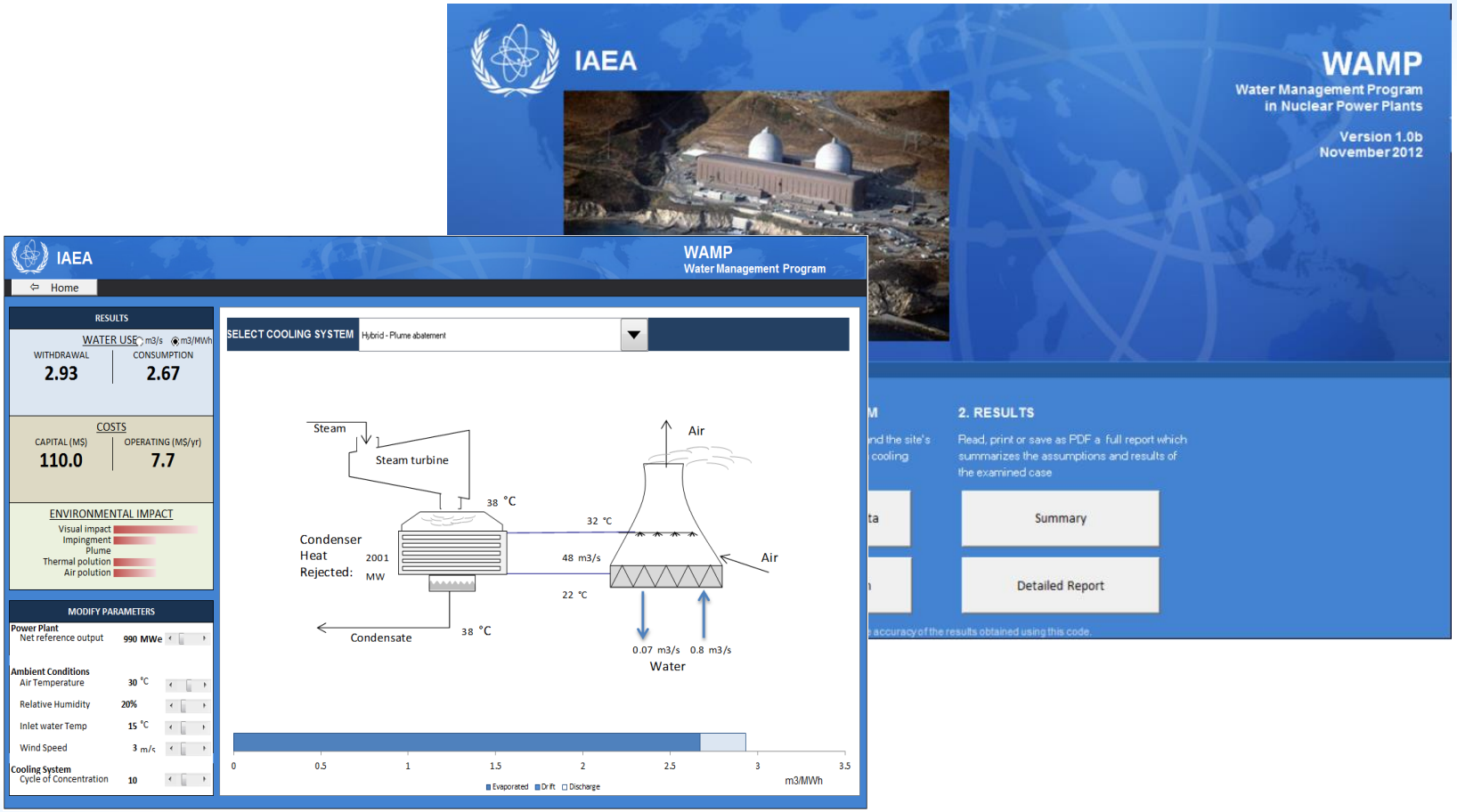
models the steam power cycle of different WCRs coupled with nonelectrical applications



Desalination Thermodynamic Optimization - NPTDS

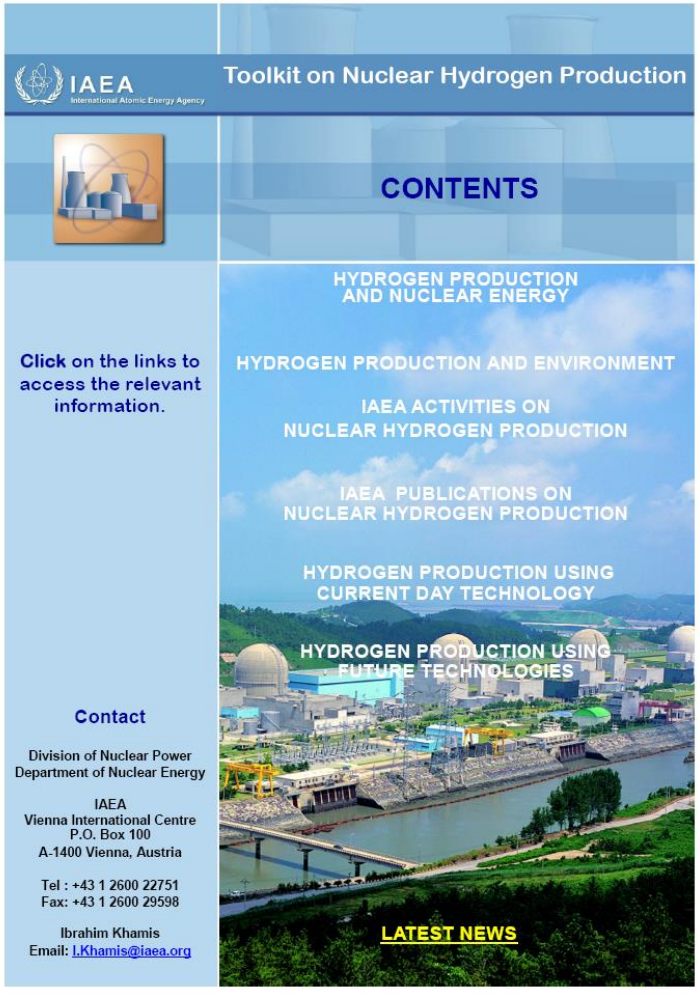
WAMP

estimates water needs in NPPs especially for WCRs



Water Management Program - NPTDS

Nuclear Hydrogen Production Toolkit - NPTDS



- Up-to-date information
- Link to IAEA tools
- Highlights of IAEA Publications
- News on IAEA Activities
- Newsletter on nuclear hydrogen production

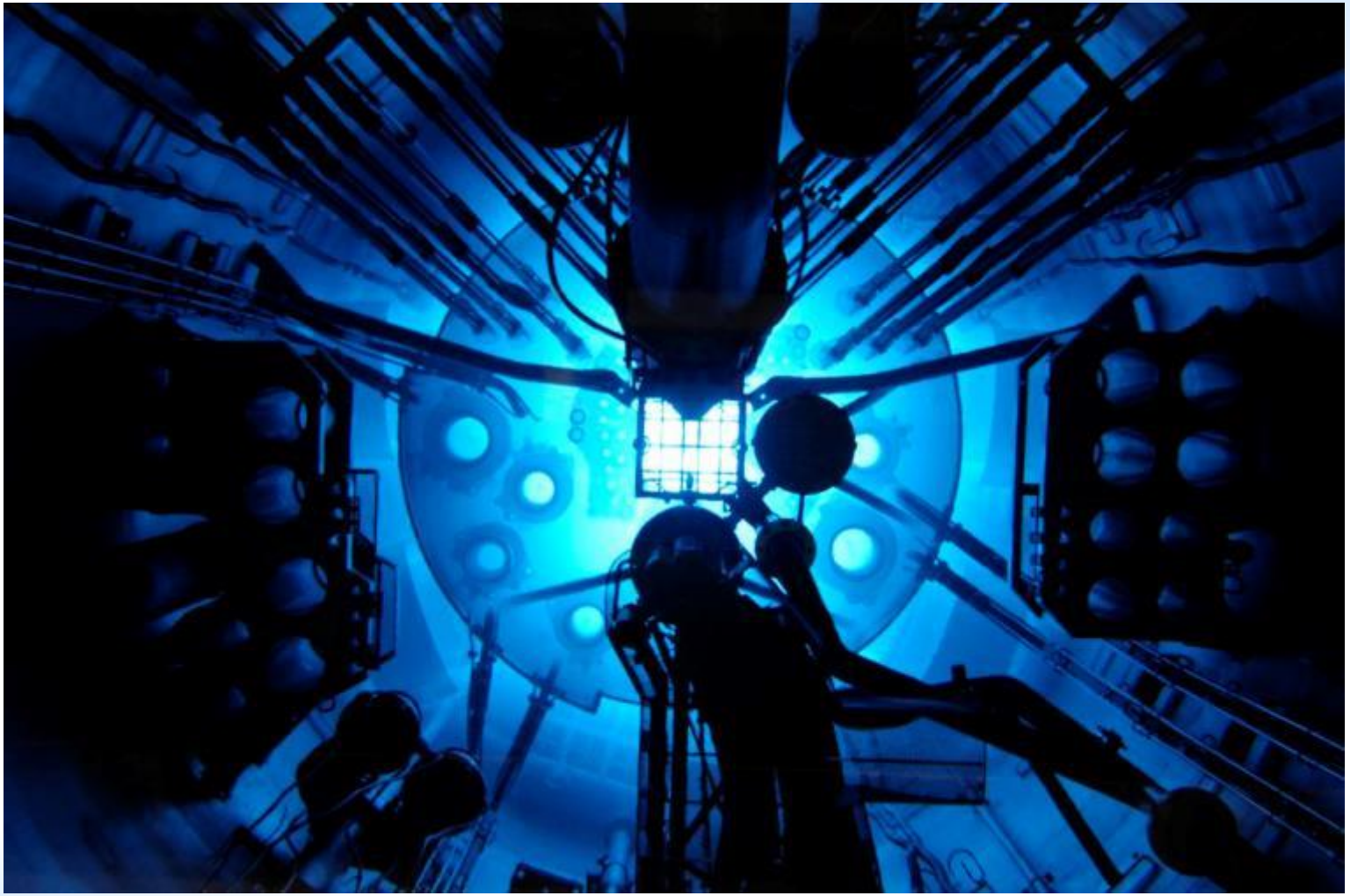
Update/Release in Jan. 2017

Nuclear Desalination Toolkit - NPTDS

- Up-to-date information
- Link to IAEA tools
- Highlights of IAEA Publications
- News on IAEA Activities
- Summaries of the TWG-ND
- Newsletter on nuclear desalination

Update/Release in Jan. 2017

Research reactors



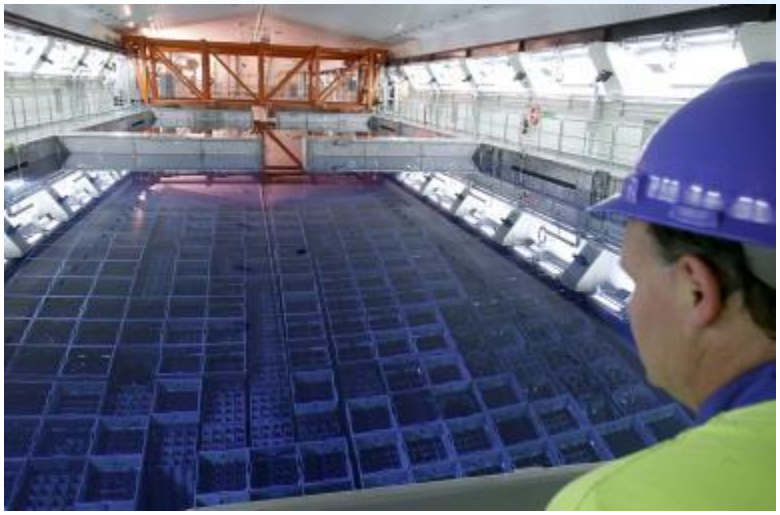
“Internet Reactor”

IAEA 60 Years Atoms for Peace and Development

HEU Removal

Spent fuel

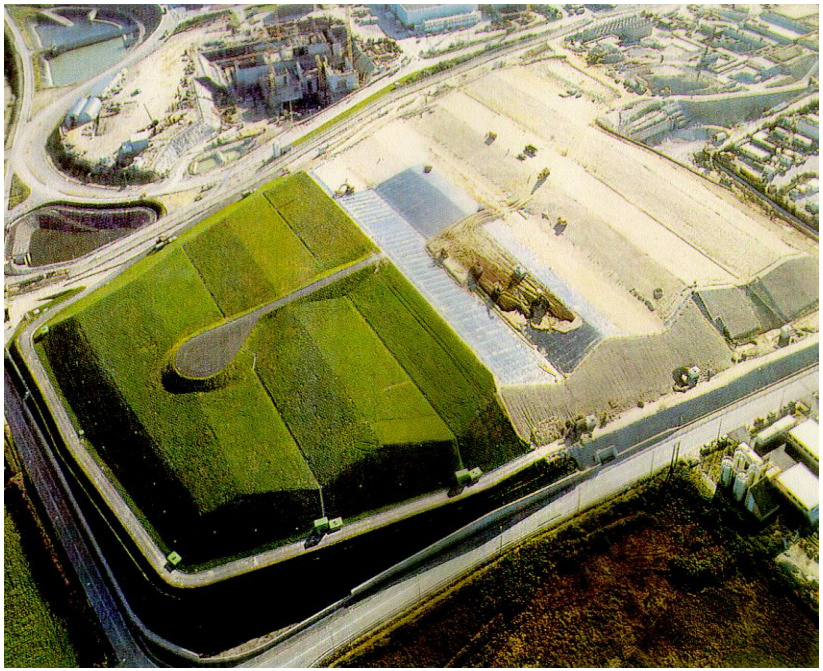
Spent fuel pool



Dry storage casks

Dry storage building

Disposal



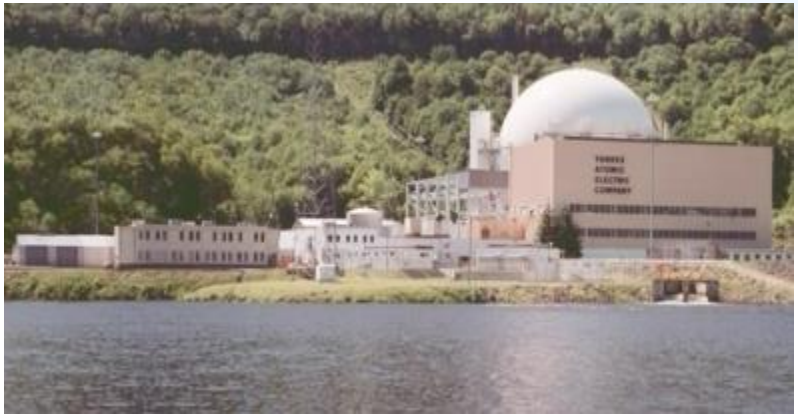
Final covering of LLW disposal facility
Centre de la Manche, France

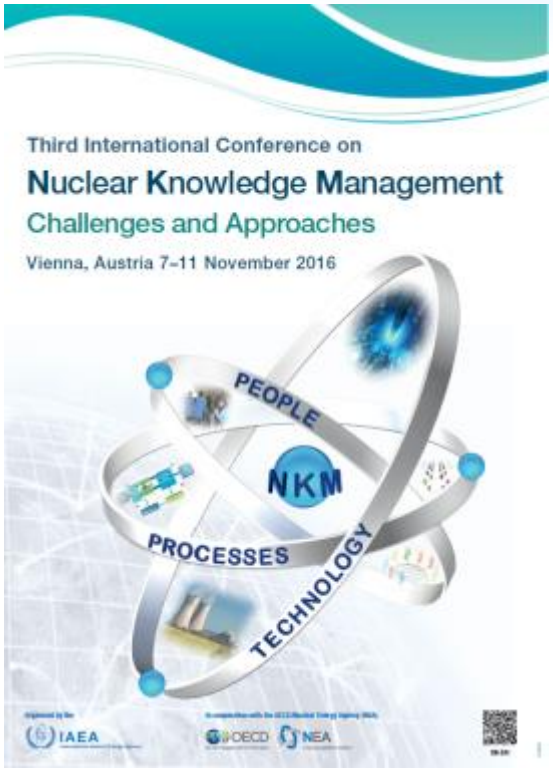
Deep underground disposal facility
for spent fuel Onkalo, Finland

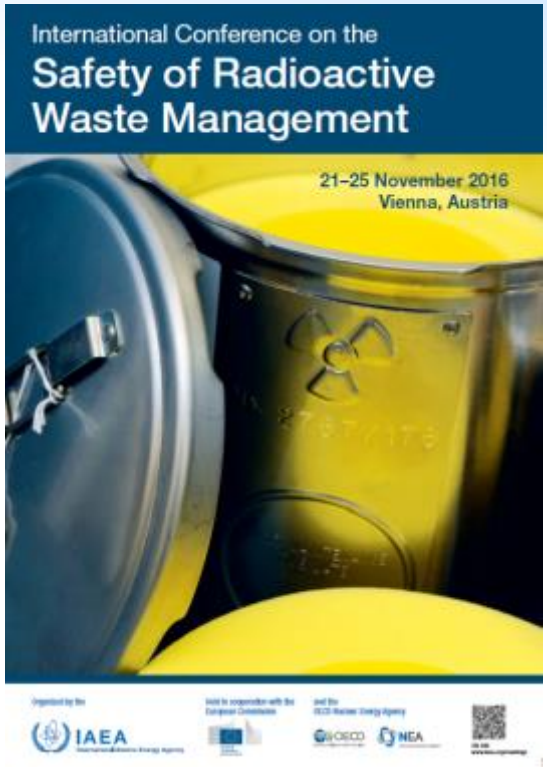
Decommissioning & Environmental Remediation

Maine Yankee being dismantled, USA

Yankee Rowe NPP







- **International Conference on Fast Reactors and Related Fuel Cycles (FR17)**
- **4th International Conference on Nuclear Power Plant Life Management (PLIM)**
- **Ministerial Conference on Nuclear Power in the 21st Century**

IAEA 60 Years
Atoms for Peace and Development

…atoms for peace
at your service…

Thank you!

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