



**IAEA**

*60 Years*

*Atoms for Peace and Development*

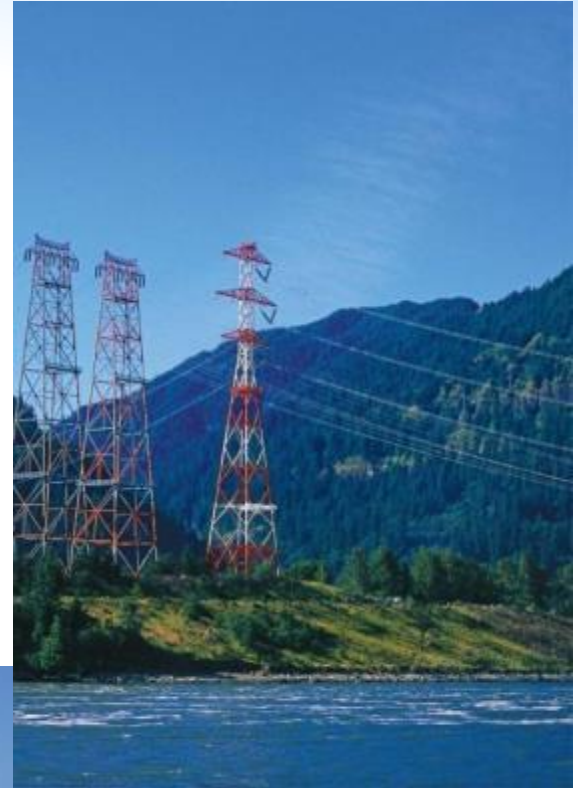
# **IAEA Assistance to Member States in development of nuclear energy**

**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: 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



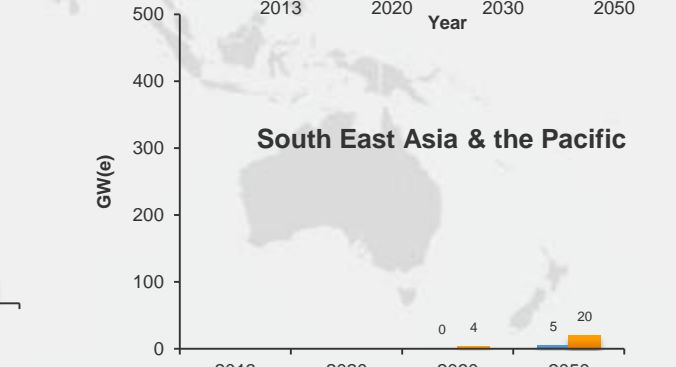
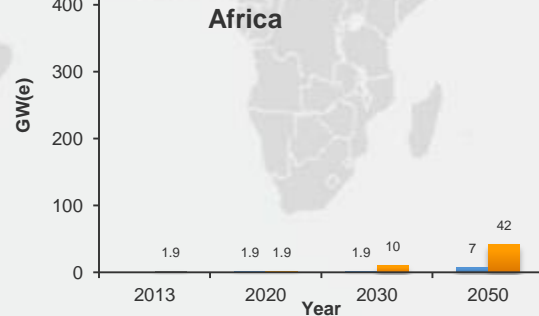
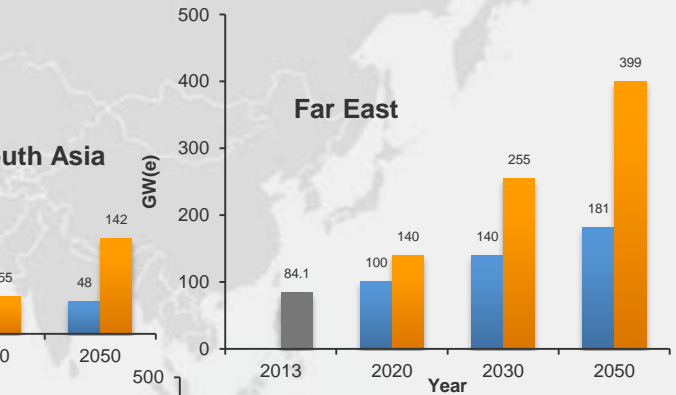
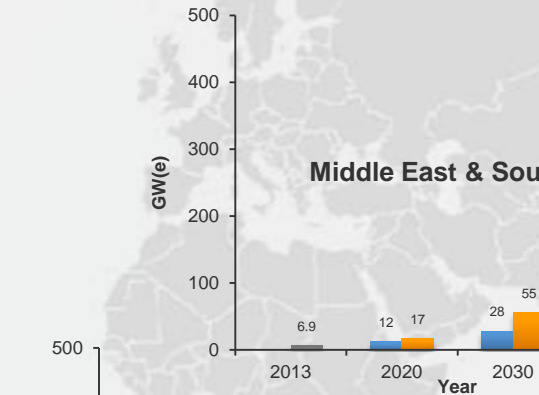
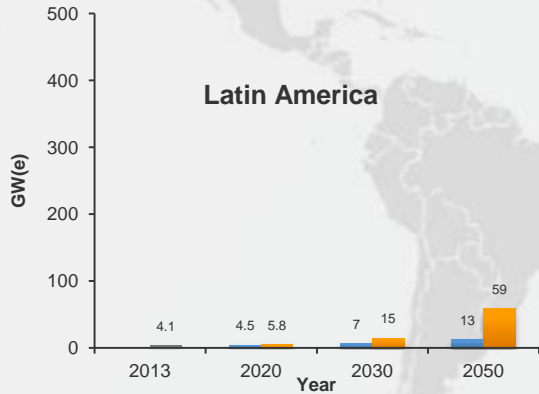
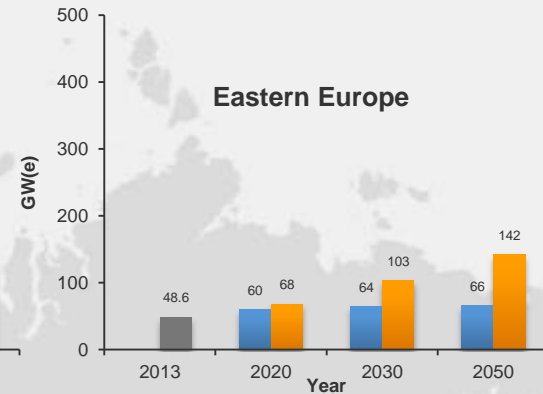
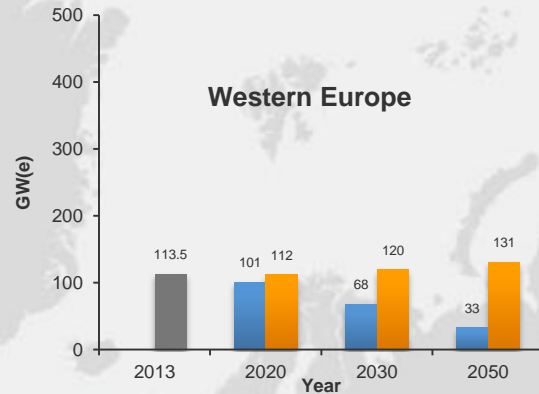
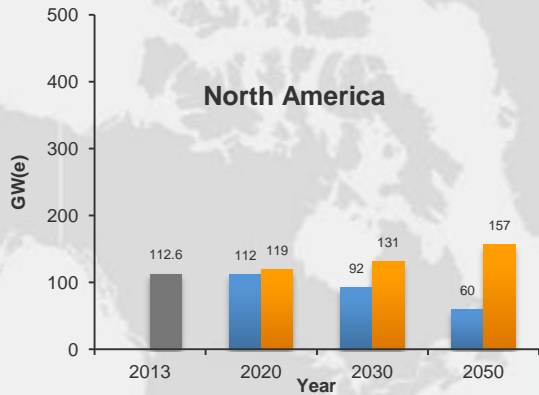
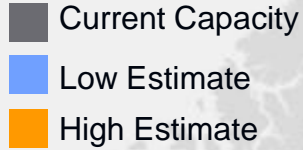
## 392 GW(e) Capacity



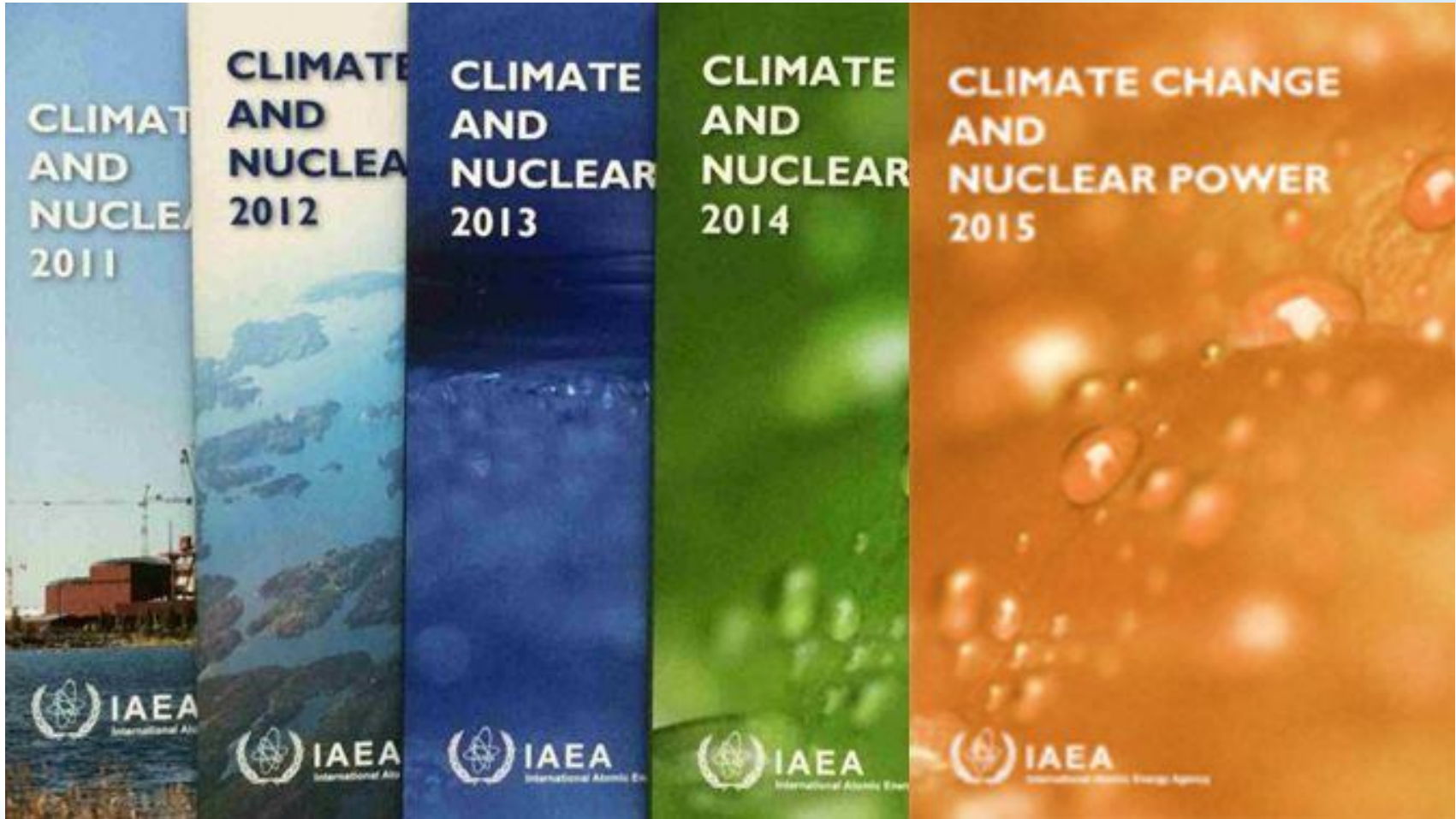
## 57 under construction (2/3 in Asia)



# NP Development in Different Regions



# Climate Change





# IAEA Assistance to Newcomers

## MILESTONE 1

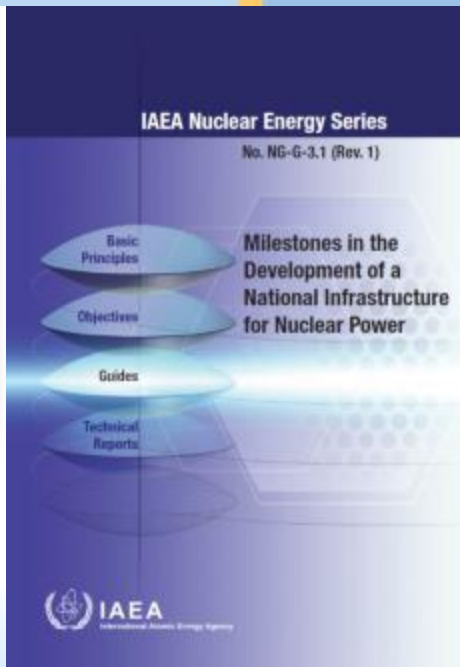
Ready to make a knowledgeable commitment to a nuclear power programme

## 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



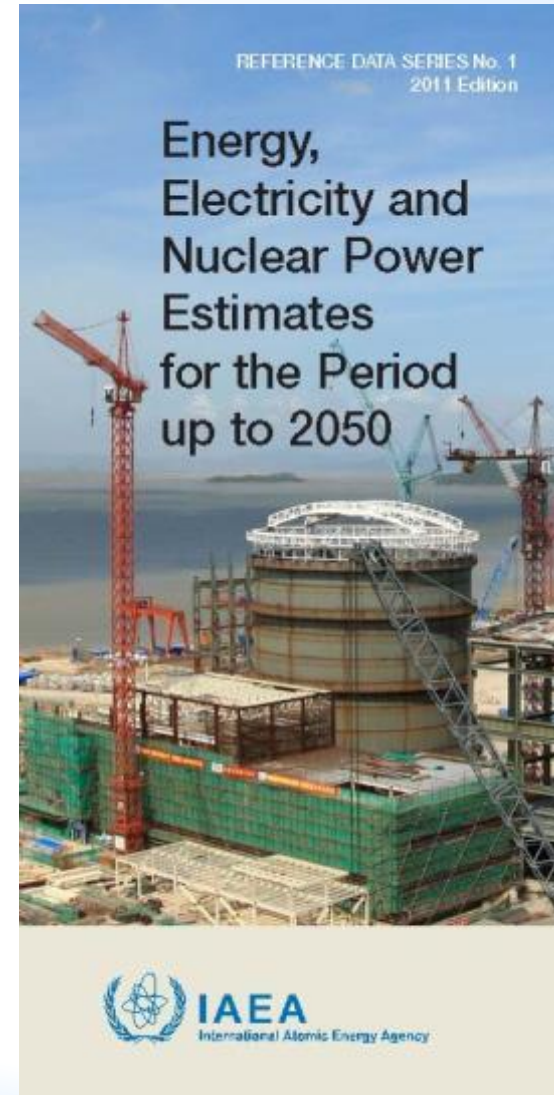
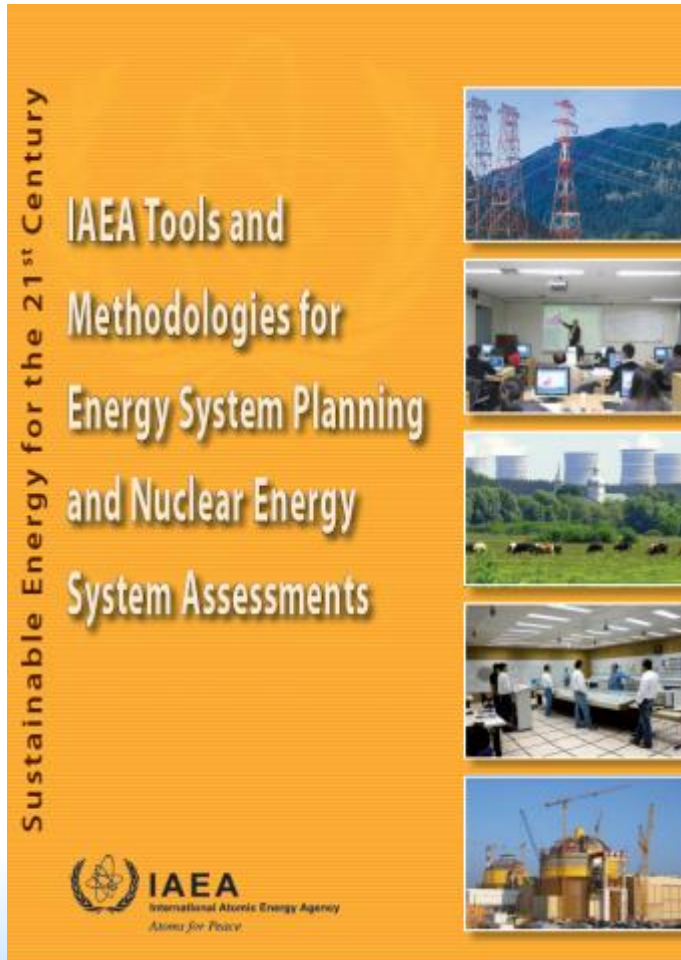
The IAEA Approach  
to Introducing a  
Nuclear Power Programme

Bringing decades of  
expertise to life.

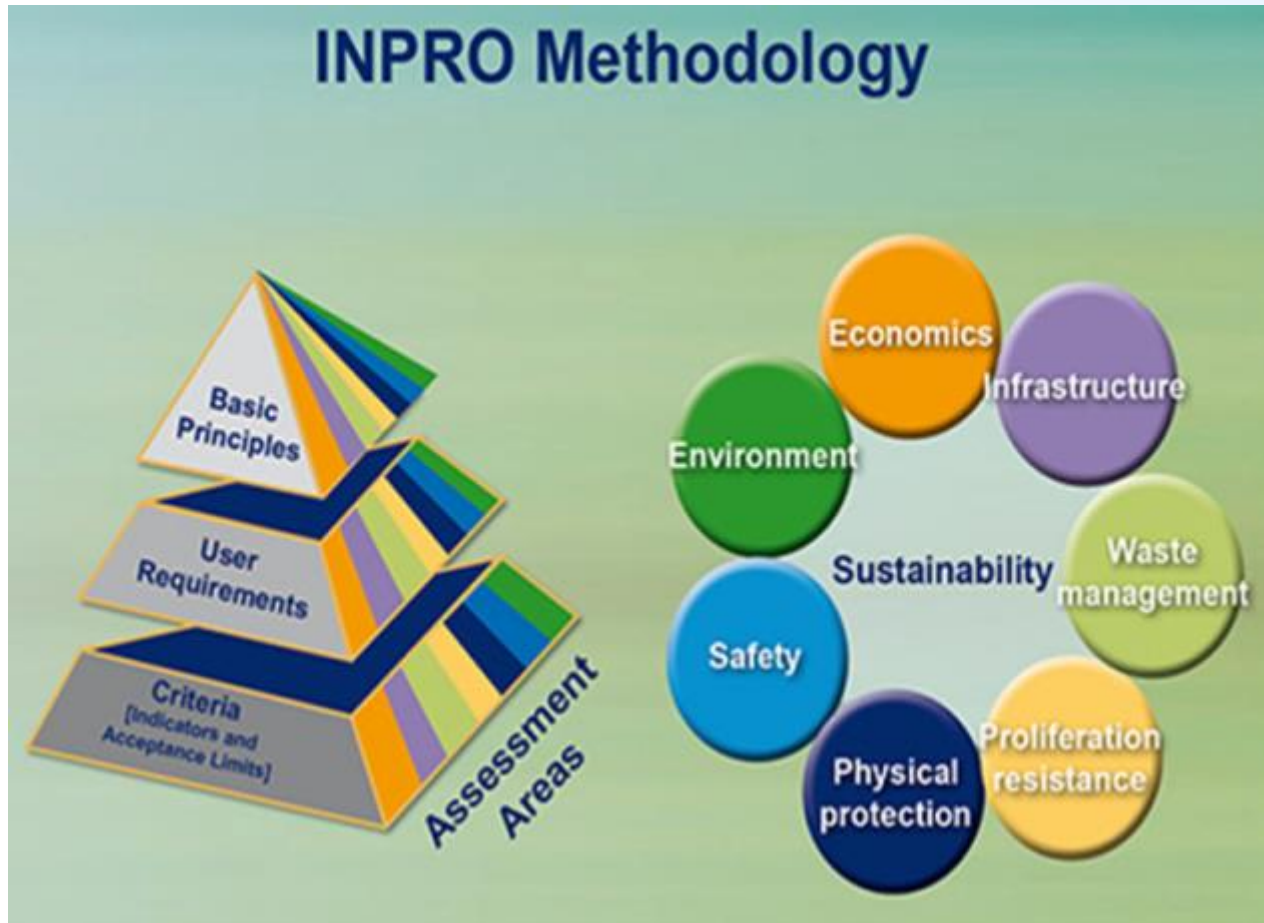
Available at  
[www.iaea.org/NuclearPower/  
Infrastructure/elearning](http://www.iaea.org/NuclearPower/Infrastructure/elearning)

00:40 00:50 01:00 01:10 01:20 01:30 01:40 01:50 02:00 02:10 02:20 02:30 02:40 02:50 03:00 03:10 03:20 03:30 03:40 03:50 04:00 04:10 04:20 04:30 04:40 04:50 05:00 05:10 05:20 05:30 05:40 05:50 06:00 06:10 06:20 06:30 06:40 06:50 07:00 07:10 07:20 07:30 07:40 07:50 08:00 08:10 08:20 08:30 08:40 08:50 09:00 09:10 09:20 09:30 09:40 09:50 10:00 10:10 10:20 10:30 10:40 10:50 11:00 11:10 11:20 11:30 11:40 11:50 12:00 12:10 12:20 12:30 12:40 12:50 13:00 13:10 13:20 13:30 13:40 13:50 14:00 14:10 14:20 14:30 14:40 14:50 15:00 15:10 15:20 15:30 15:40 15:50 16:00 16:10 16:20 16:30 16:40 16:50 17:00 17:10 17:20 17:30 17:40 17:50 18:00 18:10 18:20 18:30 18:40 18:50 19:00 19:10 19:20 19:30 19:40 19:50 20:00 20:10 20:20 20:30 20:40 20:50 21:00 21:10 21:20 21:30 21:40 21:50 22:00 22:10 22:20 22:30 22:40 22:50 23:00 23:10 23:20 23:30 23:40 23:50 24:00

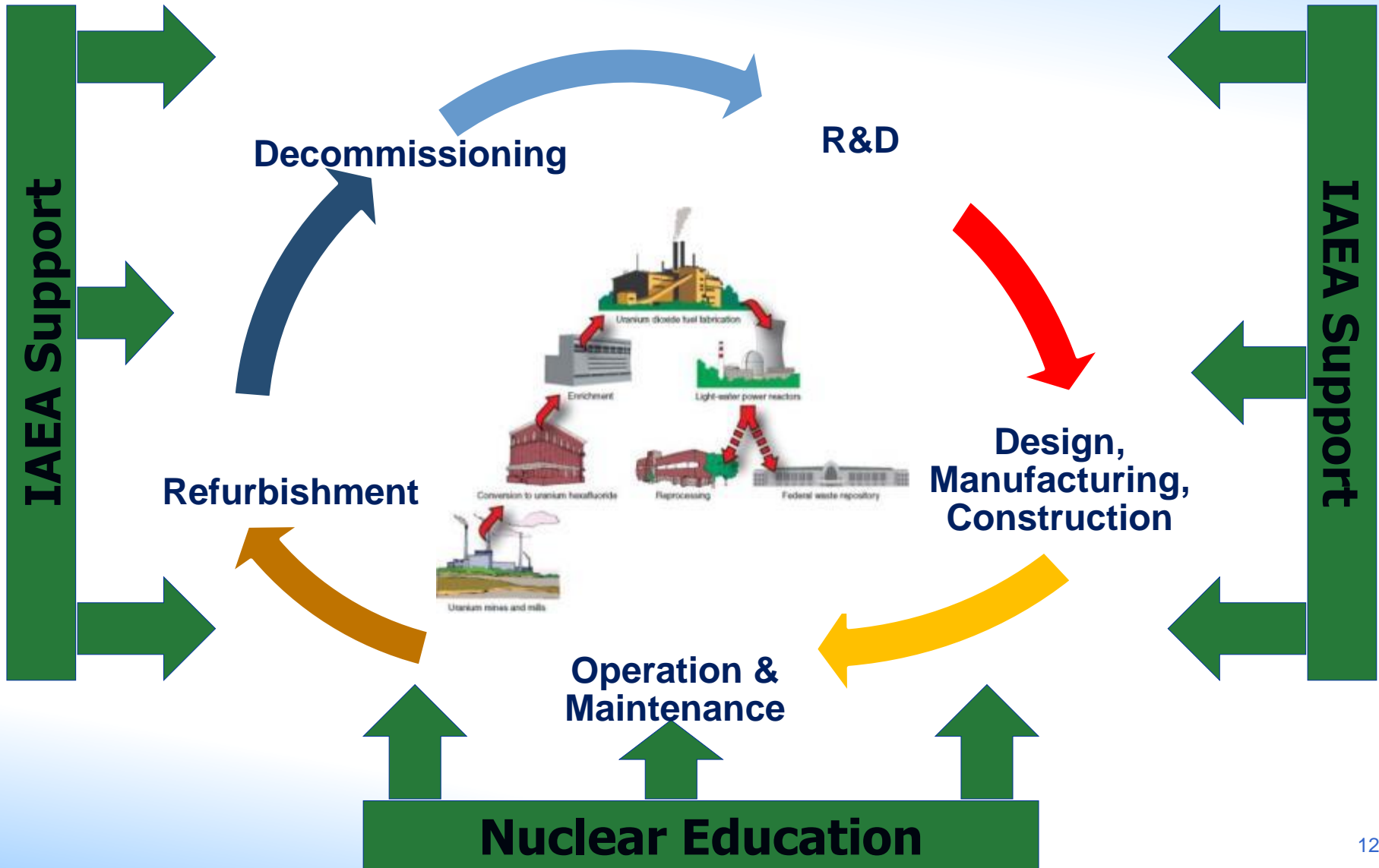
# Analysis for Sustainable Energy Development



# Energy Assessment

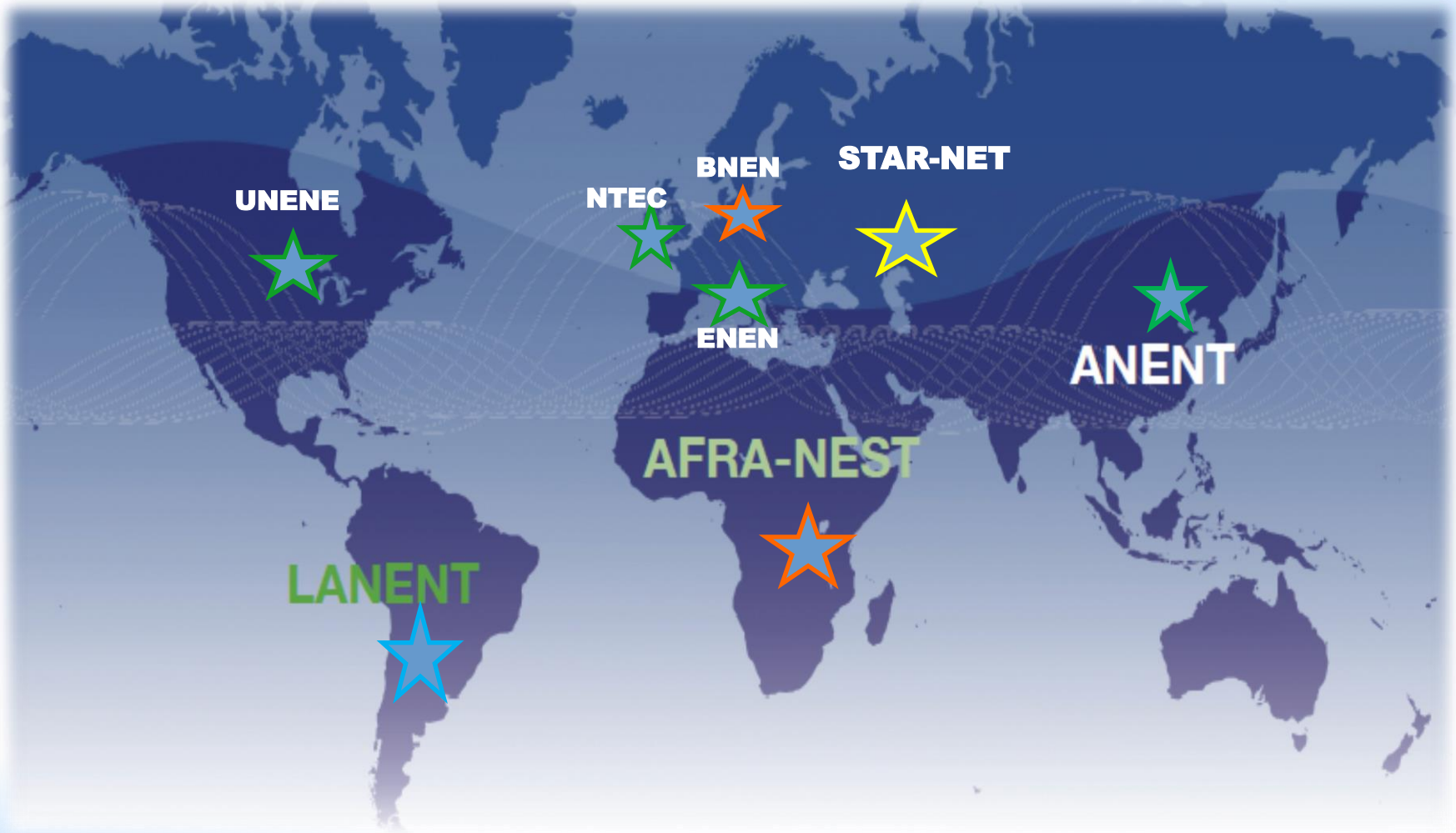


# IAEA support in Nuclear Knowledge Management





# Regional Nuclear Education Networks



# Cyber-Learning Platform



CLP4NET

Cyber Learning Platform for Nuclear Education and Training

[HOME](#) | [ABOUT](#) | [RESOURCES](#)



Communication. Collaboration. Knowledge.

# Nuclear Information

INIS: organizing the world's nuclear information and making it universally accessible

Search the INIS Repository

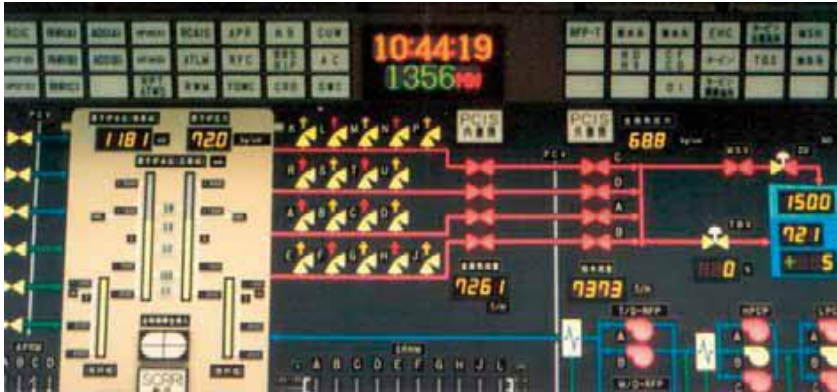
Enter your search term here

Search

[Advanced search](#)

**3.9 millions of bibliographical records**

# Support for operators



**Instrumentation & control**



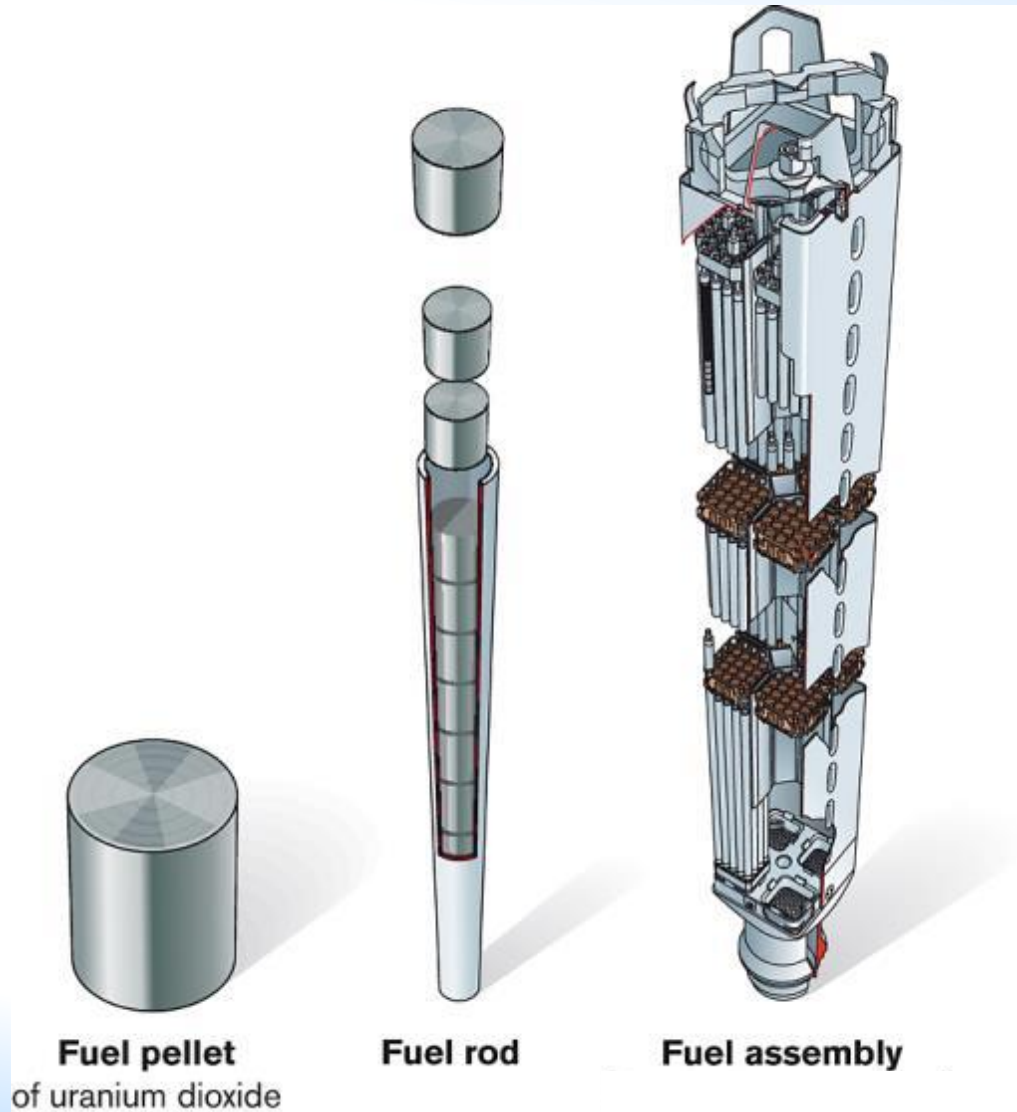
**Maintenance/  
Outage management**



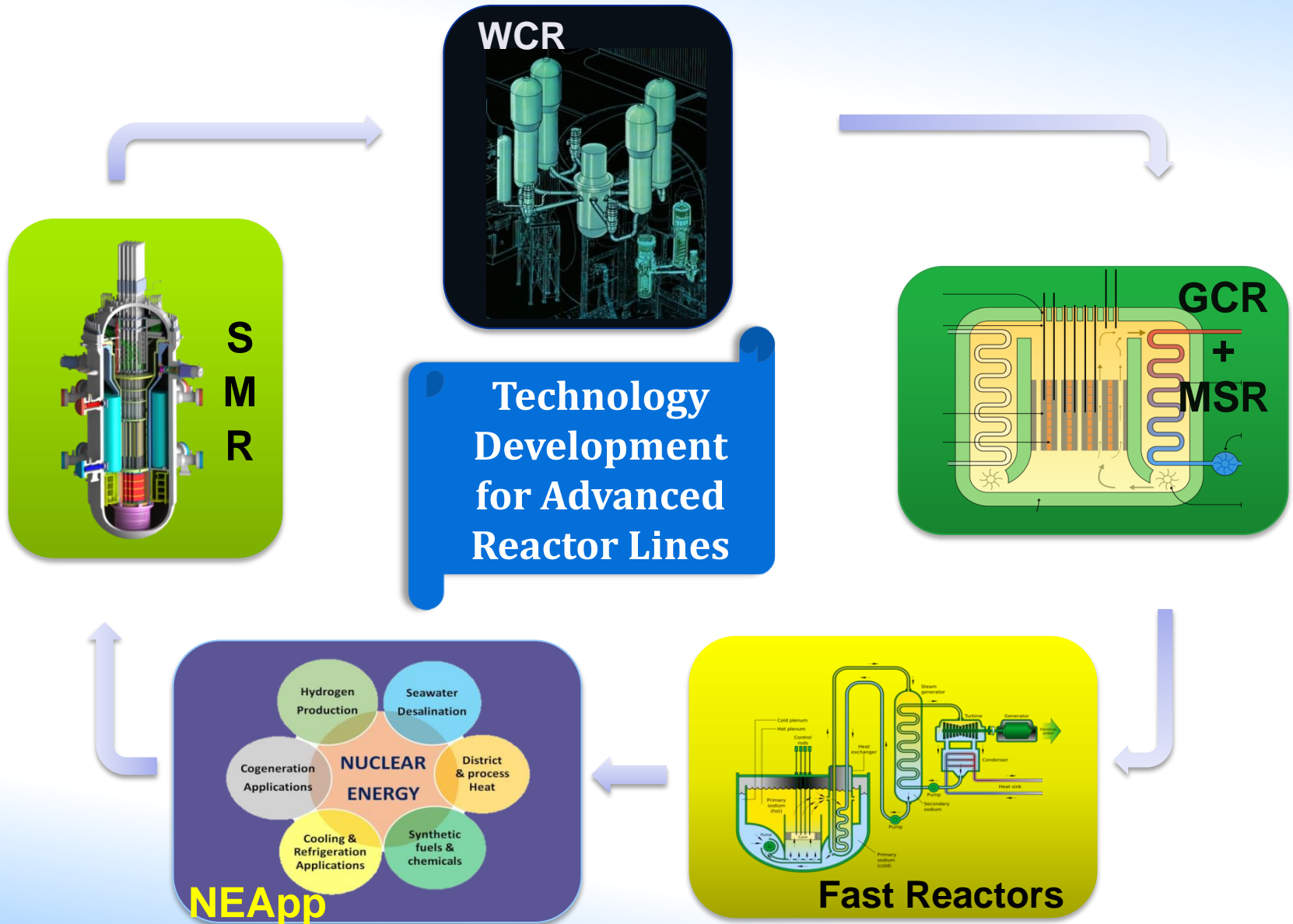
**Plant life  
management**



# Nuclear fuel



# Nuclear Power Technology Development

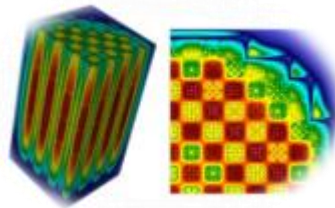


# Macro Areas for Each Reactor Line and Non-Electric Applications

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 | ARIS Advanced Reactors Information System

Technical Data

Characteristics

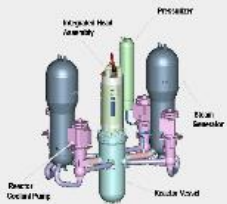
Publications

Glossary

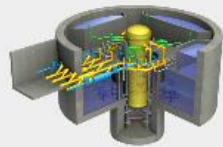
About ARIS

## ADVANCED REACTORS

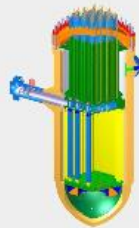
### WATER COOLED TECHNOLOGY



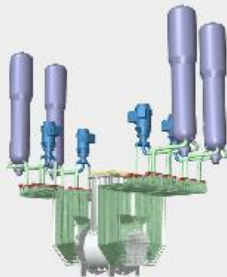
PWR



BWR



SCWR

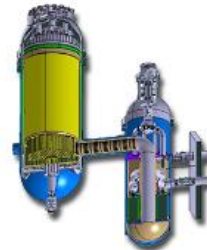


HWR



iPWR

### GAS COOLED TECHNOLOGY

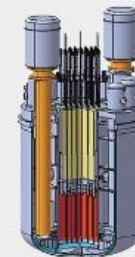


GCR

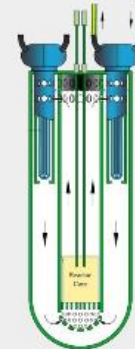


GFR

### MOLTEN METAL COOLED TECHNOLOGY

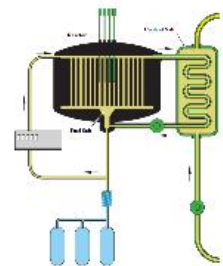


SFR

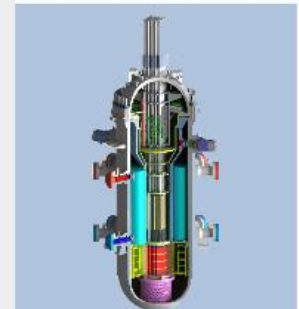


LFR

### MOLTEN SALT COOLED TECHNOLOGY



MSR



MSR

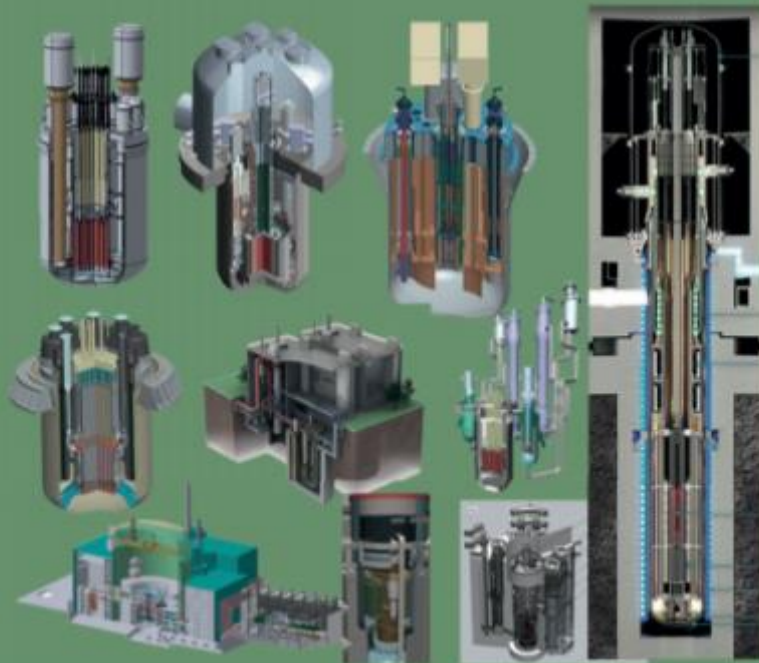


# Innovation & Technology Development

## STATUS OF INNOVATIVE FAST REACTOR DESIGNS AND CONCEPTS

A Supplement to the IAEA Advanced Reactors  
Information System (ARIS)

<http://aris.iaea.org>



## Advances in Small Modular Reactor Technology Developments

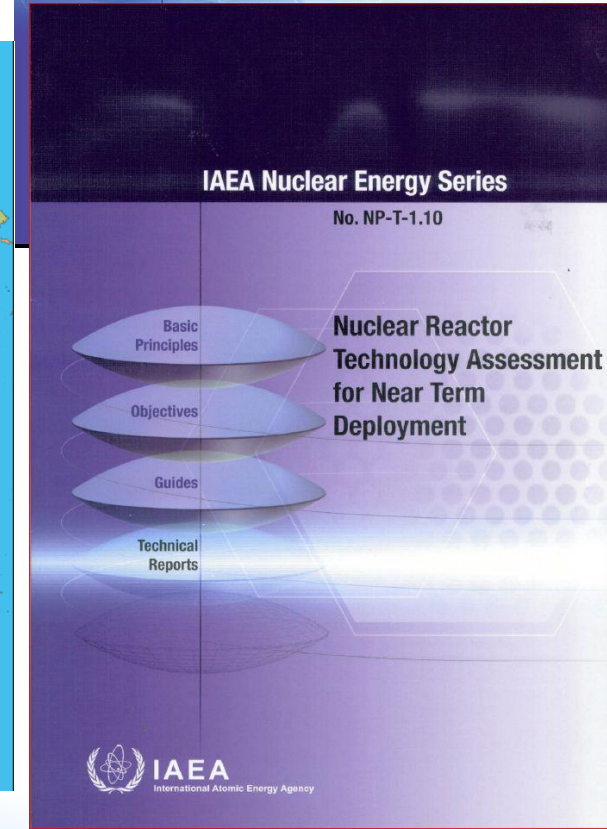
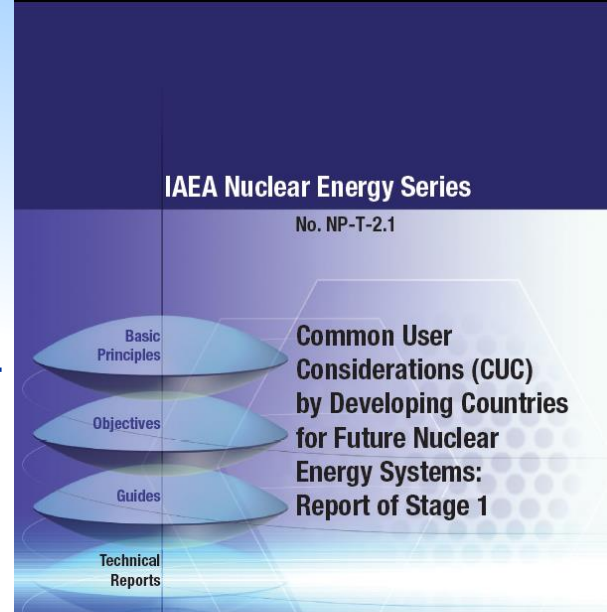
A Supplement to:  
IAEA Advanced Reactors Information System (ARIS)

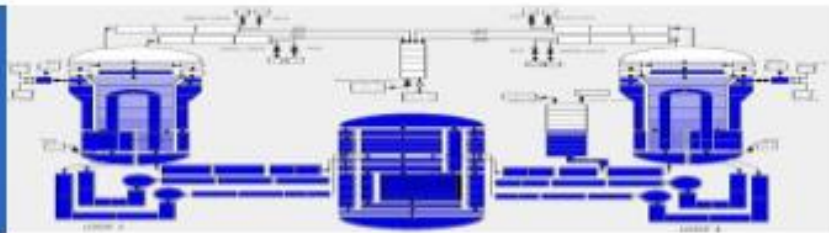


# TRAINING COURSES REACTOR TECHNOLOGY ASSESSMENT

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





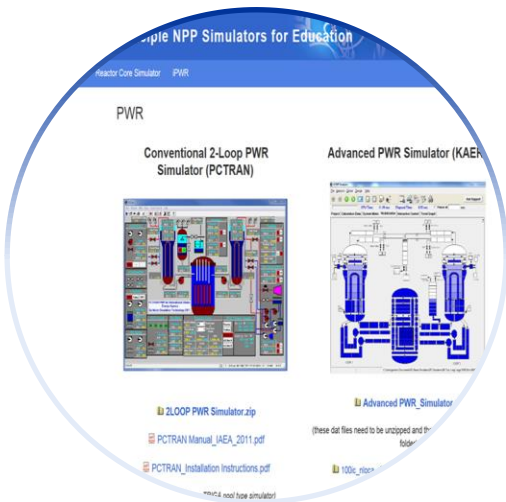
# IAEA PC Based Basic Principle Nuclear Power Plants Simulators

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

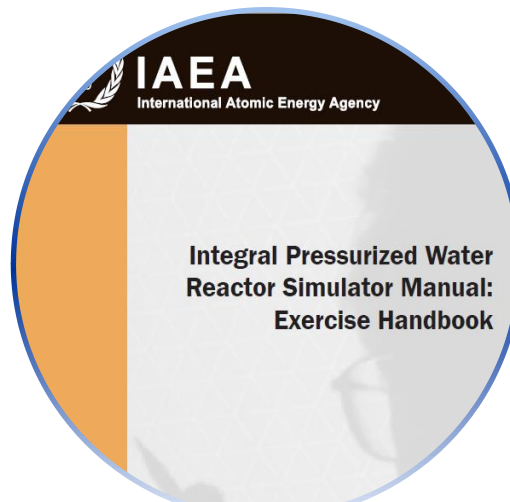


# IAEA PC Based Basic Principle Nuclear Power Plants Simulators

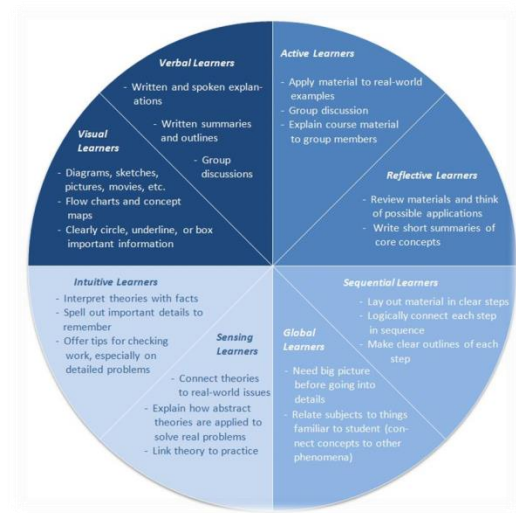
**IAEA assist Member States in educating nuclear researchers, engineers, and regulators with effective learning-by-doing approach integrating the all 4 learning dimensions**



**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**

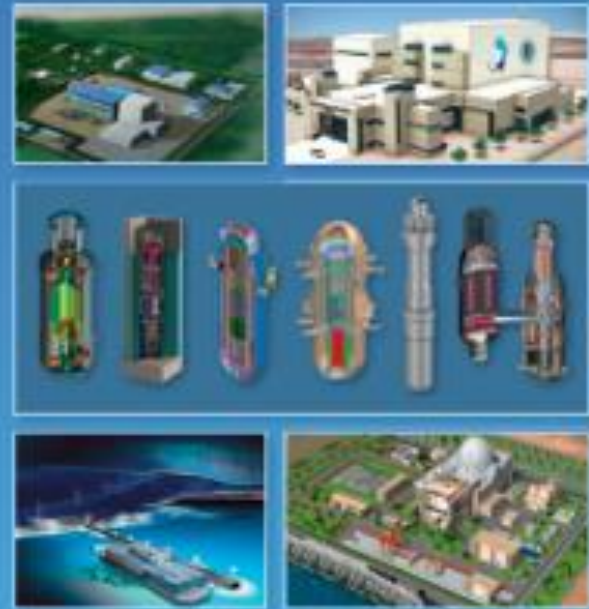


# SMR booklet

- 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/>

## Advances in Small Modular Reactor Technology Developments

A Supplement to:  
IAEA Advanced Reactors Information System (ARIS)



# 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

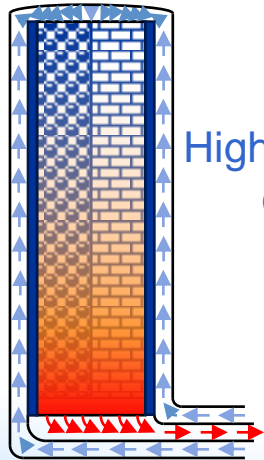


Uranium/Thorium

Cleaner products and  
waste streams / reduced  
NORM



16 member states  
participating



High Temperature Gas-cooled Reactor



Nuclear Fuel  
Manufacturing

# 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



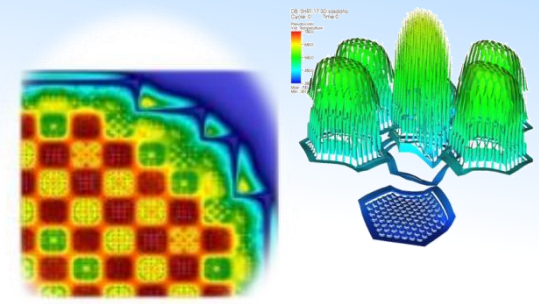
<http://nucleus.iaea.org/sites/graphiteknowledgebase/>



# Fast Reactor Technology: Key Activities

## 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



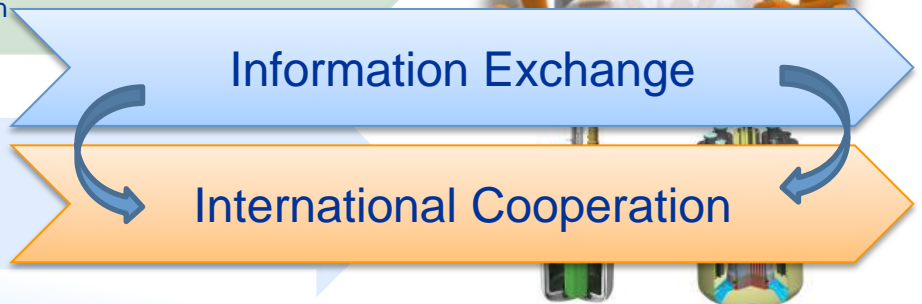
## Safety

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

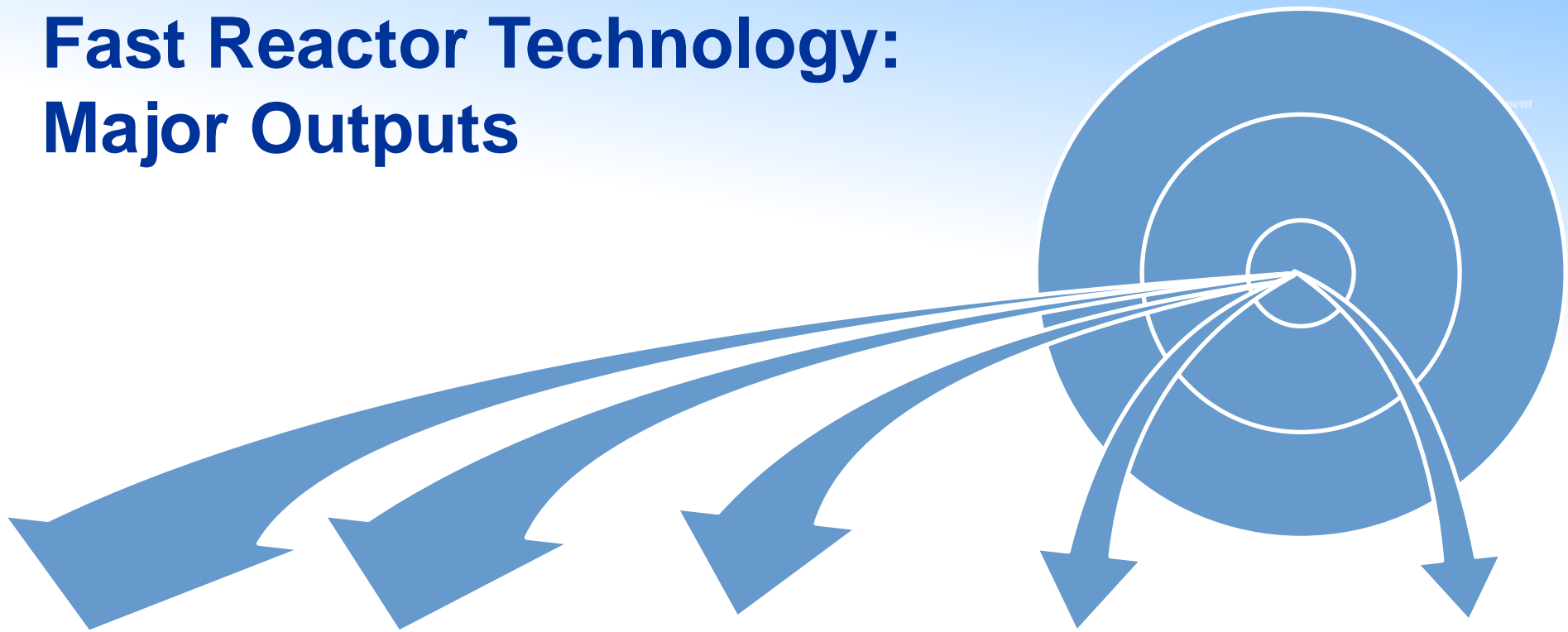


## Technology Support

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



# Fast Reactor Technology: Major Outputs



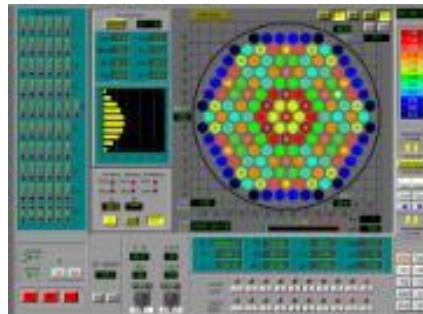
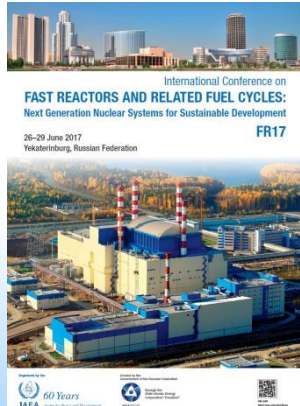
FR 17  
Conference

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



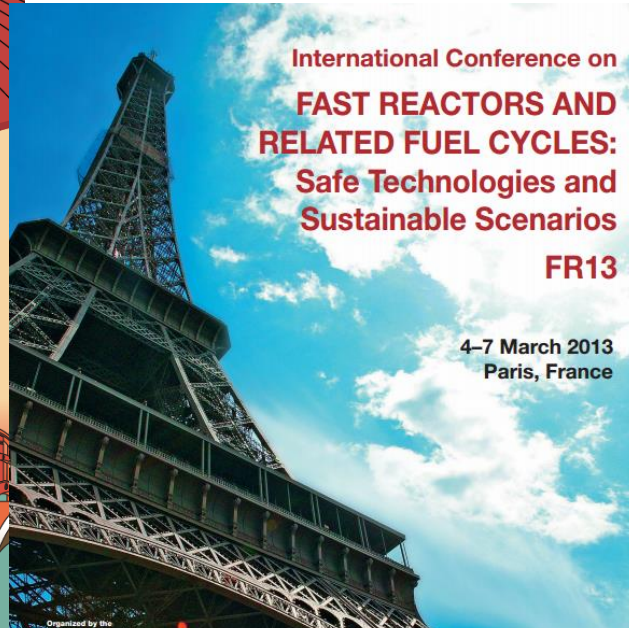
**International Conference on  
Fast Reactors and Related Fuel Cycles:  
Challenges and Opportunities  
FR09**

7-11 December 2009  
Kyoto, Japan

Organized by the  
International Atomic Energy Agency 

Hosted by the  
Japan Atomic Energy Agency 

In cooperation with the  
Japan Atomic Energy Commission  
Ministry of Economy, Trade and Industry (Japan)  
Ministry of Education, Culture, Sports, Science and Technology (Japan)  
Japan Atomic Industrial Forum, Inc.  
Wakasa Wan Energy Research Centre (Japan)  
American Nuclear Society  
Atomic Energy Society of Japan  
European Nuclear Society  
Institute of Electrical Engineers of Japan  
Japan Society for Mechanical Engineers  
Korean Nuclear Society  
European Commission  
OECD Nuclear Energy Agency



**International Conference on  
FAST REACTORS AND  
RELATED FUEL CYCLES:  
Safe Technologies and  
Sustainable Scenarios  
FR13**

4-7 March 2013  
Paris, France

Organized by the  
International Atomic Energy Agency



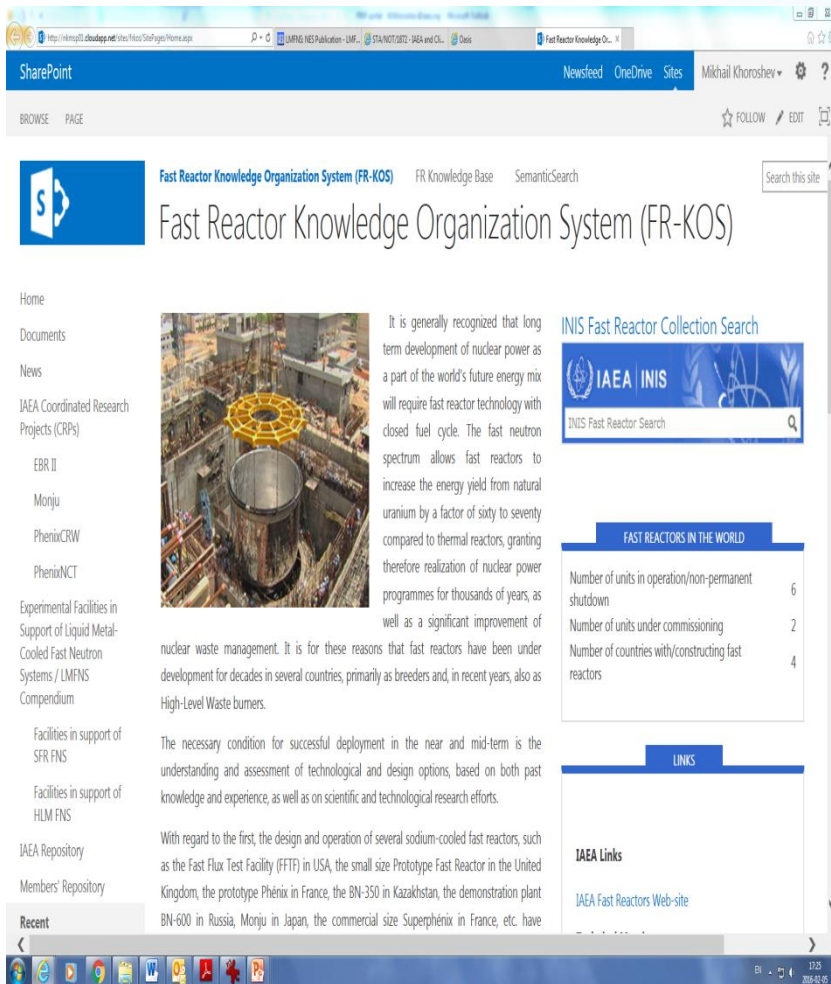
International Conference on  
**FAST REACTORS AND RELATED FUEL CYCLES:  
Next Generation Nuclear Systems for Sustainable Development**

26-29 June 2017  
Yekaterinburg, Russian Federation

**FR17**



# Fast Reactor Knowledge Preservation: FRKP Portal



The screenshot shows the FRKP Portal interface. At the top, there is a navigation bar with 'SharePoint', 'Newsfeed', 'OneDrive', and 'Sites'. Below this is a search bar and a 'Fast Reactor Knowledge Organization System (FR-KOS)' header. The main content area features a large image of a reactor core with a yellow fuel assembly. To the right of the image is a text block discussing the long-term development of nuclear power and the benefits of fast reactors. Below the text is a table titled 'FAST REACTORS IN THE WORLD' with the following data:

FAST REACTORS IN THE WORLD	
Number of units in operation/non-permanent shutdown	6
Number of units under commissioning	2
Number of countries with/constructing fast reactors	4

Below the table is a 'LINKS' section with a link to 'IAEA Fast Reactors Web-site'. The left sidebar contains a navigation menu with items like 'Home', 'Documents', 'News', 'IAEA Coordinated Research Projects (CRPs)', 'EBR II', 'Monju', 'PhenixCRW', 'PhenixNCT', 'Experimental Facilities in Support of Liquid Metal-Cooled Fast Neutron Systems / LMFNS Compendium', 'Facilities in support of SFR FNS', 'Facilities in support of HLM FNS', 'IAEA Repository', and 'Members' Repository'. The bottom of the page shows a Windows taskbar with the date 2016-02-05 and time 12:25.

**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 60 Years IAEA Atoms for Peace and Development

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



### Catalogue of Facilities in Support of Liquid Metal-cooled Fast Neutron Systems (LMFNS Catalogue)



This LMFNS catalogue is a living database, which is, in its current form, presents an electronic version of section 4 of the IAEA Nuclear Energy Series publication (*in progress*) "Experimental Facilities in Support of Liquid Metal Cooled Fast Neutron Systems. A Compendium".

[LMFNS Compendium. Summary of the IAEA publication](#)

To overview the potential capabilities of 150 experimental facilities in 14 IAEA Member States to support the development and deployment of the innovative Liquid Metal cooled Fast Neutron Systems (LMFNS) and navigate yourself through the [LMFNS Facilities Database](#) click on the below buttons:

[Overview of SFR](#)

[Overview of LFR](#)

For detailed information on these facilities 1) click on the below button "LMFNS Facilities Database" (also on top of this page), 2) select the Coolant technology - SFR, LFR or both in the search box, 3) use other search and filtering tools as appropriate, 4) click on the Facility Profile you are interested in.

[LMFNS Facilities Database](#)

- 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...”*



The Abdus Salam  
International Centre  
for Theoretical Physics

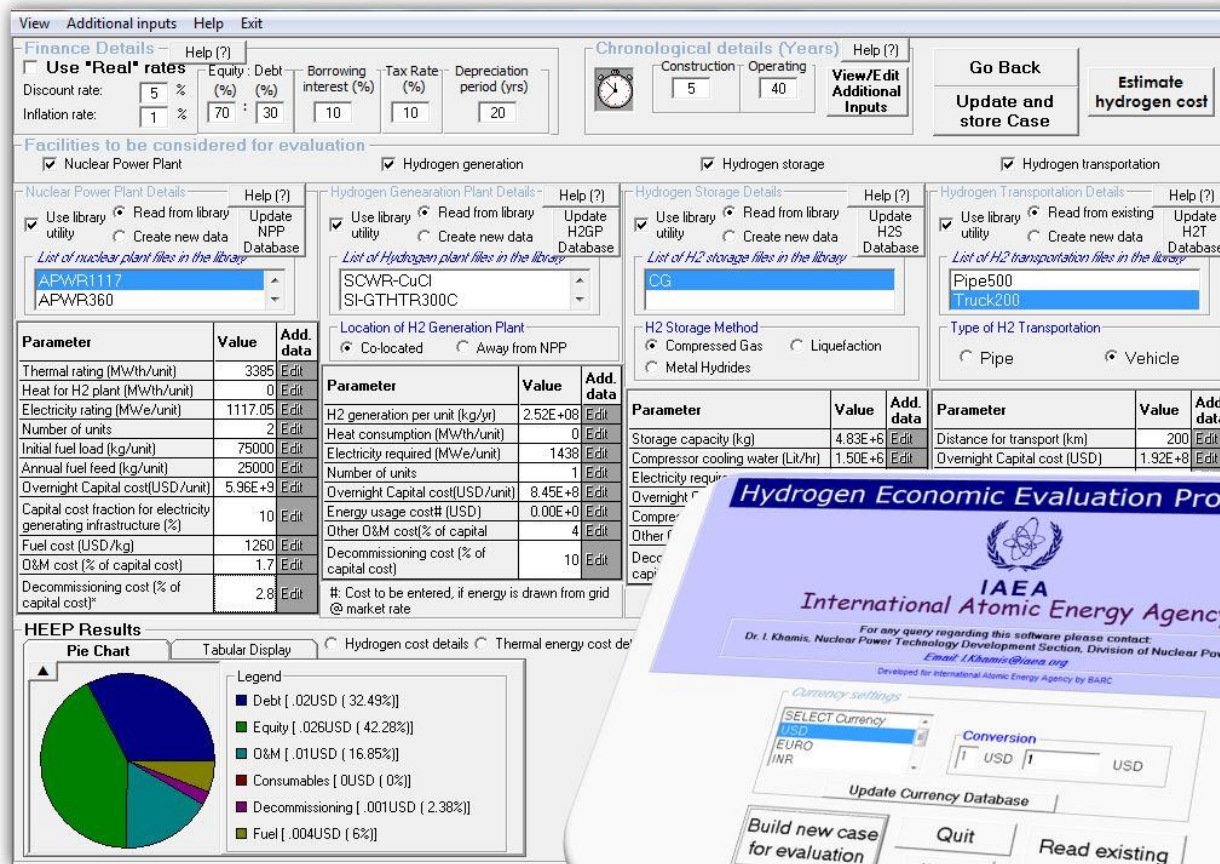


29 August - 2 September 2016  
Miframare, Trieste



# HEEP

Evaluates the economics of the most promising processes for hydrogen production

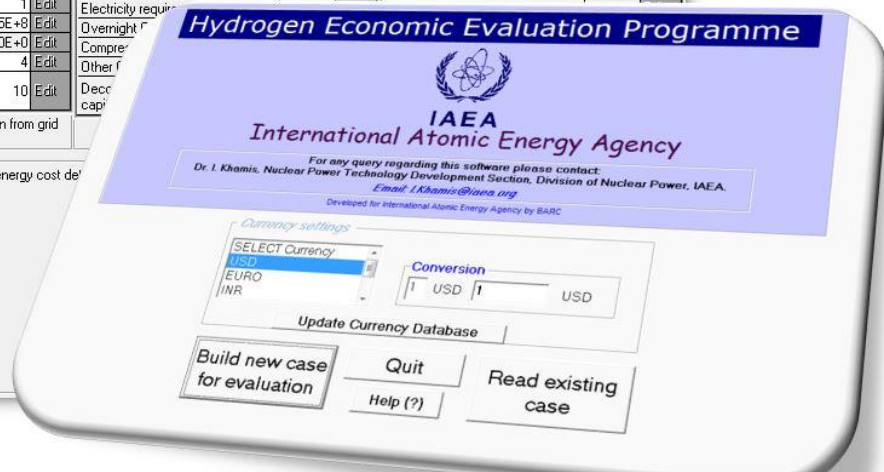


The screenshot displays the HEEP software interface with several sections:

- Finance Details:** Includes fields for Use "Real" rates, Discount rate (5%), Inflation rate (1%), Equity (%), Debt (%), Borrowing interest (%), Tax Rate (%), and Depreciation period (yrs).
- Chronological details (Years):** Includes Construction (5) and Operating (40) years.
- Facilities to be considered for evaluation:** Checkboxes for Nuclear Power Plant, Hydrogen generation, Hydrogen storage, and Hydrogen transportation.
- Plant Selection:** Lists nuclear plants (APWR1117, APWR360), hydrogen generation plants (SCWR-CuCl, SI-GTHTR300C), H2 storage files (CG), and H2 transportation files (Pipe500, Truck200).
- Parameter Tables:**

Parameter	Value	Add. data
Thermal rating (MWh/unit)	3395	Edit
Heat for H2 plant (MWh/unit)	0	Edit
Electricity rating (MWe/unit)	1117.05	Edit
Number of units	2	Edit
Initial fuel load (kg/unit)	75000	Edit
Annual fuel feed (kg/unit)	25000	Edit
Overnight Capital cost(USD/unit)	5.96E+9	Edit
Capital cost fraction for electricity generating infrastructure (%)	10	Edit
Fuel cost (USD/kg)	1260	Edit
O&M cost (% of capital cost)	1.7	Edit
Decommissioning cost (% of capital cost)*	2.8	Edit

Parameter	Value	Add. data
H2 generation per unit (kg/yr)	2.52E+08	Edit
Heat consumption (MWh/unit)	0	Edit
Electricity required (MWe/unit)	1438	Edit
Number of units	1	Edit
Overnight Capital cost(USD/unit)	8.45E+8	Edit
Energy usage cost#(USD)	0.00E+0	Edit
Other O&M cost(% of capital)	4	Edit
Decommissioning cost (% of capital cost)	10	Edit
- HEEP Results:** A pie chart showing the cost breakdown:
  - Debt: 0.02USD (32.43%)
  - Equity: 0.026USD (42.28%)
  - O&M: 0.01USD (16.85%)
  - Consumables: 0USD (0%)
  - Decommissioning: 0.001USD (2.38%)
  - Fuel: 0.004USD (6%)



**Hydrogen Economic Evaluation Programme**  
**IAEA International Atomic Energy Agency**  
 For any query regarding this software please contact:  
 Dr. I. Khamis, Nuclear Power Technology Development Section, Division of Nuclear Power, IAEA.  
 Email: i.khamis@iaea.org  
 Developed for International Atomic Energy Agency by BARC

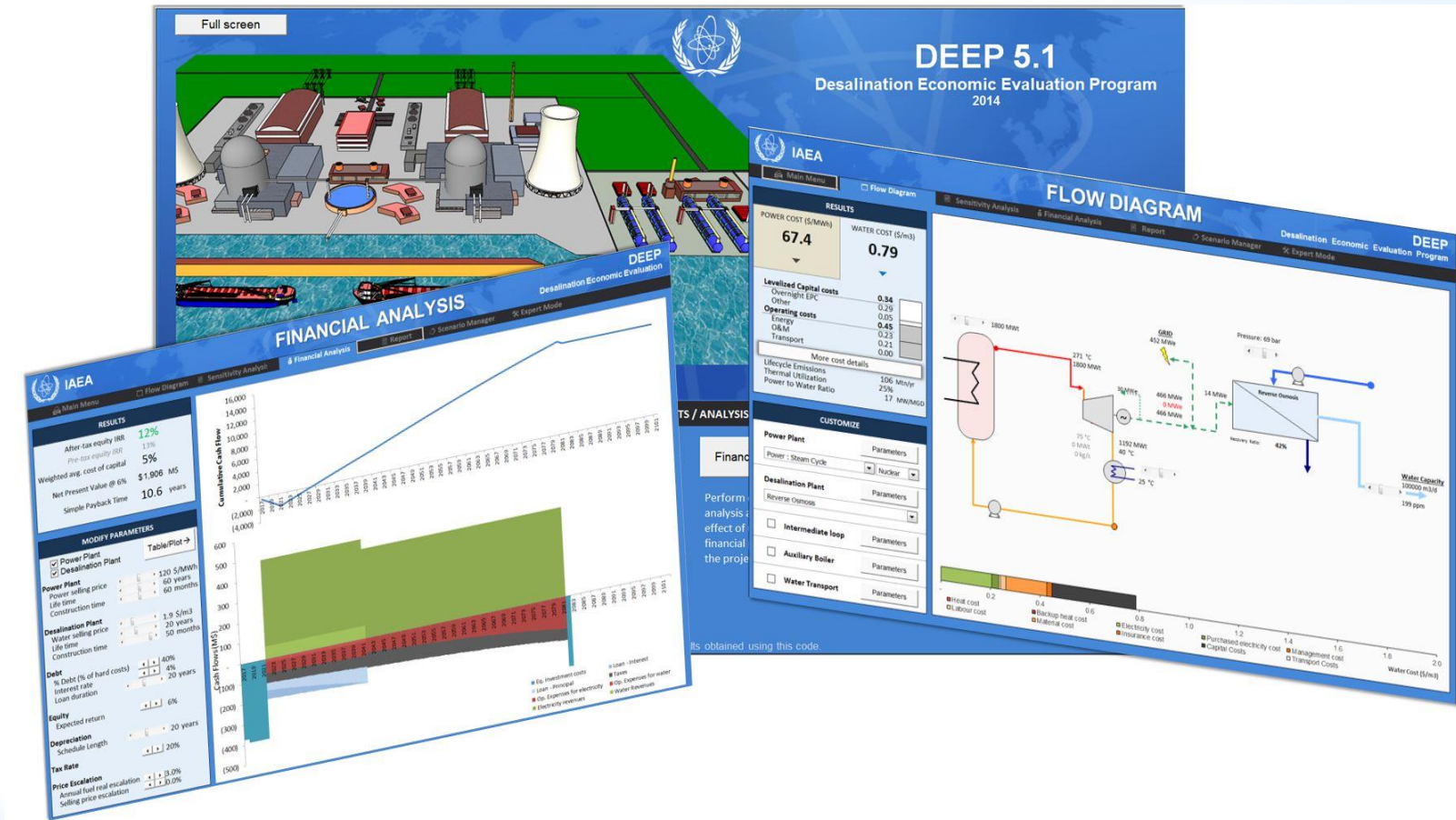
**Currency settings**  
 SELECT Currency: USD, EURO, INR  
 Conversion: 1 USD / 1 USD  
 Update Currency Database

Build new case for evaluation | Quit | Read existing case | Help (?)

## Hydrogen Economic Evaluation Programme - NPTDS

# DEEP

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



**DEEP 5.1**  
Desalination Economic Evaluation Program  
2014

**FINANCIAL ANALYSIS**

**RESULTS**

After tax equity IRR	12.7%
Pre-tax equity IRR	13%
Weighted avg. cost of capital	5%
Net Present Value @ 6%	\$1,908 M\$
Simple Payback Time	10.6 years

**MODIFY PARAMETERS**

- Power Plant
- Desalination Plant

**Power Plant**

- Power selling price: 120 \$/MWh
- Life time: 60 years
- Construction time: 60 months

**Desalination Plant**

- Water selling price: 1.9 \$/m<sup>3</sup>
- Life time: 20 years
- Construction time: 60 months

**Debt**

- % Debt (% of hard costs): 40%
- Interest rate: 4%
- Loan duration: 20 years

**Equity**

- Expected return: 6%

**Depreciation**

- Schedule length: 20 years

**Tax Rate**

- Price Escalation: 3.0%
- Annual fuel real escalation: 3.0%
- Selling price escalation: 3.0%

**RESULTS**

POWER COST (\$/MWh)	67.4
WATER COST (\$/m <sup>3</sup> )	0.79

**Levelized Capital costs**

Overnight EPC	0.34
Other	0.29

**Operating costs**

Energy	0.05
O&M	0.23
Transport	0.23
More cost details	0.00

**Life cycle details**

Lifecycle Emissions	106 MWh/yr
Thermal Utilization	25%
Power to Water Ratio	3.7 MWh/m <sup>3</sup>

**FLOW DIAGRAM**

Process flow diagram showing a power plant (1800 MWt) connected to a desalination plant (1200 MWt) via a steam cycle. The desalination plant includes a Reverse Osmosis unit (42% efficiency) and a Water Capacity of 20000 m<sup>3</sup>/day. The diagram also shows a Backup Heat source (450 MWt) and a Water Transport unit (139 ppm).

Desalination Economic Evaluation Programme - NPTDS



# DE-TOP

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

## DE-TOP

Desalination Thermodynamic Optimization Program

**Step 1**  
POWER PLANT

Define the power plant (fossil fuel power plants or water cooled reactors) from user values or predefined cases.

Define power plant

**Step 2**  
NON ELECTRIC APPLICATIONS

Define the non electric applications (e.g. desalination, district heating) from user values or predefined cases.

Define Non-Electric Applications

**DE-TOP POWER AND DESALINATION**

Non-Electric Applications

Power plant simulation | Coupling configuration | Home

MAIN PARAMETERS	DUAL PURPOSE	SINGLE PURPOSE	
Gross Efficiency	49.9%	49.9%	%
Net Efficiency	47.4%	47.4%	%
<b>THERMAL UTILIZATION</b>	<b>47.4%</b>	<b>47.4%</b>	<b>%</b>
Heat rate	7,201	7,201	BTU/KWH
<b>HEAT RATE</b>	<b>7,598</b>	<b>7,598</b>	<b>KJ/KWH</b>

PLANT PERFORMANCE PARAMETERS	DUAL PURPOSE	SINGLE PURPOSE	
<b>HEAT INPUT</b>			
Heat input steam generator	1,032,750	1,032,750	MW(H)
Heat input reheater (Nuclear)	265	265	MW(H)
Heat input reheater (fossil)	-	-	MW(H)
<b>GROSS POWER OUTPUT</b>	<b>515.1</b>	<b>515.1</b>	<b>MW(e)</b>
High pressure turbine output	154.2	154.2	MW
Low pressure turbine output	371.4	371.4	MW
Total Mechanical Output	525.6	525.6	MW
<b>AUXILIARY LOADS</b>	<b>25.8</b>	<b>25.8</b>	<b>MW(e)</b>
Feedwater pump	12.1	12.1	MW
Condensate water pump	0.4	0.4	MW
Cooling water pump	2.9	2.9	MW
Other auxiliary loads	10.4	10.4	MW
<b>NET OUTPUT</b>	<b>489.3</b>	<b>489.3</b>	<b>MW(e)</b>
<b>HEAT REJECTED CONDENSER</b>	<b>507</b>	<b>507</b>	<b>MW(th)</b>

MASS BALANCE	DUAL PURPOSE	SINGLE PURPOSE	
<b>LIVE STEAM FLOW</b>	<b>491.9</b>	<b>491.9</b>	<b>kg/s</b>
Live steam to reheater	101.4	101.4	kg/s
<b>Steam inlet to High Pressure Turbine</b>	<b>390.6</b>	<b>390.6</b>	<b>kg/s</b>
High Pressure turbine exhaust	277.2	277.2	kg/s
Moisture separator condensate	(39.0)	(39.0)	kg/s
<b>Steam inlet to Low Pressure turbine</b>	<b>316.2</b>	<b>316.2</b>	<b>kg/s</b>
Low Pressure turbine exhaust	234.7	234.7	kg/s

**COUPLED DESALINATION PLANT**

DESALINATION TECHNOLOGY	MED TVC	WATER PRODUCTION
Max brine Temperature	115 °C	
TDS	20 ppm	
GOR	51.2 [-]	<b>0 m3/day</b>
Number of Stages	32 [-]	
Cooling water temperature	23 °C	
DESALINATION PLANT CONSUMPTION		TOTAL POWER REQUIREMENTS
Heat to desalination	- MW(th)	
Power lost due to extraction	- MW(e)	<b>6.1 MW(e)</b>
Desal. electric cons.	- MW(e)	
Total specific cons.	6.12 kWh(e)/m3	
INTERMEDIATE LOOP		POWER LOST RATIO
IL hot temperature	125.5 °C	
IL condenser return temp	117.5 °C	<b>#DIV/0!</b>
IL mass flow	- kg/s	
IL pumping power	- MW(e)	

## Desalination Thermodynamic Optimization - NPTDS

# WAMP

estimates water needs in NPPs especially for WCRs

The screenshot shows the WAMP software interface. On the left, a sidebar contains 'RESULTS' with 'WATER USE' (Withdrawal: 2.93, Consumption: 2.67 m<sup>3</sup>/MWh), 'COSTS' (Capital: 110.0 M\$, Operating: 7.7 M\$/yr), and 'ENVIRONMENTAL IMPACT' (Visual impact, Impingement, Plume, Thermal pollution, Air pollution). Below is 'MODIFY PARAMETERS' for Power Plant (990 MWe), Ambient Conditions (Air Temp: 30°C, Humidity: 20%, Inlet water Temp: 15°C, Wind Speed: 3 m/s), and Cooling System (Cycle of Concentration: 10). The main area shows 'SELECT COOLING SYSTEM' set to 'Hybrid - Plume abatement'. A diagram illustrates a steam turbine connected to a condenser (2001 MW heat rejected) which is cooled by a cooling tower. The condenser inlet water is at 38°C and outlet is at 32°C. The cooling tower inlet air is at 22°C and outlet is at 38°C. Water flow rates are 0.07 m<sup>3</sup>/s and 0.8 m<sup>3</sup>/s. A bar chart at the bottom shows water requirements in m<sup>3</sup>/MWh, with a legend for Evaporated, Drift, and Discharge.

**Water Management Program - NPTDS**

# Nuclear Hydrogen Production Toolkit - NPTDS



The screenshot shows the IAEA Nuclear Hydrogen Production Toolkit website. At the top left is the IAEA logo and the text 'IAEA International Atomic Energy Agency'. To the right is the title 'Toolkit on Nuclear Hydrogen Production'. Below the title is a 'CONTENTS' section with a list of links: 'HYDROGEN PRODUCTION AND NUCLEAR ENERGY', 'HYDROGEN PRODUCTION AND ENVIRONMENT', 'IAEA ACTIVITIES ON NUCLEAR HYDROGEN PRODUCTION', 'IAEA PUBLICATIONS ON NUCLEAR HYDROGEN PRODUCTION', 'HYDROGEN PRODUCTION USING CURRENT DAY TECHNOLOGY', and 'HYDROGEN PRODUCTION USING FUTURE TECHNOLOGIES'. On the left side, there is a sidebar with a 'Click on the links to access the relevant information.' instruction and a 'Contact' section with the following details: 'Division of Nuclear Power', 'Department of Nuclear Energy', 'IAEA Vienna International Centre', 'P.O. Box 100', 'A-1400 Vienna, Austria', 'Tel : +43 1 2600 22751', 'Fax: +43 1 2600 29598', 'Ibrahim Khamis', and 'Email: [I.Khamis@iaea.org](mailto:I.Khamis@iaea.org)'. At the bottom of the main content area, there is a 'LATEST NEWS' link. The background of the website features an image of a nuclear power plant.

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

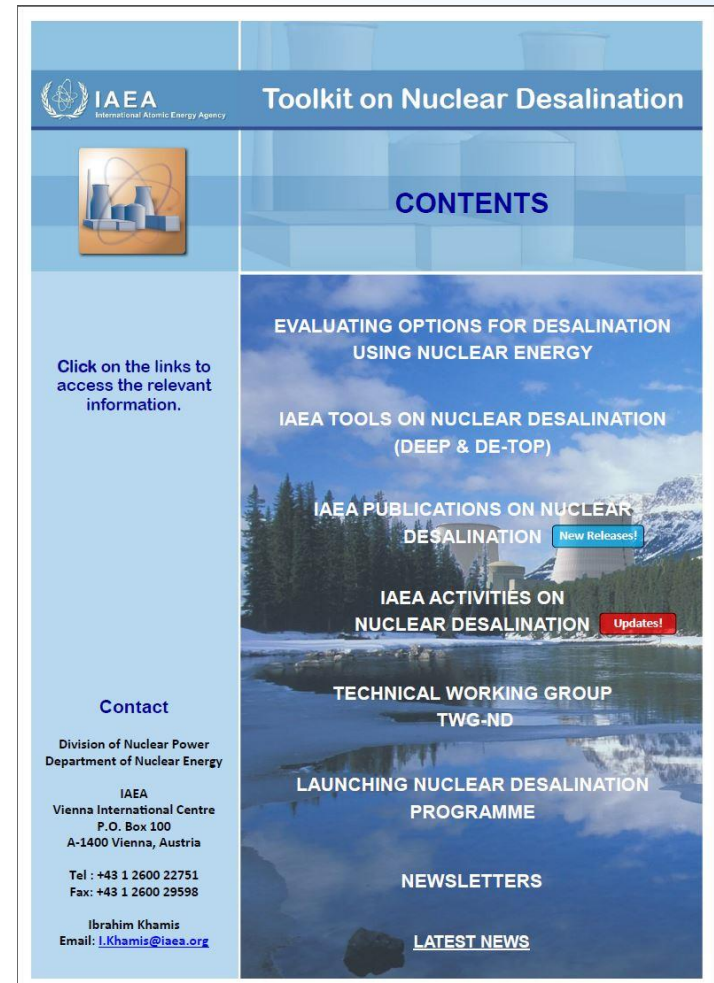
**Update/Release in Jan. 2017**



# Nuclear Desalination Toolkit - NPTDS

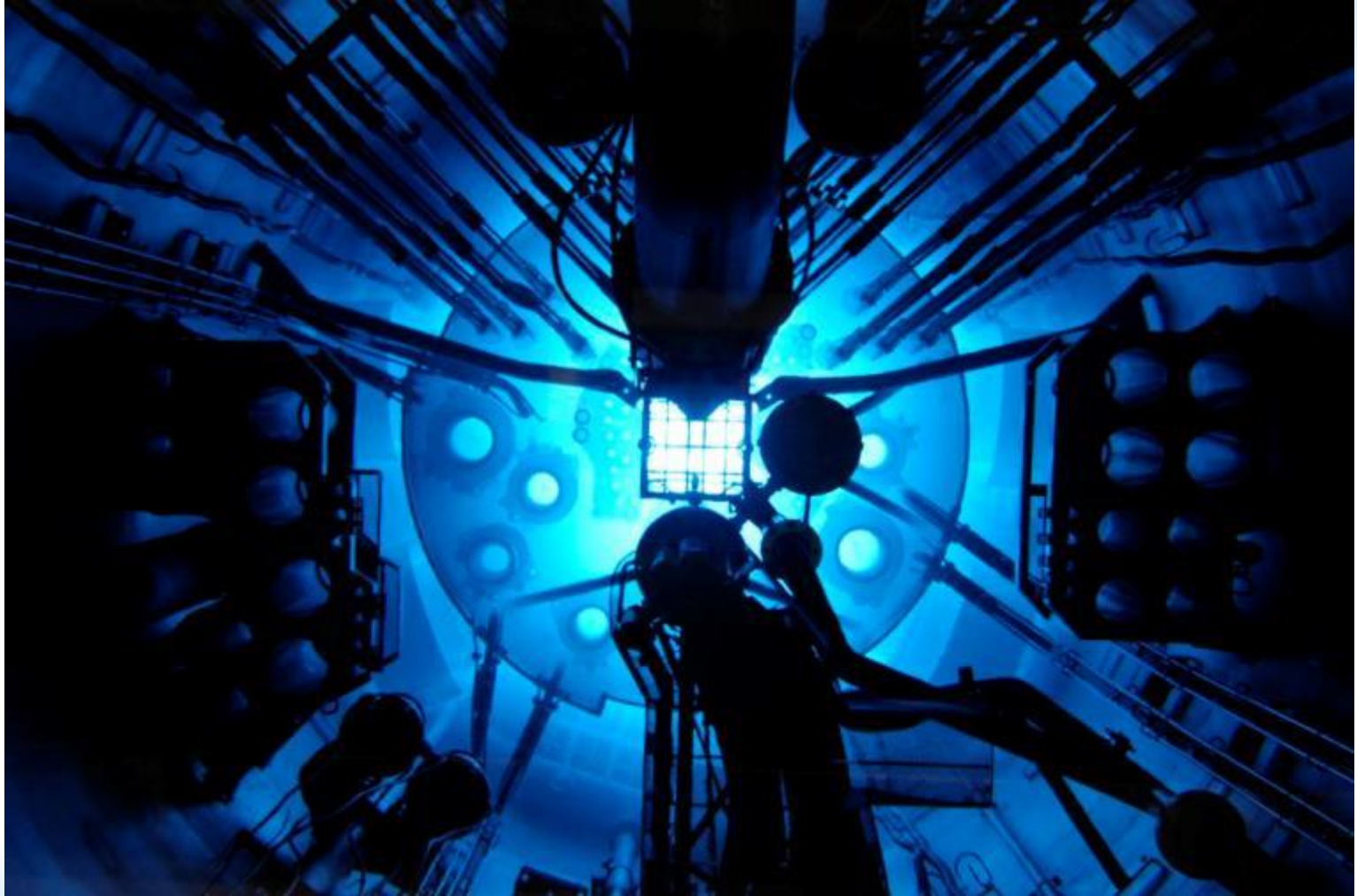
- Up-to-date information
- Link to IAEA tools
- Highlights of IAEA Publications
- News on IAEA Activities
- Summaries of the TWG-ND
- Newsletter on nuclear desalination

**Update/Release in Jan. 2017**



The screenshot shows the IAEA Toolkit on Nuclear Desalination website. The header includes the IAEA logo and the text "IAEA International Atomic Energy Agency" and "Toolkit on Nuclear Desalination". Below the header is a navigation menu with "CONTENTS" highlighted. The main content area features a large image of a nuclear power plant with a lake in the foreground. Overlaid on this image are several text boxes: "EVALUATING OPTIONS FOR DESALINATION USING NUCLEAR ENERGY", "IAEA TOOLS ON NUCLEAR DESALINATION (DEEP & DE-TOP)", "IAEA PUBLICATIONS ON NUCLEAR DESALINATION" with a "New Releases!" button, and "IAEA ACTIVITIES ON NUCLEAR DESALINATION" with an "Updates!" button. Below the image is the "TECHNICAL WORKING GROUP TWG-ND" section, followed by "LAUNCHING NUCLEAR DESALINATION PROGRAMME", "NEWSLETTERS", and "LATEST NEWS". On the left side of the page, there is a "Contact" section with the following information: "Division of Nuclear Power, Department of Nuclear Energy, IAEA, Vienna International Centre, P.O. Box 100, A-1400 Vienna, Austria, Tel: +43 1 2600 22751, Fax: +43 1 2600 29598, Ibrahim Khamis, Email: [I.Khamis@iaea.org](mailto:I.Khamis@iaea.org)".

# Research reactors



# “Internet Reactor”





# 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**



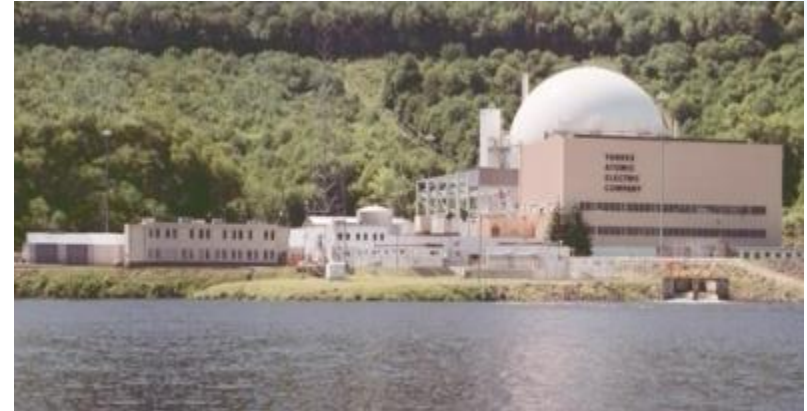


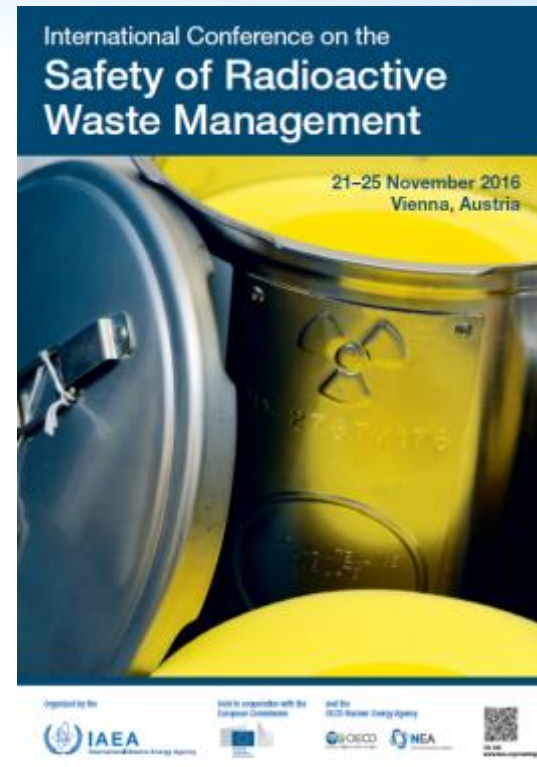
# Decommissioning & Environmental Remediation

## Yankee Rowe NPP



**Maine Yankee being dismantled, USA**





- **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

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***Thank you!***



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