# ALFRED:
# Current Status and
# Future Developments in Romania

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# *Nuclear Fission Power*

## Benefits

- ***Nuclear is a CO2-free option for sustainable energy***
- ***Stability and security of supply***
- ***Use of natural resources (U, Th) without other major utilisation***
- ***Competitive and affordable energy price***
- ***Technology incorporating high added value (knowledge, efficiency, complexity)***

## Challanges

- ***Public perception:***
  - ***risks associated with major events (see TMI, Cernobil, Fukushima)***
- ***Complexity of technology – strong requirements for HR policies***
- ***Radioactive Wastes Management – building a solution for long term governance and inter-generation ethics***
- ***Non-proliferation issues***

# *National Strategy*

- 35-40% nuclear energy in total electricity production

- Short and mid term: focused on CANDU technology

- Mid term objective: completion of Cernavoda NPP, by U3&4

- Long term (2050): adding/replacement of the units after End of Life with new NPP based on new developed technologies

- 2050, expected availability of GenIV comercial systems

- need for modern technologies imposed by criteria of sustainable development

## I. National Current Context

CANDU technology:
- Fuel production;
- Heavy water production
- RWM: LILW Repository-2019, Geological Disposal -2050
- Nuclear Safety
- Nuclear Equipment, Testing

## II. Expected

Possible changes by GenIV (ALFRED objectives and new NPP)

# *GEN IV systems: towards sustainable nuclear energy*

***Sharing R&D in an international frame:***

- ***GIF (evaluation of the concepts), 2002***
- ***INPRO (forum of technology holders & technology users to build collaborative approach and strategical investigation)***
- ***European R&D***

***Systems available on the market after 2030-2040: SFR, LFR, GFR***

***Search innovative solutions for:***

Natural resources conservation
Waste minimization
Proliferation resistance

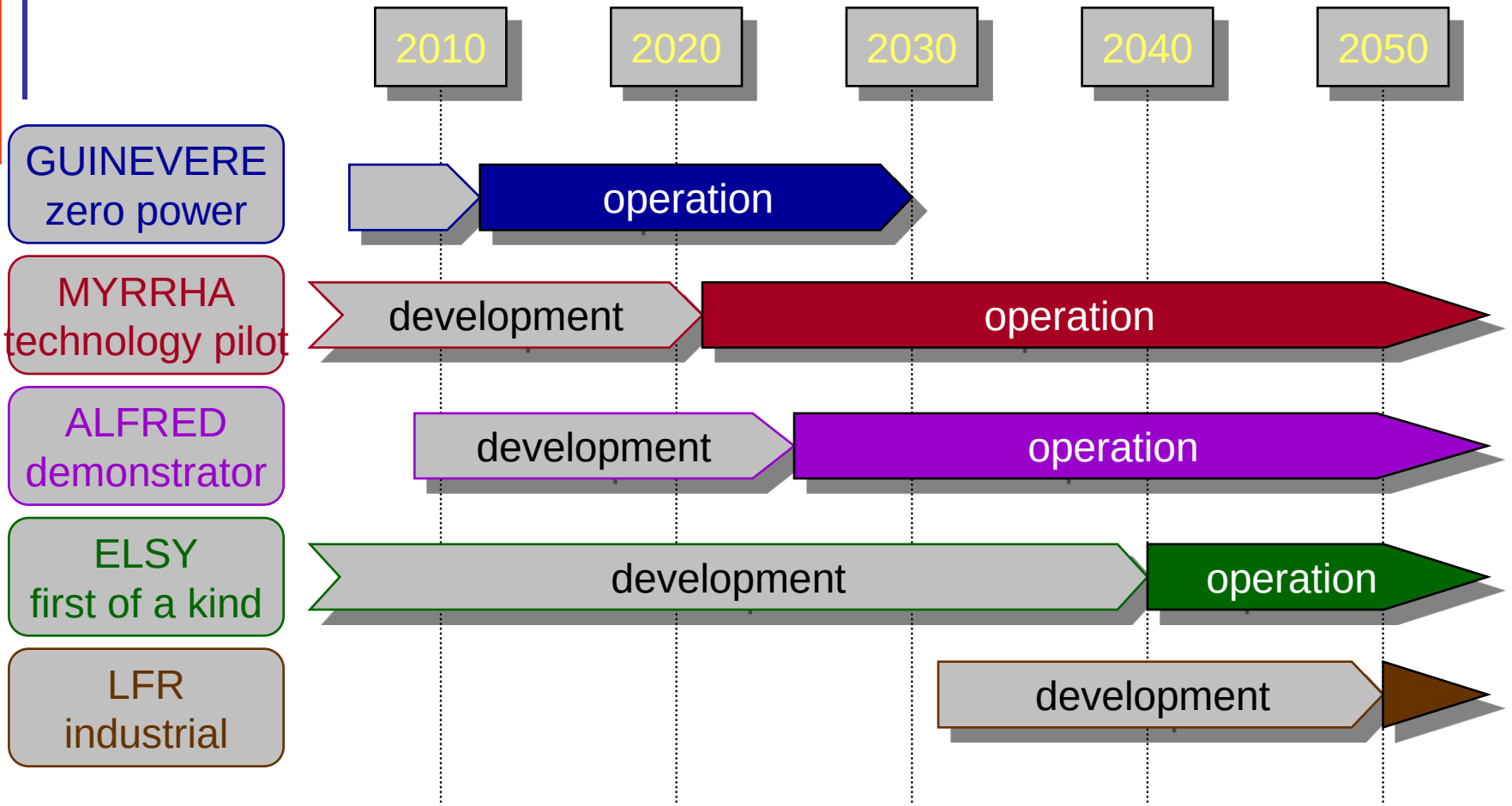
***Perform continuous progress on***:

Competitiveness
Safety and reliability

***Develop the potential for new applications:***

Hydrogen, desalinated water, high temperature applications, synthetic-fuels

# LFR Roadmap

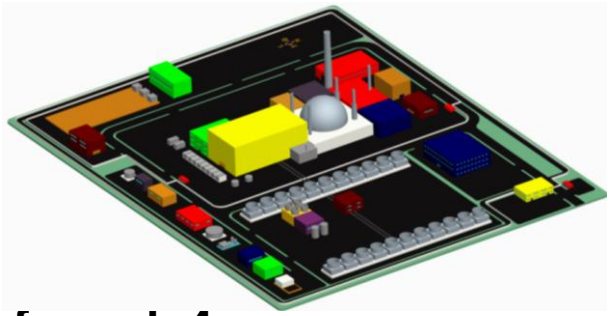

2010
2020
2030
2040
2050
GUINEVERE
zero power
operation
MYRRHA
technology pilot
development
operation
ALFRED
demonstrator
development
operation
ELSY
first of a kind
development
operation
LFR
industrial
development

# *ALFRED*

ALFRED = **European Lead Fast Reactor Demonstrator**

**Thermal power =300 MWth; Electrical power ~120 Mwe**

**Fuel type: MOX**



- **Grid connection: yes**
- **Coolant: pure lead**
- **Primary: pool type**
- **Primary coolant circulation (at power): forced, 4 pumps**
- **Core inlet temperature: 400$^0$C; Core outlet temperature: 480$^0$C**
- **Maximum temperature on fuel cladding: 600$^0$C**
- **Steam generators: 4, integrated in the main vessel**
- **Reactor vessel: cylindric**
- **Seismic design: 2D isolators supporting the reactor building**
- **Internals: removable**
- **Removal of residual heat: passive systems**

# *INR General Presentation*

INR- founded in 1971 as institute for nuclear technologies, including the design, manufacturing and testing Romanian nuclear fuel for CANDU NPP.

Infrastructure:

Research Reactors (TRIGA SSR and TRIGA ACPR)

PIE Laboratory

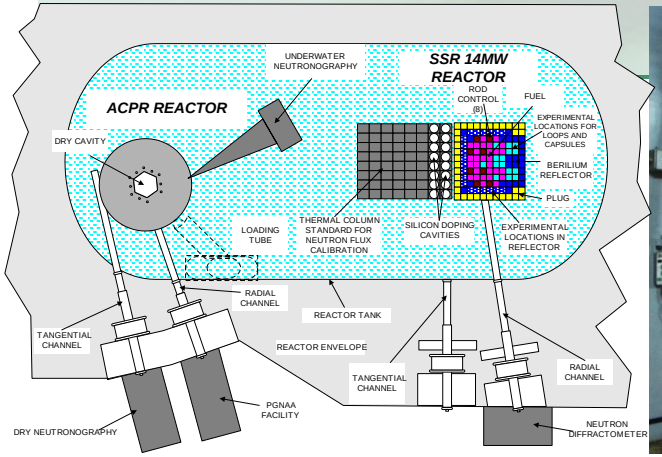
Material Testing and Nuclear Fuel Fabrication

Radioactive Waste Treatment Laboratories

Out-of-Pile Testing Laboratories

People:

Total 655 - Nuclear scientists/Engineers: 235, Technical staff: 300, Adm: 120




# *INR R&D Programmes*

INR – TSO for Cernavoda NPP (PHWR CANDU Technology)
INR - technologies, methods, computer codes, its own experimental infrastructure, directed towards an end-product or service for NPP applications

***Current Research Programmes:***

- **Reactor Physics and Nuclear Safety**
- **Fuel Channel**
- **Nuclear Fuels**
- **Fuel Handling System**
- **Radioactive Waste Management**
- **Radiation and Environmental Protection**
- **Steam Generator**
- **Nuclear equipment and process systems**
- **Circuit's Chemistry**
- **Instrumentation and Control**
- **Plant Life Management**
- **Advanced Reactors**
- **TRIGA Reactors- Improving of the Performances**
- **Radioisotopes and Irradiation Technologies**
- **Informatics**
- **Nuclear applications**
- **Heavy Water and Tritium**
- **Support for international cooperation**

**INR Current Priorities: S&T support for NPP, Gen IV, Safety, RWM, E&T**

# *INR Involvment in GenIV*

(1) Before 1991: Fast reactors R&D activities : national programme for FBR & collaboration with IFE Obninsk and other institutes from eastern-block (SFR: BN1600; PRISM; sodium small loop)

(2) Participation in Euratom FP6-7 projects: ELSY; LEADER; ADRIANA; MATTER, SEARCH; (&MAXSIMA), mainly oriented to LFR

| | |
|---|---|
| **ELSY**<br>2006-2010 | **"European Lead System"**<br>Neutronic Core Design and Shielding<br>Coordinator for "Reactor Shielding Design for selected core" |
| **LEADER**<br>2010-2013 | **"Lead Demonstrator European Reactor"**<br>**Core design**<br>**Plant Operation, instrumentation, control and protection system design**<br>**Reference Design Objectives and Specification**<br>**Coord. for DPA and radiological protection for LFR and ETPP & Instrumentation Specifications** |

ADRIANA
ADvanced Reactor Initiative And Network Arrangement

Identification of facilities for GenIV development and needs for new facilities.

# *INR Involvment in GenIV*

**MATTER**

2011-2014

**"MATerials TEsting and Rules"** Task12.1 -Refractory alloys assessment for Generation IV reactors
Task 12.2 -Ceramics and composites assessment for Generation IV reactors

**SEARCH**

**2011-2014**

**"Safe ExploitAtion Related CHemistry for HLM reactors"**
to support the licensing process of MYRRHA by investigating the safe chemical behaviour of the fuel and coolant in the reactor.
INR: Increase the experience in filtering technique

(3) Participation in IAEA-INPRO project: INPRO-Synergies "Dynamic modelling of nuclear energy systems"

(4) Activities performed in the frame of National R&D Programme

# *Hosting ALFRED – Some steps of decision*

- **February 2011 – Romanian Government approved the Memorandum of Ministry of Economy for the Romanian option to host ALFRED; Memorandum was initiated by INR; INR contributed to the national debate on the issue;**

- **Research Agreement SCK-INR (2009) and support for MYHRRA and ALFRED (2011)**

- **February 2012 – MoU (Ansaldo, ENEA, INR) for ALFRED consortium construction**

**April 2012 – Working groups of MoU:**

**WG1-Roadmap;**

**WG2-Costs;**

**WG3 –Funding mechanisms**

- **May 2012 – INR became member of ESNII**

- **Support for ESNII technologies Horizon 2020 funding**

2012 – key decision – **ranking of SFR, LFR and GFR** technologies, ESNII level

-Infrastructure planned development

- 2 lead loops:

-small loop for material testing (corrosion);

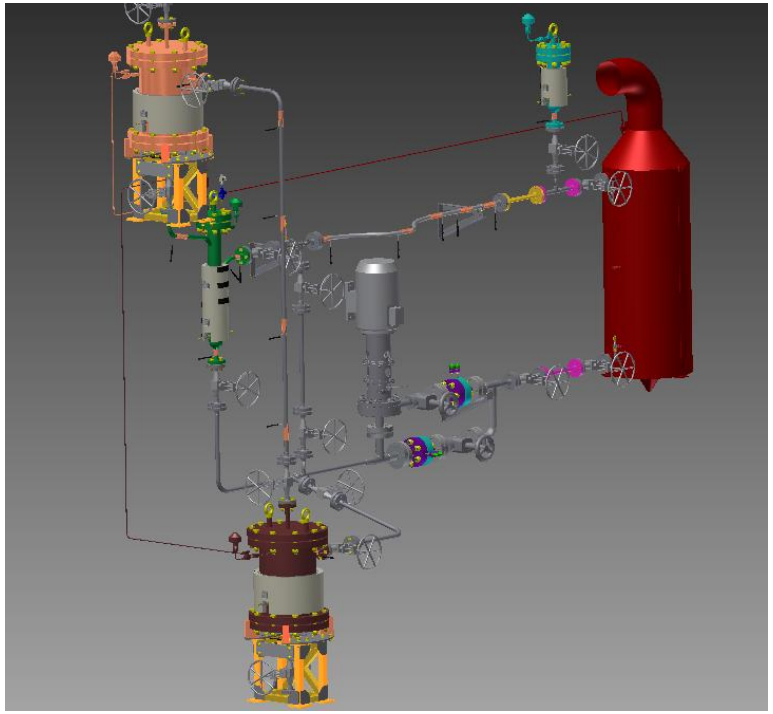
-full scale pump testing loop

ADRIANA – Del.8.4 ***Roadmap proposal for building knowledge and facilities needed for nuclear energy systems development***

-HLM Pump Test Loop

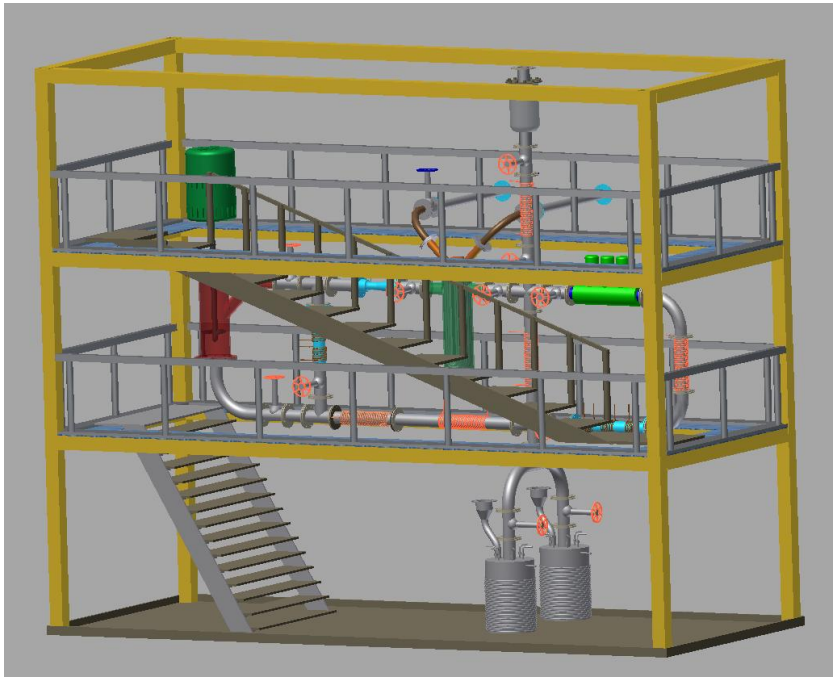
- End 2014

- Hydraulic performances endurance and reliability of Lead pumps



Material Testing Loop

- Detailed design in progress
- 2013 construction



Pump Loop

- Conceptual design in progress
- 2013 Basic design and detailed design
- 2014 Start of construction

# *INR R&D for GenIV*

Contribution of national programmes for LFR activities:

2012 - increase with 1 mil Euro R&D GenIV support

Purpose:

- preparatory activities for ALFRED hosting (formation of appropriate personnel for licensing, operating, safety analysis, etc.) – around 100 newcomers intended to be trained for LFR technology in the next 10 years
- lead technology assimilation;
- analyse of the impact of new technology on waste management, regulations and control, non-proliferation issues, etc.
- selection of appropriate computer codes and databases for phenomena simulation
- materials testing and development
- lead chemistry
- safety analysis

# *GenIV - INR R&D in national programmes*

Some specific studies:
- mechanical properties of austenitic and marthensitic steels, tantal and niobium alloys
- investigations on candidate materials for fuel cladding and SG tubes
- corrosion in lead environment
- methods for Po separation
- methods for thermal& mechanical testing of materials and components
- CFD methodology for LFR investigations
- Design of corrosion loops
- PSA for LFR
- methodology for isotopic inventory calculation
- DPA calculation
- impact of lead on radioactive waste management
- impact of ALFRED on geological disposal

# *ALFRED: current status and immediate actions*

- Investigation for the site & the influences on costs: 2012

- National licensing LFR specific framework

- Cost evaluation; review/update the details

- Identification of structural/cohesion fund scheme; lobby at national level to include ALFRED on the priority list

- Roadmap for construction of the consortium

- Public participation in decision making process

- National participation: expected national contribution to ALFRED funds: ~ 200 mil. Euro

# *Conclusions*

(1) Policy vision: country access to innovative technologies to support sustainable development

(2) Suitable national infrastructure to host ALFRED

(3) National determination to contribute to Gen IV R&D efforts and promotion at EU level

(4) National determination to invest effort for LFR development

*Thank you for your attention!*