ITALIAN NATIONAL AGENCY FOR NEW TECHNOLOGIES, ENERGY AND SUSTAINABLE ECONOMIC DEVELOPMENT

Italian national R&D on nuclear fission

P.Agostini ENEA

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National frame

- In 2011, after Fukushima accident, Italy decided to cancel the nuclear option for energy production.
- Since then, the nuclear fission activities were reduced and are now limited to:
  1. Safety studies related to NPP located in other European countries close to our borders,
  2. Waste management activities
  3. Decommissioning of old reactors
  4. **Research and Development in support to nuclear of the future. Namely GEN IV**

The GEN IV R&D is focused on Lead Fast Reactor and is supported by the government .

Yearly budget dedicated to R&D Fission activities

- An R&D program agreement (called AdP) and funded by electricity revenues, was stipulated by ENEA/Universities and the Italian Ministry of Economic Development, to grant a yearly budget of about **3 Meuro**
- The yearly budget is managed by ENEA and mostly dedicated to the development of Lead Fast Reactors technology. Nuclear safety at large is also dealt with.
- The expenditures and the goals achievement are yearly revised by an external group of experts. The R&D results are public.
- The yearly in-kind contribution of ENEA to «AdP» objectives is about 80 researchers; the Universities contribution is about 20 researchers.

Besides the AdP agreement, other funding sources contribute to the R&D of Lead Fast Reactor:

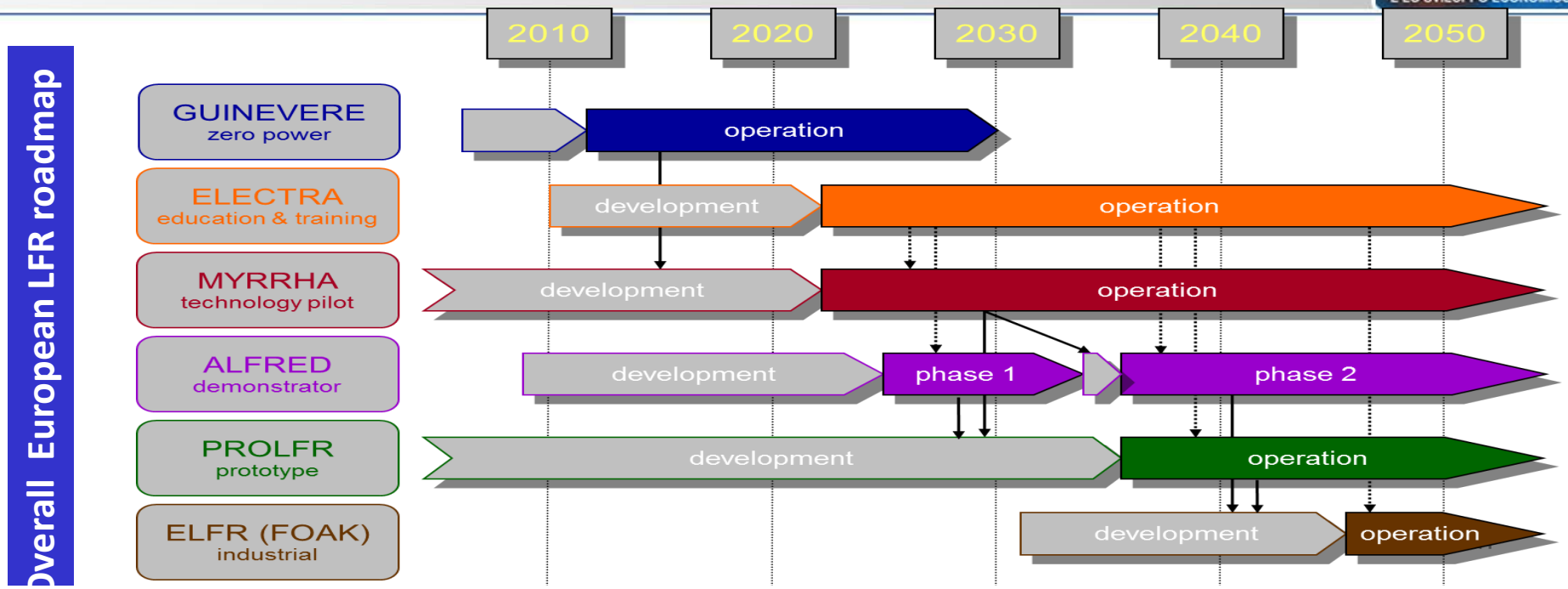
- E. U. Euratom Projects assuring a yearly budget of **1.5 Meuro**
- Commercial activities in Fission assuring about **0.5 Meuro/year**

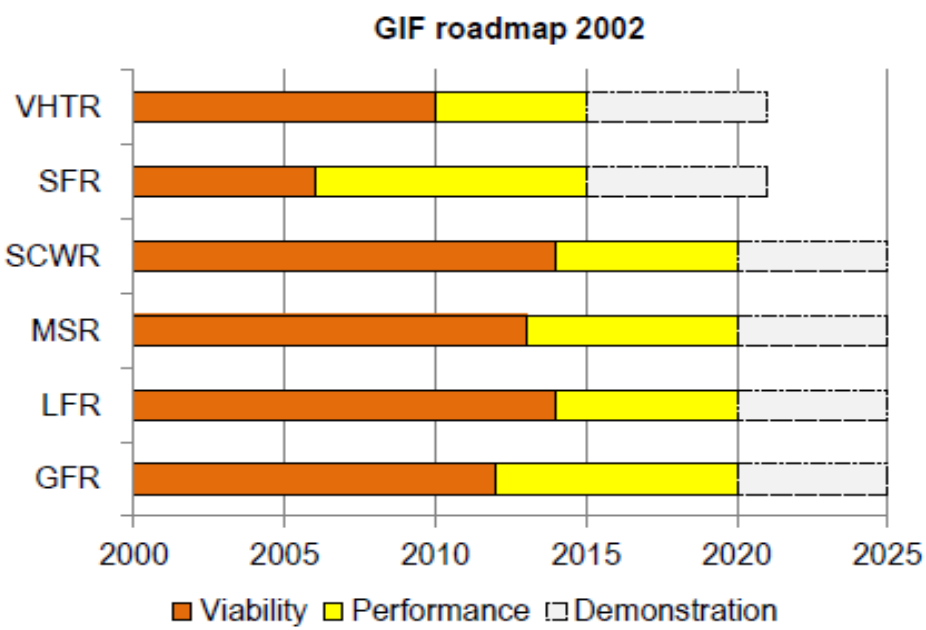
Total yearly budget dedicated to Fission R&D, comprehensive of menpower is **15 Meuro**.

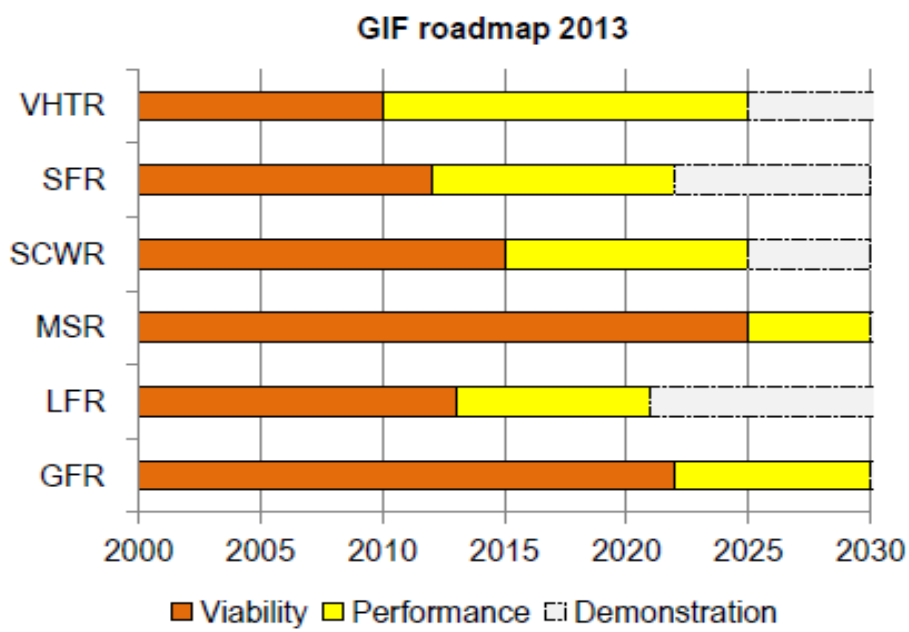
IEA Energy RD&D Budget up to 2011. Update since 2012 to 2015 including Fission and Fusion

NUCLEAR FISSION RESEARCH BUDGETS in million USD											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Italy	60	49	49	42	55	61	54	16 + 28	17 + 29	17 + 29	16+29

European roadmap of LFR and GIF roadmap







ALFRED: From Conceptual Design to Implementation

2011 – Romanian option

Romanian Government approved the Memorandum "Option to host ALFRED demonstrator", initiated by Ministry of Economy, Trade and Business Environment

2012 – MoU

Ansaldo, ICN, and ENEA signed the MoU for ALFRED

2013 Alfred Consortium: FALCON

Consortium Agreement signed on December 18 2013: Ansaldo, INR, ENEA. Other organizations ready to sign a MoA based on technology development

2014 Signature by CV-Rez of FALCON

Phase 1

FALCON, 30 months, in-kind contributions, to optimize the cooperation among the PARTIES through strategic, management, governance, financial and technical work

Phase 2

Detailed Agreement to manage R&D, design, licensing and to commit the building of ALFRED

ALFRED financing scheme by MS

Total cost of ALFRED comprehensive of viability+ preparation (661), construction (1052) is estimated as **1713Meuro**

Viability and Preparation phases:

Italy: about 2 M€/year, already financed since 2006 and agreed to be financed until 2017

Romania: 5 M€, already financed since 2010 from the public budget, plus 50M€ agreed to be financed until 2020 (based on the Governmental Memorandum);

Czech Republic: 17 M€, already financed

Construction phase:

Italy: 150 M€, agreed to be financed (Pu supply)

Romania: 150 M€ agreed to be financed (Governmental Memorandum)

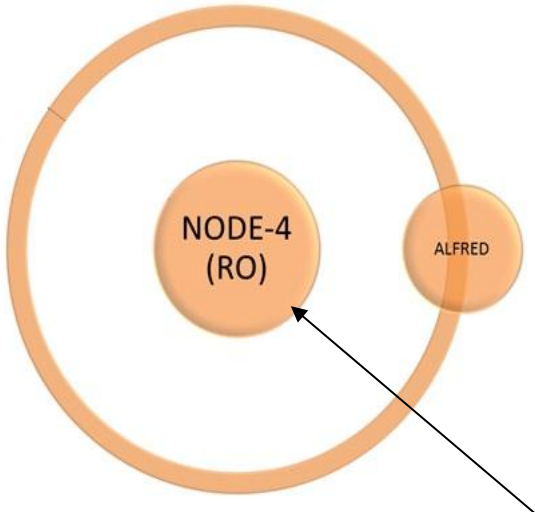
Operational phase:

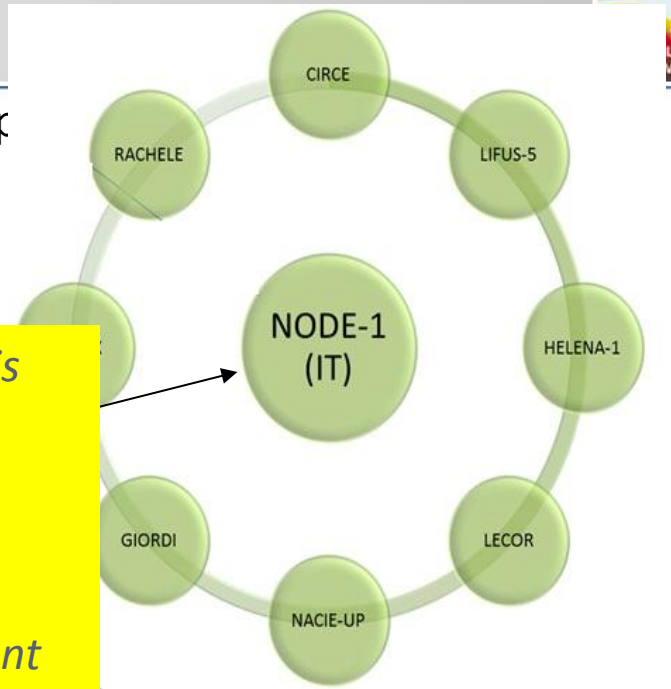
Italy, Czech Republic and Romania: agreed to cover from national programs 100% of 92 M€, inclusive of transnational access to facilities

Member states	Private contrib.	EU regional funds	Total
524	334	855	1713
30%	20%	50%	

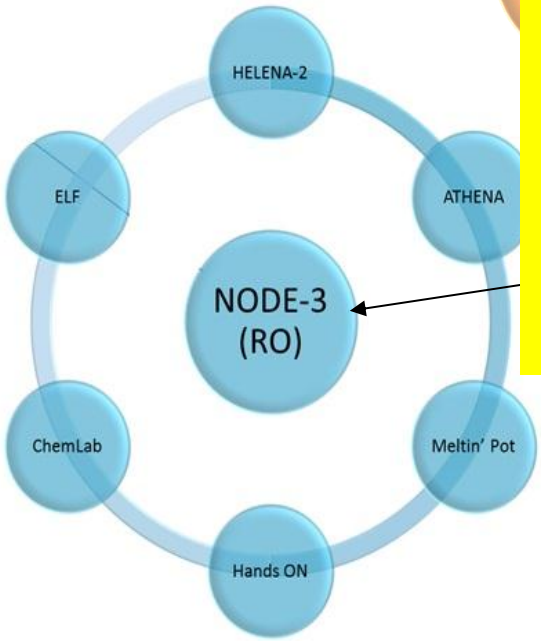
iCRADLE proposal to ESFRI: an example of Synergies

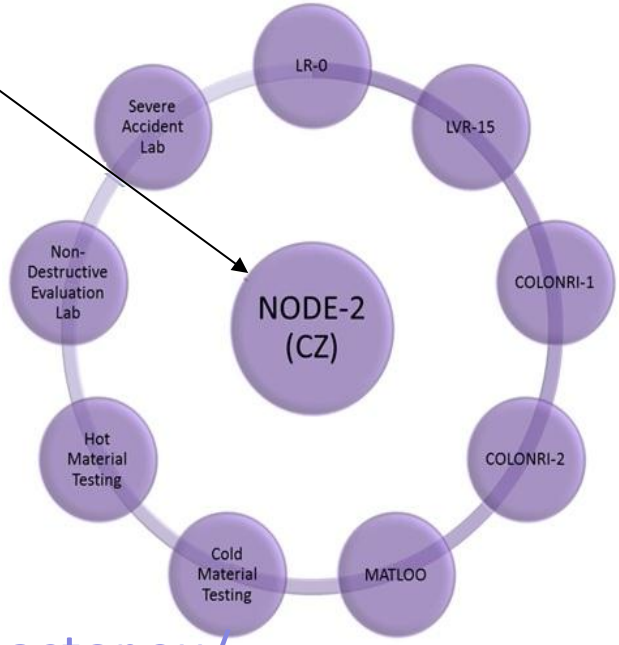
Infrastructure for Cooperative Research to Advance up





"The iCRADLE proposal is meant to provide Europe with a ***Distributed Research Infrastructure (D-RI)*** *for research, development and qualification of the Heavy Liquid Metal (HLM) technology for innovative nuclear reactors demonstration and, in a longer term, the safe and sustainable operation of future power plants."*





http://www.alfred-reactor.eu/

Contents of the AdP national programme

Core design

- Neutron computations and experiments to support the LFR reactor development
- ERANOS code implementation for perturbation and sensitivity analyses in non-linear field
- Characterization of new ALFRED core configuration
- Feasibility study for in-vessel storage of ALFRED
- Irradiation experiences to validate neutron codes
- Concept design of nuclear machine for validation of core design methodologies

Safety analysis

- Supporting studies to LFR nuclear fuel design
- Models validation for safety analysis of GEN IV reactors
- Experimental qualification of nuclear instrumentation
- Release and migration of fission products
- Simulation of interaction between coolant and fission products

Qualification of LFR structural materials and protective coatings

- Protective coatings qualification
- Structural materials characterization in Lead
- Development of double stabilized austenitic steels

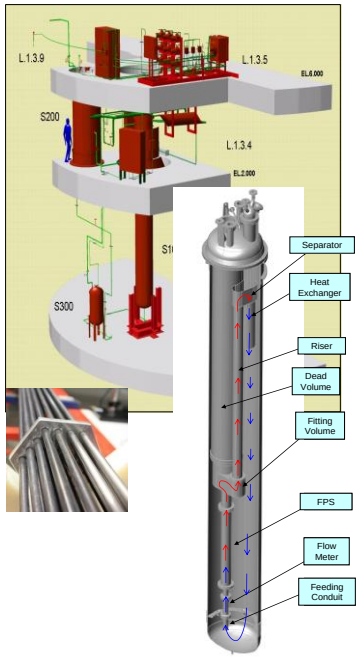
Coolant chemistry and fabrication studies

- Fuel element fabrication tests
- Implementation of coolant chemistry laboratory
- Corrosion tests in flowing lead

Testing and modelling of liquid metal thermal-hydraulics

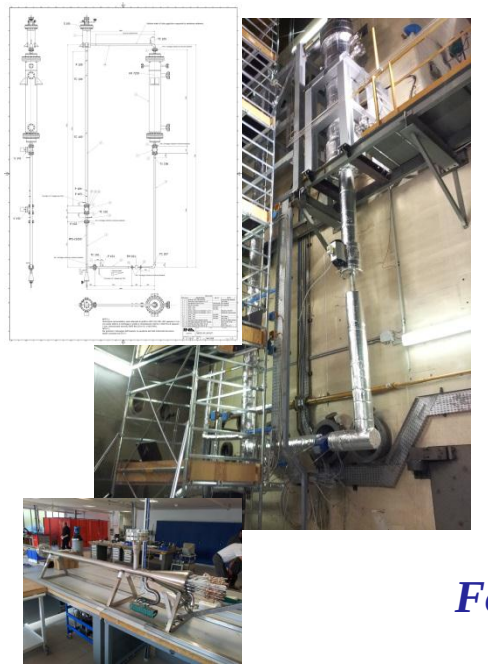
- Double tube steam generator characterization
- Large scale testing of lead –water interaction
- Monitoring and characterizing Steam Generator small water leaks
- Coupling of system code and CFX
- Studies of the coolant freezing in HLM systems

LEADING GEN. IV FACILITIES AT BRASIMONE RC (ENEA NODE)



CIRCE

90 LBE tons pool with instrumented bundle and 1to1 scale HX.
FPS power 900 kW

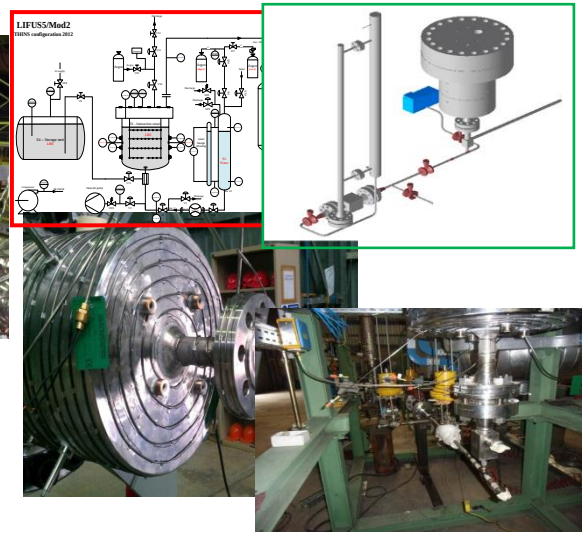


NACIE-UP

Natural/gas-lift circulation LBE loop with 19-pin instrumented **pin bundle.**

HELENA

Forced circulation Lead loop with mechanical pump, corrosion test section and valve test section



LIFUS5

Facility with several test sections to investigate ***water/LBE interaction*** and SGTR phenomena

Besides the synergies with Romania and Czech Republic, A relevant contribution is given To MYRRHA

CFD
SYS-TH
SIMMER-III and IV

⟷

Neutronic
Fuel
Coupling

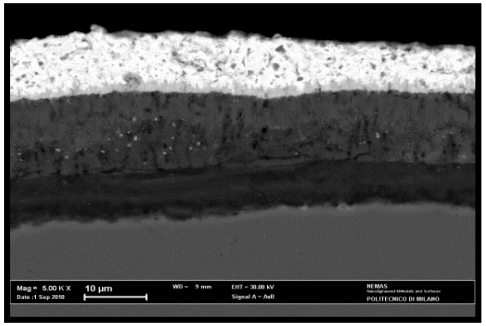
Other large and small scale exp facilities

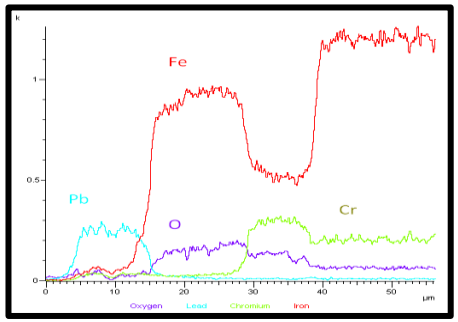
Corrosion protection by Al_2O_3

1000 hours in oxidizing liquid Pb at 600° C

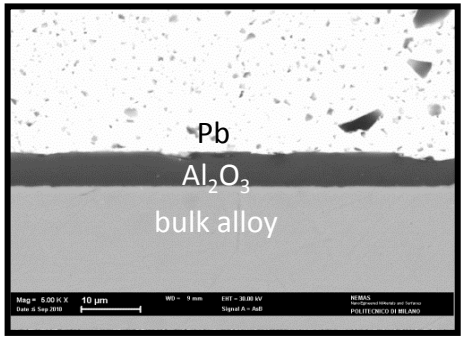
The coating shows high corrosion resistance to Pb attack
Strongly resistant to thermal cycling and to mechanical bending experiments using heavy ions showed <u>very good resistance up to 150 dpa</u>

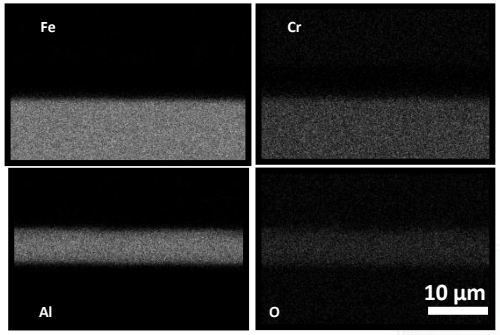
Unprotected samples → **Corrosion**





Coated samples → **Protection guaranteed**





Synergy with EERA JPNM Pilot Project Cerberus

- **CERBERUS: Corrosion ERosion BEhaviour of nucleaR materials in heavy liqUid metal coolantS**
  - Liquid Metal Corrosion (LMC) for austenitic and feritic-martensitic steels included coatings and welds and MaxPhase
  - Test procedures, data , life-predictions

Garcia Ferre et al. – Corrosion Science (2013)

Conclusions

- Fission R&D in Italy is limited to GEN IV Lead Fast Reactor by the state funded “AdP” program
- The annual support (budget + menpower) is 15 M€
- Italian nuclear actors (ENEA, Universities and ANSALDO) pursue the goal to build the ALFRED reactor in Romania.
- To this purpose the FALCON Consortium was signed together with ICN (Romania) and CVRez (Czech Republic)
- The three member states operates in synergy supporting 30% of costs while 50% will rely upon EU regional funds
- Main scientific commitments are:
  - Core design
  - Safety analysis
  - Structural materials
  - Coolant chemistry
  - Thermal hydraulics
- Additional synergies are the contributions to MYRRHA reactor and the materials cooperation in EERA JPNM

Expected outcomes by NEA roadmapping

1. Encourage the national investments in Fission R&D by a NEA sensitization towards governments
2. Strengthen the credibility of ongoing R&D towards governments and public opinion
3. Foster the international collaboration