



# **Innovative Reactor Systems and Safe Operation of Current NPPs**

*(European Research)*

**EU Science and Technology Week  
JRC – China Research Collaboration  
Shanghai, 18 June 2010**

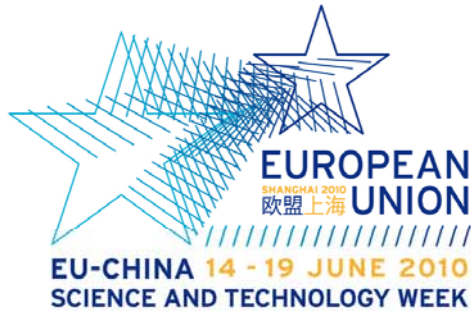
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Petten, The Netherlands**

<http://ie.jrc.ec.europa.eu>



## *Outline of the presentation*

- Nuclear Energy in the context of the European Strategic Energy Technology Plan ( SET Plan) and Sustainable Nuclear Energy Technology Platform ( SNETP)
- Euratom nuclear programme on innovative reactors and long term operation of the current NPP
- JRC research on nuclear reactor safety; Co-operation with China research institutions
- Conclusions: challenges and perspectives



## *EC position in the nuclear debate*

### Strategic Initiatives (selected):

- **March 07 Summit:** endorsement by EU27 of EC Communication “**An Energy Policy for Europe**”, including the role of nuclear energy to meet 20/20/20 targets: 20% reduction in GHG emissions; 20% reduction in energy consumption; 20% share of renewable
- **Strategic Energy Technology (SET) Plan 2007/08:**
  - Joint EU Action to develop low-carbon technologies including fission and fusion;
  - importance of continued operation of current nuclear reactors (2020 target); complete the preparation of the demonstration of GEN IV reactors (2020 target), develop in the longer-term (2050 target) more sustainable reactor technology - Gen IV



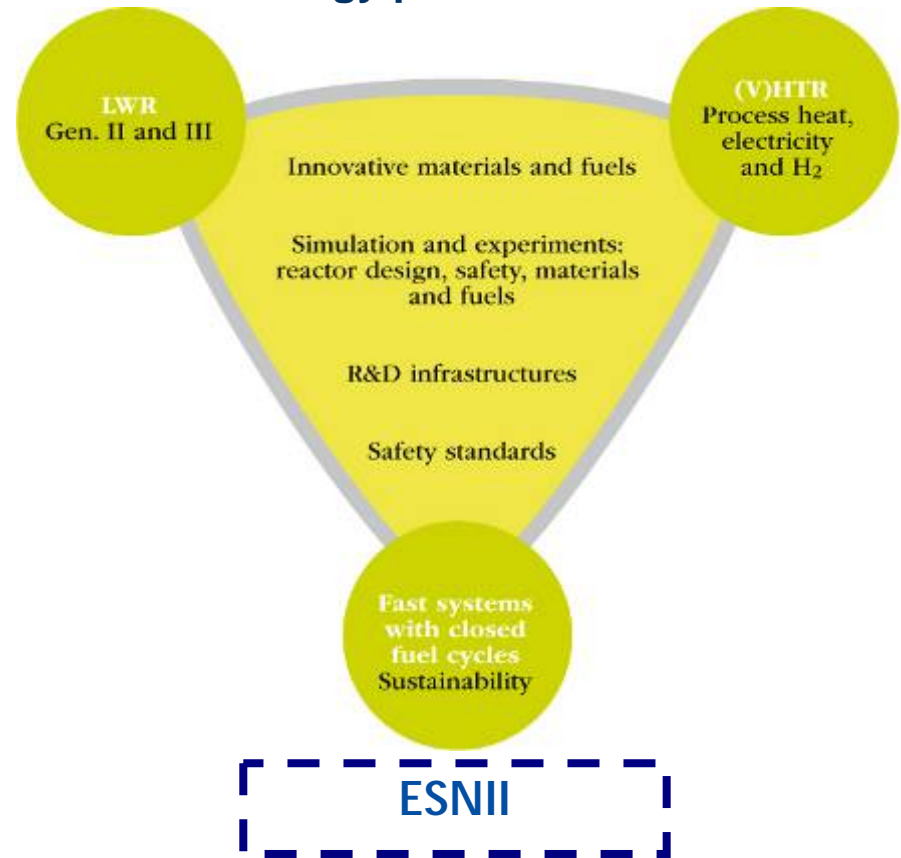
## The Sustainable Nuclear Energy TP geared to the SET-Plan objectives

- **Launched in Sept. 2007**
  - Commissioners for Research & Energy
- **Gathering EU stakeholders in the nuclear R&D sector**
  - 85 member organisations
  - industry, safety, research, ...
- **Agreed common vision**
  - Vision Report
- **Structuring nuclear fission R&D, and better aligning EU research priorities to industry's needs**
  - Strategic Research Agenda
- **Mobilising public and private funding resources**
  - Deployment Strategy – May 2010

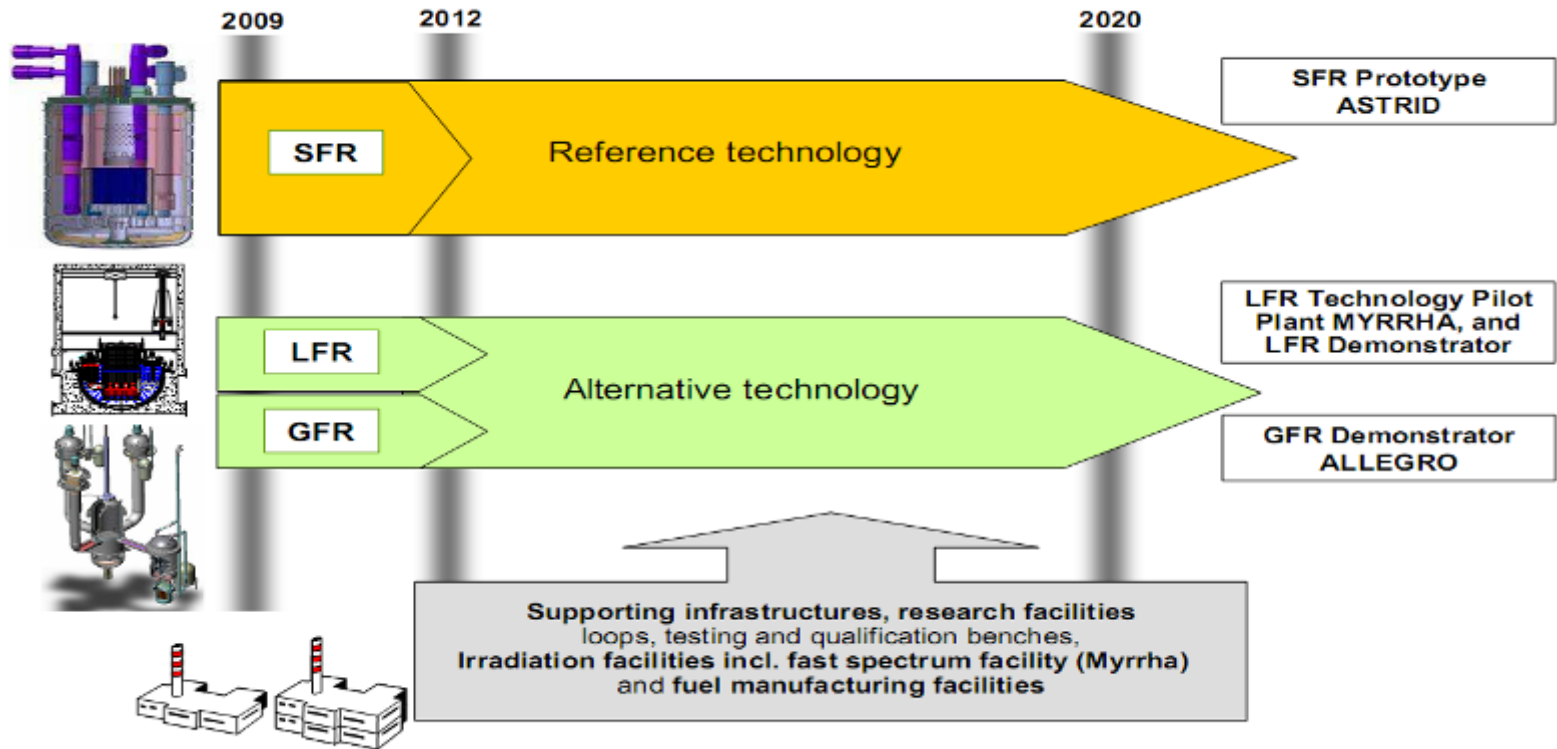


- Maintain safety and competitiveness of today's technologies
- Enlarge the nuclear fission portfolio **beyond electricity production** (H<sub>2</sub>, synthetic fuels, petrochemical/ steelmaking/ paper/ cement industries, seawater desalination, etc.)
- Develop advanced reactors with **closed cycle** to enhance sustainability

## Technology platform Three Pillars



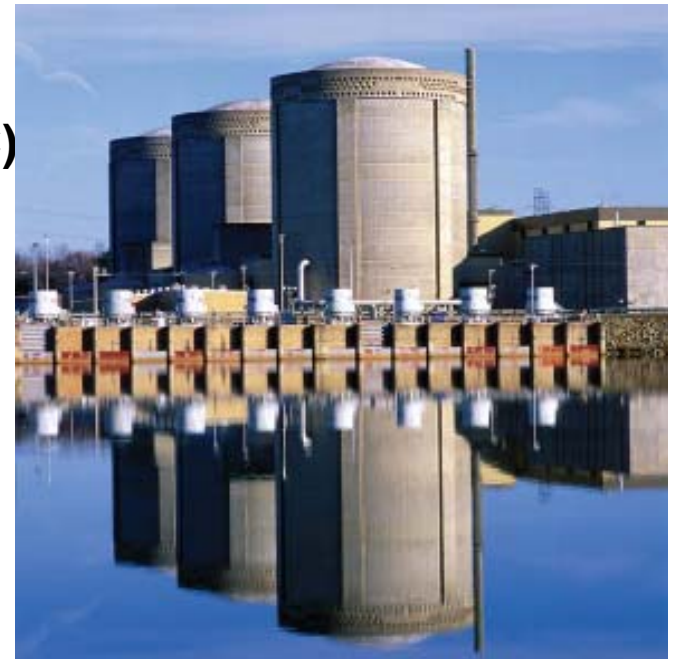
**ESNII = European Sustainable Nuclear Industrial Initiative**



## ***Nuclear research in Europe: the challenges***

### **EURATOM Programme (DG Research & JRC)**

- nuclear safety  
*(includes fuel cycle & Gen IV)***
- nuclear waste management  
*(includes basic R&D, reference data,  
environment, radiation protection)***
- nuclear security (JRC)**



***Examples from Euratom Framework Program 7 projects***

***and JRC projects on innovative nuclear reactor systems → next slides***



# European nuclear reactor research – Euratom framework program 7 projects on GEN IV



Science towards sustainability



NURISP











## European nuclear reactor research – Euratom framework program 7 projects on GEN IV



Project acronym and title	Key areas of R&D	<u>Coordinating organisation</u> & no of partners*	Start date & duration	Total budget / EU contribution
<b>CP-ESFR</b> – Collaborative Project on European Sodium-cooled Fast Reactor <a href="http://www.project-cp-esfr.eu/">http://www.project-cp-esfr.eu/</a>	Key viability and performance issues supporting development of a Gen-IV European SFR	<u>CEA (FR)</u> 26 partners (from 9 countries)	1/01/09 48 months	€11.5M / €5.8M CP
<b>LEADER</b> – Collaborative Project on European Lead-cooled Advanced Fast Reactor	Conceptual level of Lead Fast Reactor Industrial size plant of a scaled demonstrator of the LFR technology	<u>ANSALDO (IT)</u> 17 partners (from 11 countries)	Early 2010 36 months	€5.7M / 3.0M CP
<b>GoFastR</b> – Collaborative Project on European Gas-Cooled Fast Reactor	Demonstration of the viability of the GFR system and contributing to Gen-IV GFR research	<u>AMEC (UK)</u> 21 partners (from 10 countries)	Early 2010 36 months	€5.3M / €3.0M CP

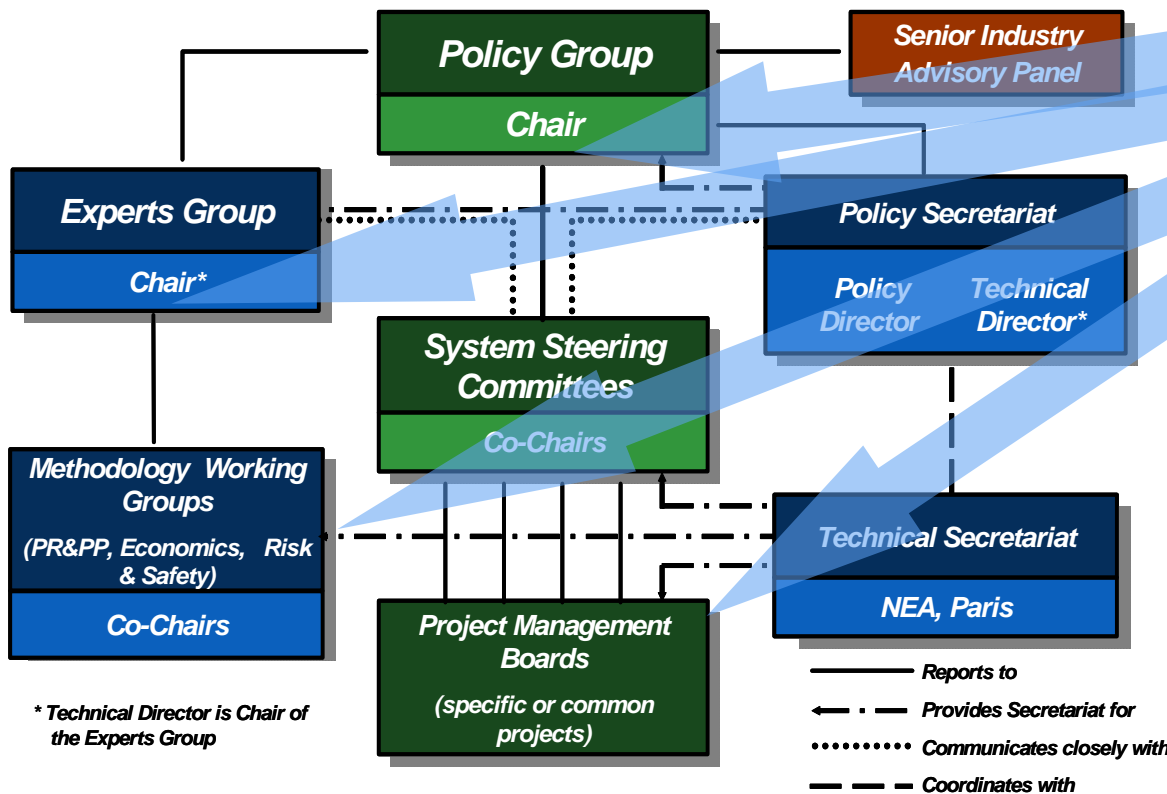
## JRC: Implementing Agent for EURATOM

									China	RF
VHTR	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
GFR		◆	◆	◆	◆		◆			
SFR		◆	◆	◆	◆			◆	◆	◆
LFR		◆		◆	◆			◆		◆
SCWR	◆	◆		◆	◆					
MSR		◆	◆							

◆ signifies Co-chair

- GFR – Gas-Cooled Fast Reactor
- LFR – Lead-Cooled Fast Reactor
- MSR – Molten Salt Reactor
- SFR – Sodium-Cooled Fast Reactor
- SCWR – Supercritical Water-Cooled Reactor
- VHTR – Very-High-Temperature Reactor

# Gen IV Reactor Systems R&D

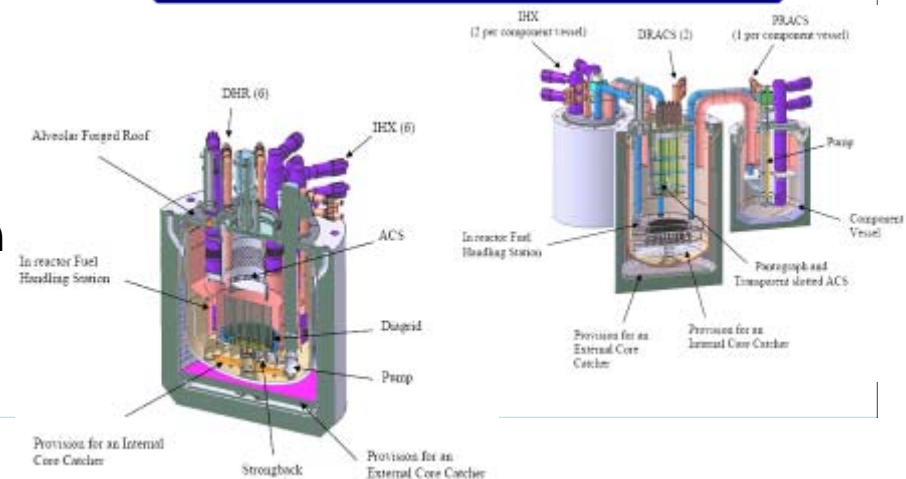
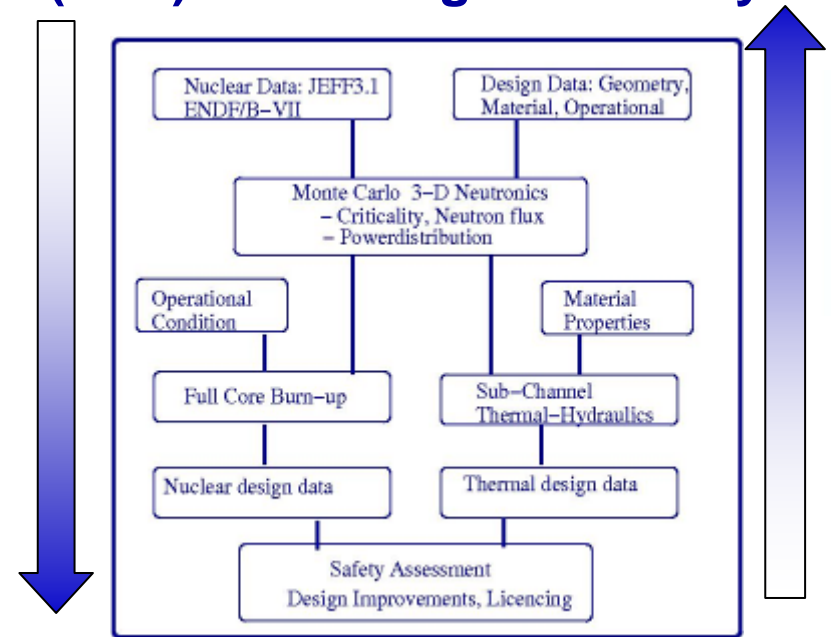


\* Technical Director is Chair of the Experts Group



# JRC R&D: Sodium Fast Reactor (SFR) core design and analysis

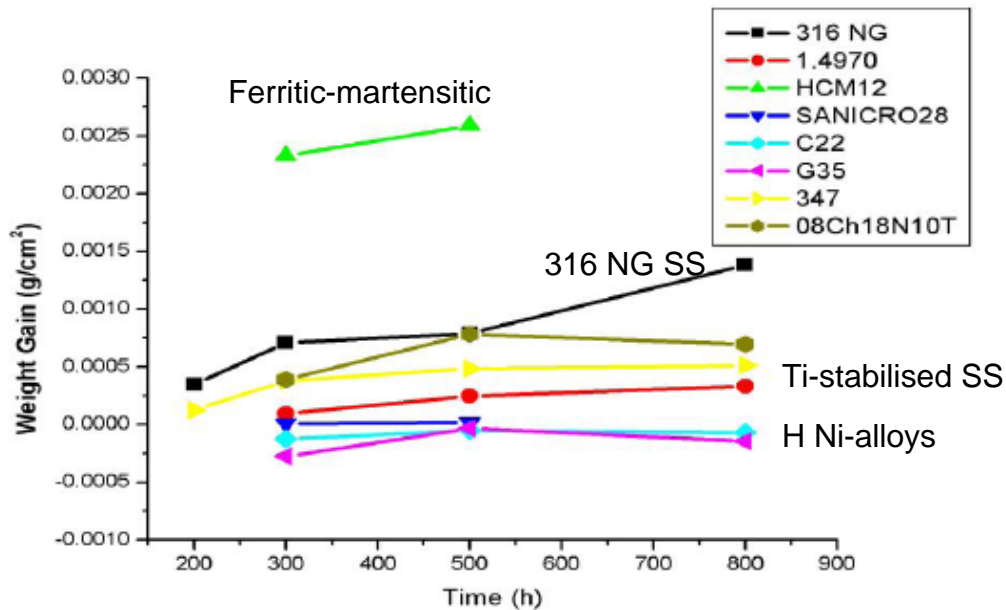
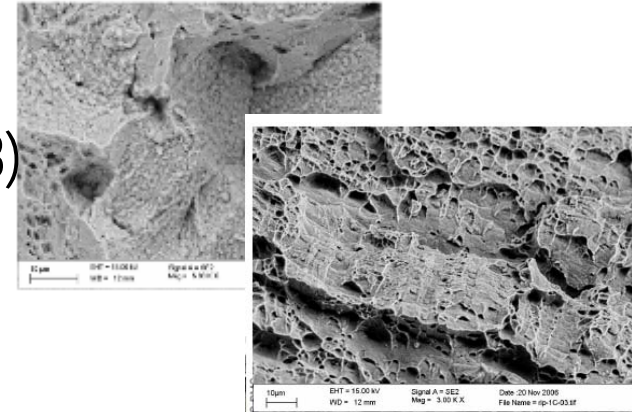
- **Neutronics using Monte Carlo method full core geometry**
- **State of art continuous energy nuclear data**
- **Pin-by-pin power distribution in meshed core geometry**
- **Full core and multilateral Monte Carlo burnup analysis**
- **Thermal-hydraulics analyses using sub-channel code**
- **Capability for hexagonal and rectangular geometries**
- **Material and thermal-correlation data for fast systems**
- **Use of HPC Linux cluster**



# JRC R&D: Material Science – Stress Corrosion Cracking

550 °C, 250 bars - 150 ppb Oxygen

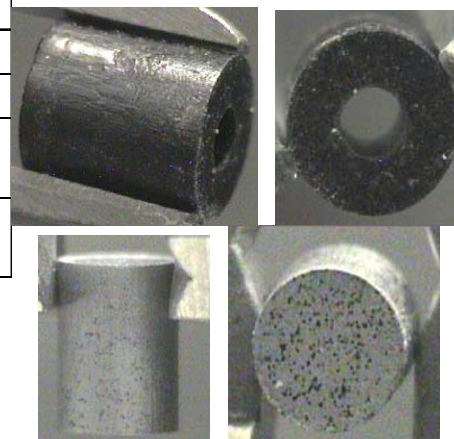
SCW - HP-LWR concept –  
- Candidates corrosion resistance materials (8)



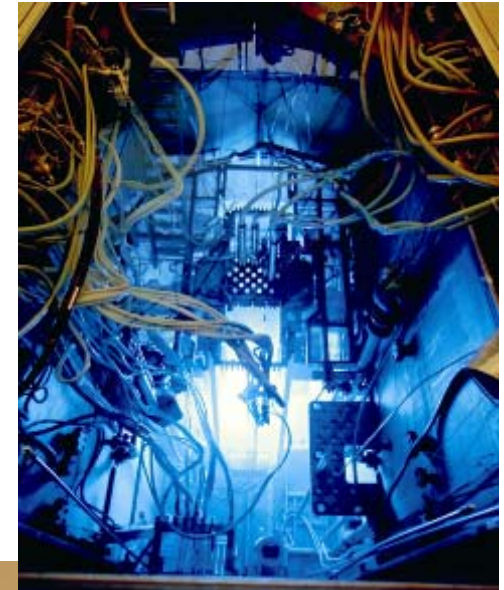
## JRC R&D: Fast Reactor and Transmutation Fuel Irradiations

**HELIOS (29.4.2009 – 19.2.2010)** within FP6 EUROTRANS (CEA + JRC-ITU fuel)  
Objective: He production and fuel swelling = f( temperature, burn-up, microstructure)

Pin	Target	Microstructure	100%TD density [g/cm <sup>3</sup> ]		%Pellet TD	As-fabricated density [g/cm <sup>3</sup> ]		Instr.
			<sup>241</sup> Am	Pu-tot	Measured	<sup>241</sup> Am	Pu-tot	
1	Am <sub>2</sub> Zr <sub>2</sub> O <sub>7</sub> + MgO	5-50 μm	0.77		91.5	0.66		
2	(Am,Zr,Y)O <sub>2</sub>	Solid solution	0.76		92.6	0.70		TC
3	(Am,Pu,Zr,Y)O <sub>2</sub>	Solid solution	0.82	0.46	89.7	0.74	0.39	TC
4	(Zr,Am,Y)O <sub>2</sub> + Mo	65-125 μm 71.3 vol% Mo	0.74		94.1	0.70		
5	(Pu,Am)O <sub>2</sub> + Mo	>150 μm 84.2 vol% Mo	0.31	1.29	96.0	0.30	1.20	



## ***JRC R&D: Gen II / III reactor safety: long term operation***



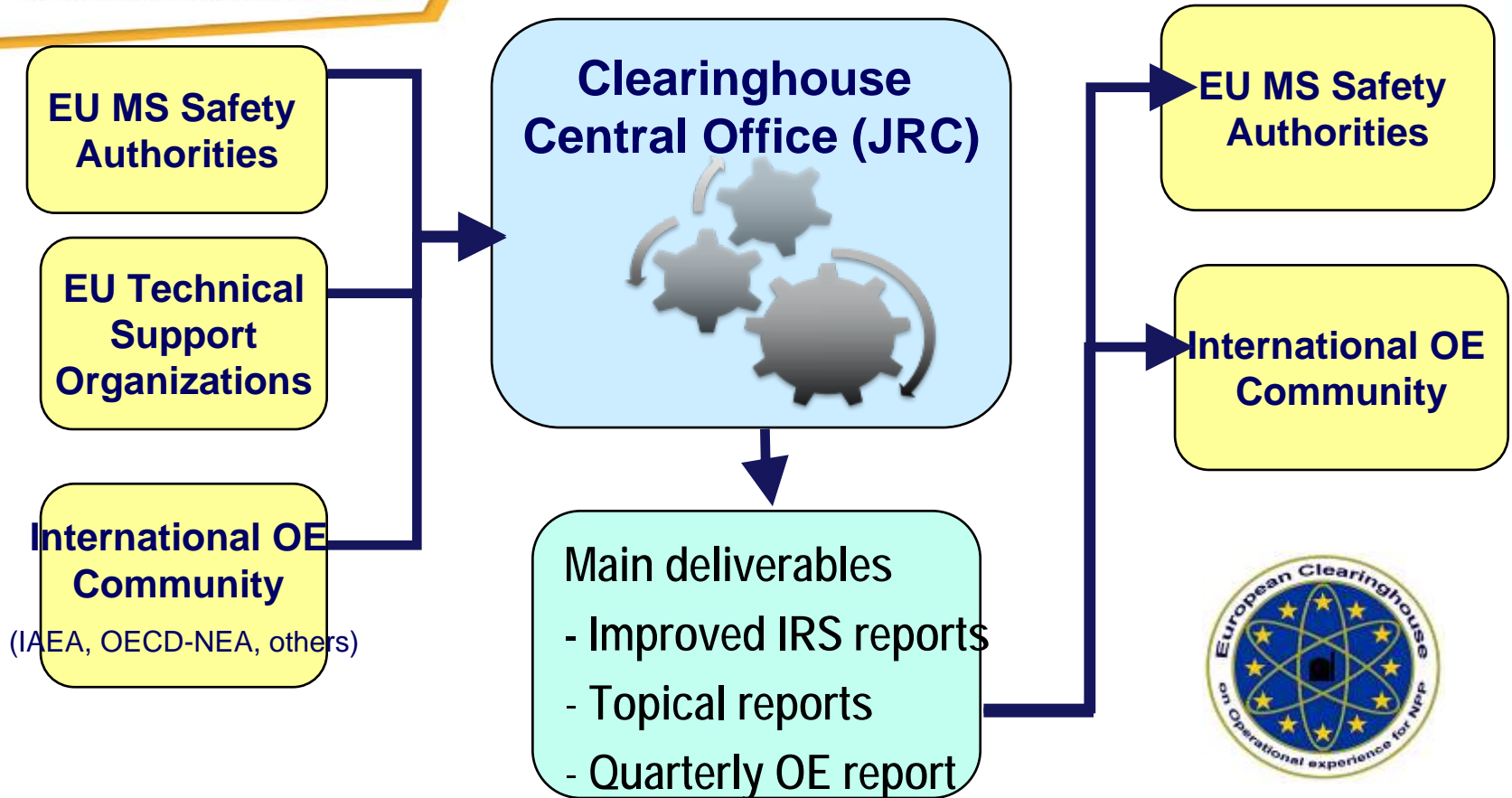
### **LYRA-10 at the High Flux Reactor in Petten, NL**

- Irradiation experiment for model steels, realistic welds and high Ni welds.
- The purpose is to identify the role of Mn, Ni, and Cr on irradiation damage.
- The experiment offers an exceptional possibility for Late Blooming study, important for the LTO of RPVs.



**LYRA-10 Side 1 of sample holder loading**

## JRC R&D: European Clearinghouse on NPP Operational Experience Feedback





## Cooperation JRC – Tsinghua University: focus on HTR



**2000:** European High Temperature Reactor Technology Network (managed by JRC-IE) initiates cooperation with Institute for Nuclear Energy Technology

**Since 2001:** Framework Agreement with INET on HTR Technology together with HTR-TN

**2006-2010:** Successful irradiation test of INET HTR fuel pebbles by JRC-IE in the HFR Petten;  
T>900°C, approx. 100 000 MWd/tHM, excellent fuel behavior;

**2010:** INET joins two Generation IV International Forum projects on VHTR: Fuel & Fuel Cycle and Materials;

**2011:** Post-irradiation examination and safety testing on irradiated fuel planned at JRC-ITU;



## Cooperation Europe – China: Super Critical Water Reactor – Fuel Test Qualification – New Project proposal for 2010-2013

Participants Europe	Participant organisation name
1. CVR	Centrum Vyzkumu Rez s.r.o.
2. KIT	Karlsruhe Institute of Technology
3. NRG	Nuclear Research and Consultancy Group
4. KFKI	Hungarian Academy of Sciences KFKI Atomic Energy Research Institute
5. VTT	VTT Technical Research Centre of Finland
6. BME	Budapest University of Technology and Economics
7. JRC-IE	Joint Research Centre – Institute for Energy
8. SIEMENS	Siemens AG

Participants China	Participant organisation name
10. SJTU	Shanghai Jiao Tong University
11. THU	Tsinghua University
12. NCEPU	North China Electric Power University
13. USTB	University of Science and Technology Beijing
14. CNNC/NPIC	Nuclear Power Institute of China
15. CIAE	China Institute of Atomic Energy
16. CGNPC	China Guangdong Nuclear Power Corporation
17. SNPTC	State Nuclear Power Technology Corporation
18. XJTU	Xi'an Jiaotong University

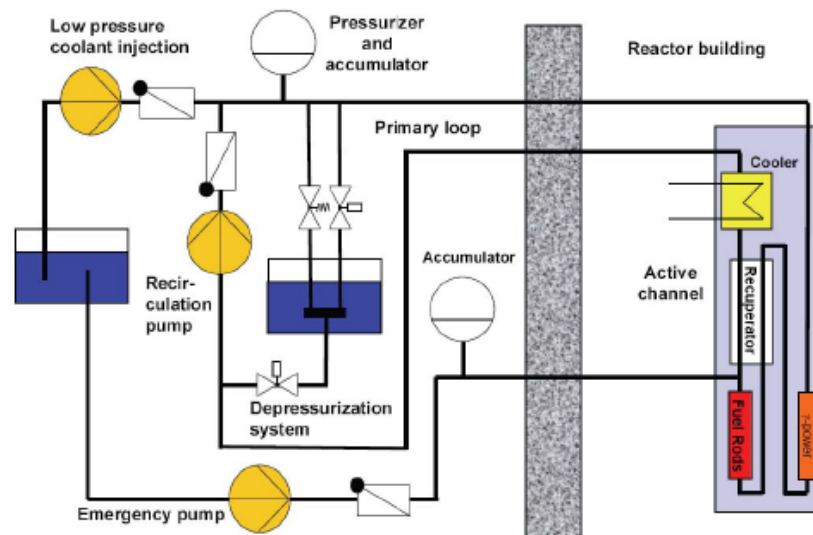


Fig. 2: Concept of the primary loop and of the safety system for the SCWR fuel qualification test.



## Conclusions: JRC is promoting Science Based Approach to Nuclear Energy Development

**44**  
pays  
veulent se doter de réacteurs

Pays candidats

Pays intéressés

Pays possédant des réacteurs (en service ou à l'arrêt)

Pays non intéressés

**Répartition des sources d'énergies**  
EN MILLIONS DE TONNES ÉQUIVALENT PÉTROLE

