

**Joint Research Centre (JRC)**

**NUCLEAR SAFEGUARDS  
&  
WASTE MANAGEMENT**



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## The advantages and disadvantages of different sources of electrical energy<sup>1</sup>

Energy sources	Technology considered for the cost estimate	2005 Cost (€/MWh)	Projected Cost 2030 (€ / MWh with €20-30/tCO <sub>2</sub> )	GHG emissions (Kg CO <sub>2</sub> eq/MWh)	EU-27 Import dependency		Efficiency	Fuel price sensitivity	Proven reserves / Annual production
		Source IEA			2005	2030			
Natural gas	Open cycle gas turbine	45 - 70	55 - 85	440	57%	84%	40%	Very high	64 years
	CCGT (Combined Cycle Gas Turbine)	35 - 45	40 - 55	400			50%	Very high	
Oil	Diesel engine	70 - 80	80 - 95	550	82%	93%	30%	Very high	42 years
Coal	PF (Pulverised Fuel with flue gas desulphurisation)	30 - 40	45 - 60	800	39%	59%	40-45%	medium	155 years
	CFBC (Circulating fluidized bed combustion)	35 - 45	50 - 65	800			40-45%	medium	
	IGCC (Integrated Gasification Combined Cycle)	40 - 50	55 - 70	750			48%	medium	
<b>Nuclear</b>	Light water reactor	<b>40 - 45</b>	<b>40 - 45</b>	15	<b>Almost 100% for uranium ore</b>		33%	low	<b>Reasonable reserves: 85 years</b>
Biomass	Biomass generation plant	25 - 85	25 - 75	30	nil		30 - 60%	medium	Renewable
Wind	On shore	35 - 175	28 - 170	30			95-98%	nil	
		35 - 110	28 - 80				95-98%		
Wind	Off shore	50 - 170	50 - 150	10			95-98%		
		60 - 150	40 - 120				95-98%		
Hydro	Large	25 - 95	25 - 90	20			95-98%		
	Small (<10MW)	45 - 90	40 - 80	5	95-98%				
Solar	Photovoltaic	140 - 430	55 - 260	100	/				

<sup>1</sup>COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN COUNCIL AND THE EUROPEAN PARLIAMENT: AN ENERGY POLICY FOR EUROPE (SEC(2007) 12)

**In today's energy and climate change context, nuclear energy becomes a vital alternative.**



**Sustainable Nuclear Energy  
Technology Platform**



## The policy issues:

To establish a nuclear energy roadmap to improve the nuclear legal framework;

To support a greater harmonisation of safety requirements at EU level for nuclear installations in the EU.

## The research challenges:

Present generation of reactors: ensure a safe and efficient operation, considering their life extension

Safe and efficient deployment of the new generation of LWRs

**Consolidate the management of technological solutions for the back-end of the fuel cycle and its societal acceptance**

Long-term sustainable solution: implement the GEN IV fast reactor systems

Explore the non-electricity use of nuclear energy: high temperature processes for heat production

**Ensure nuclear controls and security within Europe and outside**

Accelerate European research integration, and setting up of priorities

Enhance and coordinate efforts in education & training

## Nuclear Waste Management and Environmental Impact

- Spent fuel source term determination
- Long term storage spent fuel behaviour
- High level waste final disposal
- Basic data and properties
- Environmental aspects

Data used for performance assessment and modelling exercises within national programmes and international projects



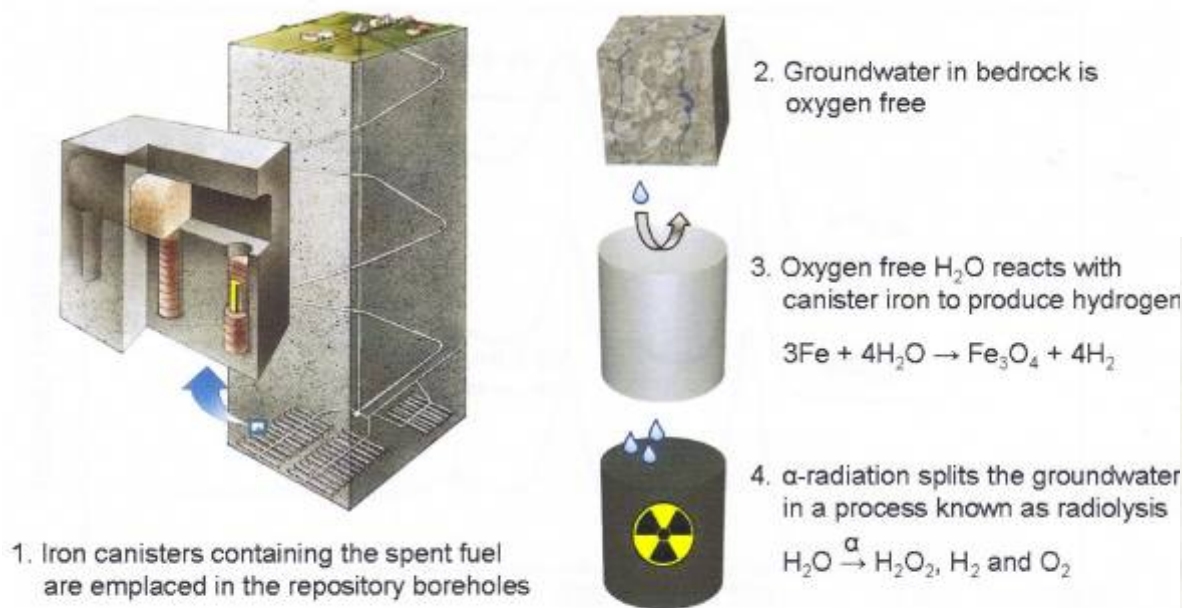
Focus on the waste form (spent fuel, other materials) and its immediate surroundings (including cladding) in a geologic repository or storage facility.

Multi-disciplinary experimental approach using a broad spectrum of facilities.

**Aim:** converge to a unified understanding/prediction of the waste form behaviour.

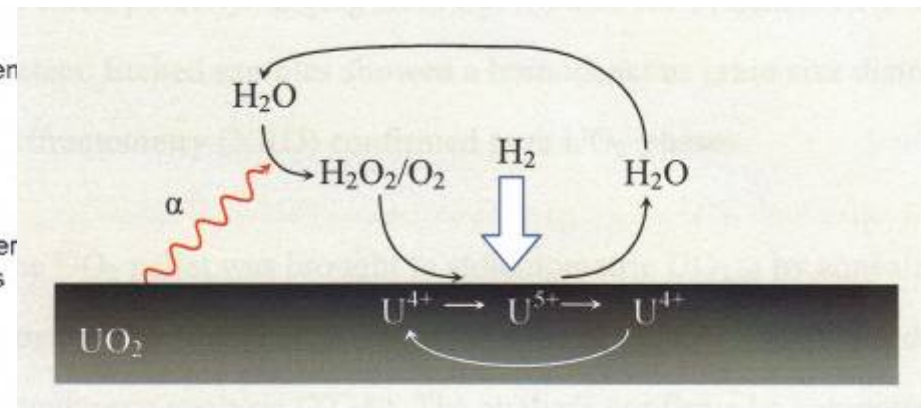
Emphasis on science.

H<sub>2</sub> overpressures are expected to form due to iron corrosion and radiolysis (up to 50 bar in a 500 m deep repository).



Original: Jan Rojmar

## H<sub>2</sub> overpressure causes suppression of the fuel matrix corrosion

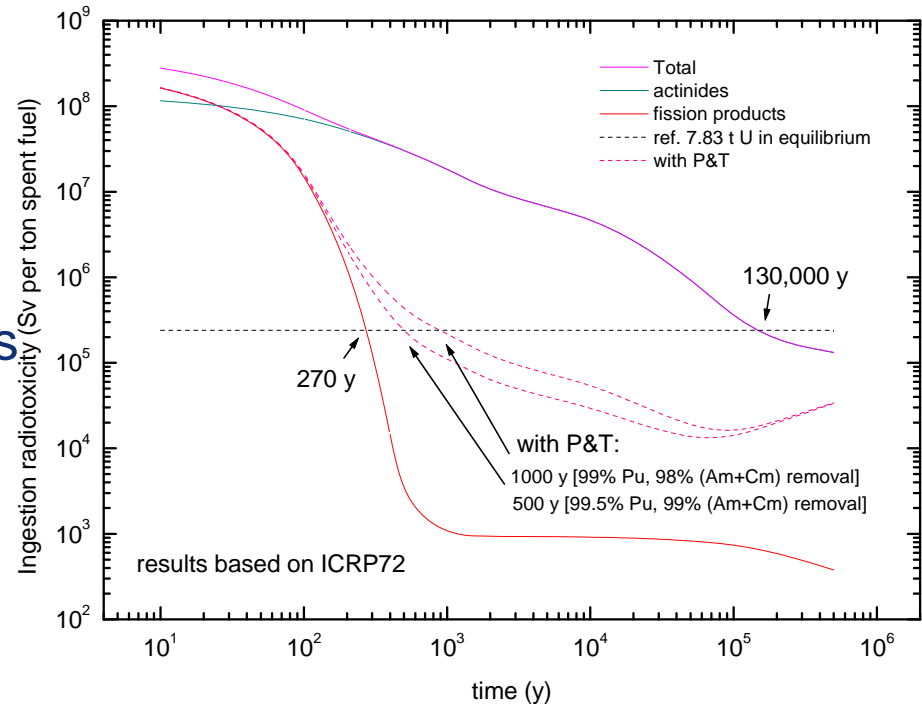


→ ongoing experiment on high burnup UO<sub>2</sub>  
 (collaboration with SKB, Chalmers Univ.)

- Similar results were obtained for alpha-doped UO<sub>2</sub> and irradiated MOX
- Corrosion inhibiting effects observed also in presence of small amounts of H<sub>2</sub>
- Mechanisms responsible for the observed behaviour need to be determined

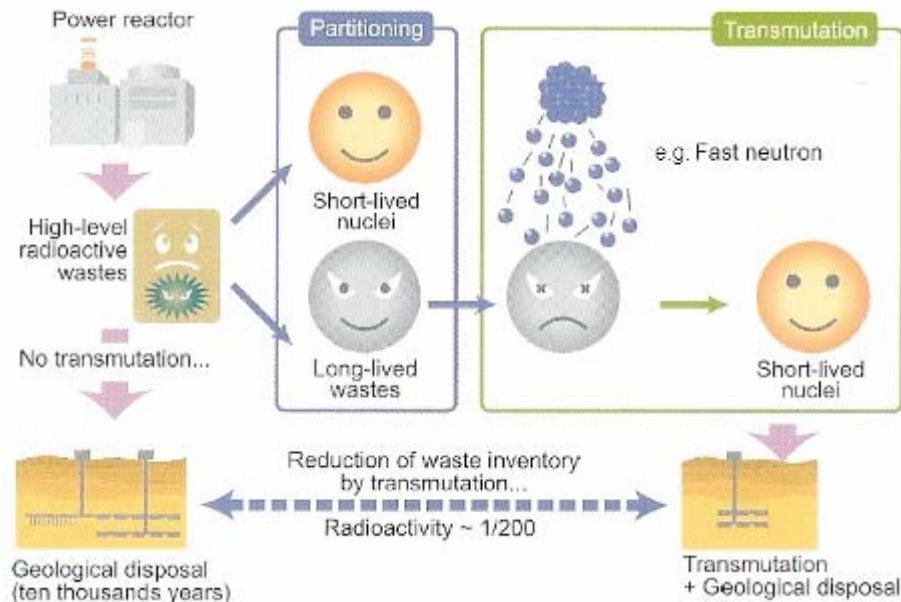
## Nuclear Waste Management and Environmental Impact

- Alternative Fuel Cycle Strategies
- Advanced spent fuel partitioning processes
- Basic data and properties
- Head-end conversion processes

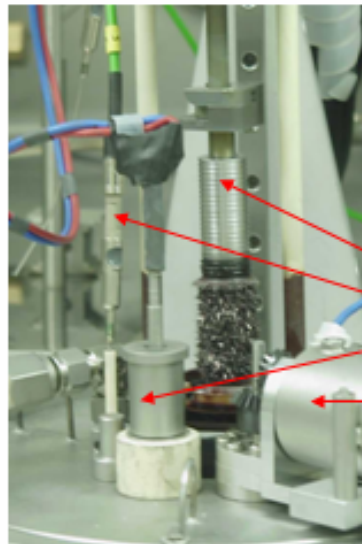
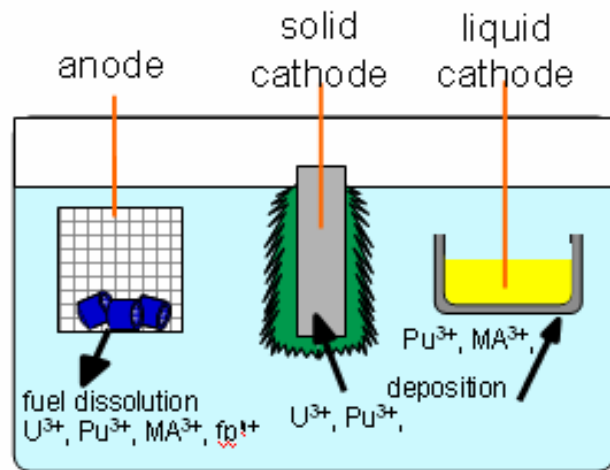


## Partitioning and transmutation

In alternative fuel cycle strategies, because of the fuel type and the very high burnup reached, traditional hydrometallurgical reprocessing might not be the most adequate method. Therefore, different pyrometallurgical (non-aqueous) separation techniques are under development



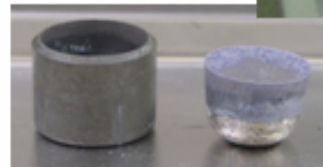
## Electrorefining of metallic fuels



solid cathode  
 TC  
 anode  
 stirrer

U deposit (12g)

Cd liquid cathode (85g) after electrodeposition of Pu/Am (~5g)



recovered Cd-Pu/Am ingot and AlN crucible

The main activities are focused on the molten chloride salt medium, LiCl-KCl eutectic:

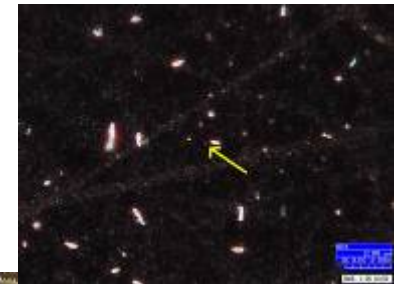
- Investigation of basic electrochemical data
- Separation of actinides by electrorefining and electrolysis
- Conversion methods (oxides to metals, oxides to chlorides....)

## Nuclear security

*Non-Proliferation is a policy objective of the EU*

### Aim:

- Technical support to Commission services under EURATOM Treaty and to IAEA under the Non-Proliferation Treaty.
- Implementation of tools for information analysis
- Additional protocol: to assure the absence of undeclared nuclear operations



## Nuclear security

### 1. Traditional Safeguards

#### Isotope & Element Assay

- Nuclear material accountancy (owner)
- Independent verification (Euratom, IAEA,...)
- reference materials, information tools, measurements

### 2. Strengthened Safeguards

#### Environmental Analysis

- Absence of undeclared activities (Add. Protocol)
- monitoring activities, particle analysis...
- Open source Information: country reports

### 3. Combating Illicit Trafficking and Nuclear Forensics

- Detection
- Source attribution
- Databases

- Chemical Analysis**
- Macroscopic Parameters**
- Microscopic Parameters**
- Reference Data**

### 4. Generation IV

- Generation IV systems are designed to be inherently more proliferation resistant
- Efficient safeguards systems need to be developed

### 5. Prevention of Radiological Risks

- security of sources
- Data bases in support to Europol, JLS
- Detection and identification of nuclear and radioactive materials
- Scenario development and modelling
- International collaboration



**Security of energy supply, competitiveness and sustainability are key concerns in the EU of today. In particular, low-carbon energy at the top of EU's policy agenda**

**Through its various programmes, the JRC addresses the major concerns of European nuclear energy technical and scientific issues.**



## C E R T I F I C A T E

**DQS GmbH**  
Deutsche Gesellschaft zur Zertifizierung von Managementsystemen  
Hereby certifies that the company

**European Commission**  
**Joint Research Centre JRC**  
**Institute for Transuranium Elements (ITU)**

Hermann-von-Helmholtz-Platz 1  
D-76344 Eggenstein-Leopoldshafen

applies the principles of Business Excellence  
in their day-to-day operations.

The management system has been assessed according to the IBECE Model

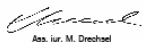
**IQNet Business Excellence Class**

and has been awarded the **bronze** level.

Assessment Date 2008-06-16 – 2008-06-20

Certificate Registration No. 059429 IB

Frankfurt am Main 2008-09-15

  
Ass. iur. M. Drechsel

MANAGING DIRECTORS

  
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Continuous contribution of **EC-JRC to the safety and security improvement**

by **being at the forefront of scientific development**

by **assisting EC policy DGs: TREN, RELEX, AIDCO, ELARG and participation in DG RTD projects**

by continuous contributions to **direct and indirect Projects through links and collaborations**

by **third party work with nuclear industry**

by **playing an important role in key initiatives such as SNE-TP, GIF, ...**