



# EURATOM Framework Programs Research Activities in Waste Transmutation & Gen IV Reactor Systems

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# OUTLINE

- **EU Energy Concerns and Strategy**
- **Euratom Research Framework Programs (FPs)**
  - **FP7 (2007-2011)\***
  - **FP6 (2002-2006)**
- **Partitioning & Transmutation and Gen IV Activities**
- **Conclusions**

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**\*Extension of FP7 to 2013 with additional 2-year budget is most likely**



# EU Energy Concerns

- Energy is the driver of economic growth and prosperity
- Energy concerns have been a permanent feature of the European reconstruction
- Two of the three European treaties deal with energy:
  - European Coal and Steel Community (ECSC) Paris 1951
  - European Atomic Energy Community (**EURATOM**) Rome 1957



# Energy

## OBJECTIVE

Transforming the current fossil-fuel based energy system into a more **sustainable** one based on a **diverse portfolio** of energy sources and carriers combined with enhanced energy **efficiency**, to address the pressing challenges of **security of supply** and **climate change**, whilst increasing the **competitiveness** of Europe's energy industry.



# EU Energy Strategy

- Implementation of EU energy strategy requires **research and development** of new technologies in a variety of areas.
- **Framework Programs** of the European Union have been a very fruitful tool to channel Member States' common research funds in areas of European-wide interest especially where European added value dominates.
- The technologies developed in Europe can be used or adapted to meet the needs of the other countries.
- International collaboration is an important policy element of the EU Framework Programs.



## Euratom Framework Programs

- European Community research has been organised in Framework Programmes (FP) of durations of 4-5 years since 1984.
- FP3: 1990-94, FP4: 1994-98, FP5: 1998-02
- FP6: 2002-06 **FP7: 2007-11** (possibly to **2013**)
- Organisation of Euratom Activities is as follows:
  - Fusion Energy Research (EC-RTD)
  - Nuclear Fission and Radiation Protection (EC-RTD)
  - Nuclear Activities of EC Joint Research Centre (JRC) \*

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\* Activities implemented by JRC are known as 'direct actions'. EC-JRC also takes part in EC-RTD 'Indirect Actions'.



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# EURATOM Framework Programs Budget

	FP6 (2002-06)	FP7 (2007-11)
	M€	M€
• Fusion Energy Res	824	1947
• <b>Fission &amp; Rad Prot</b>	<b>209</b>	<b>287</b>
• JRC's Nuclear Activity	319	517
<b>Total</b>	<b>1352</b>	<b>2751</b>



## EURATOM FP7 (2007-11) Nuclear Fission & Radiation Protection

**Geological disposal** of long-lived radioactive waste and the reduction of toxicity of radioactive waste through **partitioning & transmutation**

**Operational safety** of existing reactor systems and the **potential of future reactor systems** for safer, more efficient power plants and **competitive nuclear industry**

**Radiation protection** – especially risks from low doses, medical uses, emergency management and mitigation of the impact of **radiological terrorism**

**Key cross-cutting activities:**

- Support for **research infrastructures**
- retaining **competences and know-how** in all areas of nuclear science



# Management of Radioactive Waste in FP7

## OBJECTIVES

- **Implementation-oriented R&D** on all remaining key aspects of deep **geological disposal** of spent fuel and long-lived radioactive waste, demonstration of technologies and safety and the development of a **common European view** on the main issues related to management and disposal of waste
- RTD in all areas of **Partitioning and Transmutation** to develop **pilot facilities** for the most advanced partitioning processes and transmutation technologies involving **sub-critical** and **critical systems**
- Research on **other concepts** aimed at reducing the amount and or hazard of the waste disposal



# Reactor Systems in FP7

## OBJECTIVES

- **Safety of Nuclear Installations**
  - Continued safe operation of all relevant types of **existing reactor systems** (including fuel-cycle facilities)
  - **Lifetime extension**
  - Development of new **advanced safety assessment methodologies** (both technical and human element)
  - Prevention and **mitigation of severe accidents**
- **Advanced nuclear systems:**
  - Improve efficiency of advanced systems and fuels and collaborate with the **Generation IV International Forum**
  - Assess potential, proliferation resistance and long-term sustainability including upstream research activities (especially material science), the fuel cycle and innovative fuels and waste management aspects of **selected advanced reactor systems**



# Cross-cutting Activities in FP7

## OBJECTIVES

- **Infrastructures**

To support the availability of, and cooperation between, research infrastructures necessary to maintain high standards of technical achievement, innovation and safety in the European nuclear sector

→ **Activities:** e.g. **Pilot/test facilities for P & T, MTRs, URLs etc**

- **Human resources and training**

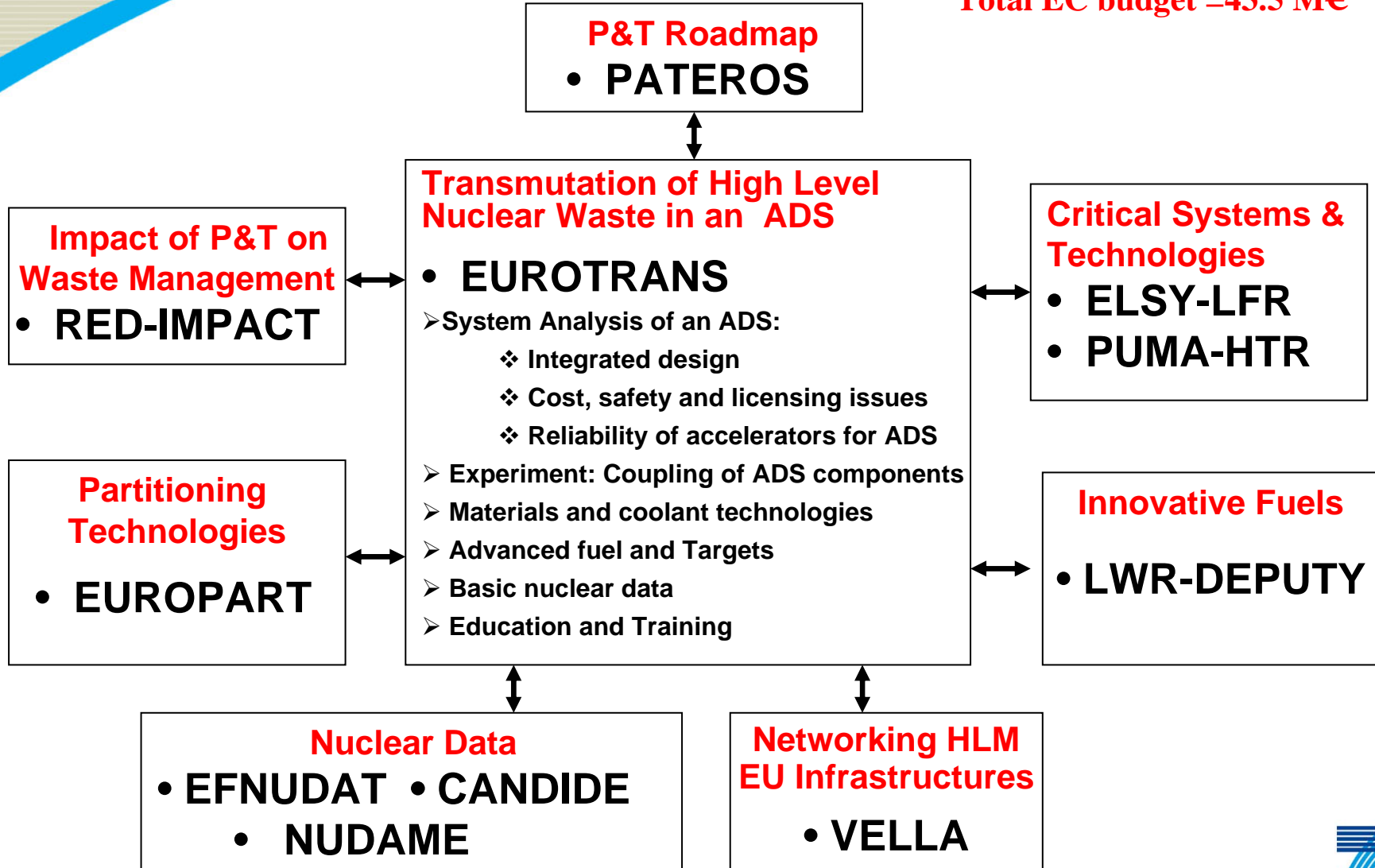
To support the retention and further development of scientific competence and human capacity in order to guarantee the availability of suitably qualified researchers and employees in the nuclear sector over the long term

→ **Activities:** **Training and mobility** of researchers in all areas of nuclear science



# FP6 (2002-06) Projects on P&T

Total EC budget =43.5 M€



## EURATOM FP6 P&T Projects Underway

SN	Acronym	Abbreviated Title	Budget (M€)		Co-ordinator	Start Date End date	Remarks
			Tot	EC			
1	<b>PATEROS</b>	P&T European Road-map	0.8	0.6	SCK/CEN (BE)	01/09/2006 30/09/2008	
2	<b>RED-IMPACT</b>	Impact study of P&T on Waste management	3.9	2.0	KTH (SE)	31/03/2004 30/09/2007	
3	<b>EURO-PART</b>	Partitioning techniques and processes	11.2	6.0	CEA (FR)	01/01/2004 30/06/2007	A new project <b>ACSEPT</b> starts 01/03/08
4	<b>EURO-TRANS</b>	All Aspects of Transmutation by sub-critical ADS	45.0	23.0	FZK (DE)	01/04/2005 31/03/2009	<b>GETMAT</b> started on 01/02/08
5	<b>ELSY</b>	Waste transmutation in Lead Cooled critical system	6.9	2.95	ANSA-LDO (IT)	01/09/2006 31/08/2009	
6	<b>PUMA</b>	Pu and MA Management by thermal Gas-cooled system	3.7	1.85	NRG (NL)	01/09/2006 31/08/2009	
7	<b>VELLA</b>	Networking of lead loop infrastructures in Europe	3.3	2.3	ENEA (IT)	01/10/2006 30/09/2009	
8	<b>LWR-DEPUTY</b>	LWR fuels for deep burning of Pu in thermal systems	2.4	1.25	SCK/CEN (BE)	01/08/2006 31/07/2009	<b>F-BRIDGE</b> starts 01/04/08
9	<b>EFNUDAT</b>	Networking of EU facilities for nuclear data	3.0	2.4	CNRS (FR)	01/11/2006 31/10/2009	
10	<b>CANDIDE</b>	Networking of Nuclear data for EU Industrial Development	0.8	0.8	UU (SE)	01/01/2007 31/12/2008	
11	<b>NUDAME</b>	Trans-national access for nuclear data	0.2	0.2	EC-JRC (IRMM)	01/04/2005 31/03/2008	
<b>Totals</b>			<b>81.0</b>	<b>43.5</b>			

# EURATOM FP6 Advanced Reactor Systems and Cross Cutting Projects underway

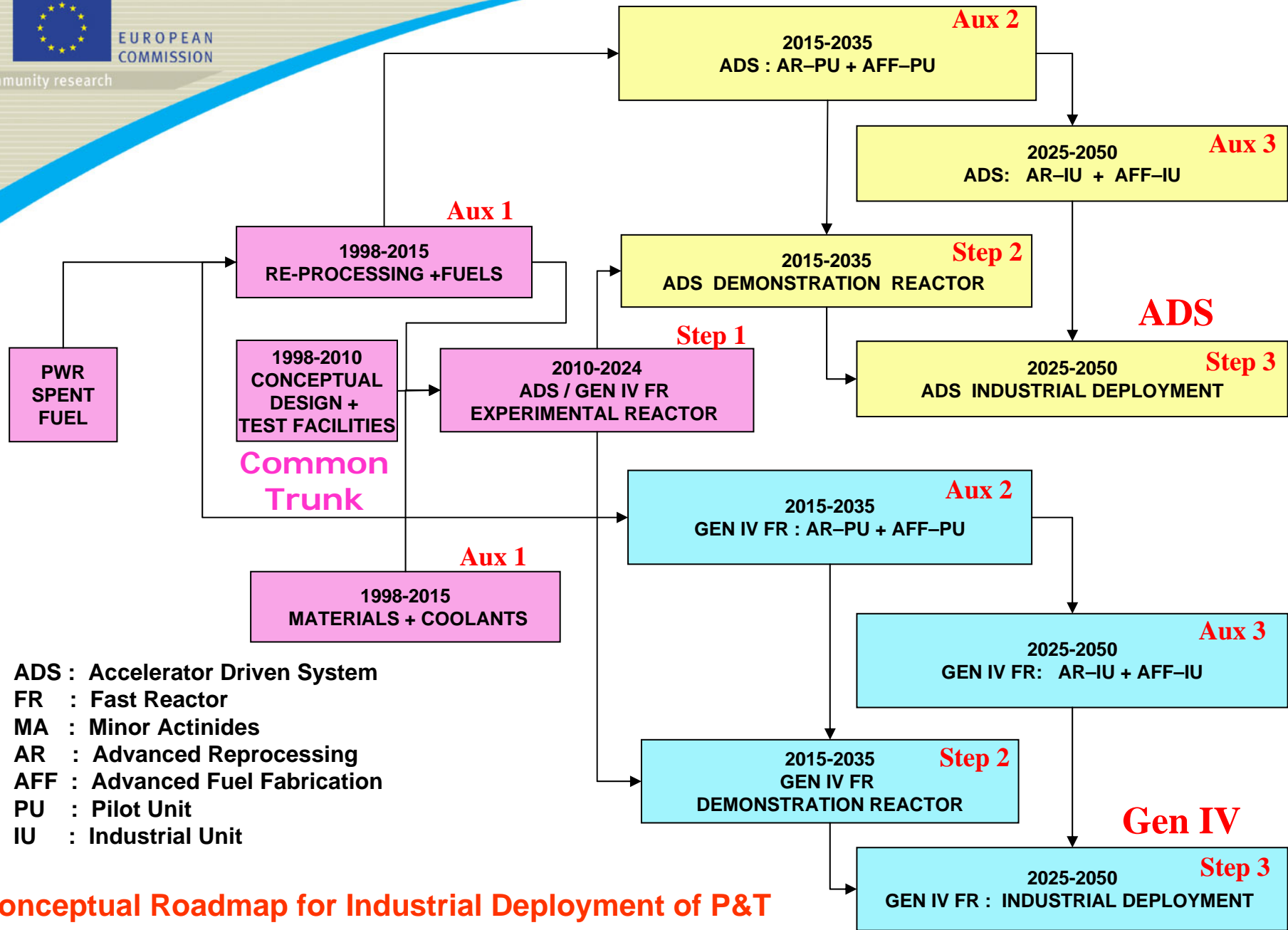
SN	Acronym	Project Title	Budget (M€)		Co-ordinator	Start date	End Date
			Tot	EC			
<b>1</b>	<b>RAPHAEL</b>	ReActor for Process heat, Hydrogen And ELectricity generation	19.8	9.0	AREVA NP	15/04/2005	14/03/2009
<b>2</b>	<b>GCFR</b>	The Gas Cooled Fast Reactor project	3.6	2.0	NNC(UK)	01/03/2005	28/02/2009
<b>3</b>	<b>HPLWR Phase 2</b>	High Performance Light Water Reactor - Phase 2	4.6	2.5	FZK(DE)	01/09/2006	31/08/2010
4	<b>ALISIA</b>	Assessment of LIquid Salts for Innovative Applications	0.6	0.25	CEA (FR)	01/01/2007	31/12/2007
<b>5</b>	<b>EISO FAR</b>	Roadmap for a European Innovative SOdium cooled FAsT Reactor	0.6	0.25	CEA(FR)	01/01/2007	31/12/2007
6	<b>STUGRANTS</b>	Students grants for RAPHAEL EURO COURSES	0.04	0.04	USU(DE)	01/07/2006	31/06/2008

## Cross-Cutting Activities

7	<b>JHR-CA</b>	Jules Horowitz reactor co-ordination action	1.50	1.50	CEA(FR)	01/01/2004	31/12/2005
8	<b>HOTLAB</b>	European network on hot laboratories	0.23	0.20	SCK/CEN (BE)	01/01/2004	30/06/2005
9	<b>SNF-TP</b>	Sustainable Nuclear Fission Technology Platform	0.80	0.60	CEA(FR)	01/10/2006	30/09/2008
10	<b>ENFTP</b>	Towards a EU nuclear fission technology Platform	0.27	0.20	CEA(FR)	01/01/2005	30/06/2005
		Totals	<b>32</b>	<b>16.5</b>			

# EURATOM FP6 Reactor Safety Projects underway

SN	Acronym	Project Title	Budget (M€)		Co-ordinator	Start date End Date
			Total	EC		
1	<b>ANTIOXI</b>	A deterministic model for corrosion and activity in nuclear power plants	0.80	0.20	VTT(FI)	01/11/2006 31/10/2008
2	<b>EC-SARNET</b>	Network for a sustainable integration of European research on severe accident phenomenology	14.0	6.30	IRSN(FR)	01/04/2004 31/03/2008
3	<b>PERFECT</b>	Prediction of irradiation damage effects on reactor components	17.7	7.50	EDF(FR)	01/01/2004 31/12/2007
4	<b>NURESIM</b>	European platform for nuclear reactor simulations	7.6	4.50	CEA(FR)	01/02/2005 31/01/2008
5	<b>COVERS</b>	VVER Safety research	2.2	1.10	NRI Rez (CZ)	01/04/2005 31/03/2008
6	<b>NULIFE</b>	Nuclear plant life prediction.	8.4	5.00	VTT(FI)	01/10/2006 30/09/2011
7	<b>MAGIC</b>	Management of AGing of Instrumentation and Control equipment in Nuclear Power Plants	0.3	0.25	EDF(FR)	01/10/2006 30/09/2008
8	<b>MTR+I3</b>	Integrated Infrastructure Initiatives for Material Testing Reactors Innovations	5.9	3.50	CEA(FR)	01/10/2006 31/09/2009
9	<b>GAIN</b>	Gap analysis for long term inspection needs of nuclear plant	0.34	0.24	MB (UK)	01/09/2004 31/10/2006
10	<b>RADE</b>	Use of RPV Dosimetry Benchmark's Results for Determining Radiation Embrittlement Damage	0.09	0.08	IRNRNE (BU)	01/07/2005 30/06/2006
11	<b>PLINIUS FP6</b>	Transnational Access to the Prototypic Corium Platform PLINIUS	0.6	0.60	CEA(FR)	01/07/2006 30/06/2010
12	<b>NICODEME</b>	Test facilities in pressurized water or steam for assessment and improvement nuclear safety	0.46	0.42	EDF(FR)	01/07/2006 30/06/2009
		<b>Total</b>	<b>59</b>	<b>30</b>		



ADS : Accelerator Driven System  
 FR : Fast Reactor  
 MA : Minor Actinides  
 AR : Advanced Reprocessing  
 AFF : Advanced Fuel Fabrication  
 PU : Pilot Unit  
 IU : Industrial Unit

### Conceptual Roadmap for Industrial Deployment of P&T

V. Bhatnagar, EC, Brussels, EFNUDAT-1<sup>st</sup> w/shop, FZD, Dresden, DE, 15/02/2008



# International Cooperation

- Cooperation agreements with Canada, USA and some other countries are in place.
  - Technical cooperation with USA, Japan, RF and S. Korea in FP6 running projects in waste management such as EUROPART, EUROTRANS, ELSY, PUMA etc.
- Cooperation with Russian Federation and Ukraine under ISTC (Moscow) and STCU (Ukraine) as well as within the framework of another forum that is being established.
  - COOPERATION FP5/FP6 & ISTC/STCU projects in the area of
    - Basic nuclear/material data and
    - Neutronics of ADS
    - Aqueous separation chemistry etc.
- Euratom cooperation with Generation IV International Forum (GIF) through EC-JRC with contribution from several FP6 projects and further projects in FP7 will contribute to achieving the aims of GIF.



# Some High-Level Nuclear Energy Activities in the EU

- **Sustainable Nuclear Energy Technology Platform (SNETP) (Launched September 2007)**
  - Gov. Board, Exec. Committee, Secretariat, Gen. Assembly
  - Working Groups: Strategic Research Agenda, Deployment Strategy, Funding, Education and Training
  - Link Technical Safety Organisations and Member States Mirror Group
- **A European Strategic Energy Technology plan (set-plan): *'Towards a low carbon future'***
  - EC Communication 10 Jan 2007: 'Energy Package'
  - Support of Council obtained in March 2007
  - Further EC Communication in Nov. 2007 (Technology and Infrastructure roadmap).
- **European Nuclear Energy Forum (Bratislava and Prague) (ENEF) (Launched Autumn 2007)**
  - Opportunities and risks of nuclear energy (Discussion with all stakeholders)



## Strategy, Rationale and Impact of P&T for sustainability of nuclear energy

- Geological disposal is indispensable.
- Maximum eventual 'dose' to human beings from a geological repository is likely to be due to fission products.
- Reprocessing and transmutation of minor actinides reduces considerably the 'radio-toxic inventory' of the disposed waste which is important for 'human intrusion scenario'.
- Separation of main heavy metals reduces the volume and thermal output of the waste to be disposed of permitting a reduction in the needed size of the repository.
- Extracting heat-bearing (Sr and Cs) components from the waste 'can also reduce thermal output' of the disposed Waste.
- Reprocessing leads the way towards sustainability as opposed to the once-through cycle which does not appear to be sustainable for nuclear energy.
- Concerns of the public related to the long-life of the waste could largely be overcome by P&T by reducing half-life of most of the waste to be disposed of to a couple of hundred years and it could thus come to the aid of geological disposal community in securing a 'broadly agreed political consensus' of waste disposal in geological repositories.



## Strategy, Rationale and Impact of P&T for sustainability of nuclear energy

- **Additional cost, additional secondary waste, activation products and ILW and dose to workers in the process of P&T itself will contribute to defining an optimal transmutation scheme.**
- **The efforts and resources that are presently being allocated to the study of P&T have an added value of training many researchers by supporting a rather large number of Ph D students. This will definitely contribute to the retaining and building of competence in the nuclear fission area.**
- **The efforts devoted to fuel, HLM technology and nuclear data research will to a large extent be applicable either to ADS concepts or to Fast-critical systems.**
- **It is clear that reprocessing of the spent fuel for a sustainable nuclear energy and fuel cycle would be required no matter what path of transmutation is followed.**
- **Efforts for the advanced partitioning processes should be reinforced towards pilot and test facilities for optimised separation processes in close cooperation with fuel fabrication teams and geological disposal community.**
- **The GD community should embrace the opportunity offered by P&T to ease the acceptance of geological repositories by society and accommodate the waste streams emanating from the advanced (minor-actinide) reprocessing systems with a view to transmutation whether in sub-critical or critical devices.**



# Conclusion

- **We should no longer discuss**
  - 'The future of P&T'
  - 'P&T is the future!' (hyperbole)
- **P&T is essential for the sustainability of nuclear energy (more realistic)**
- **Geological disposal (GD) is indispensable**
- **GD and P&T (Advanced Fuel Cycle) communities should work together for the future of nuclear energy.**


  
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**COMMUNITY POLICY & RESEARCH  
AND TRAINING ACTIVITIES**

**EURADWASTE '08**

Seventh European Commission Conference on the Management and Disposal of Radioactive Waste

**20-23 October 2008  
Luxembourg**

[www.cordis.europa.eu/fp7/euratom-fission/events\\_en.html](http://www.cordis.europa.eu/fp7/euratom-fission/events_en.html)

## OBJECTIVES and SCOPE:

- Present an overview of all recent European Commission (EC) activities in radioactive waste management (R&D, policy, strategic and socio-political aspects). Present Euratom FP6 project results in geological disposal and partitioning & transmutation.

## THEMES:

- Community Policy (management of radioactive waste, research policy, future strategies)
- Socio-political aspects (governance and decision-making, public perception and acceptance, stakeholder involvement, sustainability issues)
- FP6 research programme (repository near-field processes, Engineered Barrier Systems; radionuclide migration in the far-field; engineering studies and repository technologies; Performance Assessment; co-operation, technology transfer and developments of options for shared repositories; co-ordination of national research programmes; status in P&T techniques and technologies)

**VENUE:** EC conference centre, Luxembourg

**PROGRAMME:** Technical sessions 3 days (20-22 Oct. 2008), URL technical visits: Bure, FR and HADES Mol, BE (23 Oct. 2008)

Further information and PRE-REGISTRATION on line  
E, 15/02/2008

## **Additional Supporting Slides**

## EURATOM FP6 GD Projects Underway (1/2)

SN	Area	Acronym	Project Title	Budget (M€)		Co-ordinator	Start date
				Total	EC		End Date
1	Roadmap	<b>CARD</b>	Coordination Action for Roadmap on Geological Disposal (CA)	0,54	0,35	NIREX (UK)	01/11/2006 31/10/2007
2	Performance Assessment	<b>PAMINA</b>	PA Methodologies for Safety Case (IP)	7,5	4,0	GRS (DE)	01/10/2006 30/09/2009
3	Near-Field	<b>NF-PRO</b>	Understanding the Near Field in Repositories (NoE)	16,8	8,0	SCK.CEN (BE)	01/01/2004 31/12/2007
4	Far-Field	<b>FUNMIG</b>	Fundamental Processes of Radionuclide Migration (IP)	15,0	8,0	FZK (DE)	01/01/2005 31/12/2007
5	Engineering & Demo	<b>ESDRED</b>	Engineering Studies and Demo Repository Designs (IP)	18,1	7,3	ANDRA, (FR)	01/04/2005 31/03/2008
6	Repository Environment	<b>TIMODAZ</b>	Thermal Impact on the Excavated Damaged Zone in Clay (STREP)	4,0	2,65	EURIDICE (BE)	01/10/2006 30/09/2010
7		<b>THERESA</b>	Coupled Thermal-hydrological-mechanical-chemical Processes (STREP)	2,0	1,2	KTH (SE)	01/10/2007 31/12/2009

## EURATOM FP6 GD Projects Underway (2/2)

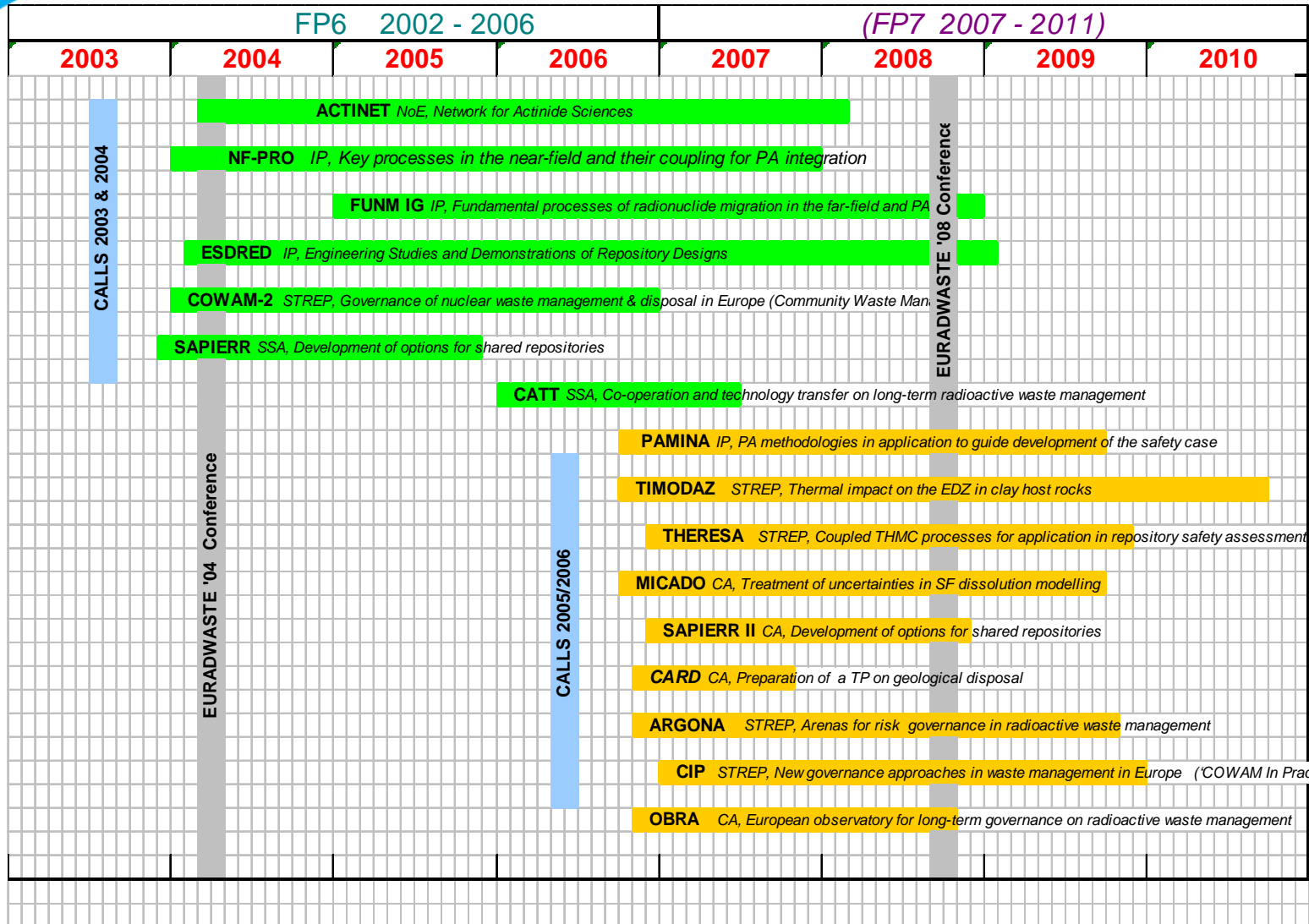
SN	Area	Acronym	Project Title	Budget (M€)		Co-ordinator	Start date End Date
				Total	EC		
9	Shared Repositories	<b>SAPIERR</b>	Pilot Initiative on European Regional Repositories (SSA)	0,35	0,2	DECOM (SK)	01/11/2006 31/10/2007
10		<b>SAPIERR II</b>	Strategic Action Plan for Implementation of European Regional Repositories-II (CA)	1,0	0,7	COVRA (NL)	01/10/2006 30/09/2009
11	Technology Transfer	<b>CATT</b>	Cooperation and Technology Transfer on long-term RWM (SSA)	0,24	0,2	NIREX (UK)	01/01/2006 30/06/2007
12	Governance	<b>COWAM-2</b>	Community Waste Management-2 -- Improving the Governance (STREP)	2,3	1,2	MUTADIS (FR)	01/11/2004 31/12/2006
13		<b>ARGONA</b>	Arenas for Risk Governance in RWM (STREP)	2,3	1,2	SKI (SE)	01/11/2006 31/10/2009
14		<b>CIP</b>	COWAM in Practice—New Governance approaches in RWM (STREP)	2,3	0,8	MUTADIS (FR)	01/01/2007 31/12/2009
15		<b>OBRA</b>	European Observatory for Long-term Governance on RWM (CA)	0,46	0,3	ENVIROS (ES)	01/11/2006 31/10/2008
16	Cross-cutting	<b>ACTINET-6</b>	Network of Actinide Sciences	10,5	6,35	CEA (FR)	01/03/2004 28/02/2008
			<b>Totals</b>	<b>85</b>	<b>43,75</b>		
	<b>Fellowships + E&amp;T Projects</b>			<b>1,9</b>	<b>1,9</b>		



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# Time schedule of FP6 GD Projects underway





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# Call FP7-Fission-2007

## Project: **ACSEPT**

**Actinide recycling by Separation and Transmutation**  
(Tot: ~24 M€, EC: 9 M€, start: 1/3/08, 4 Y, 34 partners)

**Stéphan Bourg (CEA)**

**Chemical separation processes compatible with fuel fabrication techniques, with a view to their future demonstration at pilot level**

- **Aqueous Separation: Selective & grouped separation and process optimisation.**
- **Pyro: Head-end steps, process development, salt treatment for recycling and waste conditioning**
- **Engineering and system studies on aqueous & pyro processes**
- **An effort on design of new molecules**
- **Training and mobility**



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# Call FP7-Fission-2007

## Project: **GETMAT**

### Gen IV and Transmutation Materials

(Tot: 14 M€, EC: 7.5 M€, Start: 1/2/08, 5 Y, 24 partners)

Concetta Fazio (FZK)

- Improvement and extension of 9-12 Cr Ferritic-martensitic (F/M) steels qualification
- Oxide Dispersion Strengthened (ODS) alloys development and characterisation
- Joining and welding procedures qualification (both for F/M and ODS steels)
- Development and definition of corrosion protection barriers
- Improved modelling and experimental validation



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# Call FP7-Fission-2007

## Project: **F-BRIDGE**

Merged SAFIRE & PARFUELS Proposals  
(Under processing for Grant Agreement)

Basic Research in support of Innovative Fuels  
Design for the GEN IV systems

(Tot: 10.4 M€, EC: 5.45 M€, Start: 1/4/08, 4 Y, 8 partners)

Carole Valot (CEA)  
(Sander de Groot (NRG))

- Develop multi-scale modelling and characterization tools
- Connect technological issues of Generation IV systems and basic research
- Integrate innovative fuel design, manufacturing, in-pile behaviour prediction and an optimization of the design of irradiation experiments
- Feasibility and potential of 'sphero-pac' fuel for an application to Generation IV systems