



European  
Commission

# Euratom FP7 Research & Training Projects

Volume 3

Project  
Information

## **EUROPEAN COMMISSION**

Directorate-General for Research and Innovation  
Directorate K — Energy  
Unit K.4 — Fission

*E-mail: [RTD-EURATOM-PROJECTS@ec.europa.eu](mailto:RTD-EURATOM-PROJECTS@ec.europa.eu)  
Contact: Kateřina Ptáčková*

*European Commission  
B-1049 Brussels  
E-mail: [Katerina.Ptackova@ec.europa.eu](mailto:Katerina.Ptackova@ec.europa.eu)  
[RTD-PUBLICATIONS@ec.europa.eu](mailto:RTD-PUBLICATIONS@ec.europa.eu)  
Directorate-General for Research and Innovation  
7th Framework Programme/Euratom*

# Euratom FP7 Research & Training Projects

## Volume 3

***EUROPE DIRECT is a service to help you find answers  
to your questions about the European Union***

Freephone number (\*):

**00 800 6 7 8 9 10 11**

(\*) Certain mobile telephone operators do not allow access to 00 800 numbers  
or these calls may be billed

#### **LEGAL NOTICE**

Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of the following information.

The views expressed in this publication are the sole responsibility of the author and do not necessarily reflect the views of the European Commission.

More information on the European Union is available on the Internet (<http://europa.eu>).

Cataloguing data can be found at the end of this publication.

Luxembourg: Publications Office of the European Union, 2012

ISBN 978-92-79-20029-8

ISSN 1018-5593

doi:10.2777/65063

© European Union, 2012

Reproduction is authorised provided the source is acknowledged.

*Printed in Belgium*

Printed on elemental chlorine-free bleached paper (ecf)

# Contents

INTRODUCTION	7
--------------	---

## **Management of radioactive waste**

BELBaR	12
CATCLAY	14
CROCK	16
FIRST-Nuclides	18
InSOTEC	20
IPPA	22
LUCOEX	24
PEBS	26
REDUPP	28
SeclGD	30
SITEX	32
SKIN	34

## **Nuclear Installation Safety**

ADRIANA	36
ADVANCE	38
ANDES	40
ARCHER	42
ASGARD	44
ERCOSAM	46
ERINDA	48
EVOL	50
FREYA	52
GoFastR	54
HARMONICS	56
HeLiMnet	58
HPMC	60

JASMIN	62
LEADER	64
LOGLIFE	66
MAX	68
MULTIMETAL	70
PELGRIMM	72
SARGEN-IV	74
SCWR-FQT	76
SEARCH	78
SILER	80
STYLE	82
THINS	84

#### **Radiation Protection**

ANDANTE	86
CEREBRAD	88
DoReMi	90
EPI-CT	92
EpiRadBio	94
NERIS-TP	96
PROCARDIO	98
RENEB	100
SOLO	102
STAR	104

## **Support and Access to Infrastructures**

ALICE	106
ALISA	108
EURACT-NMR	110
LACOMECO	112

## **Education and Training**

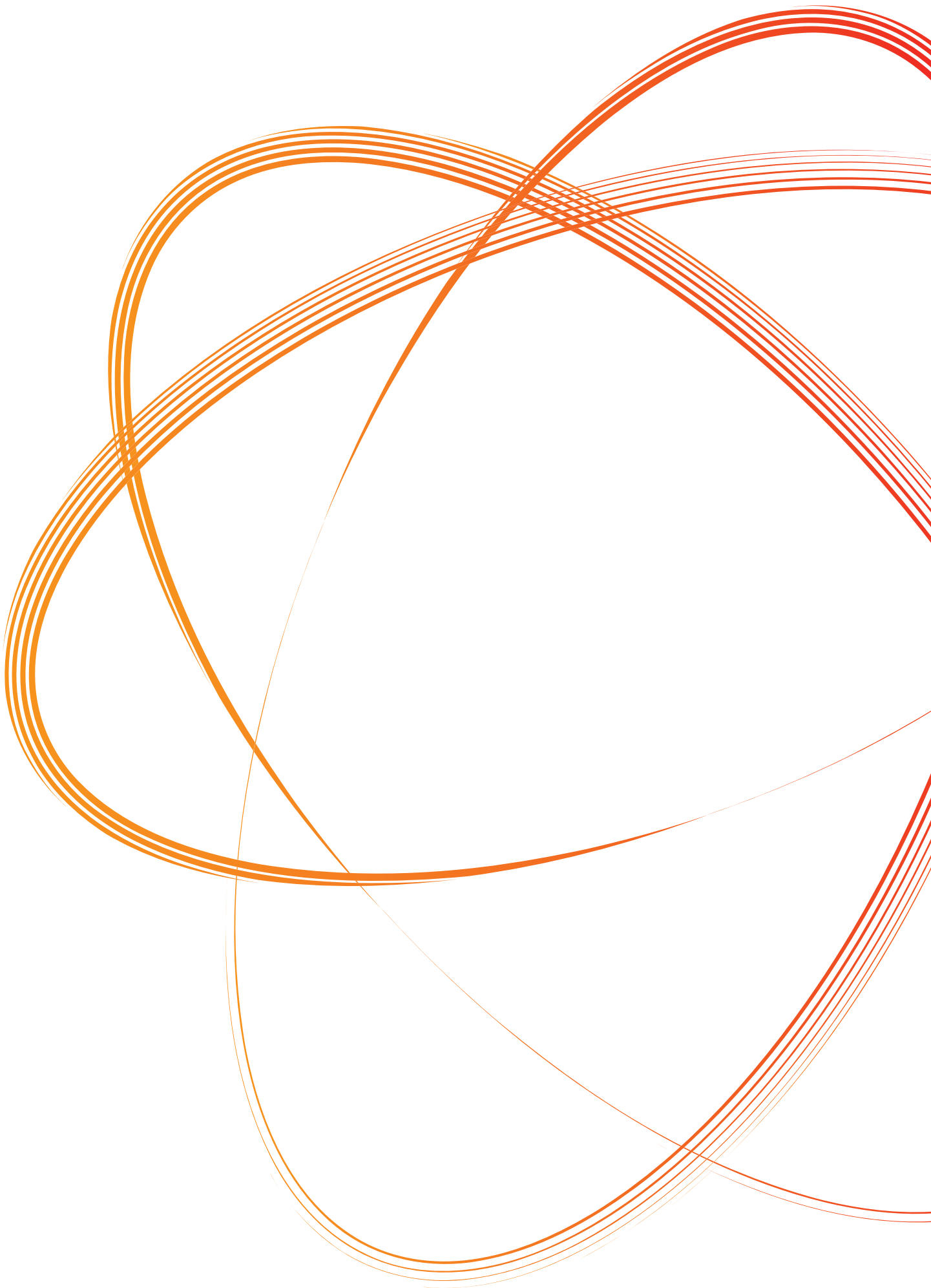
CINCH	114
CORONA	116
ECNET	118
ENEN-RU	120
EURECA!	122
TRASNUSAFE	124

## **Cross-cutting topics**

MATTER	126
NEWLANCER	128
SMILE	130

GLOSSARY	133
----------	-----

INDEX OF PROJECTS	138
-------------------	-----





## INTRODUCTION

This brochure provides an outline of the third batch of nuclear research and training activities funded by the Seventh Framework Programme of the European Atomic Energy Community (FP7 Euratom, 2007-2011). The projects described here all address major issues and challenges in nuclear fission research, such as the management of high-level/long-lived radioactive waste, nuclear safety, advanced nuclear systems, radiation protection (e.g. risks from low doses) and horizontal activities, such as research infrastructures and human resources (e.g. training and mobility).

The primary goal is to generate and exploit knowledge and develop scientific and technical competences and know-how in applied nuclear science and technology, especially in the areas of safety, reliability, sustainability and cost-effectiveness of nuclear energy systems. Importantly, these projects contribute to the further consolidation of the European Research Area (ERA) in the nuclear energy and radiation protection sectors. Euratom activities on research and development for nuclear fusion are not covered in this publication.

World energy demand is increasing rapidly. Over the next 50 years, global energy use is expected to double (at the very least), with electricity demand growing the fastest. Security of energy supply and climate change are both high on the political agenda, and the European Union (EU) has set clear targets for drastically reducing greenhouse gas emissions: 20 % by 2020, and between 60 and 80 % by 2050.

Electricity requires reliable, efficient and clean generation systems. Nuclear fission, which contributes more than 30 % of the EU's electricity generation and represents two-thirds of its carbon-free electricity production, can provide a constant base-load electricity supply, thereby reducing dependence on fossil fuels. As a reliable and indigenous source of energy, nuclear power can also contribute to the EU's energy independence and security of supply.

Therefore, nuclear energy is a viable option for countries wishing to use this technology as part of a balanced energy mix. Furthermore, emerging advanced fission technologies offer the potential of significant improvements in the efficiency and sustainability of nuclear energy, while minimising production of the most hazardous radioactive waste, and the possibility of nuclear energy use in areas other than electricity production (e.g. process heat for industrial processes such as hydrogen production). The EU is currently a world leader in the areas of nuclear technology and waste management. Maintaining Europe's competitiveness over the next decade is key to ensuring that it meets its 2020 energy targets. In the long term, the new generation of nuclear fission reactors can contribute significantly to realising the EU's 2050 vision of a low-carbon economy. Initiatives such as the Strategic Energy Technology Plan (SET-Plan) to accelerate the development and deployment of low-carbon technologies, and the Sustainable Nuclear Energy Technology Platform (SNE-TP) coordinating research and development in nuclear systems and safety in Europe, have highlighted the importance of nuclear energy to Europe's transition to a low-carbon economy. The Euratom Framework Programme seeks to support these initiatives to the extent possible.

## Informing and protecting the public

Nuclear safety is top priority. The EU has an outstanding nuclear safety record; however, research continues in order to maintain this high level of safety and to better understand the risks and hazards associated with the use of radiation in medicine and industry. In all uses of radioactive materials, the overriding principle is to protect citizens and the environment. The tragic Fukushima nuclear accident in March 2011 only further reiterated the fundamental importance of safety and now many EURATOM projects are developing methodologies based on the lessons learned from the disaster.

Radiation protection research focuses on assessing and mitigating the risks from low and protracted exposure to radiation, including from medical uses as part of diagnostic or therapeutic techniques. The main objective is to ensure a robust and socially acceptable system of radiation protection that protects both those working in the industry and citizens and at the same time does not unnecessarily limit the beneficial uses of nuclear technology. Research in this area combines a wide range of disciplines, covered both as part of Euratom and the rest of the Seventh Framework Programme (FP7), such as epidemiology, radiobiology, cellular and molecular biology and radioecology. The issue of emergency management in the highly unlikely event of a severe accident at a nuclear facility and the rehabilitation of any resulting contaminated territories are two important areas of radiation protection research.

Nuclear fission is a major contributor to Europe's carbon-free energy mix, but it is not a technology that is widely understood outside scientific circles. High on the list of public concerns are operational reactor safety and the management of long-lived radioactive waste.

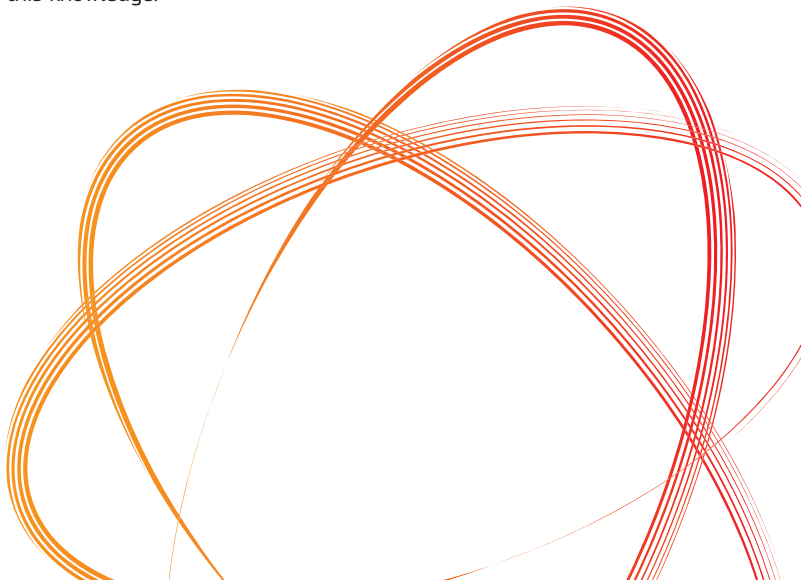
Managing radioactive waste safely is a concern for all countries, whether it relates to the waste from electricity production or from radiation use in research, industry and medicine. At present, all irradiated fuel and associated wastes from nuclear reactors are safely managed according to very strictly enforced regulatory requirements.

Low-hazard waste is disposed of at the industrial scale, while the most hazardous waste (e.g. spent nuclear fuel or the residues from the recycling of this fuel), which exists in much smaller volumes, is safely stored temporarily in surface or near-surface facilities. At the same time, research and development (R&D) into final disposal in deep geological repositories is also progressing. The study of various host rocks and barrier systems has come a long way, and there is consensus within the technical community that there is now sufficient acquired scientific and engineering knowledge to progress towards actual implementation. The R&D associated with this final phase is becoming an increasing focus of the Euratom programme.

Euratom and its EU Member States are also committed to maintaining a high level of safety of nuclear installations, both for currently operating reactors and future innovative reactors, in which the emphasis will be on passive rather than active safety systems that are designed into the fundamental concept at a very early stage. Upholding this commitment also relies on supporting the ongoing training of a highly skilled workforce, and ensuring that a steady stream of new and highly skilled scientists and engineers adds to its numbers.

In all these areas, effective communication is needed between the public and industry, researchers, engineers and policy makers. The nuclear community needs to explain relevant scientific facts clearly and dispassionately, particularly in relation to safety and waste. As part of this process, the European Commission takes its role in disseminating and communicating the results of Euratom programmes very seriously.

There is a growing EU dimension to all environmental and energy-related issues, though the decision to use nuclear power remains essentially a political one taken at the national level. Many considerations, ranging from socio-economic to technical, must be taken into account. Crucially, such decisions need to be supported by good quality science; they must be taken from a position of knowledge, not one of ignorance. Research, such as that supported by FP7 Euratom, is supplying this knowledge.



## The programme

FP7 Euratom was formally adopted at the end of December 2006, and covers the five-year period 2007-2011. The legislative basis of the FP7 Euratom programme is described in the Decision of the Council of the EU No. 2006/970/Euratom. Of FP7 Euratom's total budget of EUR 2.75 billion, EUR 287 million was earmarked for the programme on nuclear fission and radiation protection research and training activities, and the third batch of supported projects are described in this brochure. This programme is implemented through calls for proposals followed by evaluations carried out by independent experts. A range of funding schemes (see box) are available, promoting cooperation and synergy through multi-partner consortia. The basis for financial support is shared cost and non-profit.

On 19 December 2011 the Council of the European Union extended FP7 Euratom for two more years. The aim of this prolongation was to align Euratom with the end of the EU's current financial cycle in 2013. Although the Commission's general framework programme for research lasts for seven years, the Euratom treaty limits Euratom programmes to five years. This extension therefore means Euratom is now in line with the wider FP7, which runs until the end of 2013. A maximum amount of EUR 2.5 billion was allocated for the implementation of the Euratom programme for 2012 and 2013 out of which EUR 118 million is dedicated for the programme on nuclear fission, safety and radiation protection.

Many of the activities in FP7 Euratom are a continuation of long-term research supported in previous Euratom programmes. In addition, FP7 builds on the progress made during the Sixth Framework Programme (FP6) towards establishing the ERA in nuclear science and technology, particularly as a result of new funding instruments such as Integrated Projects and Networks of Excellence.

A significant development in this respect has been the creation of technology platforms, initiated as proposals from the stakeholder community and studied in pilot actions supported during FP6. During the first half of FP7, this strategy has been actively pursued and has culminated in the successful launch of SNE-TP ([www.snetp.eu](http://www.snetp.eu)) and the Implementing Geological Disposal Technology Platform (IGD-TP; see below). These forums have been established around agreed visions for future scientific and technical development in the respective fields, and members collectively define the platform's Strategic Research Agenda (SRA) and Deployment Strategy in order to realise these visions. This includes R&D in nuclear systems and safety as well as in geological disposal. Such strategic planning enables FP7 Euratom to remain as effective as possible by focusing on priority activities.

Similarly, with regard to the research on radiation protection and the risks from low doses and protracted exposures, the Multi-Disciplinary European Low Dose Initiative (MELODI; see below) is defining its own SRA. This agenda will also help prioritise Euratom support.

On the administrative side, and in common with the much larger FP7, the European Commission has also put in place simplified and standardised procedures to facilitate access to and implementation of the programme (e.g. managing calls and evaluation, project management, as well as administrative and financial guidelines and requirements). Regarding key EU policy objectives, FP7 Euratom continues to contribute to:

### > PROTECTION OF SOCIETY AND ENVIRONMENT

This principle lies at the heart of all EU policy making, and is reinforced in the founding treaties for both Euratom and the European Community.

### > ENERGY SUPPLY AND CLIMATE CHANGE

Securing the EU's energy supply, establishing sustainable economic growth, and fighting climate change are essential. The Commission's energy policy for Europe entitled 'Energy for a Changing World' (published in January 2007), and the comprehensive 'climate and energy package' (approved by the Council of Ministers in April 2009) support a strategy based on a diverse mix of low-carbon energy sources. The Community's Strategic Energy Technology Plan (SET-Plan) is an integral part of this policy and through a technology neutral approach is promoting research and innovation in all lowcarbon energy sources that can help to respond to the EU's energy challenges.

### > EUROPE'S 2020 STRATEGY

The key headline targets of Europe's 2020 strategy for 'smart, sustainable and inclusive growth' include the energy objectives already expressed in EU energy policy (i.e. targets for CO<sub>2</sub> reduction, efficiency measures, growth of renewables) together with the goal of 3% of the EU's GDP to be invested in R&D. These will therefore be key policies of the EU over the next decade and are of clear relevance to research in all low carbon energy systems.

### > INTERNATIONAL COOPERATION

The Euratom Framework Programme is making full use of the opportunities offered through multilateral (e.g. Generation IV International Forum – GIF) and bilateral agreements on nuclear R&D cooperation and peaceful uses of nuclear technology between Euratom and third countries. It is also working with other international organisations and bodies such as OECD/NEA, IAEA or ISTC and STCU. Third-country partners are welcome in Euratom projects, though normally they would receive no funding from the Euratom programme. Euratom also adopted a structured dialogue approach with key third countries that lead to specific topics of mutual interest being included in the 2009 and 2010 calls.

## FP7 research activities

The overall aims of the programme are to establish a sound scientific and technical basis to advance practical developments for the safe management of long-lived radioactive waste, to promote the safe, resource-efficient and competitive exploitation of nuclear energy, and to ensure a robust and socially acceptable system of protection of man and the environment against the effects of ionising radiation.

Research activities are proposed under five main themes: management of radioactive waste, reactor systems and safety, radiation protection, and the key cross-cutting areas of research infrastructures and human resources, mobility and training. The latter activities are increasingly embedded within the projects funded under the thematic priorities.

## Looking forward

Euratom will be a key part of Horizon 2020, the Commission's new EUR 80 billion framework programme for research that will follow on from FP7, which runs until the end of 2013. It will be a key cornerstone of the EU's Innovation Union initiative, a Europe 2020 flagship policy that aims to secure Europe's science and technology base and industrial competitiveness. Unlike previous research programmes, Horizon 2020 brings together all EU research and innovation funding under a single programme for the first time. And the focus is very much on turning scientific breakthroughs into innovative products and services that provide business opportunities and improve European citizens' lives.

## Funding Schemes

Collaborative Projects (CPs) foster collaborative R&D activities amongst European partners (e.g. industry, research institutes and organisations, academia). Both small/medium-scale focused projects and large-scale integrating projects can be funded.

Coordination and Support Actions (CSAs) promote networking and coordination type activities or provide support for such aspects as dissemination of programme results or pilot studies for possible future collaborative projects. CSAs cannot fund R&D activities per se.

Networks of Excellence (NoEs) aim to strengthen the European Community's scientific and technological excellence through developing sustainable capacities at national and regional level. Each NoE will advance knowledge in a particular research area by assembling a critical mass of expertise and organising activities targeted towards long-term, multidisciplinary objectives. A joint programme of activities is developed and implemented that covers three key aspects: joint research, sustainable integration, and the spreading of knowledge. Combinations of schemes are also possible. For each scheme, rules apply regarding minimum numbers of consortium partners from different Member States and associated countries. Apart from the 27 EU Member States, there is currently only one other country – Switzerland – fully associated to FP7 Euratom. Partners from all these countries can be reimbursed by the programme.

## The European Research Area (ERA) and Euratom

The 'Euratom experience' during previous Framework Programmes has been one of support in pursuing excellence in research across a broad range of nuclear topics: waste management, reactor technology and safety, radiation protection, and associated training activities. During the Sixth Framework Programme (FP6), with its new funding instruments, the emphasis was also on facilitating the restructuring of these sectors in line with the objectives of the ERA (e.g. reduced fragmentation, increased critical mass, and more investment in research).

These efforts to establish the ERA in nuclear fission science and technology are continuing under the Seventh Framework Programme (FP7). Technology platforms in Sustainable Nuclear Energy and Implementing Geological Disposal as well as joint programming with Member States in the area of low-dose risk are a central aspect of this strategy. This research effort is needed to retain and improve competences and know-how, thereby improving the efficiency and effectiveness of European research in these fields. This in turn contributes to maintaining high levels of nuclear safety and industrial competitiveness in these fields. By enabling a coordinated effort, the Euratom Framework Programme ensures the development of a common European view on scientific issues, the harmonisation of approaches and standards, and the promoting of a safety culture across the European Union and beyond.



## Implementing Geological Disposal Technology Platform (IGD-TP)

Safe long-term management of radioactive waste is a concern of governments and citizens alike. The Euratom programme has funded R&D on this topic for many years, and in FP7 the emphasis is increasingly on implementation-oriented activities. On 12 November 2009, with the support of the European Commission, a group of European radioactive waste management organisations launched IGD-TP. Other platform members include key research institutes, organisations and industrial players, and membership is growing all the time. All endorse the common vision that by 2025 the first geological disposal facilities for nuclear waste will be operating safely in Europe. IGD-TP will facilitate pooling of critical European resources and co-ordinate future R&D in support of this vision, which also responds to the technology challenges laid out in the SET-Plan. The Euratom work programmes are increasingly oriented to the IGD-TP strategy. More information on IGD-TP is available at [www.igdtp.eu](http://www.igdtp.eu).

## Multidisciplinary European Low-Dose Initiative (MELODI)

For many years the Euratom programme has been concerned with the fundamental question of the risks from low and protracted exposure to ionising radiation, and has recognised the need for improved structuring of the research effort across Europe in this field. The creation of the 'High-Level and Expert Group', with support from the HLEG project above, was the decisive step enabling the establishing of MELODI in 2009. This 'joint-programming initiative' brings together the major national funding agencies supporting radiation protection research in Europe. The growing use of radiation in medical diagnostic and therapeutic techniques is responsible for a significant rise in doses to the public, and MELODI will ensure the necessary multidisciplinary approach across the medical sector to understand and mitigate the risks involved. As with IGD-TP, this strategic initiative will have an increasing effect on the choice of topics for inclusion in future Euratom work programmes. For further details on this major initiative, visit [www.melodi-online.eu](http://www.melodi-online.eu)

## Sustainable Nuclear Energy Technology Platform (SNE-TP)

The Sustainable Nuclear Energy Technology Platform (SNE-TP), which is the result of successful pilot actions supported under FP6, initiated in response to a proposal from stakeholders, brings together some 100 members from 19 European countries, including all the major nuclear, industrial and research players. It was formally launched in September 2007 and represents a major effort to better coordinate research activities in the area of nuclear fission safety and systems, and to collaborate more effectively in implementing research that is strategically important for Europe.

By 2020 the aim is to maintain safety and competitiveness in fission technology and provide long-term waste management solutions. The objectives for 2050 are to have completed the demonstration of a new generation (Gen IV) of fission reactors with increased sustainability identified in the SET-Plan European Sustainable Industrial Initiative (ESNII) and enlarge nuclear fission applications beyond electricity production. For further details on this major initiative, visit [www.snetp.eu](http://www.snetp.eu)

SNETP has given mandate to NUGENIA ([www.nugenia.org](http://www.nugenia.org)) established in March 2012 as a natural progression of NULIFE project and is the result of the integration process of 3 groups active in the nuclear energy research field of Generation II & III technologies:

- (1) The first of the three SNETP pillars: Technology Working Group Gen II & III,
- (2) The NULIFE Network of Excellence on nuclear plant life management (PLIM and PLEX)
- (3) The SARNET Network of Excellence on severe accidents.

## BELBaR

The main aim of BELBaR is to increase knowledge of the processes that control clay colloid stability, generation and its ability to transport radionuclides. The overall purpose of the project is to come up with a new way of treating issues in long-term safety/performance assessment.

## Bentonite Erosion: effects on the Long term performance of the engineered Barrier and Radionuclide Transport

### A skilled consortium

The pan-European BELBaR project consortium is made up of partners with many diverging skills and competences. They include national radioactive waste management organisations (WMOs) from a number of countries, research institutes, universities and commercial organisations working in the radioactive waste disposal field.

This Collaborative Project (CP) aims to improve long-term safety assessments for repository concepts that combine a clay Engineered Barrier System (EBS) with a fractured rock. The formation and stability of colloids from the EBS may have a direct impact on assessed risk from the repository in the following two ways:

- generation of colloids may degrade the engineered barrier (Figure 1);
- colloid transport of radionuclides may reduce the efficiency of the natural barrier.

By better understanding these processes the outcomes of future assessments will be improved.

### Activities

The main aim of BELBaR is to reduce uncertainties surrounding the description of the effect of clay colloids on the long-term performance of the engineered barrier and on radionuclide transport. This will be achieved by:

- improving understanding about when bentonite colloids are unstable: this is critical information as it determines whether or not clay colloids need to be included in long-term assessments;
- improving quantitative models for erosion on the bentonite barrier for the cases when the colloids are stable;
- improving understanding of how radionuclides attach themselves to clay colloids: this information will be used to formulate improved transport models for the assessment of radionuclide transport in the Geosphere.

To meet the project objectives a number of experimental and modelling activities will be carried out within the project. An example of a typical colloid generation experiment can be seen in Figure 2.

### Coordinator

**Desirée Sundman**  
Svensk Kärnbränslehantering  
Blekhölmstorget 30, 101 24  
Stockholm, Sweden  
Tel. +46 857938698  
[desiree.sundman@skb.se](mailto:desiree.sundman@skb.se)

### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.3.2012  
**Duration** // 48 months  
**Total budget** // EUR 5 087 574  
**EC contribution** // EUR 2 581 476

### EC project officer

**Christophe Davies**  
European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/61  
B-1049 Brussels, Belgium  
[christophe.davies@ec.europa.eu](mailto:christophe.davies@ec.europa.eu)

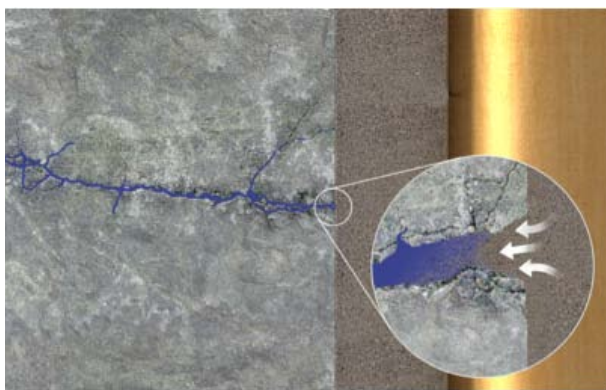


Figure 1: Colloid formation from a bentonite barrier  
© SKB, Jan Rojmar

## Expected results

There is large pool of knowledge about colloid stability both from the general scientific literature and from national and international projects within the nuclear waste management community. However, there is still a knowledge gap when it comes to our ability to transfer scientific understanding into useful applications for long-term performance assessment for real systems. BELBaR will develop tailor-made experimental programmes to resolve important safety assessment issues, develop quantitative models founded on sound science and verified by relevant experiments for the assessment of erosion and radionuclide transport, and increase knowledge about bentonite colloid stability in realistic systems that can be used in safety assessments as well as in the formulation of site investigation/site modelling programmes.

## Societal impact

It is hoped that the project outcomes will benefit the primary target audience: national WMOs. By using the project findings they will be able to reduce uncertainties in the understanding of a process that has been shown to have a direct impact on the assessed dose/risk from a repository for high level nuclear waste. Eradicating uncertainty will hopefully reduce the assessed overall risk from a repository and lead to the possibility to totally neglect the process in assessments under some circumstances. The project will also act as a form of guidance in future site selection and site characterisation programmes as well as help in the selection of engineered barriers for a nuclear waste repository.

## Getting the results out there

The BELBaR project partners hope to take full advantage of the CP structure. Therefore, key aspects to the project will be interaction, communication and cooperation. Since a large part of the work within the project will be of interest to the wider research community, the team plan to publish results in peer reviewed journals. Towards the end of the project, an international symposium will be organised to disseminate the final BELBaR outcomes to the radioactive waste stakeholder community as well as scientists and policymakers from other relevant sectors.

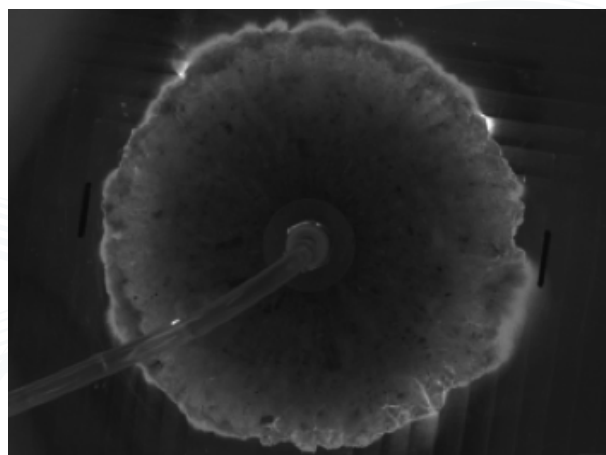


Figure 2: An expanding and eroding bentonite front in a flow field in a thin slot between two Plexiglas plates  
© Ulf Nilsson, Clay Technology

## Partners

- Svensk Kärnbränslehantering AB (SKB), SE
- Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas (CIEMAT), ES
- Nuclear Research Institute Rez plc (NRI), CZ
- Karlsruher Institut Für Technologie (KIT), DE
- Posiva Oy (POSIVA), FI

- Technical Research Centre of Finland (VTT), FI
- Clay Technology (ClayTech), SE
- University of Jyväskylä (JYU), FI
- Kungliga Tekniska Högskolan (KTH), SE
- Nuclear Decommissioning Authority (NDA), UK
- B+Tech (B+Tech), FI
- The University of Manchester (UNIMAN), UK
- University of Helsinki (HU), FI

- Lomonosov Moscow State University (MSU), RU



# CATCLAY

The aim of CATCLAY is to improve understanding of the phenomena governing migration of radionuclides in clayrocks as potential host rocks for the deep geological disposal of nuclear waste.

The project focuses on the diffusion-driven transport of cationic species  $\text{Sr}^{2+}$ ,  $\text{Zn}^{2+}$  and  $\text{Eu}^{3+}$ , which are more or less strongly sorbed on clay mineral surfaces.

## Processes of cation migration in clayrocks

### A wide skill set

Five research organisations make up the CATCLAY consortium, and they are joined by one end user and one consultant. Together, the partners bring a variety of skills to the table: modelling of retention and diffusion from meso- to macro-scale in intact clayrock materials, conducting diffusion-sorption experiments, and characterising the microstructure of clayrocks at different scales. The main aim is to provide a model of coupled sorption-diffusion in compacted clay (illite) and clayrocks for highly sorbing species such as actinides.

### Activities

CATCLAY stems from the main conclusions of the Sixth Framework Programme (FP6) 'Fundamental processes of radionuclide migration' (FUNMIG) project. For mobile species, in particular non-sorbing anions such as  $\text{Cl}^-$ , diffusion phenomena are sufficiently well understood so that the effect of clay properties (surface charge, porosity, etc.) and solution composition on diffusion-driven transport are well reproduced by the developed models. The effect of clayrock structure was clarified largely due to advances made in the capacity to map mineral grain and porosity organisation of clayrocks at sub-micron spatial resolutions.

For highly sorbing species, the coupled diffusion-sorption migration was found to be much more complex than expected, with mobility being significantly greater than that predicted by coupling sorption behaviour measured in batch systems with assumed diffusion characteristics similar to water molecules. Depending on the interpretation, the observed greater mobility can be attributed to either reduced retention or enhanced diffusion in intact rock. Due to the very low transfer characteristics, experimental results are very limited. The majority of CATCLAY activities are focused on obtaining high-quality data regarding this process and on developing interpretive models.

The aim of CATCLAY is to answer the following question: Can the migration of actinides and other strongly sorbing radionuclides in clayrock be predicted by coupling models of their sorption equilibria on representative clay minerals and the diffusion-driven mass transport of radionuclide sorbed and dissolved species in compacted masses of these clay minerals?

### Coordinator

**Sébastien Savoye**

Commissariat à l'Energie Atomique  
Bât. 450 – point courrier n°40  
CEA Saclay  
91191 Gif-sur-Yvette, France  
Tel. +33 169087751  
Fax +33 169083242  
[Sebastien.savoye@cea.fr](mailto:Sebastien.savoye@cea.fr)

### Project details

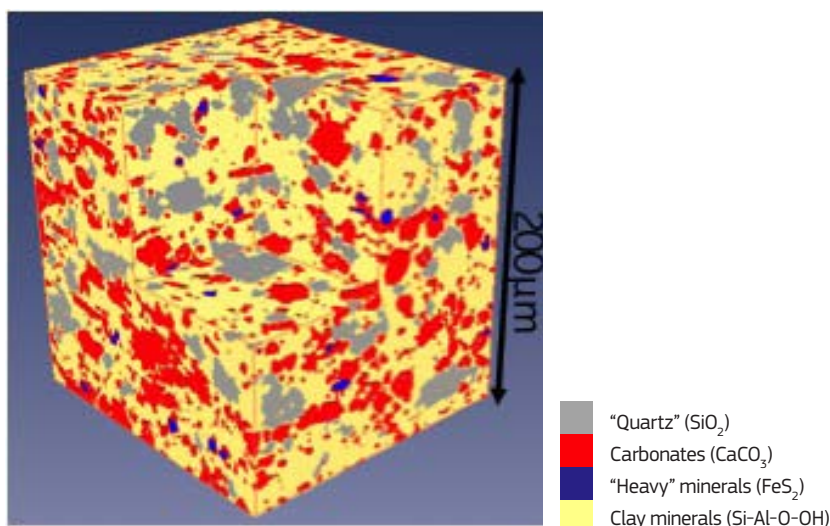
**Project type** // Collaborative Project  
**Project start date** // 1.6.2010  
**Duration** // 48 months  
**Total budget** // EUR 1 555 106  
**EC contribution** // EUR 819 498

### EC project officer

**Christophe Davies**

European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/61  
B-1049 Brussels, Belgium  
[christophe.davies@ec.europa.eu](mailto:christophe.davies@ec.europa.eu)





*3D mapping of minerals in a clayrock sample (derived from synchrotron based X-Ray tomography).*

© J.C. Robinet, ANDRA

## Societal impact

Belgium, France and Switzerland have chosen to dispose of high- and intermediate-level long half-life radioactive wastes generated in deep underground in low permeability 'clayrock' formations. Confidence in these concepts is mainly based on the capacity of the corresponding waste management organisations to demonstrate that the models used to predict radionuclide migration through the respective clayrock formations are scientifically sound. It is crucial for the credibility of future safety cases that the model used for cation migration is as scientifically solid as possible and the CATCLAY project is specifically designed to enhance this understanding.

## Public events

The project website contains a publicly accessible space to ensure wide distribution of project data. Two documents will be produced that aim to present project advances to non-specialists. A training course for students and young researchers covering theoretical and experimental aspects of diffusion studies, with a strong focus on cation behaviour in clays and clayrocks will be organised before the end of the project, in October or November 2013.

## Partners

- Commissariat à l'énergie atomique et aux énergies alternatives (CEA), FR
- Agence nationale pour la gestion des déchets radioactifs (ANDRA), FR
- Bureau de recherches géologiques et minières (BRGM), FR
- Paul Scherrer Institute (PSI), CH
- Studiecentrum voor Kernenergie - Centre d'Etude de l'énergie Nucléaire (SCK-CEN), BE
- Forschungszentrum Karlsruhe GmbH, Institut für Nukleare Entsorgung (KIT-G), DE
- Appelo Hydrochemical Consultant (Appelo), NL

# CROCK

The overall aim of CROCK is to develop a methodology for decreasing uncertainty in the long-term prediction of radionuclide migration in the crystalline rock repository far-field. The project partners will tackle the problem of not having a defensible approach for decreasing uncertainty in terms of crystalline host rock far-field radionuclide transport.

## Crystalline Rock Retention Processes

### Tackling uncertainty together

The project consortium is made up of five large European research institutions, two universities and three small and medium-sized enterprises (SMEs) from six countries with dedicated crystalline host rock disposal programmes and particular competence in this field. National waste management organisations also participate in the project by contributing co-funding to the project partners, as well as infrastructures, knowledge and information. National regulators are also on board for guidance with respect to application of the project in the disposal Safety Case.

The key overall project objective is to provide waste management organisations with a tool for improving the situation in forthcoming site investigation programmes.

The uncertainty and the associated conservatism associated with radionuclide transport in the crystalline host rock far-field around geological disposal of high level radioactive waste can be divided into three types: conceptual, modelling and experimental. Experimental uncertainties can be lowered through straightforward approaches, and conceptual uncertainties include a lack of principle understanding on how scavenging processes in nature actually take place. As a result it is unclear if the picture used for these processes is sufficiently well related to reality and how coupling of different processes results in a bulk or average impact.

### Scope

The objectives of the project are to increase scientific and process understanding in the transport simulations used to support Performance Assessment conclusions for the purpose of increasing confidence in the safety of nuclear waste disposal. For this purpose, advanced analytical methods are developed and applied for thorough characterisation of the natural samples used in the experimental programme and determination of spatial distribution and chemical state of radionuclides in the samples on the atomistic, nano and micrometre resolution scale, especially with respect to chemical and physical retention processes. Information and data are brought together from the different experiments and scales for a consistent and systematic bottom-up description with different abstraction steps. Various tools and processes are tested for modelling sorption at a large scale.

### Coordinator

**Thomas Rabung**

Karlsruher Institut für Technologie, Institut  
für Nukleare Entsorgung  
KIT-INE  
Hermann-von-Helmholtz-Platz 1  
76344 Eggenstein-Leopoldshafen, Germany  
Tel. +49 72160825846  
Fax +49 72160823927  
[thomas.rabung@kit.edu](mailto:thomas.rabung@kit.edu)

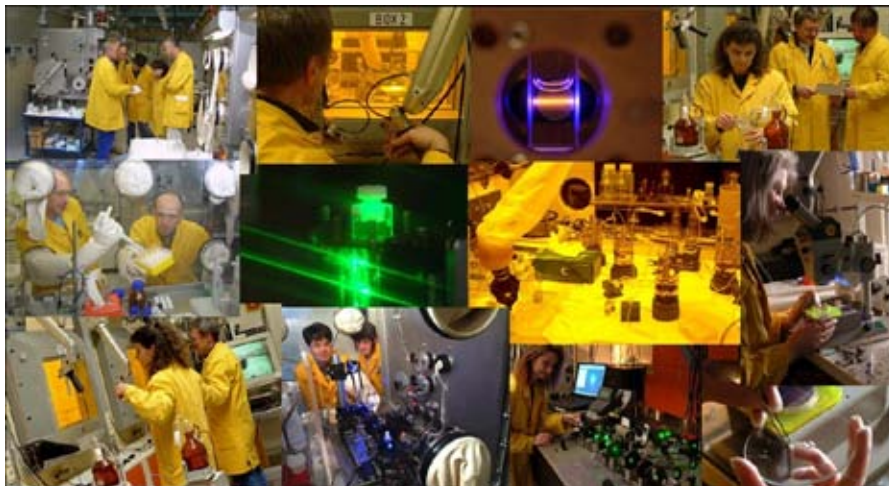
### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.1.2011  
**Duration** // 30 months  
**Total budget** // EUR 1 789 230  
**EC contribution** // EUR 1 057 927

### EC project officer

**Christophe Davies**

European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/61  
B-1049 Brussels, Belgium  
[christophe.davies@ec.europa.eu](mailto:christophe.davies@ec.europa.eu)



*Available analytical techniques and infrastructures of the project.*

© KIT-INE

## Activities

With respect to the retention of radionuclides in the crystalline host rock far-field, and the application to the associated Safety Assessment and Safety Case, the work plan aims to (i) provide a set of fresh samples from Äspö URL obtained under anoxic conditions and characterise them thoroughly for subsequent interpretation of experimental results, (ii) conduct radionuclide transport and sorption experiments and identify relevant processes from nanometre range up to large block scale experiments, (iii) identify sorption processes by natural chemical homologue inventory analysis, (iv) interpret existing and generate new matrix diffusion data, thereby combining observations from different scales, in particular using real system analysis, (v) bring the results from the experimental programme and analysis of existing data to a consistent set of model descriptions, including the different abstraction steps in the up-scaling process, (vi) formulate the results based on use for decreasing uncertainty in Safety Assessment and generate a tool for achieving a decrease in uncertainty in forthcoming site investigation programmes, (vii) document the state-of-the art at the beginning of the project and update the resulting working document towards final reporting, (viii) provide for management of documentation, communication and dissemination of the results, and (ix) provide for overall project management.

## Information about important public events

The CROCK kick-off meeting was held 10–11 February 2011 in Barcelona, Spain. There will be two project workshops for communicating the results obtained within the project. The first was held in Stockholm, Sweden from 22–24 May 2012 and the second will be held in Karlsruhe, Germany in May 2013.

## Partners

- Karlsruher Institut für Technologie (KIT), DE
- Amphos 21 Consulting S.L. (AMPHOS), ES
- Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), ES
- Helmholtz-Zentrum Dresden-Rossendorf e.v. (HZDR), DE
- Chalmers Tekniska Högskola AB (CTH), SE
- Ústav Jaderneho Vyzkumu Rez a.s. (NRI), CZ
- Conterra Aktiebolag (CONTERRA), SE
- Lomonosov Moscow State University (MSU), RU
- Teknologian Tutkimuskeskus (VTT), FI
- Kemakta Konsult AB (KEMAKTA), SE



# FIRST-Nuclides

The overarching aim of FIRST-Nuclides is to provide improved understanding of fast/instantly released radionuclides from disposed high burn-up spent uranium oxide (UO<sub>2</sub>) fuels in geological repositories. This waste type is a source of significant release of radionuclides after loss of the canister integrity. The fast release fraction consists of radionuclides showing high solubility in groundwater. Some important nuclides undergo only marginal retention on their way to the biosphere. For safety analysis, the mobilisation of these radionuclides needs to be quantified.

## Fast / Instant Release of Safety Relevant Radionuclides from Spent Nuclear Fuel

### Skilled project partners

The project consortium is made up of ten beneficiaries. Six experimental facilities have specialised installations and equipment for working with highly radioactive materials and have experience practising advanced experimental techniques and analytical methods. Four organisations have specific knowledge in conceptualisation of processes and their formulation in models. National waste management organisations (WMOs) contribute to the project by sharing knowledge and providing co-funding.

### Activities

The project, which kicked off in January 2012 and will run until December 2014, directly answers questions about inadequately supported knowledge on fast/instant radionuclide release for license applications related to the disposal of high burn-up fuel. The knowledge and data obtained will reduce uncertainties and provide realistic data on the relevant radionuclide release for the Safety Case which will increase confidence in predictions. In particular, it is expected that the scientific basis will be strengthened with respect to decreasing the calculated peak-doses to individuals. The project therefore contributes to the Safety Case of all European disposal concepts for spent nuclear fuel.

The results generated will be communicated to all project stakeholders as well as those in the broader community. The web portal of the project will be used to disseminate and communicate the results. Project workshops will also be organised, and the project outcomes will be presented at international conferences, and workshops. Training activities will include annual workshops with invited experts and on-the-job training mobility measures.

Plans for a future training course on the physics and chemistry of spent nuclear fuel and on related modelling will be discussed.

### Coordinator

**Bernhard Kienzler**

Karlsruher Institut für Technologie, Institut für Nukleare Entsorgung (KIT-INE)  
Hermann-von-Helmholtz-Platz 1  
76344 Eggenstein-Leopoldshafen, Germany  
Tel. +49 72160824467  
Fax +49 72160824308  
[bernhard.kienzler@kit.edu](mailto:bernhard.kienzler@kit.edu)

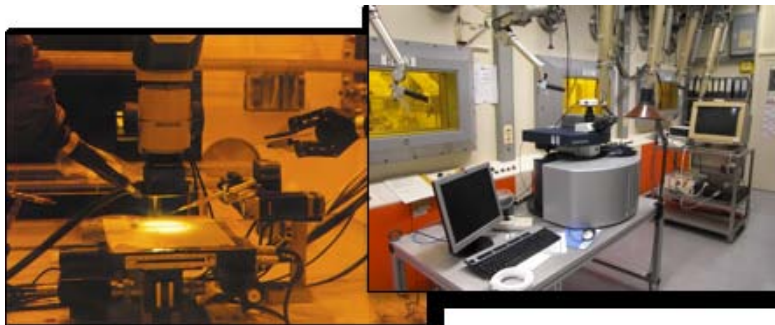
### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.1.2012  
**Duration** // 36 months  
**Total budget** // EUR 4 741 261  
**EC contribution** // EUR 2 494 513

### EC project officer

**Christophe Davies**

European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/61  
B-1049 Brussels, Belgium  
[christophe.davies@ec.europa.eu](mailto:christophe.davies@ec.europa.eu)



Available analytical techniques and infrastructures of the project.

© KIT-INE

## Expected results

The project aims to meet the following objectives:

- (i) selection, characterisation and preparation of materials and setup of tools for handling and transporting the highly radioactive materials;
- (ii) experimental determination of fission gas release;
- (iii) experimental investigation of rim and grain boundary diffusion;
- (iv) experimental investigation of dissolution-based radionuclide release and (to the extent possible) the chemical speciation of the relevant isotopes;
- (v) modelling of migration/retention processes and of chemical speciation of fission products in the spent fuel structure, the grain boundaries, and in the pellet interfaces;
- (vi) assessment and discussion of potential impact on the Safety Case;
- (vii) establishment of the state-of-art with regular updating, and stepwise build-up of scientific-technical reporting, its dissemination and communication, as well as training;
- (viii) project coordination and management.

## Societal impact

The main expected impact of the project is to obtain improved data for the rapid release fraction for spent  $\text{UO}_2$  fuel and improved understanding of its dissolution behaviour, in relation to licensing repositories set to be operational by 2025.

As average fuel burn-up will increase for many reactors over the next 5–10 years, the project considers high burn-up  $\text{UO}_2$  fuel and requirements for the Disposal Safety Case independent on the host rock under consideration with respect to: experimental determination of fission product

distribution in fuel pellets, the fission gas release after puncturing of high burn-up spent fuel rods or segments and determination of fission gas and non-gaseous fission product release from spent fuel in the case of contact with an aquatic phase.

The project will realise a database that can be used for predicting the fast/instant release of fission and activation products for the whole range of  $\text{UO}_2$  fuel elements to be disposed of in Europe. These include pressurized water reactor (PWR) and boiling water reactor (BWR) fuels of different initial enrichments, fuel element configurations, burn-up and burn-up history as well as linear power and fuel temperatures.

## Information about important public events

Three project workshops will be held over the course of the project; these contribute to communicating about the project to the wider community. The first one was held 9–11 October 2012 in Budapest. In addition, the experimental and modelling plans of the project were presented at a 'Spent Fuel Workshop' in Avignon, France in April 2012, the E-MRS Spring meeting in Strasbourg, France, May 2012, the 4th International ATALANTE Conference on Nuclear Chemistry for Sustainable Fuel Cycles in September 2012, Montpellier, France, and the MRS Fall Meeting in November 2012, Boston, USA.

## Partners

- Karlsruher Institut Für Technologie (KIT), DE
- Amphos 21 Consulting S.L. (AMPHOS21), ES
- Joint Research Centre – Institute for Transuranium Elements (JRC-ITU), DE
- Forschungszentrum Jülich GmbH (JÜLICH), DE
- Paul Scherrer Institute (PSI), CH
- Studiecentrum voor Kernenergie (SCK-CEN), BE
- Centre National de la Recherche Scientifique (CNRS), FR
- Fundació CTM Centre Tecnològic (CTM), ES
- Magyar Tudományos Akadémia Energiatudományi Kutatóközpont (EK/MTA), HU
- Studsvik Nuclear AB (STUDSVIK), SE

## InSOTEC

InSOTEC is a social sciences research project which aims to generate a better understanding of the complex interplay between the technical and the social in radioactive waste management and, in particular, in the design and implementation of geological disposal. It currently investigates and analyses the most striking socio-technical challenges to implementing geological disposal of radioactive waste in 14 national programmes. Concrete examples of socio-technical challenges are: the question of siting, introducing the notion of reversibility/retrievability into the concept of geological disposal, or monitoring for confidence building.

## International socio-technical challenges for implementing geological disposal

### Linking up related fields

InSOTEC broadens the stream of socio-political research on radioactive waste management to include research on social aspects of science and technology in radioactive waste management and on the technical translation of socio-political requirements.

The InSOTEC consortium members have sound experience researching different aspects of radioactive waste management from a social science perspective, both at national and local level. All academic partners have specific expertise, know-how and experience investigating energy and radioactive waste management policy and the relationship between science, society and technology.

### Activities

InSOTEC's main research objective is to develop a broad overview and understanding of the socio-technical challenges surrounding geological disposal, and to come up with approaches to tackle these challenges in national and international contexts. The consortium partners will review national and international experience on the correlation of socio-political and technical challenges, assess mechanisms that look at the interaction of social and technical challenges through a number of case studies, and map out interactions on socio-technical issues within knowledge networks on radioactive waste management. A core part of the project is the linking up of the results of the research activities to the practice of radioactive waste management, to provide reflections and recommendations to the Implementing Geological Disposal Technology Platform (IGD-TP) and other interested parties.

In parallel, InSOTEC seminars will combine research and dissemination activities aimed at a diversity of audiences interested in questions related to radioactive waste management and geological disposal.

### Coordinator

**Anne Bergmans**  
Faculty of Political and Social Sciences  
University of Antwerp  
Sint Jacobstraat 2  
2000 Antwerp, Belgium  
Tel. +32 32655542  
Fax +32 32655798  
[anne.bergmans@ua.ac.be](mailto:anne.bergmans@ua.ac.be)

### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.3.2011  
**Duration** // 36 months  
**Total budget** // EUR 3 254 855  
**EC contribution** // EUR 1 999 856

### Project website

[www.insotec.eu](http://www.insotec.eu)

### EC project officer

**Kateřina Ptáčková**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/60  
B-1049 Brussels, Belgium  
[katerina.ptackova@ec.europa.eu](mailto:katerina.ptackova@ec.europa.eu)





© Andrea Danti, #22626567, 2012. Source: Fotolia.com

## Expected results

The aim of InSOTEC is to develop a fine-grained understanding of how the technical and the social influence, shape, build upon each other in the case of radioactive waste management and the design and implementation of geological disposal. How are socio-technical combinations in this field translated and materialized into the solutions finally adopted? With what kinds of tools and instruments are they being integrated? Complementary to providing better theoretical insight into these socio-technical challenges/combinations, InSOTEC aims to provide concrete suggestions on how to address these within national and international contexts. To this end, InSOTEC will deliver insights into how mechanisms for interaction on technical and safety issues between the technical community and a broad range of socio-political actors could be developed.

The project will also provide recommendations to the IGD-TP on how non-institutional actors can be linked to the platform's Exchange Forum on a structured basis. In addition, advice will be provided on how to set priorities for a multidisciplinary research agenda that incorporates social sciences and addresses socio-technical challenges in a coherent and integrated way. The InSOTEC Stakeholder Reflection Group will ensure that different perspectives from potential end-users are taken into account and that the results are useful to the 'practitioners' in the field.

## Societal impact

One of the main challenges surrounding the implementation of geological disposal is gaining confidence and support beyond the technical community. The InSOTEC project approaches consider the technical and social aspects of the waste problem to be intimately linked. As such, the concept of deep geological disposal is represented as being part of a social environment and therefore as being partially shaped by it. On the basis of this understanding, InSOTEC will offer targeted social scientific research that addresses scientific and technical issues associated with long-term waste management. This project hopes to have an impact not only on the work of the technical community and the networking approach of the IGD-TP via the platform's Exchange Forum, but also on a broad variety of stakeholders concerned with geological disposal and with radioactive waste management in general.

## Information about important public events

InSOTEC will organise two open seminars to communicate project progress and intermediary results. A first one was held in Barcelona on March 21-22, 2012. In addition, InSOTEC results will be presented at national, European and international events. The project website includes up-to-date relevant information on the project, upcoming events and publications.

## Partners

- Universiteit Antwerpen (UA), BE
- University of East Anglia (UEA), UK
- Öko-Institut e.V. — Institut für angewandte Ökologie (OEKO), DE
- Göteborgs Universitet (UGOT), SE
- Centre national de la recherche scientifique (CNRS), FR
- Magyar Tudományos Akadémia Szociológiai Kutatóintézet (MTA SKI), HU
- Group of European Municipalities with Nuclear Facilities (GMF), ES
- Tampereen Yliopisto (UTA), FI
- Jyväskylän Yliopisto (JYU), FI
- Univerza v Ljubljani (UL), SI
- Univerzita Karlova v Praze (CUNI), CZ
- Merience Strategic Thinking (MERIENCE), ES
- Universitetet i Oslo (UiO), NO

## IPPA

The IPPA project is focused on enhancing the quality of decision-making processes in nuclear waste management through clarity, awareness, fairness and trust. A key principle is the implementation of participative processes and transparency, and the involvement of stakeholders in 'safe spaces'. The project involves the practical organisation of safe spaces in national programmes and exploring how this can also be implemented in the multinational context.

## Implementing public participation approaches in radioactive waste disposal

### A safe space

A safe space is an arena for dialogue where stakeholders come together to increase their understanding of the issues and also of their respective views without feeling like hostages bound to a single viewpoint. The focus is on clarifying issues rather than rushing decisions. The RISCUM (RISK COMMunication) model offers a way of doing this through clarification of arguments with respect to their scientific value, as well as through the integrity of the person or organisation making the arguments.

The consortium is made up of 16 organisations from 12 countries. Together they represent academic research, other research institutions, consultant companies, nuclear waste management organisations, and non-governmental organisations (NGOs). The participants have backgrounds and expertise in a broad spectrum of areas such as physics, geology, nuclear engineering, radioactive waste treatment, environmental science, environmental impact assessment, environmental policy, political science, sociology, economics and international affairs.

### Process implementation and establishment of arenas

The IPPA project provides participants with information, and gives an overview of theoretical achievements and practical experiences from research and national programmes. This should be valuable when organising activities and arenas for participation and transparency.

The RISCUM model and other approaches to public involvement are implemented in five radioactive waste management programmes in central and eastern European countries (the Czech Republic, Poland, Romania, Slovenia and Slovakia). The project will also examine means of building a safe space for common, and sometimes highly controversial, issues around national borders — such as the transboundary Environmental Impact Assessment (EIA) and the Strategic Environmental Assessment (SEA), regional repositories, and application of the Aarhus Convention. The project considers how negotiations on compensation and added value can be implemented at the local level.

### Expected results

From practical experience and earlier research projects, such as the Sixth Framework Programme (FP6) 'Arenas for risk governance' (ARGONA) project,

#### Coordinator

**Kjell Andersson**  
Karita Research  
Box 6048  
SE 18706 Täby  
Sweden  
Tel. +46 851014755  
[kjell.andersson@karita.se](mailto:kjell.andersson@karita.se)

#### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.1.2011  
**Duration** // 36 months  
**Total budget** // EUR 2 398 335  
**EC contribution** // EUR 1 599 988

#### EC project officer

**Kateřina Ptáčková**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/60  
B-1049 Brussels, Belgium  
[katerina.ptackova@ec.europa.eu](mailto:katerina.ptackova@ec.europa.eu)



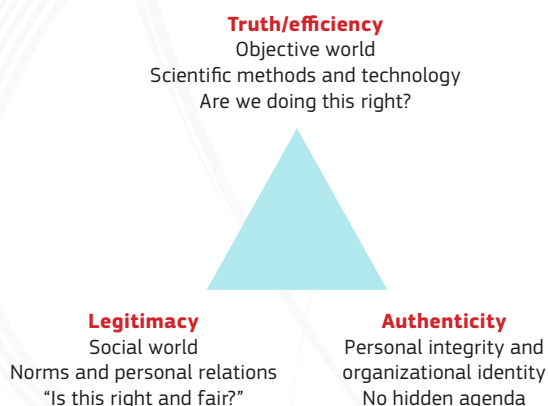


IPPA presented in the Senate of the Czech Republic on April 24, 2012.

© Senate of the Czech Republic

we know that long-term and proactive public involvement in decision-making processes makes them more stable, because participation empowers key actors such as municipalities and protects them from harmful fragmentation in sensitive phases of political decision-making. As processes of participation and transparency can be linked to existing political decision-making structures, including representative democracy, stakeholders often need a safe space for their involvement, but success or failure depends on trust in the process. IPPA will show the way forward by demonstrating these findings in practical reality.

The project is designed to respond to the social and political challenges to successful implementation of radioactive waste management programmes. Testing and implementing novel approaches to public participation and transparency in direct connection with repository development programmes will result in guidance for further progress, by showing ways forward and suggesting concrete schemes for establishing a safe space for participation and transparency; this will lead to increasing awareness of the issues involved among decision-makers, stakeholders and the general public. A 'toolbox' of approaches and methods for public participation will be developed that can be accessed by interested agencies and implementing bodies wishing to select and apply specific approaches in particular situations.



## Societal impact

Often, a major challenge in technology development is devising a proper plan that will offer all stakeholders the chance to influence decision-making without creating blockages. The intention is to 'vaccinate' decision-making processes against unnecessary narrow framing and fragmentation that may later become serious obstacles to decision-making. Experience has shown that such narrow framing is often the result of technology expertise lacking proper acknowledgement of broader societal perspectives, but it could also come about in part due to social sciences neglecting 'hard facts'.

This concept of 'vaccination' is further enhanced by IPPA networking and exchange of experience at national and international levels, which aim to make progress on issues of common interest between countries. Furthermore, new methods will be honed to bridge the gap between research and successful implementation of processes for participation and transparency. This may be valuable not only when challenging the results of social sciences projects, but also for technical and natural science research results. This should be of interest for the clarification of the meaning of research in many areas, not just within the realm of nuclear waste management.

## Major public events

A European Workshop took place in September 2012 and an End Users Conference will take place towards the end in 2013, designed to challenge the results of the project and clarify their practical meaning.

## Partners

- Karita Research AB (Karita), SE
- Nuclear Research Institute at Rez plc (NRI), CZ
- Radioactive Waste Repository Authority (RAWRA), CZ
- Galson Sciences Ltd (GSL), UK
- University of Tampere (UTA), FI
- Öko-Institut (Oeko), DE
- DECOM (DECOM), SK

- Matej Bel University Banská Bystrica (MBU), SK
- Mutadis Consultants Sarl (MUTADIS), FR
- Institute of Nuclear Chemistry and Technology (INCT), PL
- Institute of Atomic Energy (IAE), PL
- University of Ljubljana (UNILJ), SI
- Institute for Nuclear Research (INR), RO
- Romanian Association for Nuclear Energy (AREN), RO

- Regional Environmental Center for Central and Eastern Europe (REC), HU
- Center for the Study of Democracy (CSD), BG

# LUCOEX

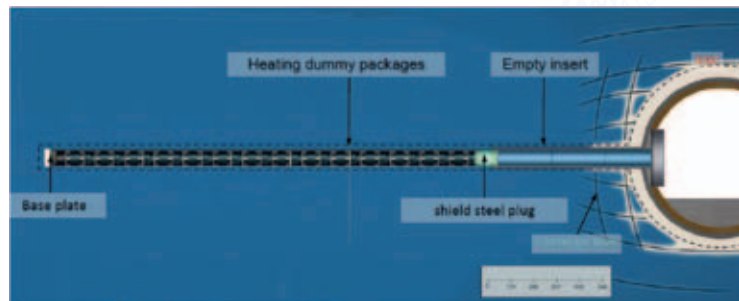
Nuclear waste disposal implementers involved in experiments in underground research laboratories (URLs) have established a joint collaboration with the purpose of carrying through four full-scale demonstration tests of concepts designed to dispose of high-level, long-lived nuclear waste in clay or crystalline host rocks. The objectives of the tests are to check the suitability of the concepts for their intended purpose, and compare and improve understanding of important parameters for their implementation and long-term performance.

## Large Underground Concept Experiments

### Nature and scope of the project

The consortium consists of four European implementers – SKB, Andra, Nagra and Posiva – who have a long history of cooperation, interaction and shared experience on demonstration projects in URLs. Each of the implementers has experience as an owner and operator of a URL and in carrying out full-scale demonstration activities, often as part of joint projects with some of the other implementers.

The aim is to gain experience in terms of testing and method improving, equipment, technologies, processes or operability related to the construction, operation and closure of a repository system. The key technical areas to address are the gallery construction, the manufacturing and emplacement of buffers around waste canisters, the emplacement of waste packages, and the backfilling and sealing of galleries.



*Schematic view of the demonstration test on horizontal disposal of waste packages in Callovo-Oxfordian clay in the Bure URL.*

### Activities

The project centres around the final verification steps that need to be taken in the process of achieving the so called 'initial state'. The 'initial state' refers to the situation that occurs when a disposal cell is filled with waste package(s) and sealed, after which no performance improvement can be applied by man. The defined 'initial state' is the basis for the analysis of the long-term evolution of the repository. The accuracy in the prediction of long-term safety is thereby directly dependent on the knowledge of conditions at the 'initial state'. These conditions are basically defined as a span with limits of deviations from the ideal condition. The main aim of a repository's engineering work is therefore not only to obtain methods and machines for doing the job, but also to assure that they do the job within acceptable deviations from the design.

### Coordinator

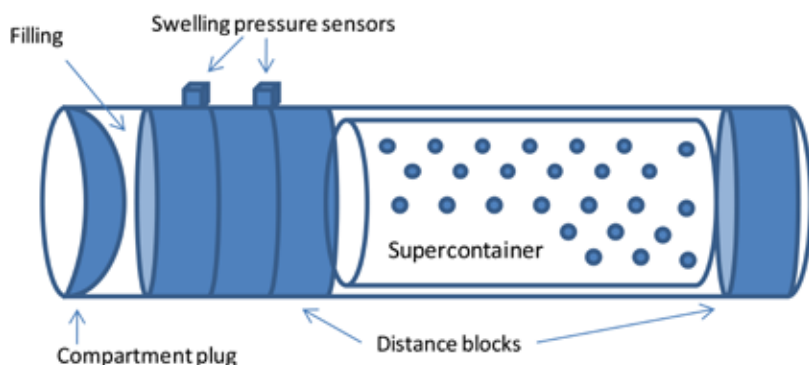
**Fredrik Johansson**  
Swedish Nuclear Fuel and Waste  
Management Company  
Box 250  
101 24 Stockholm  
Sweden  
Tel. +46 8-459 84 50  
Fax +46 857938610  
[fredrik.johansson@skb.se](mailto:fredrik.johansson@skb.se)

### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.1.2011  
**Duration** // 48 months  
**Total budget** // EUR 9 350 292  
**EC contribution** // EUR 4 390 000

### EC project officer

**Christophe Davies**  
European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/61  
B-1049 Brussels, Belgium  
[christophe.davies@ec.europa.eu](mailto:christophe.davies@ec.europa.eu)



*Schematic view of the demonstration test on horizontal emplacement of buffer and supercontainer in the Äspö URL.*

## Expected results

Different disposal concepts are demonstrated in order to facilitate the step-by-step implementation of safe, deep geological disposal by solving the scientific, technological and social challenges, and to support Member State waste management programmes. Other waste management organisations will also be able to benefit from the work completed by participating in workshops and through accessing the published information.

The demonstration activities will show how feasible concepts are by:

- proving evidence that different tested disposal concepts of geological disposal are technically feasible and that they can be implemented in line with the compliance of requirements;
- advancing the treatment and/or understanding of key remaining issues;
- improving the robustness of associated performance and safety analyses;
- increasing confidence in the safety case related to the disposal concepts;
- proving operability of the different disposal concepts;
- collecting the information and knowledge of different demonstration experiences; and
- increasing confidence among decision makers and the public.

## Societal impact

The successful implementation of a repository programme relies on both the technical aspects of a sound safety strategy and scientific and engineering excellence, as well as stakeholder acceptance and confidence. The project's programme on large-scale experiments performed in URLs is crucial for demonstrating the feasibility of common elements of repository concepts.

The project will help build specific technical knowledge among technicians and deeper insight in technical feasibility among stakeholders and the general public. This will be achieved by opening up analysis and dissemination of results on common repository elements via visits to demonstration sites and workshop discussions. This should increase the overall possibility for implementing geological disposal facilities in Europe.

## Information about important public events

A workshop will take place at Äspö in Sweden in April 2014. It will serve the dual purpose of exchanging information among project participants and their professional networks, and disseminating information on results to a broad public of technically trained persons, stakeholders, decision makers and interested members of the public.

The project website (<http://www.lucoex.eu>) will publish project news and results. It will also communicate the dissemination events and the announcement of different scholarships for training and participating in workshops. Direct communication links are opened with European organisations responsible for development of national repository concepts for engagement in discussion and dissemination of project results.

## Partners

- Swedish Nuclear Fuel and Waste Management Company (SKB), SE
- National Agency for Radioactive Waste Management (ANDRA), FR
- National Cooperative for the Disposal of Radioactive Waste (Nagra), CH
- Posiva Oy (Posiva), FI



## PEBS

Nuclear power plants produce heat-generating radioactive waste that has to be disposed of very carefully. For such disposal various natural and technical barriers will be used. The PEBS project concentrates on the construction and analysis of technical clay barriers by performing technical experiments in an underground lab. Models for long-term forecasts will be developed and results from in situ experiments and modelling will be compared and calibrated stepwise to achieve reliable information.

## Long-term Performance of Engineered Barrier Systems

### Experienced partners

The consortium is made up of the main European implementing organisations, experienced modellers, universities, Bentonite experts, researchers, mining experts, technology and innovation centres and international partners. All these partners will come together and bring their respective know-how to the table. Nearly all partners have been or are involved in previous EU-funded projects such as FEBEX ('Full-scale Engineered Barriers Experiment in crystalline host rock'), EURATOM NF-PRO ('Understanding and physical and numerical modelling of the key PROCESSES IN THE NEAR-FIELD and their coupling for different host rocks and repository strategies') and ESDRED ('Engineering Studies and Demonstrations of Repository Designs'). An international High Level Expert Committee will observe the project.

The PEBS project aims to evaluate sealing and barrier performance of the Engineered Barrier System (EBS) for final storage of heat-generating radioactive waste through the development of a comprehensive approach involving experiments, model development and consideration of potential impact on long-term safety functions. The experiments and models cover the full range of conditions from initial emplacement of wastes through to later stage establishment of near steady-state conditions, i.e. full restoration and thermal equilibrium with the host rock (see following Figure)

### Activities

Five of the PEBS work packages focus on research and technological development (RTD) and several additional work packages concern dissemination and project management. The RTD work packages include i) Analysis of system evolution during early post-closure period and the impact on long-term safety functions, ii) Experimentation on key engineered barrier systems, processes and parameters, iii) Modelling of short-term effects and extrapolation to long-term evolution, iv) Analysis of impact on long-term safety, and v) Comparison of approaches between Europe and China.

Various tests in an underground lab (see Figure) and in technical laboratories will be conducted. Under the impact of heat (T), pressure (M), water (H) and chemical reactions (C) the behaviour of clay has to be analysed. Coupled HM, THM and THMC analyses will be performed.

PEBS will review recent advances in the current state of the art affecting processes in the early evolution of barriers and their treatment in performance assessment, in particular the relationship to EBS safety functions. This will clarify the need for additional laboratory and field experiments

### Coordinator

#### Michael Mente

Federal Institute for Geosciences and Natural Resources  
Stilleweg 2  
D-30655 Hannover  
Germany  
Tel. +49 5116432246  
Fax +49 5116433694  
[michael.mente@bgr.de](mailto:michael.mente@bgr.de)

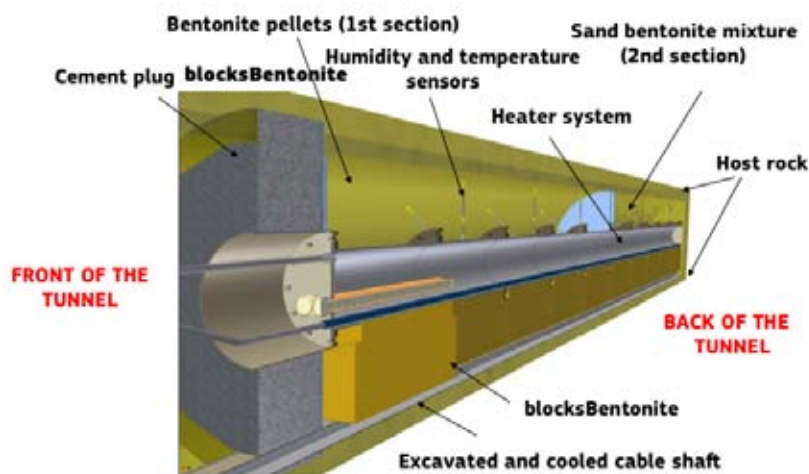
### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.3.2010  
**Duration** // 48 months  
**Total budget** // EUR 6 525 008,80  
**EC contribution** // EUR 2 806 333

### EC project officer

#### Christophe Davies

European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/61  
B-1049 Brussels, Belgium  
[christophe.davies@ec.europa.eu](mailto:christophe.davies@ec.europa.eu)



THM experiment layout in Mount Terri Rock Laboratory.  
© NAGRA

targeted at supporting assessments of normal and altered evolution scenarios. Good quality and reliable experimental databases for HM, THM and THMC processes, including different time and spatial scales, for various models and a synthesis will be provided. Experimental data and calibrated process models for extrapolation to long-term evolution of the repository EBS will be used for normal and altered scenarios. Finally, PEBS will relate the experimental and modelling results and uncertainties to the long-term safety functions of the repository components and to the overall long-term performance of the repository, giving feedback and guidance for repository design and construction.

In addition to the scientific-technical aim, the PEBS consortium will spread the essential results to the broad scientific community both within and outside the EU. The consortium will use its expertise for public information purposes and promote knowledge and technology transfer through training. Work Package 5 brings together all activities concerning dissemination and training.

## Expected results

The objective is to come away with definitions of important processes and scenarios during the early evolution of the barrier and its effects on long-term performance and safety functions of the repository. On the basis of these processes, various experiments will be performed to provide a reliable good quality experimental database, including different time and spatial scales, as input to the modelling and extrapolation work for long-term evolution and to investigate model uncertainty and its impact on long-term prediction.

On the basis of information developed from various experiments and models related to the evolution of the barrier, a synthesis of what significance the work has for showing how the barrier and near-field rock will behave both during and after the transient period will be developed. The study will make use of results from ongoing experiments in China where possible.

## Societal impact

National repository designs under development in the EU put strong emphasis on the containment properties of the EBS and the near-field of a geological repository for heat-generating waste disposal. Building confidence in the barrier performance of the EBS and the containment function of near-field will therefore contribute to the acceptance of nuclear power as an essential component of the energy mix within the EU.

## Information about important public events

Exploitation and dissemination of results at the European level includes a clay lab training course and related workshop, a scientific excursion to a Bentonite mine, two workshops for Regulatory Authorities to discuss the first results and further steps for the ongoing project as well as the specific impact on licensing and agencies, and a final workshop to present and discuss the PEBS results. More details can be found on the project website.

## Partners

- Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), DE
- Nationale Genossenschaft für die Lagerung radioaktiver Abfälle (NAGRA), CH
- Svensk Kärnbränslehantering AB (SKB), SE
- Gesellschaft für Anlagen- und Reaktorsicherheit mbH (GRS), DE
- Empresa Nacional de Residuos Radioactivos SA (ENRESA), ES

- Asociación para la Investigación y el Desarrollo Industrial de los Recursos Naturales (AITEMIN), ES
- Centre International de Méthodes Numériques en Ingénierie (CIMNE), ES
- University of La Coruña (UDC), ES
- Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT), ES
- Agence Nationale pour la Gestion des Déchets Radioactifs (ANDRA), FR

- Universidad Autónoma de Madrid (UAM), ES
- DM Iberia S.A., ES (until December-2010)
- Golder Associates Global Ibérica S.L.U. (as of 2011)
- Solexperts AG, CH
- TK Consult AG (TKC), CH
- Clay Technology, SE
- Beijing Research Institute for Uranium Geology (BRIUG), CN
- Japan Atomic Energy Agency (JAEA), JP

## REDUPP

The long-term safety of a planned spent nuclear fuel repository needs to be demonstrated through a safety assessment. At the heart of this assessment lie issues regarding spent fuel dissolution. Although current knowledge in this area is significant, questions do remain. The main objective of this project is to reduce remaining uncertainty in the dissolution rate of spent uranium oxide ( $\text{UO}_2$ ) fuel. A second objective is to train young scientists for the future needs of research in the field of nuclear waste management.

## Reducing Uncertainty in Performance Prediction

### Getting to grips with spent fuel

Our understanding of interactions between solid surface and fluid during the dissolution process will be significantly improved as a result of this project. The combination of dissolution testing, surface characterisation and theoretical modelling of the dissolution process will also provide a breakthrough in the understanding of the long-term changes in dissolution rate of spent nuclear fuel. Project management and research coordination are handled by SKB and Posiva, two nuclear waste management organisations (WMOs) at the forefront of spent nuclear fuel repository research. Two of the project participants, VTT (Finland) and University of Sheffield (UK) are, along with SKB and Posiva, active in the European Implementing Geological Disposal Technology Platform (IGD-TP). The fifth participant, Uppsala University, has a history of fruitful research collaboration with SKB concerning physics of actinide materials. The consortium has been designed to focus not only on addressing the research topic, but also on developing a training network for young researchers.

### Activities

The project activities are mainly focused on dissolution experiments and surface characterisation of a succession of materials with the same crystal structure:  $\text{CaF}_2$ ,  $\text{CeO}_2$ ,  $\text{ThO}_2$  and  $\text{UO}_2$ . Previous experiments, on which the determined dissolution rate of spent nuclear fuel in repository conditions are based, were performed with  $\text{UO}_2$  and synthetic ground water of a simplified and controlled composition. However, these waters do not contain all of the chemical elements that occur in natural ground waters and the effect of the chemical complexity of natural waters on the dissolution rate remains unknown.

Often in laboratory dissolution experiments the samples are fragmented and contain sharp edges and defects. During dissolution, material is more rapidly dissolved from the sharp edges and defects than from smoother areas, so that the fragments become more rounded as the experiment proceeds. One of the project goals is to determine how this 'ageing' of the sample surface affects the measured dissolution rate. By integrating laboratory results with first principles calculations and computational modelling, a model of how the surface evolves during dissolution can be produced.

### Coordinator

**Lena Zetterström Evins**  
SKB  
Blekhölmstorget 30  
Box 250  
101 24 Stockholm, Sweden  
Tel. +46 857938688  
[lena.z.evins@skb.se](mailto:lens.z.evins@skb.se)

### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.4.2011  
**Duration** // 36 months  
**Total budget** // EUR 1 596 802  
**EC contribution** // EUR 929 303

### EC project officer

**Christophe Davies**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/61  
B-1049 Brussels, Belgium  
[christophe.davies@ec.europa.eu](mailto:christophe.davies@ec.europa.eu)





*Nuclear fuel pellets.*  
© SKB

The project will interact with PhD students in associated networks and put on a series of lectures with the aim of introducing students to the needs of the nuclear community in Europe. New knowledge which arises from the project will be communicated to a wider audience through a web page, the publication of the annual reports newsletters and a final open scientific meeting.

## Expected results

Through controlled laboratory experiments, the fractional dissolution rate of spent nuclear fuel has been determined to be approximately  $10^{-7}$  per year, meaning complete dissolution of all spent fuel would take about 10 million years. Even though this may seem like a slow rate it is clear that it is faster than rates deduced from observations of uranium ores. There are plenty of examples of uranium oxide ores that have persisted for many hundreds of millions of years, thus implying that the dissolution rate in those ores have been much slower than  $10^{-7}$  per year.

The apparent discrepancy between rates in laboratory and in nature is addressed in this project by investigating processes at the solid-liquid interface. One expected result is reduced uncertainty regarding the dissolution process through deeper understanding of surface changes during dissolution. The studied materials have very low solubility and analysed solutions will therefore contain very low amounts of the elements of interest. Analytical data of high quality is attained through analyses by high resolution ICP-MS (inductively coupled plasma mass spectrometry); thereby this project will also contribute to method development, personnel training and the improvement of databases. The aim is to present a general model that could then be applied in further nuclear fuel dissolution research.



*Spent nuclear fuel dissolution experiment.*  
© SKB

## Societal impact

The project research is both connected to fundamental scientific questions, since it concerns the detailed mechanisms of dissolution, and to applied science in the nuclear industry. Therefore, the results of REDUPP will be of interest to both stakeholders in the nuclear waste management industry and research departments throughout the world. In particular, the project will maintain close contact with other organisations involved in the European IGD-TP. International collaboration is essential for achieving REDUPP goals, and the project can help to strengthen communication between countries in a range of research areas.

By ensuring efficient knowledge transfer between experienced people in the field and young scientists, this project contributes to future European competitiveness in nuclear waste management. The overall aim of the project is to reduce uncertainty concerning core issues of the safety assessments which will be developed and reviewed by authorities in the near future. Since questions, comments and requirements are expected as a result of those reviews, the idea is to make sure there will still be skilled people in place who are ready to respond to these questions when the time comes.

## Partners

- Svensk Kärnbränslehantering AB (SKB), SE
- Posiva Oy (Posiva), FI
- Technical Research Centre of Finland (VTT), FI
- Uppsala Universitet (UU), SE
- The University of Sheffield (USFD), UK

## SecIGD

The goal of the SecIGD project is to put in place a secretariat to support the IGD-TP ('Implementing of geological disposal of radioactive waste technology platform') project and help meet its aim of being the first safely operating geological-disposal facilities site for spent fuel, high-level waste, and other long-lived radioactive waste in Europe by 2025.

## Secretariat of the Implementing Geological Disposal Technology Platform

### Playing a supporting role

The broad objective of both the IGD-TP and the SecIGD projects is to address certain remaining scientific, technical, and social and political challenges that stand in the way of safe deep-geological disposal of spent fuel, high-level waste, and other long-lived radioactive waste.

The concept of the IGD-TP and its secretariat derives from the results of the Fifth Framework Programme (FP5) project 'Network of excellence in nuclear waste management and disposal' (Net.Excel) and from the Sixth Framework Programme (FP6) project 'Co-ordination of research, development and demonstration (RD and D) priorities and strategies for geological disposal' (CARD), where the feasibility to establish a technology platform for deep geological disposal in Europe was studied with positive end results.

### Activities

The SecIGD project includes three major activities. The main activity (Work Package 1) is the setting up and running of a secretariat, which contributes to the daily management of the IGD-TP and acts as an open information centre on the platform activities, and for stakeholder participation. This secretariat is located at the Swedish Nuclear Fuel and Waste Management Company (SKB).

The second activity, led by the Agence nationale pour la gestion des déchets radioactifs (ANDRA) in France, is to plan for forms of cooperation and deployment of the IGD-TP's joint activities and strategic research in alignment with the vision. The third activity is the project management of the SecIGD project. The project coordination is carried out by POSIVA in Finland, in close cooperation with the secretariat, the IGD-TP's Executive Group and the project's partners.

### Coordinator

**Marjatta Palmu**

Posiva Oy

Olkiluoto

FI-27160 Eurajoki, Finland

Tel. +358 2837 23 855

Fax +358 2837 23 809

[marjatta.palmu@posiva.fi](mailto:marjatta.palmu@posiva.fi)

### Project details

**Project type** // Coordination and Support Action

**Project start date** // 4.1.2010

**Duration** // 24 months

**Total budget** // EUR 551 560

**EC contribution** // EUR 500 000

### EC project officer

**Christophe Davies**

European Commission

Directorate-General for Research

Directorate Energy

Unit K.4 – Fission

CDMA 1/61

B-1049 Brussels, Belgium

[christophe.davies@ec.europa.eu](mailto:christophe.davies@ec.europa.eu)





*SecIGD project introduction at the IGD-TP launch event 2009.*

© Wernt Brewitz

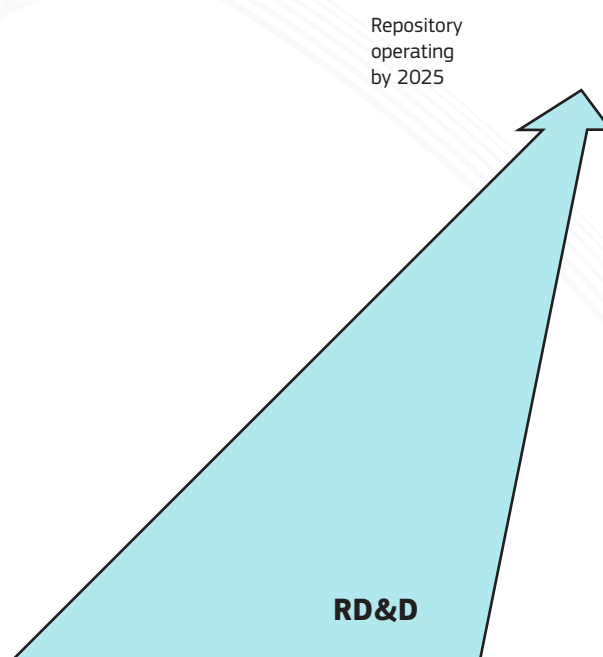
## Societal impact

Within the European geological disposal community, the IGD-TP is expected to create opportunities to carry out joint research development and demonstration work, competence building in geological disposal, joint work on developing strategies for the licensing and implementation of deep repositories, and knowledge transfer within the geological disposal community and for stakeholders.

The implementation of safe solutions in geological disposal will enhance public confidence related to Member States' ability to manage the back end of the nuclear fuel cycle and radioactive wastes.

## Results

The SecIGD project results are linked to the outcomes of the IGD-TP project, the overall aim of which is to produce a Strategic Research Agenda (SRA) and a Deployment Plan (DP). In November 2009, the IGD-TP was launched and the Vision Report published. The working group for drawing up the SRA proceeded at full speed, and the SRA drafting work was finalised at an SRA seminar in June 2010. Two Exchange Forum meetings for all interested stakeholders took place in February and November 2011. The SRA and the DP are consulted and published on the IGD-TP's website, <http://www.igdtp.eu>.



*Towards the IGD-TP vision.*  
© IGD-TP

## Partners

- Posiva Oy (POSIVA), FI
- Svensk Kärnbränslehantering AB (SKB), SE
- Agence nationale pour la gestion des déchets radioactifs (ANDRA), FR
- Bundesministerium fuer Wirtschaft und Technologie (BMWi), DE

## SITEX

The aim of SITEX is to set up a network capable of harmonising European approaches to technical expertise in geological repositories for radioactive waste. Coordinated by IRSN (L'Institut de Radioprotection et de Sûreté Nucléaire), SITEX brings together 15 organisations representing technical safety organisations (TSOs) and safety authorities, as well as civil society outreach specialists.

## Sustainable network of independent technical expertise for radioactive waste disposal

### Building a network

SITEX will help put in place the conditions required for developing a sustainable network of technical safety experts who are both capable of using their skills and analytical tools independently of the operators, and conducting their own research programmes in coordination with research activities performed by operators.

The project consortium's work will focus on:

- the potential for harmonising technical expertise practices by identifying what needs to be done to develop safety guides through technical discussions between regulatory authorities and operators; to this end the participants will also define and implement a training programme tailored to the role of technical assessment;
- the ability to run research and development (R&D) programmes dedicated to developing the scientific knowledge necessary to perform independent technical assessments, by encouraging joint research and scientific and technical exchanges between TSOs and regulatory authorities as well as with operators at the European level.

### Activities

The scientists hope to achieve mutual understanding between regulatory bodies, TSOs and waste management organisations by identifying areas where development and harmonisation of technical guidance is a priority, as well as identify the expertise and technical support needed by the regulatory function in order to perform an independent assessment of compliance with safety requirements.

The team also aim to facilitate the sharing of technical expertise among various stakeholders by identifying ways of developing their technical skills so that they are more involved in the project beyond communication and dissemination activities. A dedicated workshop will be organised a few months before the end of the project to allow project members and stakeholders to share expertise and guidance.

### Coordinator

**Christophe Serres**

IRSN

BP17

31 Avenue de la Division Leclerc

92262 Fontenay-aux-Roses Cedex, France

Tel. +33 158359164

[christophe.serres@irsn.fr](mailto:christophe.serres@irsn.fr)

### Project details

**Project type** // Coordination and Support Action

**Project start date** // 1.1.2012

**Duration** // 24 months

**Total budget** // EUR 1 340 312

**EC contribution** // EUR 950 080

### EC project officer

**Christophe Davies**

European Commission

Directorate-General for Research and Innovation

Directorate Energy

Unit K.4 – Fission

CDMA 1/61

B-1049 Brussels, Belgium

[christophe.davies@ec.europa.eu](mailto:christophe.davies@ec.europa.eu)



SITEX will ensure competence building among experts in charge of technical reviews and knowledge transfer on safety and radiation protection by identifying what needs to be done to improve harmonisation of the technical review activity. They will set up dedicated training activities to share expertise and best practices.

The project also seeks to develop the independent scientific capabilities of TSOs and regulatory authorities for supporting the review of the Safety Cases by defining an R&D programme and priorities for TSOs and regulatory authorities. This will be done in coordination with the Implementing Geological Disposal Technology Platform (IGD-TP).

## Expected results

SITEX will:

- provide a common basis for independent technical expertise in the radioactive waste disposal safety and radioprotection fields;
- harmonise and coordinate research programmes involving TSOs and regulatory authorities;
- ensure competence building and transfer of knowledge without replacing national competencies.

A sustainable network of expertise will make scientific and technical dialogue between actors involved in the licensing of deep geological disposal projects possible. This workforce will contribute to encouraging the development of harmonised technical expertise methods among the EU Member States, in particular in terms of the practical implementation of the EC Directive on responsible and safe management of spent fuel and radioactive waste (including the peer review process), the Aarhus Convention and others.

## Important public events

SITEX will be presented at important nuclear energy events such as international conferences and workshops. A dedicated workshop will be organised under the SITEX aegis to facilitate an exchange of views between non-governmental organisations (NGOs) and the IGD-TP.

## Partners

- Autorité de Sûreté Nucléaire (ASN), FR
- Bel V (BELV), BE
- Canadian Nuclear Safety Commission (CNSC), CA
- DECOM a.s. (DECOM), SK
- Eidgenössisches Nuklearsicherheitsinspektorat (ENSI), CH
- European Nuclear Safety Training and Tutoring Institute (ENSTTI), FR
- Federal Agency for Nuclear Control (FANC), BE
- Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), DE
- Institut de radioprotection et de Sûreté Nucléaire (IRSN), FR
- Lietuvos Energetikos Institutas (LEI), LT
- Ministerie van Economische Zaken, Landbouw en Innovatie (ELI), NL
- Mutadis Consultants SARL (MC SARL), FR
- Nuclear Research and Consultancy Group (NRG), NL
- Stralsakerhetsmyndigheten (SSM), SE
- Ústav Jaderneho Vyzkumu Rez a.s. (UJV), CZ

## SKIN

Implementation of geological disposal of radioactive waste requires assessment of relevant processes in the near-field (wasteform and engineered barriers) and far-field (host rock and pathways to the biosphere) to allow for development of robust methodologies for performance and safety assessment. Relevant processes are all those affecting the mobility of radionuclides. Questions need to be answered as to whether the engineered and geological barrier systems can isolate and retain the radionuclides in the waste for hundreds of thousands of years. Due to slow groundwater movement in confined deep geological formations, the system of radionuclides, minerals, engineered barrier materials and water will be close to chemical equilibrium. These systems, controlling radionuclide mobility, have been studied for many years, but only little attention has been paid to the fact that, due to the long disposal time, individual very slow processes can have a significant impact on the mobility of radionuclides, despite local equilibrium states being achieved.

## Slow processes in close-to-equilibrium conditions for radionuclides in water/solid systems of relevance to nuclear waste management

### Studying radionuclides

The project will study slow processes influencing radionuclide mobility in close-to-equilibrium scenarios in a detailed and systematic manner in relation to surface properties, surface site detachment/attachment kinetics, irreversible sorption and surface incorporation for cases relevant to the assessment of radionuclide mobility in nuclear waste repository sites. Emphasis is on the temporal evolution of surface detachment and attachment rates on minerals and the coupling of surface equilibrium with slow bulk phase diffusion/recrystallisation processes of trace element (incorporation or release). This concerns kinetic studies, thermodynamic evaluations of solid solution/aqueous solution equilibrium, trace and principal element relations, structural and morphological observations and molecular modelling.

The project consortium is made up of 10 partners, including national waste management organisations, national research centres, universities and small and medium-sized enterprises (SMEs). The partners hail from five EU Member States (Germany, Spain, France, Sweden and the United Kingdom), one Associated Country (Switzerland) and China.

### Activities

The proposed strategy combines laboratory experiments and model development with analyses of safety implications. The work consists of combining, for relevant time frames, bottom-up approaches with individual mineral/water systems with top-down analyses of performance assessment needs to describe non-linearly coupled exchange processes in geological disposal environments.

The work programme covers various experimental case studies for solubility and sorption equilibria combined with surface incorporation and associated model development of practical relevance for application within performance assessment.

### Coordinator

**Bernd Grambow**

Ecole des Mines de Nantes – SUBATECH

4 rue Alfred Kastler

44307 Nantes, France

Tel. +33 251858400

Fax +33 251858452

[grambow@subatech.in2p3.fr](mailto:grambow@subatech.in2p3.fr)

### Project details

**Project type** // Collaborative Project

**Project start date** // 1.1.2011

**Duration** // 36 months

**Total budget** // EUR 2 004 728

**EC contribution** // EUR 1 171 470

### EC project officer

**Christophe Davies**

European Commission

Directorate-General for Research and Innovation

Directorate Energy

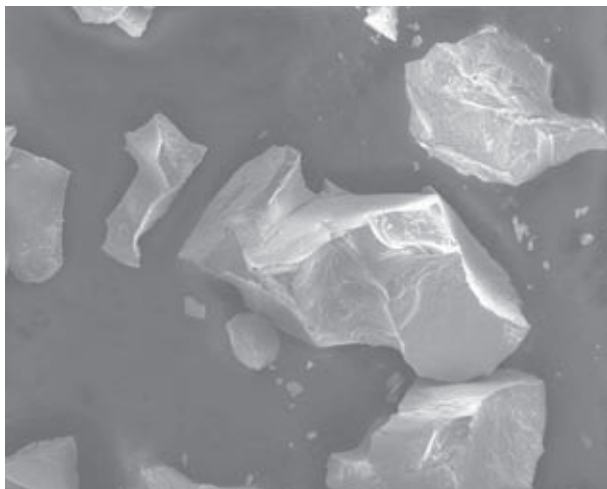
Unit K.4 – Fission

CDMA 1/61

B-1049 Brussels, Belgium

[christophe.davies@ec.europa.eu](mailto:christophe.davies@ec.europa.eu)





*Scanning electron microscope (SEM) image of Thorium dioxide (ThO<sub>2</sub>) fragments used for dissolution experiment.*

© Daqing Cui

The research and development (R&D) work programme is structured along two experimentally-oriented research and technology development (RTD) work packages and a work package for model development as well as for assessing consequences in safety analyses. In addition, there is one RTD work package for synthesis.

The main areas of focus will be:

- identification of the substitution scheme for complex metal ion substitutions and ion binding (precipitation, co-precipitation, surface uptake) in complex cement related systems;
- questions of reversibility of solid/solution interaction with clays;
- assessment of the kinetics of dissolution of tetravalent oxides under quasi-equilibrium conditions and the impact of major systems present in the repository environment on the rate of dissolution of matrix-related material and retention/release of radionuclides.

## Results and impact

The results of the project will probably show that safety margins in geological disposal concepts are larger than anticipated. SKIN will have a strong impact on the development of a scientific methodology for assessing the long-term aspects of radionuclide migration in geological disposal. A number of questions of general relevance will be addressed as part of the project which are also of relevance to performance assessment and to different responses expected for the different solid/water systems studied.

The project results are expected to impact strongly on the:

- use/misuse of solubility data for thermodynamics;
- understanding of affinity/rate relations close-to-equilibrium;
- inclusion of irreversibility in models on the long-term mobility of radionuclides in geological disposal systems;
- coupling of radionuclide chemistry with main element chemistry in the repository environment.

The research results expected from the SKIN project will have a direct impact on the European nuclear power community, including authorities representing public safety concerns. This impact is related to the environmental, economic and political advantages of continued use of clean and economic nuclear power, as well as its contribution to political stability through lowered dependency of energy import. This is directly related to long-term improvement in European competitiveness, employment, environmental quality and quality of life.

Anyone who is interested in the project may participate in annual workshops. These are announced via the project website.

## Partners

- Association pour la Recherche et le Développement des Méthodes et Processus Industriels (ARMINES), FR
- Karlsruher Institut Für Technologie (KIT), DE
- Forschungszentrum Jülich GmbH (FZJ), DE
- Svensk Kärnbränslehantering AB (SKB), SE
- AMPHOS 21 Consulting, S.L. (AMPHOS21) ES
- Chalmers University of Technology (CHALMERS), SE
- Stockholms Universitet (SU), SE
- Paul Scherrer Institute (PSI), CH
- Loughborough University (LU), UK
- Peking University (PKU), CN

# ADRIANA

The aim of ADRIANA is to set up a network dedicated to the construction and operation of research infrastructures in support of developments for the European Industrial Initiative for sustainable nuclear fission. The project will define what new research infrastructures are required, and what existing facilities — such as irradiation facilities and hot laboratories — need to be refurbished or upgraded. ADRIANA will also examine the available state-of-the-art instrumentation technologies, and consider transnational access to experimental facilities.

## Advanced reactor initiative and network arrangement

### Developing the Generation IV prototypes

The general objective of ADRIANA is to analyse what needs to be done to further develop the three chosen Generation IV (Gen IV) prototypes (sodium fast reactor or SFR, gas fast reactor or GFR and lead fast reactor or LFR), to specify their parameters and characteristics, and to define what experimental facilities are necessary. Some of these facilities already exist while others still remain to be constructed. Knowledge and information about such facilities and capacities will be used in the project and made available to all beneficiaries.

All sustainable nuclear systems as defined under the Sustainable Nuclear Energy Technology Platform's (SNETP) Strategic Research Agenda (SRA) are represented within the project consortium. To stay abreast of developments in the field, related activity is monitored by many bodies: the Generation IV International Forum (GIF); the International Atomic Energy Agency (IAEA) International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO); the SNETP European Sustainable Nuclear Industrial Initiative (ESNII) task force; the Task Group on Advanced Reactor Experimental Facilities (TAREF) programme of the Nuclear Energy Agency (NEA), a specialised agency within the Organisation for Economic Co-operation and Development (OECD); the Jules Horowitz Reactor; and numerous Euratom Sixth and Seventh Framework Programme (FP6 and FP7) projects.

It is also important to maintain links with OECD and IAEA programmes that involve experimental research carried out beyond the EU.

### Objectives

The central aim is to strengthen links between parties involved in research and development (R&D) for new reactor systems: regulatory bodies, utilities, research and technical support organisations, engineering companies, governmental research organisations and universities. The project shares experimental equipment and facilities, and integrates partial research findings for the sake of new types of nuclear energy development.

Another aim is the creation of a common database to coordinate the dissemination of relevant data to benefit all involved parties. The project will identify and carry out required R&D tasks that involve experimental programmes and computer codes.

### Coordinator

**Ivo Vasa**

Nuclear Research Institute Rez plc  
Husinec-Rez 130  
250 68, Czech Republic  
Tel. +420 266173550  
Fax +420 220941029  
[vasa@ujv.cz](mailto:vasa@ujv.cz)

### Project details

**Project type** // Coordination and Support Action

**Project start date** // 1.2.2010

**Duration** // 18 months

**Total budget** // EUR 1 429 911.20

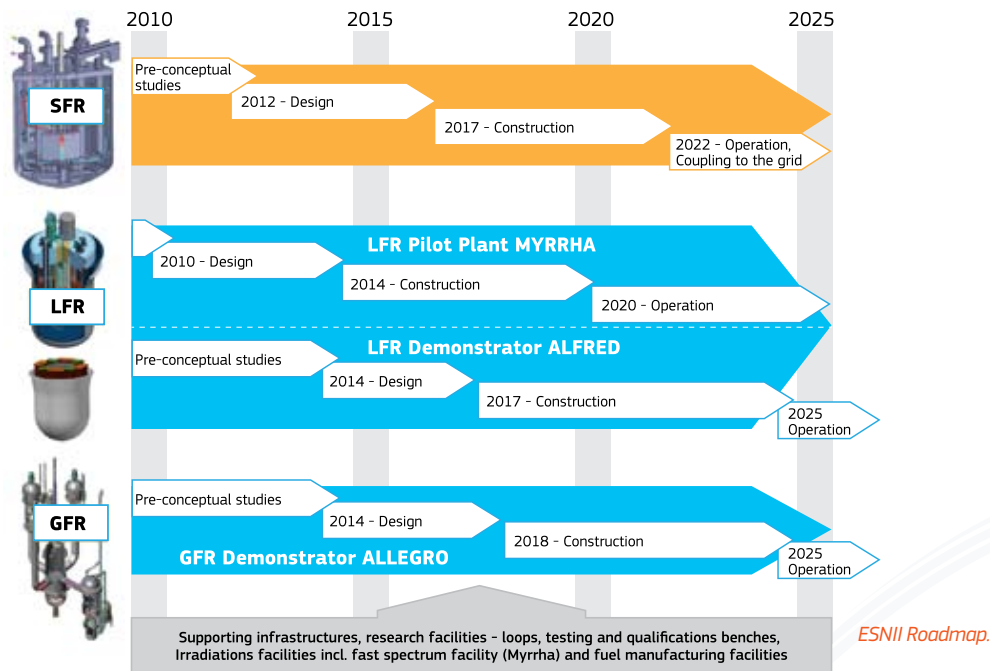
**EC contribution** // EUR 992 560.00

**Project website** // <http://adriana.ujv.cz/>

### EC project officer

**Roger Garbil**

European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/70  
B-1049 Brussels, Belgium  
[roger.garbil@ec.europa.eu](mailto:roger.garbil@ec.europa.eu)



A lasting legacy of the project will be the availability of concrete arguments that decision-makers can use for support in discussions about Gen IV fast spectrum reactors. Moreover, a significant part of the overall goal of the project is to create viable organisational structures that can efficiently continue with the task of developing new reactor systems, beyond the end of the project.

## Expected results

The project aims to produce results from a survey of research disciplines and activities needed for the development of systems and technologies, and a survey of requirements for safety assessments of future reactor systems.

ADRIANA will also determine the required specifications of infrastructures and experimental devices, and survey the existing facilities to work out what is missing and what needs upgrading.

The results of the project will be useful for stakeholders in the field as well as for education and training purposes.

## Societal impact

The project is part of the EU's broad 2050 vision: completing preparations for the demonstration of a new generation (Gen IV) of fission reactors for increased sustainability that can contribute to the timely deployment of non-carbon energy production within the next 10 years.

A European network of research facilities infrastructure for the development of fast reactor systems will also lead to bounds in research into other reactor systems such as the SFR, the LFR and the GFR, instrumentation, diagnostics and experimental devices, irradiation facilities, and hot laboratories and zero power reactors.

Gen IV fast reactor systems with a closed fuel cycle will produce 50 to 100 times more electricity than current reactors from the same amount of uranium, enabling natural resources to last thousands of years. All these systems are designed to meet the GIF requirements on sustainability, safety, competitiveness, and proliferation resistance.

Information about important public events

The project results will be made available online to the public, and professionals and citizens alike are invited to take part in a series of seminars, workshops, international conferences and symposiums organised by the project partners.

## Partners

- Ustav jaderného výzkumu Rez a.s. - Nuclear Research Institute Rez plc (UJV-Rez), CZ
- Commissariat à l'énergie atomique et aux énergies alternatives (CEA), FR
- Agenzia Nazionale Per Le Nuove Tecnologie, L'energia e Lo Sviluppo Economico Sostenibile (ENEA), IT
- Karlsruher Institut fuer Technologie (KIT-G), DE

- Studiecentrum Voor Kernenergie (SCK-CEN), BE
- Centrum výzkumu Rez s.r.o. (RC-Rez), CZ
- Magyar Tudományos Akadémia, KFKI Atomenergia Kutatóintézet (AEKI), HU
- Forschungszentrum Dresden - Rossendorf EV (FZD), DE
- Regia Autonomă Pentru Activități Nucleare Drobeta Tr. Severin Ra Sucursala Cercetari Nucleare Pitesti (INR), RO

- Institut de Radioprotection et de Surete Nucleaire (IRSN), FR
- JRC - Joint Research Centre - European Commission (JRC-ITU), DE
- Nuclear Research and Consultancy Group (NRG), NL
- VUJE a.s. (VUJE), SK
- Latvijas Universitātes Agentūrai Latvijas Universitātes Fizikas Institūts (IPUL), LV
- Lagrange Sarl (LGI), FR

# ADVANCE

Extending the lifetime of a Nuclear Power Plant (NPP) to over 60 years is one of the most important concerns in the global nuclear industry.

As electric cables are one of the long-life items that have not yet been considered for replacement during the life-design of NPPs (typically 40 years), assessing their degradation state and predicting their remaining lifetime is essential.

The main aim of ADVANCE is to adapt, optimise and assess electrical Condition Monitoring (CM) techniques that will allow nuclear utilities to assess in situ the degradation condition of installed safety-related cables and obtain information about how long they will remain useful for.

## Ageing Diagnostics and Prognostics of low-voltage I&C cables

### Scope and aim

ADVANCE brings together 11 partners from 8 European countries and represents nuclear utilities with their associated competence centres, research and engineering institutes and universities, one cable manufacturer, and one provider of nuclear products and services. There are also plans to extend cooperation to China, through the parallel partner project ANTIAGE. The aim is to address the assessment of safety-related cables that are required to operate not only under normal service operating conditions but also in the event of an accident, like the Loss of Coolant Accident (LOCA).

The main goals of the project are to:

- adapt, optimise and assess promising electrical CM techniques for nuclear cables that are non-destructive and can be used in the field to determine the current condition of installed cables over their entire length;
- establish acceptance criteria by correlating physical cables' properties to electrical properties in order to evaluate the degree of degradation and to provide information about the cable's remaining useful life.

In addition, a complementary investigation into new cables design and formulation will provide fundamental knowledge for the next generation of cables for future NPPs with improved electrical diagnostic capability.

### Activities

The focus will be on electric CM methods and their potential to detect global and local insulator ageing with a full-length cable assessment from its terminals. Thanks to recent advances in electrical diagnostic techniques, measuring sensitivity has improved to a level where it is feasible to distinguish even small changes in a cable's electrical characteristics. Existing techniques will be adapted, optimised and assessed on different cable types and materials to better understand and compare how they perform and what their limitations are.

In order to simulate ageing in operation, accelerated ageing (thermal and radiation) will be performed on a representative selection of cables. Periodic measurement of condition indicators given by promising electrical in situ CM techniques (based on reflectometry) will be compared with those obtained from other more conventional CM methods. End-of-life

### Coordinator

**Jacopo Testa**

EDF

Avenue des Renardières – Ecuelles

77818 Moret Sur Loing, France

Tel. +33 160736390

Fax +33 160736543

[jacopo.testa@edf.fr](mailto:jacopo.testa@edf.fr)

### Project details

**Project type** // Collaborative Project

**Project start date** // 1.1.2011

**Duration** // 36 months

**Total budget** // EUR 3 955 534

**EC contribution** // EUR 2 311 788

### EC project officer

**Panagiotis Manolatos**

European Commission

Directorate-General for Research and Innovation

Directorate Energy

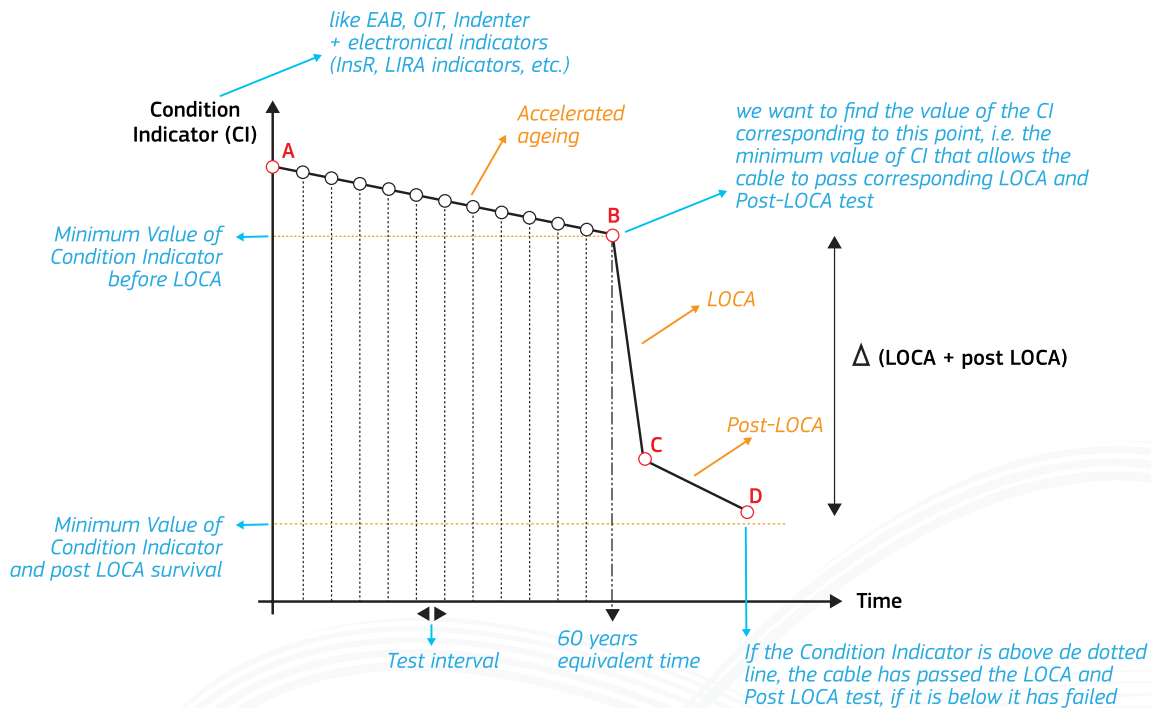
Unit K.4 – Fission

CDMA 1/53

B-1049 Brussels, Belgium

[panagiotis.manolatos@ec.europa.eu](mailto:panagiotis.manolatos@ec.europa.eu)





values of cable condition indicators will be determined by appropriate correlations and/or by tests under accident conditions (see Figure). The objective is to find good electrical indicators together with their limiting values (point B) that still guarantee that the cable will survive a severe accident (LOCA and post-LOCA).

Project experiments will be supported by the study of the impact of cable ageing on the electrical parameters. The main objective is to interpret electric CM techniques measurements by understanding and correlating the evolution of electrical properties with the physical/chemical degradation mechanisms of polymers for different kinds of cable materials and composition.

Field tests during NPP outages using promising electrical CM techniques will be planned. The results obtained on cables artificially aged in the laboratory will then be compared with those obtained from field tests on naturally aged cables in NPPs in order to verify how they perform in real situations. This will allow the team to detect the presence of cable local and global degradation.

## Societal impact

The ADVANCE project will reinforce the competitiveness of the European nuclear industry by producing innovative research results in the CM of nuclear cables field. Advances on promising electrical CM techniques that are capable of assessing the condition of existing cables in situ as well as providing valuable indications on their remaining lifetime will help avoid unnecessary and expensive cable replacements and guarantee improved margins of plant safety.

## Events and training

More than 5 % of the 'project budget is dedicated to training, mobility and dissemination activities.

Over the course of the project, progress will be charted at NUGENIA (NUclear GENeration II & III Association) network meetings so that information on the project is spread around the European nuclear community. In the final year of the project, a training seminar on CM techniques for cable ageing assessment will be organised.

Public events will be listed on the ADVANCE website ([www.advance-fp7.eu](http://www.advance-fp7.eu)).

## Partners

- Electricite de france S.A. (EDF), FR
- Forsmarks Kraftgrupp AB (FORSMARKS), SE
- Commissariat a l'Energie Atomique et aux Energies Alternatives (CEA), FR
- Alma Mater Studiorum-Universita di Bologna (UNIBO), IT
- Tecnatom S.A. (TECNATOM), ES
- Ustav Jaderného Vyzkumu Rez a.s (NRI), CZ
- Nexans Deutschland GmbH (NEXANS), DE
- Instytut Chemii i Techniki Jądrowej (INCT), PL
- Belgisch Laboratorium van de Elektriciteitsindustrie (LABORELEC), BE
- Kungliga tekniska högskolan (KTH), SE
- Westinghouse Electric Sweden AB (WSE), SE

# ANDES

Building on a collaboration between 20 research centres and universities, the ANDES project responds to a list of recommendations to the EU about how nuclear data research should be organised in the Seventh Framework Programme (FP7) and beyond. The aim of ANDES is to take a group of selected differential measurements, improve uncertainties and covariance within the evaluation process, and validate present and new data libraries using integral experiments, to bring the most critical nuclear data up to an accurate level.

## Accurate nuclear data for nuclear energy sustainability

### Next step in a collaborative journey

ANDES came about following recent publications about nuclear data needs associated with new reactors and new fuel cycles, from the Sustainable Nuclear Energy Technology Platform (SNETP) in its Strategic Research Agenda (SRA) and in the European Sustainable Nuclear Industrial Initiative (ESNII) proposal.

Priority lists for nuclear data from the Nuclear Energy Agency (NEA), a specialised agency within the Organisation for Economic Co-operation and Development (OECD), an intergovernmental organisation of industrialised countries, and the FP6-EURATOM projects 'European research Programme for the transmutation of high level nuclear waste in an accelerator driven system' (EUROTRANS-NUDATRA') and the Coordination action on nuclear data for industrial development in Europe (CANDIDE) also provide much of the basis for the project.

### Measurements

To measure low and medium energies for advanced reactor systems, a combination of the world's best facilities are being used: the Institute for Reference Materials and Measurements (IRMM) neutron sources, both the e- linear and the Van de Graaff accelerators, the n\_TOF spallation neutron beam facility at the European Organization for Nuclear Research (CERN), the Jyväskylä cyclotron and the Ion Guide Isotope Separator On-Line (IGISOL) facility, the CNRS/Orsay accelerators, and the Grand Accélérateur National d'Ions Lourds (GANIL) accelerator complex.

Measurements the team are currently working on include:

1. high-accuracy measurements of neutron inelastic scattering cross sections of <sup>238</sup>U and isotopes of structural materials and inert fuel (<sup>23</sup>Na, Zr, Mo);
2. high-accuracy measurements of neutron total and capture cross sections of <sup>238</sup>U and <sup>241</sup>Am;
3. high-accuracy measurements of fission cross sections, several of Pu isotopes (<sup>238</sup>Pu, <sup>240</sup>, <sup>242</sup>Pu), and minor actinides (<sup>241</sup>, <sup>243</sup>Am and <sup>245</sup>Cm), including the fission yields for isotopes of Np, Pu and Cm by surrogate neutrons and inverse kinematics;
4. state-of-the-art decay data measurements for reactor kinetics and decay heat to improve the experimental information for the beta decay probability and strength functions, and the delayed neutron emission of relevant fission fragments (<sup>88</sup>Br, <sup>94</sup>Rb, <sup>95</sup>Rb and <sup>137</sup>I).

### Coordinator

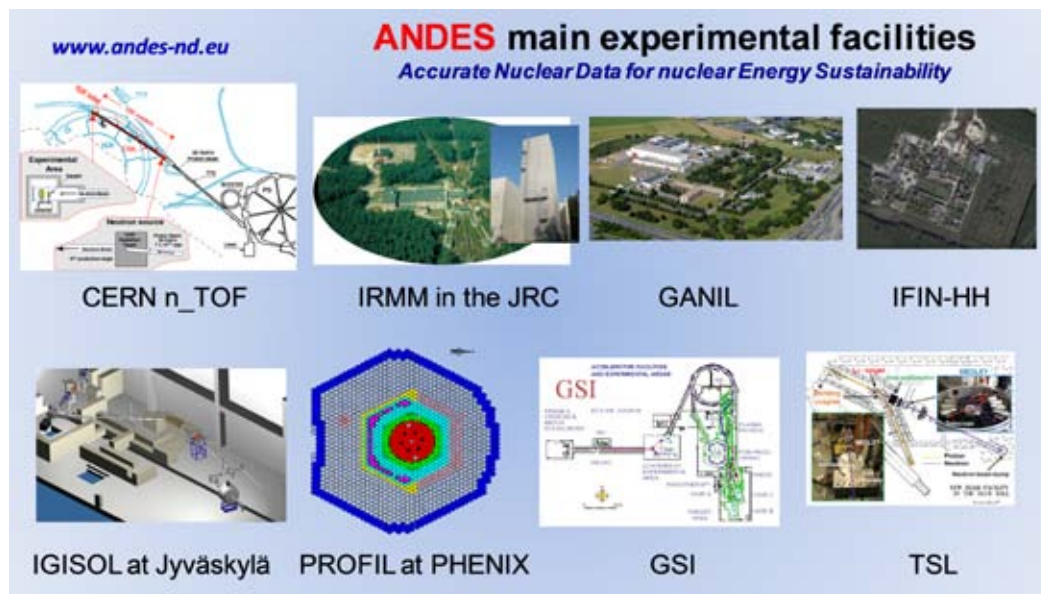
**Enrique Gonzalez-Romero**  
CIEMAT  
Avda. Complutense, 22 (Edif. 17)  
28040 Madrid, Spain  
Tel. +34 913466120  
Fax +34 913466576  
[enrique.gonzalez@ciemat.es](mailto:enrique.gonzalez@ciemat.es)

### Project details

**Project type** // Collaborative project  
**Project start date** // 1.5.2010  
**Duration** // 36 months  
**Total budget** // EUR 6 165 497  
**EC contribution** // EUR 2 995 000  
**Project website** // [www.andes-nd.eu](http://www.andes-nd.eu)

### EC project officer

**Roger Garbil**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/70  
B-1049 Brussels, Belgium  
[roger.garbil@ec.europa.eu](mailto:roger.garbil@ec.europa.eu)



© ANDES consortium

## Assessing the results

To improve and assess the absolute accuracy of the results from computer simulations, the ANDES team decided to concentrate efforts on nuclear data evaluation around data uncertainties and correlations. The project will devote special efforts to the codes TALYS, GENEUS, CONRAD, ACAB and FISPIN. A similar effort will be made to prepare simulation programmes to use covariance information. To demonstrate the performance of these tools, ANDES will evaluate covariance matrices of one major and one minor actinide (from  $^{238}\text{U}/^{239}\text{Pu}$ ,  $^{241}\text{Am}$ ).

Integral experiments provide highly relevant information for evaluation and validation of nuclear data.

To provide directly useful data for the ESNII Accelerator Driven Systems (ADS) demonstration facility, the main objective for ANDES in the high-energy range is the model validation in the 150 MeV-to-600 MeV energy domain, and improving the predicting capabilities of the models in this range. Another objective is to use new measurements at 500 MeV (p+Pb), and the post-irradiation examination of MEGAwatt Pilot Experiment (MEGAPIE) samples.

## Important public events

In parallel to its technical activities, ANDES will develop an intensive education and training programme, and is organising a training course specialising in nuclear data for sustainable nuclear energy.

ANDES results are available on the website for both project partners and members of the public.

ANDES is also setting up an end users group with representatives from universities, R&D organisations, experimental reactors and nuclear facilities, international nuclear data agencies, industries involved in design or exploitation activities for Gen IV and ADS utilities, and regulatory bodies. The end users group will have early access to the project results, and their feedback will be used for future nuclear data activities.

## Partners

- Centro de investigaciones energeticas, medioambientales y tecnologicas (CIEMAT), ES
- Commissariat à l'énergie atomique et aux énergies alternatives (CEA), FR
- Centre national de la recherche scientifique (CNRS), FR
- Gesellschaft fuer schwerionenforschung GmbH (GSI), DE
- National nuclear laboratory limited (NNL), UK
- Institutul national de cercetare -dezvoltare pentru fizica si inginerie nucleara "horia hulebei" (IFIN-HH), RO
- Istituto nazionale di fisica nucleare (Infn), It
- Instituto tecnologico e nuclear (ITN), PT
- European Commission – Joint Research Centre (JRC-IRMM), EU
- Institut Jozef Stefan (JSI), SI
- Jyväskylä Yliopisto (JYU), FI
- Nuclear research and consultancy group (NRG), NL
- Paul scherrer institut (PSI), CH
- Studiecentrum voor kernenergie (SCK-CEN), BE
- Technische universitaet wien (TUW), AT
- Universitatea din bucuresti (UB), RO
- Universite de liege (ULG), BE
- Universidad politecnica de madrid (UPM), ES
- Universidade de santiago de compostela (USC), ES
- Uppsala universitet (UU), SE

# ARCHER

High temperature gas-cooled nuclear reactors (HTRs) combine high safety with high efficiency. They are particularly suitable for operating in cogeneration mode, by supplying of heat and electricity specifically for the European process industry, as an alternative to fossil fuel burning. Europe has a strong history of HTR development and has focused developments on robust safety, appropriate size and high temperature heat generation. The ARCHER project aims to move this technology base forward by extending knowledge of state-of-the-art European High Temperature Reactors (HTRs) by supporting a nuclear cogeneration demonstration.

## Advanced High-Temperature Reactors for Cogeneration of Heat and Electricity R&D

### Moving technology forward

The ARCHER project's aims are in line with the Sustainable Nuclear Energy Technology Platform's (SNETP) plans, set out in its Strategic Research Agenda (SRA) and Deployment Strategy (DS). The state-of-the-art of HTR technology has been established mainly by the previous European and United States HTR programmes, which were active until the end of the 1980s. ARCHER builds on this, and on the large European HTR technology base (re-)established in previous EU Framework Programmes (FP) such as the FP6 project RAPHAEL ('ReActor for Process heat, Hydrogen And Electricity generation') and the FP7 project EUROPAIRS ('End User Requirement fOr Process heat Applications with Innovative Reactors for Sustainable energy supply') and the nuclear cogeneration working group in SNETP.

The ARCHER consortium is made up of stakeholders from both the nuclear and conventional energy industries, along with utilities companies, technical support organisations (TSOs), and research and development (R&D) institutes and universities.

### Activities

The R&D activities in ARCHER are split into four key areas:

- evaluating and assessing the system integration of an HTR in connection to industrial processes;
- resolving open questions regarding confirmation of HTR safety, as preparation for a licensing framework;
- providing a basic insight into fuel behaviour to support fuel performance code and support robust demonstrator design;
- progressing HTR and VHTR technology developments on materials and component technology by developing, building and testing an advanced heat exchanger prototype putting Europe at the forefront of advances in this technology.

### Coordinator

**Sander de Groot**

Nuclear Research and Consultancy Group  
1755 ZG Petten, Netherlands  
Tel. +31 224564338  
Fax +31 224568606  
[s.degroot@nrg.eu](mailto:s.degroot@nrg.eu)

### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.2.2010  
**Duration** // 48 months  
**Total budget** // EUR 9 772 783  
**EC contribution** // EUR 5 400 000

### EC project officer

**Panagiotis Manolatos**

European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/53  
B-1049 Brussels, Belgium  
[panagiotis.manolatos@ec.europa.eu](mailto:panagiotis.manolatos@ec.europa.eu)

### Partners

- Nuclear Research and Consultancy Group (NRG), NL
- Akademia Gorniczo-Hutnicza im. Stanislaw Staszica w Krakowie (AGH), PL
- Alfa Laval Packinox sas (ALP), FR
- Alfa Laval Vicarb sas (ALV), FR
- Alstom Power Ltd (ALSTOM), UK
- AMEC Nuclear UK Limited (AMEC), UK
- Areva NP sas (AREVA), FR
- Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), FR
- Furnaces Nuclear Applications Grenoble (FNAG), FR



ARCHER will provide insight into an HTR's integrated system coupled with industrial processes. A concrete example will be worked out, with direct input from an actual and representative industrial site. The first results from the ARCHER system integration sub-project focus on the coupling between a nuclear cogeneration unit, and electricity and heat supply systems. An artist's impression of an HTR system in cogeneration mode is shown in Figure.

## Educating and engaging

Transferring knowledge to the younger generation of engineers and scientists is at the heart of ARCHER, and will be crucial for the next stage of HTR development: technology demonstration. To address education and training, ARCHER will produce a textbook on HTR technology, put on two new EURO COURSE seminars (in 2012 and 2013) for students and professionals with a conventional (non-nuclear) engineering background, and develop an online HTR simulator to give students the chance to better understand the technology through practice.

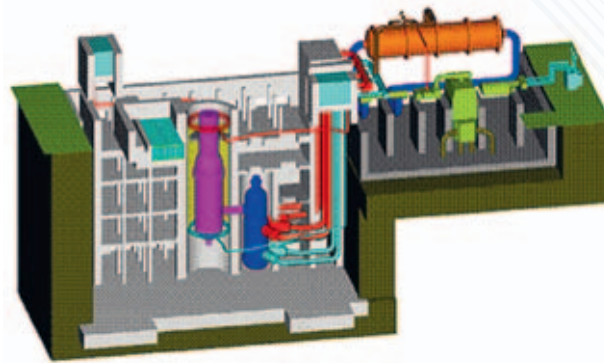
The public and non-nuclear technology networks will be informed via websites, a documentary film and presentations at conferences by ARCHER representatives. From Europe, the connection to international activities is mainly coordinated via the GIF (Generation IV Forum), and a pre-defined list of deliverables that will be made available for information exchange via GIF.

## Societal impact

The amount of fossil fuels consumed by the process industry sector in Europe equals the amount consumed by the electricity production industry. Therefore, European industry, although very effective in reducing its fossil fuel demand, remains a major fossil fuel user which impacts European resource dependency and carbon emissions. Nevertheless, the European process industry has a multi-billion euro turnover, and provides millions of European jobs and essential products for our everyday life.

There are currently few alternatives for the use of fossil fuels in industry and European industry faces strong price volatility and unstable and generally unfavourable European policy. As a result new industrial sites are not developed in Europe but where fossil fuels are located and where policy is more supportive. Nuclear cogeneration intends to provide a responsible European alternative, for a healthy process industry sector in Europe. The size, flexibility, safety features and efficiency of HTR systems allow that.

As a first market target it is envisaged to apply nuclear cogeneration to large industries such as refineries, chemical plants, etc. which require high power density and large amounts of process steam (typically at 550-600°C, determined by the maximum temperatures current technology allows steam to be transported by piping). There is virtually no competition in this market other than with prime fossil fuels; in particular there is no conflict with further development of renewable energies. As a result from previous investments in HTR development and the broad international collaboration and interest in this field, today Europe owns many of the key technologies required to demonstrate nuclear cogeneration of heat and power (CHP) and to take a significant share in an international demonstrator project. Even if only process steam and electricity is provided by HTR to a typical refinery (~10 million tonnes of crude oil per year) this will result in a reduction of ~1.4 million tonnes of carbon dioxide (CO<sub>2</sub>) and 450 000 tonnes of crude oil for the feed of the refinery.



*Artist impression of an HTR system in cogeneration mode.*

© ARCHER project consortium

- Forschungszentrum Jülich GmbH (JÜLICH), DE
- Ucar snc - Groupe Graftech International Ltd. (GTI), FR
- British Energy Generation Ltd (BE), UK
- Institut de Radioprotection et de Sureté Nucleaire (IRSN), FR
- Joint Research Centre (JRC) – European Commission, BE
- Westinghouse Electric Germany GMBH (Westinghouse), DE
- Lagrange SARL (LGI), FR
- Paul Scherrer Institute (PSI), CH
- Saipem S.p.A. (Saipem), FR

- Empresarios Agrupados Internacional S.A. (EA), ES
- SGL Carbon GmbH (SGL), DE
- Association pour la Recherche et le Développement des Méthodes et Processus Industriels, Armines (ARMINES), FR
- ThyssenKrupp VDM GmbH (ThyssenKrupp), DE
- Technische Universiteit Delft (TUDelft), NL
- Technische Universitaet Dresden (TU Dresden), DE
- TUV Rheinland Industrie Service GmbH (TUV), DE
- Centrum výzkumu Rez s.r.o. (CV Rez), CZ
- The University of Manchester (UNIMAN), UK

- Rheinisch-Westfälische Technische Hochschule Aachen (RWTH), DE
- Universitaet Stuttgart (USTUTT), DE
- Karlsruher Institut Für Technologie (KIT), DE
- Forschungszentrum Dresden-Rossendorf e.V. (FZD), DE
- The Chancellor, Masters and Scholars of the University of Cambridge (UCAM), UK
- Centre National de la Recherche Scientifique (CNRS), FR

## ASGARD

Nuclear fission energy represents today about one third of the production of electricity in Europe.

Development of fast Generation IV reactors will help increase use of nuclear fuel and make the fuel cycle sustainable, however some potential contentious issues surrounding new generation nuclear reactors remain; namely the selection of fuel type and coolant. The main focus of ASGARD will be on investigating future fuels. The main problem today is linking the recycling of used nuclear fuel to the fabrication of new fuels, which show efficient recycling (transmutation) behaviour in new reactor systems.

## Advanced fuels for Generation IV reActors: Reprocessing and Dissolution

### Bridging the gap

ASGARD's principal aim is to bridge the gap between existing knowledge in nuclear fuel manufacturing and existing knowledge in separation techniques used for waste treatment and recovery. The project will also investigate the production and behaviour of new novel and improved nuclear fuels for the next generation of nuclear reactors. The targeted result of the project itself is to interconnect the recycling of nuclear fuel to the fabrication of new nuclear fuel. Oxide, nitride and carbide fuels are addressed with a special focus on dissolution, reprocessing and fabrication behaviour.

The consortium consists of partners with extensive experience in research on fabrication of various kinds of fuels and in the recycling process, as well as basic science laboratories capable of handling highly active radioactive materials such as Chalmers University of Technology, Sweden as well as national research laboratories and also university laboratories with more limited radiochemical possibilities. The participation of fuel manufacturing specialists such as Westinghouse, Areva, and Vattenfall, ensures that the processes developed have the possibility of being used by industry.

### Activities

Researchers working on ASGARD will look at oxide, nitride and carbide nuclear fuels. The breakdown in these technical domains forms the backbone of the project. Concerning oxides, the main focus is on so-called Inert Matrix Fuels that have a ceramic or metallic carrier material surrounding the fissile material that is being recycled. Magnesium oxide and Molybdenum are the materials under investigation. Work carried out under earlier EU Framework Programmes has already produced extensive fabrication knowledge; efficient use and recycling are now the keywords. In addition, the conversion of reprocessed materials into suitable precursors for fabrication is investigated. Today most of the nuclear fleet is based on thermal reactors using oxide fuels and the so called 'once through' fuel option meaning that the nuclear fuel is run once in the reactor and then deposited in a final repository for 100,000 years. Only about 1% of the energy in the fuel is used. Some countries, such as the United Kingdom and France, do recycle plutonium and potentially uranium once before final repository. The ASGARD project will join up these activities and develop and investigate novel fuels.

### Coordinator

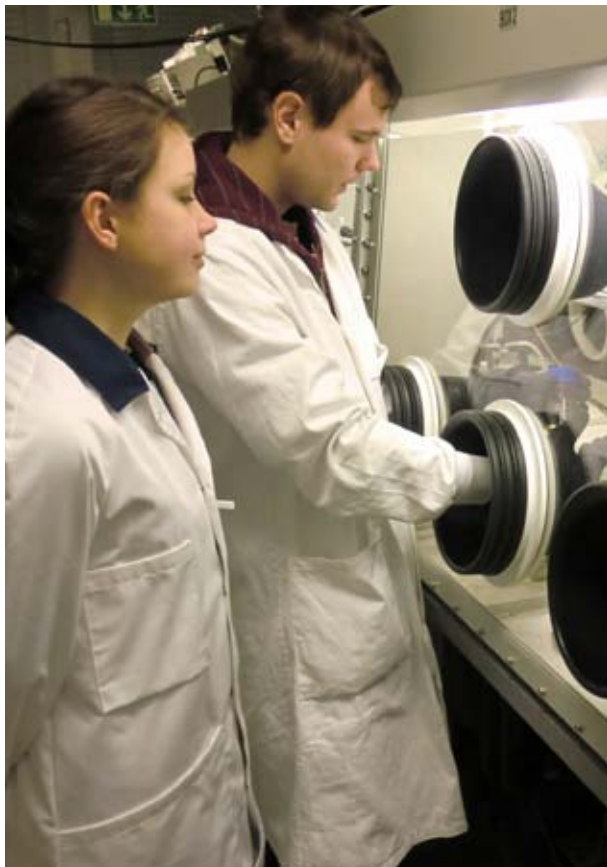
**Christian Ekberg**  
Chalmers university of Technology  
SE-412 96 Gothenburg  
Sweden  
Tel. +46-31-7722801  
or +46-707535034  
[che@chalmers.se](mailto:che@chalmers.se)

### Project details

**Project type** // Collaborative project  
**Project start date** // 1.1.2012  
**Duration** // 48 months  
**Total budget** // EUR 9364186  
**EC contribution** // EUR 5493725

### EC project officer

**Michel Hugon**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/52  
B-1049 Brussels, Belgium  
[michel.hugon@ec.europa.eu](mailto:michel.hugon@ec.europa.eu)



*Young scientists learning to work with radioactive material.  
© Chalmers University of Technology, Sweden*

A major part of ASGAR is its extensive education and training programme that gives young researchers and professionals the chance to learn and train in these highly specialised nuclear applications, see Figure. This has never been more important considering that the 'nuclear population' is ageing and being replaced at a much slower rate than necessary.

## Expected results

Results from carbide fuel production and reprocessing will provide an insight into the safest and most economical carbide fuel design and establish the safest way to process carbide fuel while minimising waste production. Deciding which dissolution route to select needs to be addressed since the fuel by itself is pyrophoric and produces at the same time unwanted carbon compounds upon direct dissolution.

Concerning nitride fuels, one of the main challenges is the recovery of the isotopically pure N-15. The use of this isotope is a prerequisite to minimising production of unwanted C-14 activity. From an industrial perspective, an even more important result will be the ability to enrich N-15 at a sufficiently low cost, as well as to recover N-15 during the dissolution process. In addition the impact of carbon and oxygen impurities on the dissolution rate in nitric acid will be clarified.

## Societal impact

As European energy policy is to drastically cut carbon emissions, it is essential that significant emphasis is placed on future energy sources that are low carbon, reliable and sustainable. Nuclear power is one proven technology that can meet these criteria. Research in the nuclear field shows that medium to long term energy needs can be met by complementing the current nuclear fleet with fast neutron spectrum reactors incorporating a complete recycling of all actinides – the so called Generation IV of nuclear power.

ASGAR contributes significantly to increasing the sustainability of nuclear energy by bridging the gap between different fuel recycling research investigations. The knowledge advances of ASGAR will show governments and European utilities and technology providers that there are several options when it comes to the manufacturing and recycling of novel fuels. It is vital that the outcome of the project is meaningful for the fuel manufacturing industry, and a major part of the project is an analysis of the ASGAR results with respect to their applicability in industry through an Industrial Users Group (Westinghouse, Sweden).

### Information about important public events

The public will be continuously informed throughout the project via the website and through press releases publicising project key events such as, lectures, trainings, courses, open seminars, summer schools and international conferences organised with the aim of sharing knowledge gathered as part of the project.

## Partners

- S Chalmers University of Technology (Chalmers), SE
- Forschungszentrum Julich GmbH (Julich), DE
- Instytut Chemii i Techniki Jądrowej (ICHTJ), PL
- National Nuclear Laboratory Limited (NNL), UK
- Paul Scherrer Institut (PSI), SUI

- Nuclear Research and Consultancy Group (NRG), NL
- Karlsruher Institut für Technologie (KIT-INE), DE
- Commissariat à l'énergie atomique et aux énergies alternatives (CEA), FR
- Ceske Vysoke Ucení Technické v Praze (CTU), CZ
- Kungliga Tekniska Högskolan (KTH), SE
- Evalion s.r.o. (EVALION), CZ

- Westinghouse Electric Sweden (WESTINGHOUSE), SE
- Institutul National de Cercetare-Dezvoltare Pentru Tehnologie Izotopice si Moleculare (INCOTIM), RO
- University of Leeds (LEEDS), UK
- University of Manchester (UMAN), UK
- University of Cambridge (UCAM), UK



# ERCOSAM

The presence of a stratification in a nuclear power plant containment is a source of concern: pockets of hydrogen in high concentration could lead to a deflagration or detonation risk. With this in mind, the aim of ERCOSAM is to investigate containment thermal-hydraulics of current and future light water reactors (LWRs) for severe accident management.

## Containment thermal-hydraulics of current and future LWRs for severe accident management

### Aims

The project aims to investigate the effect of scaling on the hydrogen mixing and stratification phenomena, and how it is addressed experimentally as well as by codes. The ultimate goal is to establish the limits within which it is possible to achieve a well-mixed hydrogen atmosphere using existing plant hardware.

The project has a two-fold strategy. One is to establish whether in a test sequence representative of a severe accident in a LWR, a hydrogen (helium) stratification can be established during part of the transient, starting from the initiation of the loss-of-coolant accident (LOCA) blowdown until the end of bulk hydrogen release from the reactor vessel into the containment. The second is to determine how this stratification can be broken down by the operation of severe accident management systems (SAMs), sprays, coolers and passive autocatalytic recombiners.

### Nature and scope of the project

The ERCOSAM consortium is made up of six organisations, three of which (the Paul Scherrer Institut (PSI), Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA) and the Institute for Radiological Protection and Nuclear Safety (IRSN)), possess experimental facilities at three different scales and are equipped with simulators of engineered hydrogen/steam mitigation systems such as sprays, coolers and passive catalytic recombiners. The facilities generate Computational Fluid Dynamics (CFD)-grade high spatial and time resolution data on gas distribution and gas flow. The role of the other three organisations of the consortium (Karlsruhe Institute of Technology (KIT), the Nuclear Research and consultancy Group (NRG) and Atomic Energy Canada Limited (AECL)) is to provide analytical contributions. All organisations will be involved in planning the experiments and analysing the data by using advanced lumped parameter (LP), CFD and in-house developed codes with 3D capabilities.

### Coordinator

**Salih Guentay**  
Paul Scherrer Institut  
OHSA C11  
5232 Villigen-PSI  
Switzerland  
Tel. +41 563102677;  
+41 563104156  
[salih.guentay@psi.ch](mailto:salih.guentay@psi.ch)

### Project details

**Project type** // Collaborative project  
**Project start date** // 1.7.2010  
**Duration** // 48 months  
**Total budget** // EUR 2 586 894.30  
**EC contribution** // EUR 1 000 000.00

### EC project officer

**Michel Hugon**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/52  
B-1049 Brussels, Belgium  
[michel.hugon@ec.europa.eu](mailto:michel.hugon@ec.europa.eu)



## Activities

Experimental data generated as parts of many different programmes have mainly addressed the erosion and disintegration of a deliberately generated stratified hydrogen layer by means of jets, plumes and sprays. These programmes were not geared towards following the accident sequences from the start; they produced the interlinked and interplaying processes associated with the air distribution during the pure steam discharge and the later steam and hydrogen discharge into the containment. Since none of the past programmes were linked together, the scaling issues driven by the different facilities were not studied at all.

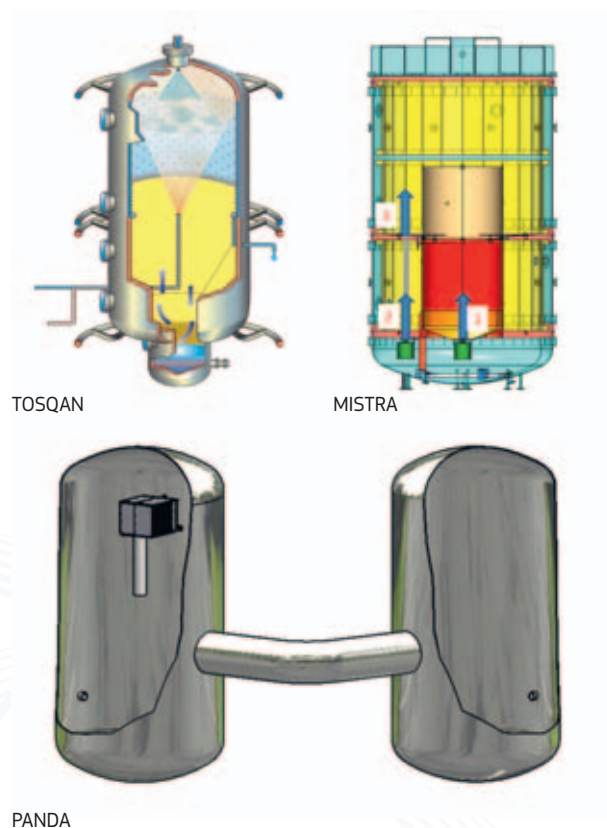
The ERCOSAM project is the first initiative to generate data from different facilities, link them together and use scaling analysis of predicted steam and hydrogen loads for different full-size plants.

## Expected results

The schematics of the experimental facilities (PANDA/PSI, MISTRA/CEA and TOSQAN/IRSN) (not to scale) are shown in

The TOSQAN vessel is 7 m<sup>3</sup>, whereas the MISTRA vessel is 98 m<sup>3</sup> and the two PANDA vessels (interconnected by a bended pipe of 1 m in diameter) are 180 m<sup>3</sup> combined. The TOSQAN is not compartmentalised, although the other two, whether within the same vessel (MISTRA) or by using two interconnected vessels (PANDA), facilitate inter-compartmental flow of the steam and non-condensable gases. Therefore, the facilities provide essential characteristics to produce the data as planned. The fourth facility is a hypothetical facility with similar characteristics to a much larger scale facility, KMS (Scientific and Technological Research Institute (NITI), Russia) with a volume of 1 920 m<sup>3</sup> that will be defined by ERCOSAM's sister project Stratification And Mixing of steAm and hydRo-gen during Accident (SAMARA) funded by the Russian State Atomic Energy Corporation (ROSATOM). It will be used for code benchmarking which will employ conditions linked to the initial and boundary conditions of those of the three facilities.

The interlinked approach of the project partners will help realise the transfer of gained knowledge and in turn attain three goals: ascertaining under which conditions a stratified hydrogen environment may develop, the effectiveness of operating engineered mitigation systems in obtaining a well-mixed containment atmosphere which reduces the hydrogen risk, and the limits of the codes in simulating the relevant processes.



*Schematic of Facilities used in ERCOSAM.*  
© PSI, CEA, IRSN

## Societal impact

The project will demonstrate how effective engineered systems are at preventing containment pressurisation due to large steam generation, which can cause erosion and disintegration of the hydrogen layer. Utilising the data and the assessed computer programmes will potentially increase the safety of the current and advanced light water reactors by enabling the implementation of additional measures in the severe accident management guidelines. Therefore, the utilities and vendors of the LWR plants will be the main end users who are set to benefit from the project results.

Project partners have directly employed young researchers to perform certain tasks and are therefore already engaging with academia.

## Partners

- Paul Scherrer Institut (PSI), CH
- Institute for Radiological Protection and Nuclear Safety (IRSN), FR
- Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA), FR
- Karlsruhe Institute of Technology (KIT), DE
- Nuclear Research and consultancy Group v.o.f. (NRG), NL
- Atomic Energy Canada Limited (AECL), CA
- Forschungszentrum Jülich GmbH, DE
- US Nuclear Regulatory Commission, USA

# ERINDA

The ERINDA project aims to coordinate European efforts to exploit up-to-date neutron beam technology for novel research on advanced concepts for nuclear fission reactors and the transmutation of radioactive waste.

Such waste already exists in appreciable quantity due to the year-long operation of existing nuclear reactors. New types of reactors like accelerator-driven systems or Generation IV nuclear reactors will have the potential to transmute most of the long-lived waste in their respective fuel cycles.

For the development of these transmutation systems and for improved nuclear safety, accurate nuclear data shall be obtained as part of the ERINDA project.

## European research infrastructures for nuclear data applications

### Nature and scope of the project

The ERINDA consortium brings together all relevant neutron data facilities: time-of-flight facilities for fast neutrons, charged-particle accelerators and experimental nuclear reactors in Europe ready to offer part of their available beam time to the project. The majority of the facilities involved are modern (recently built or refurbished) and equipped with state-of-the-art nuclear data measurement instrumentation. The aim is to establish access for nuclear data measurements at the consortium facilities and to direct their use towards the highest priority nuclear-data requests with the greatest scientific value. As transmutation of nuclear waste and innovative reactor systems are two key issues for the present and future use of nuclear energy, the best option should be chosen by using simulation methods in order to predict their running conditions. The availability of complete, accurate and consistent nuclear data libraries is crucial here, and measured nuclear-reaction cross sections establish the experimental basis for these data.

### Activities

The ERINDA projects aims to provide 2 500 hours of beam time at the consortium facilities over the next 3 years to European groups. A total of 25 experiments will be carried out, as will 10 short-term visits (8 weeks each) for scientists from consortium institutes; this will allow theoretical data analysis and computer simulations relevant to the experiments to be performed. To optimise the scientific output of the experiments, a Project Advisory Committee (PAC) comprising five external experts will select the submitted experiment proposals and determine the best facility for the experiment.

### Expected results

A major factor behind long-lifetime radiotoxicity of fuel rods after their extraction from a nuclear reactor is the presence of heavy nuclides like plutonium or minor actinides like americium. These are produced as by-products in today's nuclear reactors by capturing neutrons in uranium. Coupled with the long lifetime of such isotopes, this calls for the development of strategies for their transmutation into short-lived fission products.

#### Coordinator

**Arnd Junghans**

Helmholtz-Zentrum Dresden-Rossendorf  
Postfach 510119  
01314 Dresden, Germany  
Tel. +49 3512603589  
Fax +49 3512601 3589  
[a.junghans@hzdr.de](mailto:a.junghans@hzdr.de)

#### Project details

**Project type** // Coordination and Support  
Action  
**Project start date** // 1.12.2010  
**Duration** // 36 months  
**Total budget** // EUR 1 141 702  
**EC contribution** // EUR 999 958  
**Project website** // [www.erinda.org](http://www.erinda.org)

#### EC project officer

**Roger Garbil**

European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/70  
B-1049 Brussels, Belgium  
[roger.garbil@ec.europa.eu](mailto:roger.garbil@ec.europa.eu)

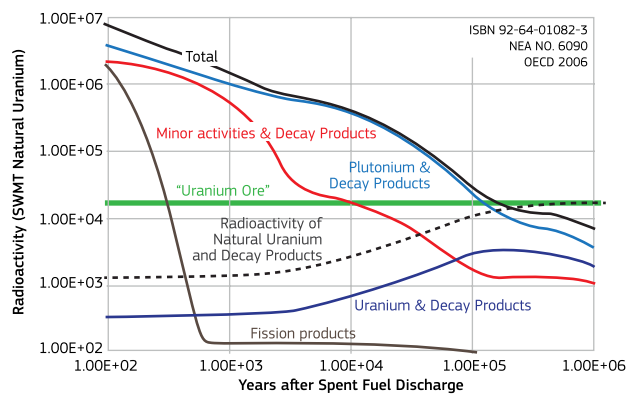


Figure 1: Evolution over time of the radiotoxicity of the waste from a conventional uranium reactor and its components. This graph was prepared for the Organisation for Economic Co-operation and Development (OECD) Nuclear Energy Agency (NEA). The radiotoxicity shown in this plot results from possible incorporation of waste components decaying by  $\alpha$ -decay or fission. The radiotoxicity of plutonium and other (minor) actinides decay to the natural level of the uranium ore required to produce the fuel after 10 to 100 thousand years, and thus their removal by transmutation is especially important.

© OECD Nuclear Energy Agency, Report No. 6090 (2006) Fig. 1.2

Extremely long-term radiotoxicity (of approximately 200 000 years) is determined by plutonium. If 99.9 % of the plutonium and of the minor actinides can be transmuted in a nuclear transmutation system, the time frame required for safe final disposal will be reduced to historical times, i.e. fewer than 1 000 years.

Nuclear fuel containing plutonium and optimisation for very-high nuclear burn-up are first steps towards decreasing the amount of long-lived highly radioactive nuclear waste. To really minimise its accumulation, a dedicated nuclear transmutation system is required, one that will use a fast neutron spectrum to transmute nearly all of the plutonium and the minor actinides. To design nuclear reactor cores capable of transmutation, precise nuclear data with fast neutrons are required for fuel and construction and cooling materials, as is illustrated in Figure 2 for americium. The ERINDA consortium aims to measure these data in precise experiments at their facilities and to distribute the results to the relevant nuclear databases at the OECD NEA and the International Atomic Energy Agency (IAEA).

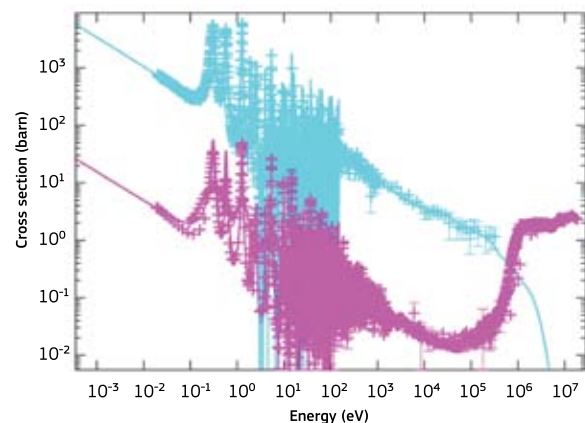


Figure 2: Neutron-induced reaction data on the nuclide americium-241. Especially for the fast-neutron energy range, around 106 eV precise data for capture (cyan) and fission (magenta) are required.

© Arnd Junghans, HZDR

## Societal impact

The ERINDA project, just like its predecessor 'European facilities for nuclear data measurements' (EFNUDAT), will continue to foster long-term partnerships and the exchange of ideas. It will also coordinate research in the field of nuclear data measurements and help European efforts to be visible on a global scale. Several nuclear energy companies have expressed interest in the results of this research and they are connected through the PAC. With interest in replacing fossil fuel with nuclear energy increasing in many European countries, it is expected that there will be a long-term impact in terms of environmental gain and quality-of-life enhancement.

As the nuclear research community faces the reality of declining young researcher numbers, the consortium is also responsible for actively encouraging the participation of postdoctoral fellows and PhD students in all ERINDA activities. This will generate a new generation of nuclear scientists and engineers who can continue this type of research in the future. An important aim of ERINDA is to make this type of project appealing to young researchers.

## Information about important public events

The ERINDA kick-off meeting took place on 27 and 28 January 2011, at Helmholtz-Zentrum Dresden-Rossendorf. The first progress meeting took place in the last week of November 2011 in Řež near Prague, the Czech Republic. Four European scientific meetings are planned to communicate on progress and disseminate the results of the ERINDA project.

## Partners

- Helmholtz-Zentrum Dresden-Rossendorf (HZDR), DE
- Institute for Reference Materials and Measurements, Geel (JRC-IRMM), BE
- The neutron facility, European Organization for Nuclear Research, Geneva (CERN nTOF), CH
- National institute of nuclear and particle physics, National Center for Scientific Research (CNRS/IN2P3), FR

- Uppsala University (UU-TSL), SE
- Physikalisch-Technische Bundesanstalt, Braunschweig (PTB), DE
- Nuclear Physics Institute (NPI), Academy of Sciences of the Czech Republic (ASCR), Řež, CZ
- Institute of Isotopes, Hungarian Academy of Sciences, Budapest (II HAS), HU
- Department of Physics, University of Jyväskylä (JYU), FI

- Horia Hulubei National Institute of Physics and Nuclear Engineering, Bucharest (IFIN-HH), RO
- National Physical Laboratory Teddington (NPL ), UK
- Goethe University, Frankfurt (FRANZ), DE
- Commissariat à l'énergie atomique et aux énergies alternatives (CEA), FR

## EVOL

Based on the particularity of using a liquid fuel, the French National Center for Scientific Research (CNRS) has been developing an innovative molten salt fast reactor (MSFR) concept since 2004. The objective of this project is to come up with a MSFR design by 2013 that gives the best system configuration issued from physical, chemical and material studies for the reactor core, the reprocessing unit and waste conditioning. The aim is to demonstrate that this design can meet the goals of Generation IV, in terms of sustainability (thorium breeder), non-proliferation (integrated fuel cycle, multi-recycling of actinides), resources (close uranium/thorium fuel cycle, no uranium enrichment), safety (no reactivity reserve, strongly negative feedback coefficient) and waste management (actinide burner).

## Evaluation and viability of liquid fuel fast reactor system

### A strong consortium

The EVOL project consortium gathers together key actors from the fields of nuclear physics, molten chemistry, pyrochemistry, molecular modelling and material science. Each partner will help contribute towards the overall aim of developing a pre-conceptual MSFR design and recommendations for pyrochemical reprocessing and for structural materials.

The EVOL project is managed under the framework of a Euratom/ Russian State Atomic Energy Corporation (ROSATOM) collaboration; its partner Russian project is titled Minor Actinides Recycling in Molten Salt (MARS). The complementarity and the scientific exchanges between Euratom and ROSATOM will be largely developed during the joint meetings dedicated to defined topics: solubility of lanthanides and actinides in fuel salts; corrosion studies of nickel-based alloys provided by the EVOL consortium; safety and neutronic and fuel cycle calculations; and recommendations for molten salt system and components technology such as pumps, gates, and junctions.

### Activities

The crux of the MSFR concept is to adopt a multidisciplinary research approach towards neutronics, thermal-hydraulics, chemistry, and materials science. Technological research will also be carried out based on the construction of a molten salt loop in France to test the efficiency of helium sparging for the extraction of noble metals.

Two workshops will be held towards the end of the project based on the contributions of international researchers, including those from the MARS project involved in molten salts research for molten salt reactor (MSRs) as well as other molten salt applications.

### Expected results

The overall objective of the EVOL project is the design and the safety of a non-moderated thorium MSR, principally addressing the definition of the core geometry, the reactor part and the salt clean-up unit. Since fuel salt chemistry, reactor physics and salt thermal-hydraulics are interlinked with the MSR design, the integral analysis of the proposed MSR system will be an important scientific challenge.

### Coordinator

**Sylvie Delpech**  
CNRS  
IPNO  
Université Paris Sud  
Batiment 100  
91406 ORSAY CEDEX  
Tel. +33 169157344  
[delpech@ipno.in2p3.fr](mailto:delpech@ipno.in2p3.fr)

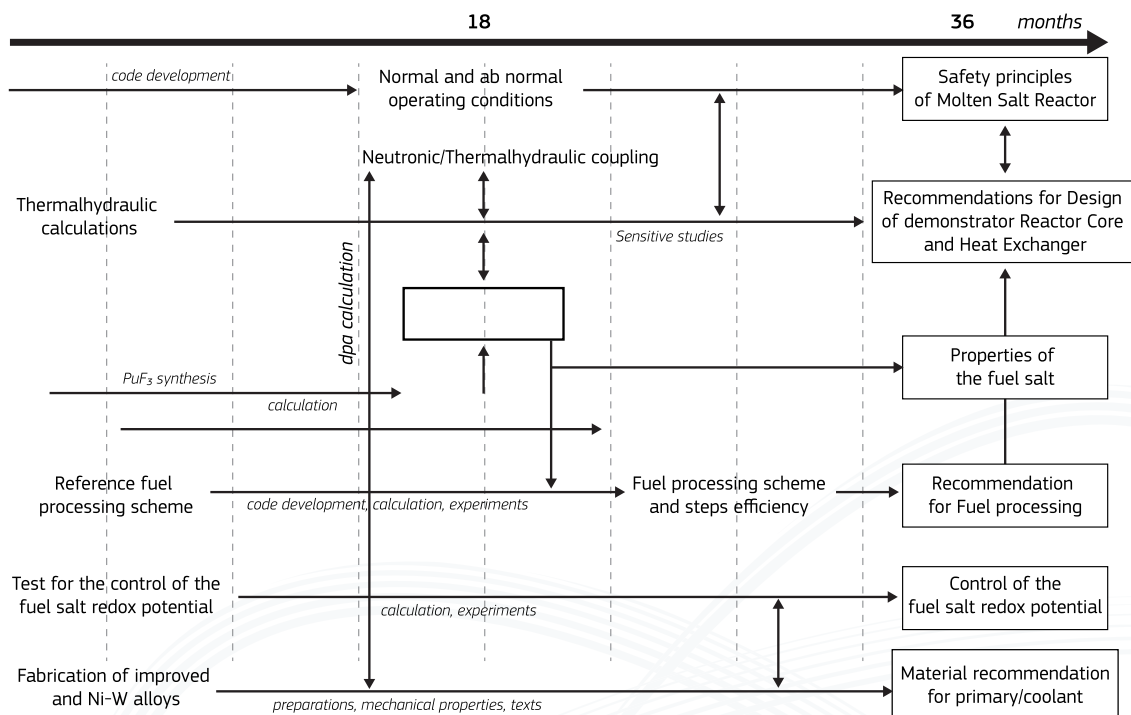
### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.12.2010  
**Duration** // 36 months  
**Total budget** // EUR 1 847 947  
**EC contribution** // EUR 995 860

### EC project officer

**Mykola Džubinský**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 01/58  
B-1049 Brussels, Belgium  
[mykola.dzubinsky@ec.europa.eu](mailto:mykola.dzubinsky@ec.europa.eu)





#### General description of the EVOL project.

The project will address the following points:

- the proposition of fundamental safety guidelines and transposition of in-depth defence principles;
- the recommendation for the design of core and heat exchangers;
- the selection of a fuel salt composition, determination of salt properties and fuel salt redox control;
- establishing a fuel processing flow sheet, with emphasis on the actinide-lanthanide separation;
- the recommendation of core structural material composition.

### Societal impact

The concept developed in this project will be an innovative non-moderator system that is capable of breeding uranium-233 from thorium-232, and that can also operate as a burner for plutonium and minor actinides. The proposed work will be a major European contribution to the Generation IV initiative and specifically to MSR activity. The concept is based on a closed fuel cycle; the proposed work will demonstrate the

MSFR's potential as a sustainable energy system and open up the possibility for large-scale thorium utilisation.

The EVOL project will create an alternative option for partitioning and transmutation compared to the solid fuel and the aqueous processing route that currently prevails. This will allow the closure of the current light water reactor (LWR) fuel cycle by employing MSFR systems starting with transuranic elements in the thorium/plutonium fuel cycle, as an alternative to fast neutron reactors operated in the uranium/plutonium fuel cycle.

Studying the properties of molten salts will help advance scientific knowledge on liquid salts in general. Such knowledge is of specific interest for MSR research and it relevancies likewise relevant to research into all industrial processes that use liquid salts.

### Partners

- Centre national de la recherche scientifique (CNRS), FR
- JRC-Joint Research Centre –European Commission (JRC-ITU), BE
- Technische Universiteit Delft (TUD), NL
- Karlsruher Institut fuer Technologie (KIT), DE
- Forschungszentrum Dresden-Rossendorf EV (FZD), DE
- Politecnico di Torino (POLITO), IT
- The Chancellor, Masters and Scholars of the University of Oxford (UOXFDJ), UK
- Aubert & Duval SAS (AD), FR
- Energovyzkum spol.s.r.o. (EVM), CZ
- Budapesti Műszaki és Gazdaságtudományi Egyetem (BME), HU
- Inopro SARL (INOPRO IAO), FR

## FREYA

The FREYA project aims to continue investigations into the subcritical configurations for validating methodology applied to online reactivity monitoring of critical and subcritical accelerator-driven systems (ADSs) and the lead fast reactor (LFR) as well as for neutronic code validation. FREYA builds on the groundwork developed in projects carried out under previous framework programmes: 'The muse experiments for subcritical neutronics validation' (MUSE) under the Fifth Framework Programme (FP5); and the 'Generator of uninterrupted intense neutron at the lead Venus reactor' (GUINEVERE) project that forms part of the Sixth Framework Programme (FP6) 'European research Programme for the transmutation of high level nuclear waste in an accelerator driven system' (EUROTRANS) project.

The investigations will be related to the different subcriticality levels for the nominal operation mode of ADSs. In order to investigate the robustness of several suggested measurement techniques with regard to the reflector effect, FREYA work will involve performing experiments with different reflector materials.

The FREYA consortium is both multidisciplinary and pan-European, made up of experts from research institutes, academia and industry. The staff of the VENUS-F facility, housed at the coordinating institution, the Belgian Nuclear Research Centre (SCK-CEN), have 50 years experience in zero-power experiments, and all members of the consortium are specialists in accelerator physics and calculations.

## Fast reactor experiments for hybrid applications

### Project scope

To complete the validation of the methodology for subcriticality monitoring, the robustness of the reactivity indicators with regard to a change in vertical position of the neutron source will be investigated in view of possible variations of the height of the spallation source in a real ADS.

The project will involve developing and operating, as a subcritical facility and a critical facility, a Multi-purpose hybrid Research Reactor for High-tech Applications (MYRRHA) as envisaged under the Seventh Framework Programme (FP7) project 'Central Design Team (CDT) for a Fast Spectrum Transmutation Experimental Facility (FASTEF). An experimental programme in support of the design and licensing of both operation modes is needed. Although the experimental programme for the critical operation mode of MYRRHA/FASTEF can generate useful information for the validation of reactor codes for LFR development, a dedicated effort for the validation of reactor codes for LFR developments is envisaged by the LFR community.

### Activities

The results of zero-power experiments carried out in four different fast cores of VENUS-F will validate ADS online reactivity monitoring methodologies and support the design and licensing of subcritical and critical configurations for MYRRHA/FASTEF and LFRs.

To make sure that the MYRRHA/FASTEF design works in subcritical mode and in critical mode, supporting reactor physics experiments must be carried out as a follow-up to the experimental programme for online reactivity monitoring. Investigations on subcritical VENUS-F lead and uranium cores coupled with the GENEPI-3C accelerator will be extended and the critical core will be investigated separately.

### Coordinator

**Anatoly Kochetkov**

Institute of Advanced Nuclear Systems

SCK-CEN

Boeretang 200

BE-2400 Mol, Belgium

Tel. +32 14332193

Fax +32 14321529

[akochetk@sckcen.be](mailto:akochetk@sckcen.be)

### Project details

**Project type** // Collaborative Project

**Project start date** // 1.3.2011

**Duration** // 48 months

**Total budget** // EUR 5 061 000

**EC contribution** // EUR 2 800 000

### EC project officer

**Roger Garbil**

European Commission

Directorate-General for Research and

Innovation

Directorate Energy

Unit K.4 – Fission

CDMA 1/70

B-1049 Brussels, Belgium

[roger.garbil@ec.europa.eu](mailto:roger.garbil@ec.europa.eu)

In LFR development, until now, no supporting reactor physics programme based on integral measurements in a zero-power facility has yet been carried out. In this respect, FREYA's activity links up both the FP6 project 'European lead-cooled system' (ELSY) and the FP7 project 'Lead-cooled European advanced demonstration reactor' (@). First of all, the definition and realisation of LFR simulation at the VENUS-F core will be carried out. Then the experiments for the design and licensing support of LFR will be fulfilled.

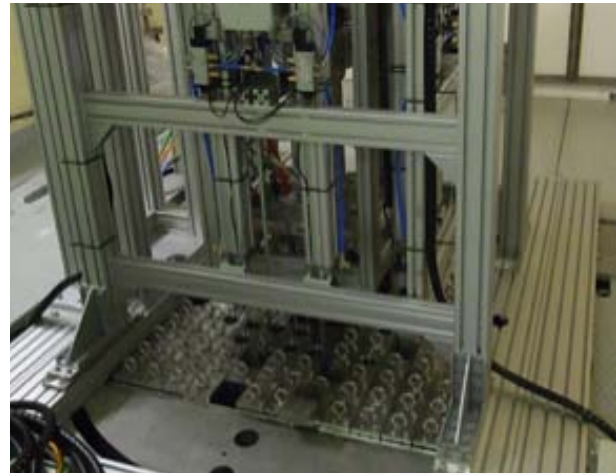
Using the results of FREYA experiments, online reactivity monitoring methodologies of ADSs will be validated so computational tools for the design and licensing of subcritical/critical configurations for MYRRHA/FASTEF and for LFR core design can be created.

## Expected results

The four VENUS-F configuration experiments will complete the experimental programme for the validation of the methodology for online reactivity monitoring initiated as part of the FP6 GUINEVERE project. Two configurations for the nominal operation mode of ADSs and specific configurations with deep subcriticality will be investigated. Similar experiments to those carried out under GUINEVERE will be conducted in these cores to obtain a full set of data points for the validation of reactivity monitoring methodology.

For the next VENUS-F configurations in the FREYA project, the necessary experiments will be conducted in support of the design and licensing of MYRRHA/FASTEF subcritical and critical cores, and in support of the design and licensing of LFRs.

The results of measurements such as power distributions, spectral indices, control rod worth, effective delayed neutron fraction and reactivity effects including coolant voiding will be estimated by different calculation tools. Calculating comparisons between the experiment results will help reduce design safety margins and prove the reliability of the computational tool for the licensing of the design. The FREYA results will make it possible to start MYRRHA/FASTEF construction in 2016.



*VENUS-F structure // VENUS-F coupled with a GENEPI-3C accelerator.*

© SCK-CEN

## Societal impact

The Sustainable Nuclear Energy Technology Platform's (SNETP's) Strategic Research Agenda (SRA) describes the different fast reactor systems to be developed for the future, especially waste burners. Besides the reference to sodium technology, the SRA also identified the need for the development of an alternative technology (lead or gas). The SRA also acknowledges the need to pursue research and development (R&D) activities that support ADSs.

The results from the VENUS-F cores simulated MYRRHA critical phase experiment and the LFR core experiment will be applied for the validation of neutronic calculation codes to reduce design safety margins and to support licensing applications for the construction of both ADSs and Generation IV LFRs.

## Information about important public events

FREYA will collect different reports produced during the project and its Coordination Committee will encourage their publication in journals as well as their presentation at international conferences. On the basis of the experience gained during FREYA, one-week pilot lab sessions for training and education purposes will be organised and several PhD programmes have been planned around the results of the project. The project website will be used to disseminate information to the general public.

## Partners

- Studiecentrum voor Kernenergie/ Centre d'Etude de l'énergie Nucléaire (SCK-CEN), BE
- Karlsruhe Institute of Technology (KIT), DE
- Commissariat à l'énergie atomique et aux énergies alternatives (CEA), FR
- Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (ENEA), IT

- Centre National de la Recherche Scientifique (CNRS), FR
- Instituto Tecnológico e Nuclear (ITN), PT
- Universidad Politécnica de Madrid (UPM), ES
- Ansaldo Nucleare SpA (ANSALDO), IT
- Royal Institute of Technology (KTH), SE
- Delft University of Technology (TUD), NL
- Istituto Nazionale di Fisica Nucleare (INFN), IT

- Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT), ES
- Forschungszentrum Dresden-Rossendorf (FZD), DE
- Chalmers University Technology (CUT), SE
- Budapest University of Technology and Economics (BME), HU
- Akademia Górniczo-Hutnicza (AGH), PL

## GoFastR

Fast reactors possess the unique ability of being able to both generate their own fuel and burn minor actinides (the main long-lived components of nuclear waste) to reduce the quantity and radiotoxicity of nuclear wastes. The gas-cooled fast reactor (GFR), one of the six Generation IV systems, combines existing technologies from sodium-cooled fast reactors and high-temperature gas-cooled thermal reactors. Such a fusion of technologies creates a system which bypasses the sodium handling issues that often plagued the former, and benefits from the high efficiency and diverse heat applications of the latter. And all this, whilst running on a sustainable closed fuel cycle and producing minimal waste.

## European gas-cooled fast reactor

### Objectives

The main objective of GOFASTR is to develop a Generation IV GFR system through its viability phase. To this end, by the end of 2012, the main issues that impact the viability of GFRs as a commercial nuclear energy system need to have been addressed. Specifically for GFRs, the main issues are centred around the development of a suitable fuel and achieving the necessary diversity and reliability of the safety systems.

GFRs require a robust fuel that can operate continually at high temperatures and high-power densities whilst achieving good fission product retention and economically viable burn-up. With regard to GFR-specific safety systems, unlike gas-cooled thermal reactors, GFRs do not (and cannot) have a large solid moderator structure, so there is little thermal inertia in the core structure. Therefore, to limit fuel temperatures in fault conditions, the safety systems have to supply a flow of coolant through the core with high reliability. The challenge in this instance is providing reliability without compromising the economics of the system.

### An international effort

The GOFASTR project builds on work that started under the Fifth Framework Programme (FP5) to develop the GFR into a safe sustainable nuclear energy source, and it is part of wider international efforts to develop the system that is coordinated by the Generation IV International Forum (GIF). Two of the countries represented within GOFASTR are also members of the GIF (France and Switzerland), this helps promote the integration of European research efforts with those of the GIF. The GOFASTR consortium is made up of a variety of partners: industrial organisations and national research centres; universities and research centres; and technical support organisations (TSOs) for regulators.

Partners from France, Germany and the United Kingdom bring their experience of having built and operated sodium-cooled fast reactors to the table, with the United Kingdom and Germany both strong in gas reactor technology and the latter particularly so in the field of high temperature reactors. The project consortium is strengthened by the participation of organisations from the Czech Republic, Hungary and Slovakia. These three nations have signed a memorandum of understanding to work together to enable a GFR demonstration plant (ALLEGRO) to be situated in one of these three countries.

### Coordinator

**Richard Stainsby**  
AMEC  
Booths Park  
Chelford Road  
Knutsford  
Cheshire  
WA16 8QZ, United Kingdom  
Tel. +44 1565684903  
Fax +44 1565684876  
[richard.stainsby@amec.com](mailto:richard.stainsby@amec.com)

### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.3.2010  
**Duration** // 36 months  
**Total budget** // EUR 5 357 548  
**EC contribution** // EUR 3 000 000

### EC project officer

**Georges Van Goethem**  
European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/47  
B-1049 Brussels, Belgium  
[georges.van-goethem@ec.europa.eu](mailto:georges.van-goethem@ec.europa.eu)



## Activities

The activities of the GOFASTR project are aligned with those of the Generation IV GFR system. As such, the structure of GOFASTR mirrors that of the latter. GOFASTR includes additional work packages concerned with education and training, and generic safety studies that aim to coordinate the training of masters and PhD students and the staging of formal courses on GFR technology.

The work of the design and safety work packages is aimed at demonstrating the viability of the basic designs of the reactor unit (including the core and fuel subassemblies), the GFR-specific safety systems, the balance of plant and the containment concept. The fuel (and other core materials) work package aims to contribute towards the development of a robust fuel concept in terms of its structure, fissile compound and cladding material. Whilst irradiation of test fuel specimens is beyond the scope of GOFASTR, all of the necessary development work in terms of designing the irradiation capsule and preparation of the supporting safety documentation will be completed for irradiation of a test fuel specimen in the High Flux Reactor at the Nuclear Research and Consultancy Group (NRG) Petten.

GOFASTR features a work package dedicated to liaising with other Seventh Framework Programme (FP7) European projects and initiatives, the most important being the Sustainable Nuclear Energy Technology Platform (SNETP). The GFR features strongly in its roadmap and in the European Sustainable Nuclear Industry Initiative (ESNII), which is set to be the vehicle via which fast reactor elements of the SNETP roadmap are to be implemented.

## Expected results

The results from the project will be presented in 67 contractual deliverables, of which 18 have been identified as being Euratom's contribution to the Generation IV GFR system. The work presented in many of the deliverables will represent stepping stones towards the three main outputs from the project. These are the GFR viability report, the ALLEGRO viability report and the fuel irradiation test preparation documents, all three of which are deliverables to Generation IV.

GOFASTR is mainly concerned with the technical and safety challenges posed by the GFR system, and it is still too early to carry out a true economic assessment. However, the work is focused on

reducing costs by achieving high reliability, plant simplicity and efficient usage of fuel and rare materials (such as helium).

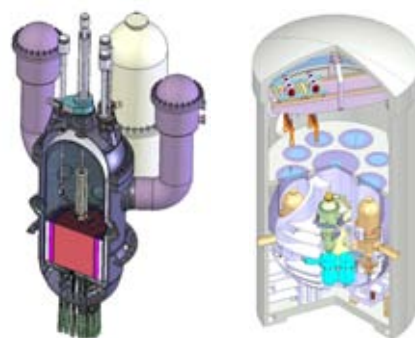
ALLEGRO is being developed as a GFR demonstrator by the Czech Republic, Hungary and Slovakia. GOFASTR will provide information on the design, safety assessment and viability to these Member States so that fabrication costs can be refined beyond provisional costings developed within the ESNII.

## Societal impact

Beyond the goals of the GFR system, the project will have a major impact both in maintaining fast reactor technology within Europe and in extending this technology to nation states that have not had a historical association with the technology. In this respect, activities of GOFASTR will be complementary to other European fast reactor projects and the ESNII. Education and training is an important route by which the technology will be maintained and developed. It is important that young engineers and scientists be exposed to challenging technical projects whilst at university, to encourage them to take up careers within the nuclear industry and to enable them to lead future research projects.

## Events

A paper based on the Generation IV Gas-cooled Fast Reactor' was presented at the International Congress on Advances in Nuclear Power Plants (ICAPP) 2011 that took place in Nice. An education and training event was held in June 2011, the 'Gas-cooled Fast Reactor Course' at the French Alternative Energies and Atomic Energy Commission (CEA) Cadarache.



*GFR reactor unit (left) and located within its containment building (right).*

© Commissariat à l'Énergie Atomique

## Partners

- Commissariat à l'énergie atomique et aux énergies alternatives (CEA), FR
- AMEC Nuclear UK Ltd (AMEC), UK
- AREVA NP SAS (AREVA), FR
- InterUniversities Consortium for Nuclear Technological Research (CIRTEN) — University of Pisa (UNIP), IT
- Empresarios Agrupados Internacional S.A. (EA), ES
- Karlsruhe Institute of Technology (KIT-G), DE
- Imperial College of Science, Technology and Medicine (Imperial), UK
- Institut De Radioprotection et de Sûreté

- Nucléaire (IRSN), FR
- European Commission — Joint Research Centre — Institute for Transuranium Elements (JRC-ITU), EU
- Nuclear Research and Consultancy Group (NRG), NL
- Paul Scherrer Institute (PSI), CH
- Rolls-Royce Power Engineering plc (Rolls-Royce), UK
- Technical University Delft (TUD), NL
- TÜV Rheinland Industrie Service GmbH (TUV), DE
- S.R.S. Servizi di Ricerche e Sviluppo Srl (SRS), IT
- Budapesti Műszaki és Gazdaságtu-

dományi Egyetem (BME), HU

- Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (ENEA), IT
- Ansaldo Nucleare SpA (Ansaldo), IT
- Magyar Tudományos Akadémia KFKI Atomenergia Kutatóintézet (AEKI), HU
- Forschungszentrum Jülich GmbH (Jülich), DE
- Centrum výzkumu Řež s.r.o. (RC-Rez), CZ
- National Nuclear Laboratory Ltd (NNLL), UK
- VUJE a.s. (VUJE), SK
- The Nuclear Research Institute Rez (UJV), CZ
- Slovak University of Technology in Bratislava (STUBA), SK

# HARMONICS

The overall objective of the HARMONICS project is to ensure that the nuclear industry has well-founded and up-to-date methods and data for assessing software of computer-based safety systems. It will take advantage of the advances in the field to propose systematic and consistent, yet realistic and practical approaches for software verification, software safety justification and quantification of software failure rates.

## Harmonised assessment of reliability of modern nuclear I&C software

### Scope of the project

The ongoing nuclear renaissance means new nuclear power units are being constructed and the lifetime extension of existing units is being upgraded. The reliability and safety of computer-based systems that implement safety functions is a critical issue, in particular due to the fact that it is difficult to prove that software is completely defect-free.

Differences in current safety justification principles and methods between the EU and China hinder the emergence of widely accepted best practices. They also prevent cost sharing and unnecessarily increase licensing uncertainties. The objective of the HARMONICS project is to ensure that the nuclear industry has well-founded and up-to-date methods and data for assessing safety system software in Generation II and Generation III nuclear power plants.

The project consortium will work in close cooperation with sister Chinese project 'Reliability And verification of nuclear safety I&C systems' (RAVONSICS), and will take into consideration the different views, practices, and requirements of the participating countries. Also, in addition to the core project team, a larger end-user group will be formed with other interested stakeholders (utilities companies, regulatory bodies, and suppliers) to review and give feedback on the project work. Thus, the project should foster an international consensus based on a sound scientific and technical approach, and provide a good basis for harmonisation.

### A structured project plan

The project stages are as follows: the clarification of needs, practices and experiences in the EU and China; the development of common approaches to the assessment and justification of the reliability of safety-critical software making use of experience from recent licensing processes and research projects; testing the approaches in case studies; and assessing the results from the case studies. At the end of the project, the results will be disseminated through end-user workshops.

As part of the project, the term 'software' is interpreted in a broad sense, to include not only 'classical' software (to be executed in a microprocessor), but also hardware description language (HDL) designs, usually for field programmable gate arrays (FPGAs), and digital systems architectures.

### Coordinator

**Jan-Erik Holmberg**

VTT Technical Research Centre of Finland  
PO Box 1000  
FI-02044 VTT  
Finland  
Tel. +358 207226450  
[jan-erik.holmberg@vtt.fi](mailto:jan-erik.holmberg@vtt.fi)

### Project details

**Project type** // Collaborative project  
**Project start date** // 12.1.2011  
**Duration** // 48 months  
**Total budget** // EUR 1 577 237  
**EC contribution** // EUR 999 458

### EC project officer

**Georges Van Goethem**

European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/47  
B-1049 Brussels, Belgium  
[georges.van-goethem@ec.europa.eu](mailto:georges.van-goethem@ec.europa.eu)

## Activities

The project will first of all deal with technical and scientific issues. Current state-of-the-play and needs regarding software verification will be established, as well as safety justifications and quantifications of failure rates. Then the development of software verification methods and the evaluation of justification frameworks for software-based systems tools will begin. Project partners will also work on the development of approaches to the quantification of software failure rates (i.e. the part of system failure rates that is directly related to software).

Regarding software verification, the main objective is to provide direct evidence of software correctness. Three main verification approaches are to be investigated: formal verification, statistical testing, and logic coverage testing. Formal verification will address different types of safety properties, such as:

- functional properties (i.e. ability to meet functional and timing requirements);
- integrity properties (i.e. freedom from certain types of faults, in particular intrinsic faults detectable without knowledge of functional and timing requirements);
- structural properties (i.e. properties related to claimed design measures, in particular for fault tolerance, defence against common-cause failure or failure rate quantification);
- equivalence properties (in order to verify that translation tools such as compilers, synthesisers or place and route tools have not introduced discrepancies with the source code).

Regarding justification frameworks, HARMONICS will build upon the groundwork of the Fifth Framework Programme (FP5) project 'Cost effective modernisation of systems important to safety' (CEMSIS). A first objective will be to investigate different approaches to justify Category A systems and software, in particular goal-based, rule-based, and risk-informed approaches, in order to identify their strengths and weaknesses, their applicability domains, and how they can complement one another. A second objective will be to determine how different types of evidence (such as formal verification, dynamic and static analysis, operational experience, statistical testing, development processes, and quality controls) can be combined to justify a claim.

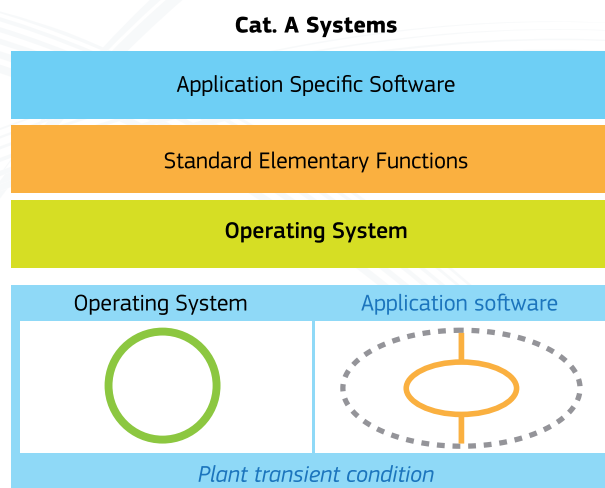
For quantification, one of the approaches to be investigated is based on the identification of failure mechanisms and the evaluation of the effectiveness of the defences provided, either as design measures or as verification measures. Other approaches are also to be considered, such as fault model-

ling (estimating the number of residual faults), estimating components reliability, and overall architecture effects.

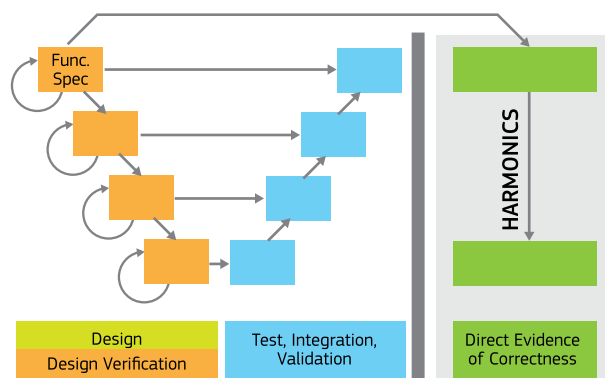
Work on case studies will complement work in methods development. Regarding verification methods, different types of case studies will be needed to cover the different types of software that can be found in systems implementing Category A functions (platform software, application software, and possibly HDL designs). Each type of software may be the object of specific verification methods. For failure rates in quantification and justification frameworks, system-level case studies will be used.

## Important public events

A Public Case Study will be developed to present the HARMONICS methods to the widest audience possible.



Harmonics scope © Harmonics consortium



## Partners

- Commissariat à l'énergie atomique et aux énergies alternatives (CEA), FR
- VTT Technical Research Centre of Finland (VTT), FI
- Électricité de France (EDF), FR
- Institute for Safety Technology (ISTec), DE
- Adelard LLP (ALLP), GB
- Strålsäkerhetsmyndigheten (SSM), SE

## HeLiMnet

HeLiMnet aims to integrate and harmonise research and development (R&D) efforts in the heavy liquid metal (HLM) technologies for nuclear applications field, both within Europe and beyond. Thirteen institutions from all over Europe will participate in the project with a view to creating a functional network to support the implementation of the Sustainable Nuclear Energy Technology Platform's (SNETP) Strategic Research Agenda (SRA).

## Heavy Liquid Metal Network

### Nature and scope of the project

The HeLiMnet project aims to create and build a large network for the diffusion of information on the use of nuclear applications of HLMs. It aims to rationalise knowledge through the development of guidelines, protocols and standards. The overarching goal is the appraisal of the liquid metal technology research area through the analysis of approaches and activities going on at both the national and international levels in different areas. The project will also identify possible cooperation opportunities and define existing gaps and possible future R&D activities to close these gaps. The project consortium is made up of partners from a plethora of research institutions with varying specialist expertise and know-how.

The SRA takes involves:

- i) innovations for a new generation of Sodium Fast Reactor (SFR);
- ii) selection of an alternative fast reactor type between 2010 and 2012;
- iii) assessment of Accelerator Driven Systems (ADS) as dedicated facilities for transmutation on an industrial scale and the merits of an experimental ADS by 2020.

The realisation of an industrial plant Lead-cooled Fast Reactor (LFR) prototype by 2030 is a potential outcome of the SNETP. The implementation of a LFR needs a strong R&D effort that includes:

- system design and component development;
- materials qualification and lead technology development;
- innovative fuels and fuel cycle.

### Activities

Given the possible future extensive use of lead and lead alloys in nuclear systems, a rationalisation of the results obtained so far is essential for helping researchers better understand its physical properties and engineering applications. Actors at the national level as well as within the European Commission have already dedicated considerable efforts to the development of HLM technologies. In this context, specific efforts dedicated to the rationalisation of the research area can have a positive impact.

The project is centred on the following specific actions:

- knowledge and results dissemination through the use of both advanced information technologies and traditional tools such as workshops and seminars, etc.;
- identification of operational procedures with the aim of optimising the use of experimental facilities and improving data reliability;
- cooperation with LFR and Accelerator-Driven System (ADS) design teams to identify R&D priorities;

### Coordinator

**Enrica Ricci**

Institute for Energetics and Interphases -  
IENI CNR  
Via de Marini, 6,  
16149 Genoa, Italy  
Tel. +39 0106475720  
Fax +39 0106475700  
[e.ricci@ge.ieni.cnr.it](mailto:e.ricci@ge.ieni.cnr.it)

### Project details

**Project type** // Coordination Action  
**Project start date** // 20.1.2010  
**Duration** // 24 months  
**Total budget** // EUR 718348.00  
**EC contribution** // EUR 499984.00

### EC project officer

**Mykola Džubinský**

Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/58  
B-1049 Brussels, Belgium  
[mykola.dzubinsky@ec.europa.eu](mailto:mykola.dzubinsky@ec.europa.eu)





- survey of ongoing HLM technologies activities worldwide and in different areas to maximise knowledge transfer and possible harmonisation of experimental and numerical approaches.

Conceptual designs of three different ADS machines have been developed and these results have been used to define the advanced design of MYRRHA/XT-ADS, an Experimental Transmutation Accelerator Driven System. R&D efforts have been identified, such as system and plant design, material qualification and fuel development and qualification.

### Expected results

The HeLiMnet project is expected to support the implementation of the SRA, and obtain three specific results:

- implementation of a large and effective network for the diffusion of information on HLM technologies, thanks to the realisation of an interactive website and the creation of strong links among laboratories;
- rationalisation of the existing knowledge, thanks to the development of guidelines and recommendations for good procedures;
- harmonisation of the European Research Area (ERA) in the HLM technologies field, thanks to the identification of gaps and efforts to avoid duplication of activities.

### Societal impact

The project outcomes are expected to impact beneficially on the ERA, promoting the integration of existing European infrastructures and developing synergies and complementarities among laboratories and research groups. This is coupled with collaboration with other existing national and international programmes and exploiting possible shared approaches between different liquid metal systems.

### Information about important public events

Two thematic workshops have taken place as part of the project: the 'HeLiMnet/ DEMETRA International Workshop on Development and Assessment of Structural Materials and Heavy Liquid Metal Technologies for Transmutation Systems' held in Berlin in March 2010, and the 'International Workshop on Liquid Metal Fast Reactor: respective issues and synergies' held in Aix-en-Provence in October 2011.

### Partners

- Consiglio Nazionale delle Ricerche (CNR), IT
- Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas (CIEMAT), ES
- Ustav Jaderného výzkumu Řež a.s. (UJV), CZ
- Ente per le Nuove tecnologie l'Energia e l'Ambiente (ENEA), IT
- Forschungszentrum Karlsruhe GmbH (KIT-G), DE
- Studiecentrum voor Kernenergie – Centre d'Etude de l'énergie Nucléaire (SCK-CEN), BE
- Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), FR
- SINTEC s.r.l. (SINTEC), IT
- Paul Scherrer Institute (PSI), CH
- Forschungszentrum Dresden-Rossendorf e.V. (FZD), DE
- Institute of Physics, University of Latvia (IPUL), LV
- Institut Químic de Sarrià (IQS), ES
- Kungliga Tekniska Högskolan (KTH), SE

## HPMC

Nuclear reactor calculations have improved enormously in recent years; however they remain based on a number of approximations. For neutronic calculations the Monte Carlo method is the only one that avoids approximations.

The HPMC project will combine this method with thermal-hydraulics and burn-up calculations for reactor safety analysis.

## High-Performance Monte Carlo reactor core analysis

### Making the Monte Carlo method safe

The overall objective of the project is to realise Monte Carlo safety-related nuclear reactor full-core analysis while taking into account the time dependence, thermal-hydraulic feedback and burn-up of the system. Such an analysis is impossible today and its achievement will open up unprecedented possibilities for verification of standard reactor safety analysis calculations.

### Activities

Current reactor safety analysis calculations use a number of approximations with respect to the representation of the reactor geometry, neutron transport treatment and nuclear data for neutron interactions, in order to be able to predict the power distribution in a reactor. The Monte Carlo technique can avoid using these approximations, but it generally takes a long time to compute. To provide tools for full-size reactor core safety calculations, the project researchers will integrate thermal-hydraulic feedback, fuel burn-up and time dependence on the seconds and minutes scales. At the same time, the Monte Carlo calculations will be optimised so they can run on parallel supercomputers.

### Expected results

The project will come up with Monte Carlo computer codes tailored to reactor core calculations and highly optimised to run on massively parallel supercomputers. The codes will be capable of performing burn-up calculations for all fuel pins, subdivided in axial volumes.

Using a flexible and efficient coupling scheme, the Monte Carlo calculations can be coupled with thermal-hydraulics codes to take into account the feedback effect of temperatures and coolant densities for all coolant channels in the reactor. The target is to perform a static reactor calculation for a full-size reactor core with all details of fuel assemblies and fuel pins (about 70 000 in a large core) and control rods with acceptable statistical uncertainty of the local power density per axial fuel volume (about 1 to 5%) in an acceptable execution time (24 hours) on a supercomputer.

Dynamic calculations with feedback can be performed to analyse effects of reactivity insertion due to control rod movements or for loss-of-coolant accidents (LOCAs). As the Monte Carlo method is not restricted to specific reactor types, the resulting code combinations can also be applied to new reactor designs.

### Coordinator

**Victor Sanchez**

Karlsruhe Institute of Technology (KIT)  
Hermann-von-Helmholtz-Platz 1  
D-76344 Eggenstein-Leopoldshafen,  
Germany  
Tel. +49 72160822283  
Fax +49 72160823718  
[victor.sanchez@kit.edu](mailto:victor.sanchez@kit.edu)

### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.10.2011  
**Duration** // 36 months  
**Total budget** // EUR 880 611  
**EC contribution** // EUR 550 906

### EC project officer

**Michel Hugon**

European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/52  
B-1049 Brussels, Belgium  
[michel.hugon@ec.europa.eu](mailto:michel.hugon@ec.europa.eu)

## Societal impact

The integration and optimisation of computer codes that will be produced by the project will primarily be used for verification of standard (deterministic) reactor safety analysis methods. This will lead to more reliable safety analysis calculations and hence to the improved safety of nuclear reactors.

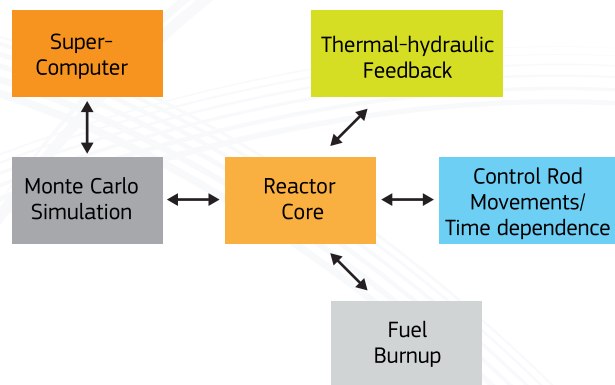
Target groups for the project are reactor designers, reactor operators, technical support organisations (TSOs), nuclear research organisations and university research groups. They will be able to validate their computing methods and codes using less manpower and effort. Thus, using the Monte Carlo method to validate computer codes can save considerable time and money, meaning these resources are freed up for use on more expensive and tricky experiments.

This will be even more important for new reactor designs like the Generation (GEN) IV reactor types, for which no or only limited experimental test facilities are available. Using the combination of computer codes developed in the current project will make the European nuclear industry and research organisations more competitive in current and future reactor design and operation.

## Information about important public events

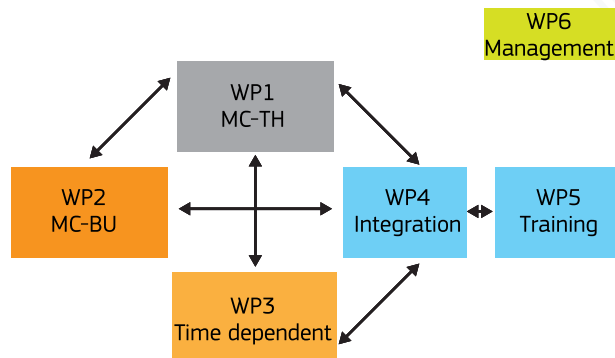
Hands-on training sessions will be organised for users interested in the developed computer software.

Scientific results of the project will be presented at conferences like the International Conference on Supercomputing in Nuclear Applications & Monte Carlo (SNA+MC), the International Conference on Mathematics and Computational Methods Applied to Nuclear Science and Engineering (M&C), as well as in international scientific journal articles.



*Ingredients of the Monte Carlo based reactor safety analysis.*

© DNC



*HPMC project structure in work packages (WP).*

© DNC

## Partners

- Karlsruher Institut Für Technologie (KIT), DE
- Delft Nuclear Consultancy (DNC), NL
- Technical Research Centre of Finland (VTT), FI
- Kungliga Tekniska Högskolan (KTH), SE

## JASMIN

This project will support the ESNII (European Sustainable Nuclear Industrial Initiative) roadmap and the Strategic Research Agenda and the Deployment Strategy of SNETP (Sustainable Nuclear Energy Technology Platform) on the enhancement of Sodium-cooled Fast neutron Reactors (SFR) safety, with a focus on achieving higher resistance from severe accidents.

## Joint Advanced Severe accidents Modelling and Integration for Na-cooled fast neutron reactors

### Making accidents safer

This project will support the ESNII (European Sustainable Nuclear Industrial Initiative) roadmap and the Strategic Research Agenda and the Deployment Strategy of SNETP (Sustainable Nuclear Energy Technology Platform) on the enhancement of Sodium-cooled Fast neutron Reactors (SFR) safety, with a focus on achieving higher resistance from severe accidents.

In the initial phase of a SFR core disruptive accident, it is essential to investigate the impact of new core designs that may disperse core debris and minimise the risk of core compaction. As the available codes used today were developed in the 1980's the objective of JASMIN is to develop a new European simulation code, ASTEC-Na, with improved physical models, accounting for results of recent LWR research, with modern software architecture and high flexibility to account for innovative reactor designs. It will be based on some modules of the ASTEC European code system, developed by IRSN and GRS for severe accidents in water-cooled reactors. This will allow for capitalising on state-of-the-art knowledge on SFR severe accidents.

The code will evaluate the consequences of fuel pin failure conditions on materials relocation and primary system loads, and the source term produced by migration inside the reactor of activated fission products and aerosols that may be released into the environment.

### Activities

The project, which lasts for 4 years, brings together partners with sound experience in SFR safety and/or in ASTEC code. Specific SFR physical models will be developed, on the basis of results from the Seventh Framework Programme (FP7) project CP-ESFR ('Collaborative project on European sodium fast reactor'). After the elaboration of general specifications and of a validation matrix, the models will be developed, implemented into the code, validated vs. experiments (like past CABRI ones) and benchmarked with other codes. The further extension of ASTEC-Na to cover other parts of SFR severe accidents (transition phase, fires) and to LFR will be investigated.

### Coordinator

**Jean-Pierre Van Dorsselaere**

IRSN

Direction de la prévention des accidents majeurs

BP3

FR-13115 Saint-Paul-lez-Durance Cedex

Tel. + 33 4 42 19 97 09

Fax + 33 4 42 19 91 56

[jean-pierre.van-dorsselaere@irsn.fr](mailto:jean-pierre.van-dorsselaere@irsn.fr)

### Project details

**Project type** // Collaborative Project

**Project start date** // 1.12.2011

**Duration** // 48 months

**Total budget** // EUR 5 650 534

**EC contribution** // EUR 2 991 182

### EC project officer

**Roger Garbil**

European Commission

Directorate-General for Research and Innovation

Directorate Energy

Unit K.4 – Fission

CDMA 1/70

B-1049 Brussels, Belgium

[roger.garbil@ec.europa.eu](mailto:roger.garbil@ec.europa.eu)



An Education programme will include workshops as well as the secondment of young researchers in other organizations.

Specifically, ASTEC will cover four types of activities:

- Scientific management of the code, i.e. implementation of models in the ASTEC code through Fortran 95 programming, overall verification of the integration of the different models: this task will be exclusively performed by the ASTEC code developers, IRSN and GRS;
- Elaboration and review of general specifications of the code and of the validation matrix;
- Elaboration and review of detailed specifications of the new models, sharing of knowledge on existing physical models, validation of the code vs. available experiments, and benchmarking by comparison with existing codes
- Dissemination of knowledge and training of young researchers or students.

Four main domains of associated physical phenomena can be defined: sodium thermal-hydraulics, pin thermo-mechanical behaviour (before and after rupture), source term (i.e. behaviour of fission products after their release from fuel) and neutronics. The detailed modelling work for each of these domains will be organised in four problem-driven sub-WPs. For the sake of simplicity, the containment phenomena will be addressed in the same sub-WP as the evaluation of the source term.

## Expected results

The project will result in a European validated reference code for simulation of SFR severe accidents. It will also allow for the carrying out of investigations into new SFR core designs with favourable inherent and passive safety features in the initial phase of such severe accidents. It will support ESNII in maintaining its leading European role in nuclear technology by developing a computation tool needed for the indispensable safety assessments of the SFRs, as like in many other fields the reference codes were initially developed in the United States.

Links with possible end-users of the code, such as European organisations/institutes currently involved in SFR safety studies, will be developed. In addition, during the project, investigations into the possibility of extending the ASTEC platform to another Gen IV nuclear system such as LFR (Lead Fast Reactors) will be done. Another project's result will be a database of the most relevant experiments on SFR se-

vere accidents. Beyond Europe, the project will be support the EURATOM contribution to the Generation IV International Forum (GIF) by sharing some Deliverable reports which will help to further stimulate exchanges of knowledge and information between international partners, in particular Japan, Korea, and China.

## Societal impact

As the end-products developed by the project may be used not only for R&D activities but also for industrial applications, they will contribute to better prevention and mitigation of severe accidents in future SFRs, and thus to the improvement of their safety. European end-users are currently mostly using integral computer codes developed in the United States, which results in a strong dependence on US technology. By fostering collaborative work on the ASTEC code, the role of Europe as a world leader in this domain will be consolidated.

Through education and training programmes, JASMIN will develop synergies with educational institutions, thus maintaining the attractiveness of the relevant domain of activity for students and young researchers. This will also contribute to enhancing and preserving European scientific leadership in a sustainable way.

## Information about important public events

The dissemination of the results will take place through:

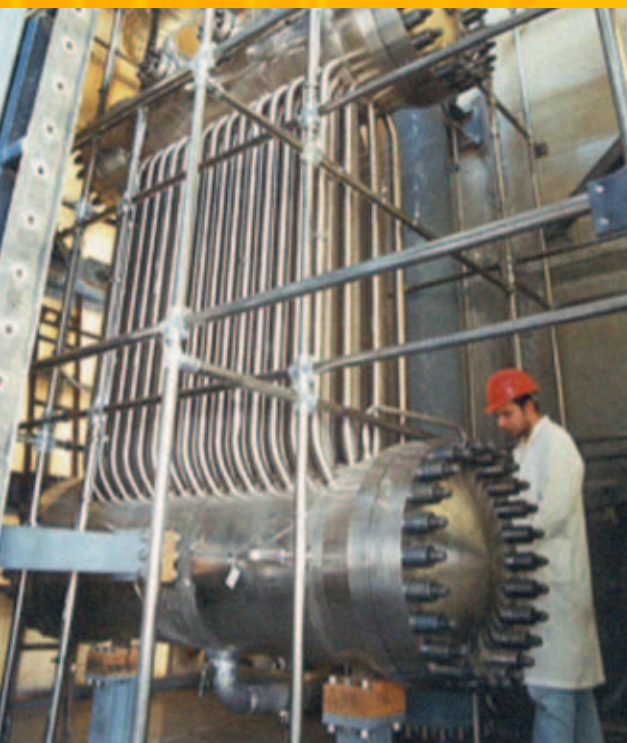
- Periodic workshops: the last workshop which will be organised at the end of the project will be open to external organisations, including the LFR community, in order to present the main features of the code ASTEC-Na and to discuss possible future exchanges of information or collaboration.
- Education and training programme: a specific programme of PhDs will be defined, including their participation in the periodic workshops and their secondment in the laboratories or offices of the project partners (priority given towards code developing organisations) for training.
- Publications in scientific journals and participation in international conferences like ICAPP or ICONE.
- The public web site will present up-to-date information to all people interested in the subject of SFR severe accidents.

## Partners

- Institut de Radioprotection et de Sûreté Nucléaire (IRSN), FR
- Karlsruher Institut für Technologie (KIT), DE
- Gesellschaft für Anlagen- und Reaktorsicherheit mbH (GRS), DE
- Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (ENEA), IT
- Centro de Investigaciones Energeticas Medio Ambientales y Tecnologicas (CIEMAT), ES
- Universität Stuttgart (USTUTT), DE
- Joint Research Centre – European Commission (JRC), BE
- AREVA NP SAS (AREVA NP SAS), FR
- Electricité de France SA (EDF), FR

## LEADER

The LEADER project aims to develop the concept of a lead-cooled fast reactor (LFR) industrial size plant and of a scaled demonstrator of the LFR technology. Innovative yet simple ready-to-build technological solutions will help accelerate progress already made in Europe over the last decade. The project partners are committed to the conceptual design of a scaled/ demonstrator plant for construction in the relatively short term. Once LEADER is complete, a detailed design phase can begin.



## Lead-cooled European Advanced Demonstration Reactor

### Working together

The consortium is made up of partners from industry, the European Commission's Joint Research Centre (JRC), various research and development (R&D) organisations and academia. Whilst the industry partners are responsible for system integration and component design, the R&D organisations are responsible for core design, safety assessment and technological development. The university partners involved play a supporting role on several aspects like safety analysis, core design, mechanical and thermal verifications, their activity is strongly focused on Education & Training.

### Building on previous research

Most of the partners had been involved in the Sixth Framework Programme (FP6) project 'European lead-cooled system' (ELSY) — the results of which form the basis of the LEADER project — as well as other ongoing EU projects related to Generation IV (Gen IV) reactors. The project acknowledges the conclusions that emerged from the European Strategic Research Agenda as well as the main goals of the European Industrial Initiative on Fission and the EU's Sustainable Nuclear Energy Technology Platform (SNETP).

### Activities

Innovative Gen IV fast-reactor systems with a closed fuel cycle will bring about great improvements in sustainability. They produce up to 100 times more electricity than current reactors from the same amount of uranium, thus enabling natural resources to last thousands of years.. In addition, with advanced fuel cycles and the partitioning and transmutation (i.e. recycling) of minor actinides and long-lived fission products, they will produce significantly less waste for disposal (in terms of volume, thermal load and radioactive inventory), thereby further reducing environmental impact and optimising geological disposal.

The LFR system was considered a promising technology in the Gen IV Technology Roadmap, particularly in terms of sustainability, actinide management, economics for electricity production as well as in terms of Safety characteristics of the installation.

*Installation of the isolation condenser at SIET Labs in Italy.*

*© courtesy of SIET and ENEA*

### Coordinator

**Alessandro Alemberti**

Ansaldo Nucleare S.p.A.

Corso Perrone, 25

16152 Genova, Italy

Tel. +39 0106558473

Fax +39 0106558400

[alessandro.alemberti@ann.ansaldo.it](mailto:alessandro.alemberti@ann.ansaldo.it)

### Project details

**Project type** // Collaborative project

**Project start date** // 02/04/2010

**Duration** // 36 months

**Total budget** // EUR 5 688 186

**EC contribution** // EUR 2994 088

### EC project officer

**Mykola Džubinský**

European Commission

Directorate-General for Research and Innovation

Directorate Energy

Unit K.4 – Fission

CDMA 01/58

B-1049 Brussels, Belgium

[mykola.dzubinsky@ec.europa.eu](mailto:mykola.dzubinsky@ec.europa.eu)

Another key element of the project is the emphasis on educating and training the next generation of nuclear energy designers. Students on PhD and Masters courses are trained in the science and technology that surrounds the design and development of Gen IV LFRs. To ensure that project results are available for use, they are published in international journals and on the LEADER website. They are also presented at international conferences and workshops. Registering European patents is also an important part of this process.

A specific task is devoted to scientific exchange and comparison with a parallel complementary research project on the development of a LFR financed by the Russian State Atomic Energy Corporation (ROSATOM).

## Expected results

The LEADER project builds on the ELSY project results by analysing problems identified with the previous reactor configuration. The focus of the first part of the project will be on resolving key issues to reach a new consistent reactor configuration.

With this new reactor configuration of an industrial size LFR, the ELFR (European Lead Fast Reactor), a low-cost and fully representative scaled down demonstrator of a suitable size, ALFRED (Advanced Lead Fast Reactor European Demonstrator) will be designed.

ALFRED activities as part of the LEADER project are based on the following pillars:

- the definition of the main suitable characteristic and design guidelines for the Demonstrator;
- ALFRED thermal rating has been sized to 300 MWth, will be connected to the electrical grid and the expected thermal cycle efficiency is above 40%.
- ALFRED design is based on components/technologies already available in the short term, so as to be able to proceed in the near future to a detailed design followed by the construction phase;
- evaluate safety aspects and perform a preliminary safety analysis;
- minimise the cost of the demonstrator.

Most importantly, the demonstrator will confirm whether or not the newly developed and adopted materials (both structural materials and innovative fuel materials) are able to sustain high fast neutron fluxes and high temperatures.

## Societal impact

Electricity generated from nuclear power plants currently makes an important contribution to the overall amount of electricity that is generated in Europe and the wider world, and it continues to be a viable option for future energy production. The main issue surrounding its widespread implementation is that it needs to be at once competitive, reliable, sustainable and safe. It is also imperative that the public have a positive opinion of nuclear power, helped by the absence of production of long-lived waste, at least in its final industrial implementation.

Modern water-cooled reactors are competitive and safe, but their energy generation is far from sustainable. This is due to ineffective use of fuel, the production of long-lived highly radioactive waste and the high operating pressure, which make high levels of safety harder to achieve.

The LEADER project will put the emphasis back on sustainability and safety of the nuclear installation; public confidence in nuclear power depends to a large extent on the ability of scientists to demonstrate that it is an unlimited energy resource that poses no waste management problems. If LEADER confirms LFR as a reactor able to substantially reduce the long-term burden of geological disposal and increase the extent of present uranium resources, it will raise public confidence and drive nuclear power to be accepted as an essential component in the EU's energy mix.

## Information about important public events

So far two conferences have been held: 'ELSY - The European lead fast reactor: International Conference on Fast Reactors and Related Fuel Cycles' in Kyoto, Japan; and 'From ELSY to LEADER - European LFR activities' in Barcelona, Spain.

An International workshop on Heavy Liquid Metals (HLM) took place in Pisa, Italy, on 17-20 April 2012.

## Partners

- Ansaldo Nucleare S.p.A. (ANSALDO), IT
- Akademia Górniczo-Hutnicza (AGH), PL
- Commissariat à l'énergie atomique et aux énergies alternatives (CEA) FR
- Consorzio Interuniversitario Nazionale per la Ricerca Tecnologica Nucleare (CIRTEN), IT
- Empresarios Agrupados (EA), ES
- Agenzia nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Industriale (ENEA), IT
- Karlsruhe Institute of Technology (KIT-G), DE

- Institute for Nuclear Research (INR), RO
- Joint Research Centre of the European Commission (JRC), EC
- Royal Institute of Technology-Stockholm (KTH), SE
- Nuclear Research and Consultancy Group (NRG), NL
- Paul Scherrer Institut (PSI), CH
- Studiecentrum voor Kernenergie/Centre d'étude de l'Energie Nucléaire (SCK), CEN BE

- Servizi di Ricerche e Sviluppo (SRS), IT
- Ústav Jaderného Vyzkumu Rez, a.s. (Nuclear Research Institute Rez, plc.) (UJV), CZ
- Università di Bologna (UNIBO), IT



## LONGLIFE

The project aims at an improved understanding of irradiation effects in reactor pressure vessel (RPV) steels under conditions representative of long-term operation (LTO).

Phenomena which might become important at high neutron fluences (such as late-blooming effects and flux effects) must be considered in detail as part of the process of upgrading safety assessments and embrittlement surveillance procedures, to underwrite the safety of the LTO of RPVs.

## Treatment of long term irradiation embrittlement effects in RPV safety assessment

### Age management

Fast neutrons generated during nuclear fission interact with lattice atoms of materials used in the fabrication of nuclear power reactors. This interaction leads to irradiation-induced damage at the nanostructural level, with consequential detrimental changes in macroscopic mechanical properties, i.e. increases in yield strength and reductions in fracture toughness. Ultimately, these changes impact on the safe lifetime of critical structures, notably ferritic steels used to fabricate the RPVs. The increasing age of the fleet of European nuclear power plants and envisaged extensions of RPV lifetimes from nominal design lifetimes — from around 40 years to 80 years — require a reliable and efficient system of ageing management. The accurate prediction and management of RPV neutron irradiation embrittlement is a key component in this process.

### Activities

Project work starts with the collection and evaluation of plant-specific information and data such as target neutron fluences for LTO, prerequisites and RPV materials. By carrying out a survey of available results of RPV materials data from decommissioned plants, the 16-partner strong LONGLIFE team can validate surveillance data and study specific irradiation effects relevant for LTO.

Microstructural data from irradiated surveillance specimens of either representative or original RPV materials will be obtained with the aim of assessing the adequacy of current dose-damage models, with respect to their relevance to the mechanisms of irradiation damage associated with LTO of RPVs. Complementary mechanical tests will be performed in order to address gaps in existing experimental data.

### Impact and results

LONGLIFE will aim to improve knowledge of LTO phenomena that determine RPV safe lifetimes of European light water reactors (LWRs) by focusing on assessment of prediction tools, codes and standards applicable to the assessment of RPV integrity for LTO and development of surveillance guidelines for LTO of RPV base materials and welds.

#### Coordinator

**Eberhard Altstadt**

Helmholtz-Zentrum Dresden-Rossendorf  
Bautzner Landstrasse 400  
D-01328 Dresden, Germany  
Tel. +49 3512602276  
Fax +49 3512602205  
[e.altstadt@hzdr.de](mailto:e.altstadt@hzdr.de)

#### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.2.2010  
**Duration** // 36 months  
**Total budget** // EUR 5 222 397  
**EC contribution** // EUR 2 621 575

#### EC project officer

**Panagiotis Manolatos**

European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/53  
B-1049 Brussels, Belgium  
[panagiotis.manolatos@ec.europa.eu](mailto:panagiotis.manolatos@ec.europa.eu)



The overall aim is to help harmonise European procedures for RPV safety assessment and plant lifetime extension. The development of the proposed LTO guidelines will enhance efforts by European industry to use carbon-free nuclear energy to generate long-term electricity, in keeping with the highest possible standards of safety. This will contribute to increasing acceptance of nuclear energy within EU Member States and elsewhere, as well as contribute to worldwide efforts to reduce global warming.

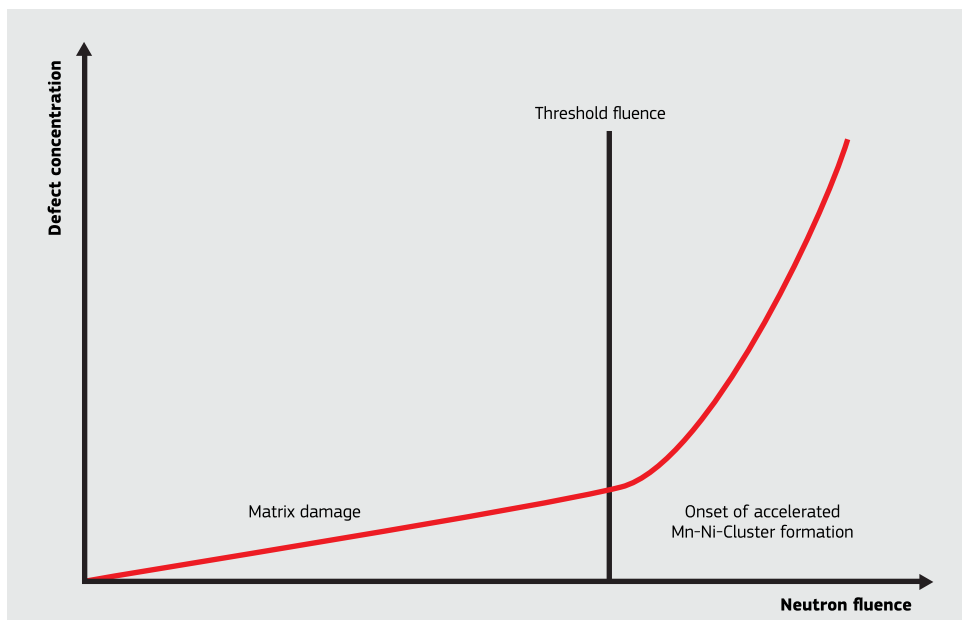


Figure 1: Illustration of the late blooming effect.

© Forschungszentrum  
Dresden-Rossendorf

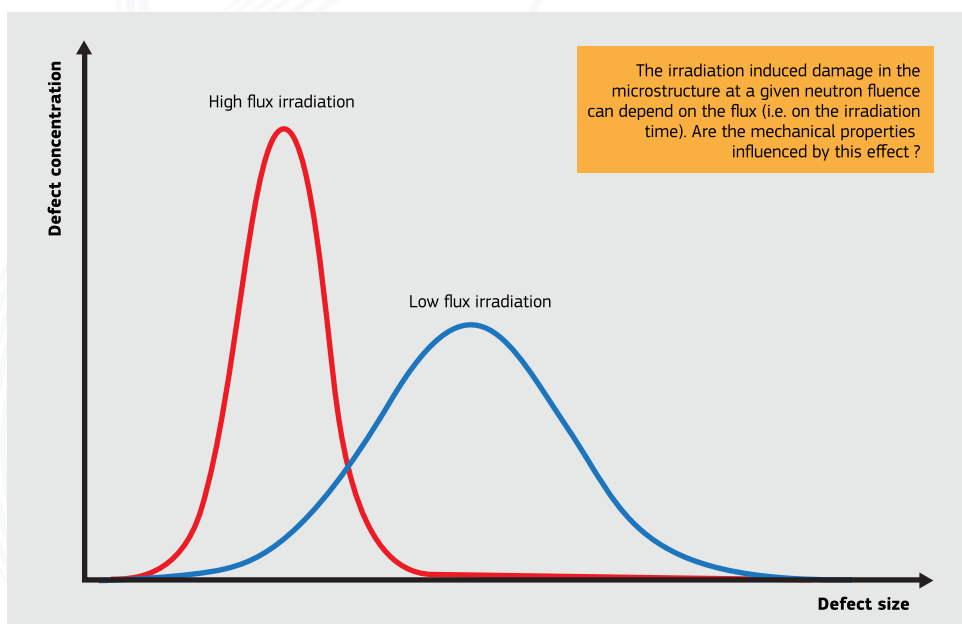


Figure 2: Illustration of the flux effect.

© Forschungszentrum  
Dresden-Rossendorf

## Partners

- Helmholtz-Zentrum Dresden-Rossendorf e. V. (HZDR), DE
- AREVA NP GmbH (ANP-G), DE
- Serco Ltd (SERCO), UK
- Magyar Tudományos Akadémia KFKI Atomenergia Kutatóintézet (AEKI), HU
- Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), ES
- Tecnatom s. a. (TECNATOM), ES

- Ústav jaderného výzkumu Řež a. s. (NRI), CZ
- Studiecentrum voor Kernenergie – Centre d'Etude de l'énergie Nucléaire (SCK-CEN), BE
- Valtion Teknillinen Tutkimuskeskus (VTT), FI
- Centre national de la recherche scientifique (CNRS), FR
- Commissariat à l'Énergie Atomique (CEA), FR
- Ringhals AB — Vattenfall (RAB), SE

- Rolls-Royce Power Engineering Plc (ROLLS-ROYCE), UK
- Electricité de France SA (EDF), FR
- University of Oxford (UOXFDJ), UK
- Commission of the European Communities Directorate General, Joint Research Centre (JRC), BE

## MAX

The MAX project was born out of the recommendations of the European Union's Strategic Energy Technology Plan for the development and deployment of sustainable nuclear fission technologies in Europe. MAX will participate in addressing the issue of high-level, long-lived radioactive waste transmutation by pursuing the development of the high-power proton accelerator as specified by the MYRRHA Accelerator-Driven System (ADS) demonstrator project in Belgium.

## MYRRHA Accelerator eXperiment, research and development programme

### Nature and scope of the project

MYRRHA ('Multi-purpose Hybrid Research Reactor for High-tech Applications') is a new flexible fast spectrum research reactor that is planned to be operational around 2023 at the SCK-CEN in Mol, Belgium. Made up of a proton accelerator, a spallation target and a 100 MW<sub>th</sub> core cooled by liquid lead-bismuth, it is especially designed to demonstrate the feasibility of the ADS concept in view of high-level waste transmutation.

To feed its sub-critical core with an external neutron source, the MYRRHA facility requires a powerful proton accelerator (600 MeV, 4 mA) operating in continuous mode, and above all featuring a very limited number of unforeseen beam interruptions. The MAX team, made up of accelerator and reliability experts from industries, universities and research organisations, has been set up to respond to these very specific two-fold specifications.

### Activities

The conceptual design of the ADS-type proton accelerator has been initiated during previous EURATOM Framework Programmes (PDS-XADS and EUROTRANS projects). It is a LINAC-based (LINear ACcelerator) solution that brings excellent electric efficiency thanks to the use of superconductivity and high potential for reliability by the use of several redundancy schemes.

The MAX team will pursue the research and development (R&D) on this ADS-type, specifically focusing on the MYRRHA case. Developments and experiments on accelerator test sections will be performed to increase the level of confidence in the fact that MYRRHA requirements will be fulfilled. On top of these activities, dedicated studies and simulations on general accelerator design and reliability issues will be carried out.

The MAX website will be used to disseminate all non-confidential results to the general public, and to publicise important events of general interest related to the project like workshops and seminars. Organisation of training seminars in schools, communicating results at international conferences and getting publications in peer-reviewed journals will be encouraged by the MAX Project Coordination Committee.

### Coordinator

**Jean-Luc Biarrotte**

Centre National de la Recherche Scientifique (CNRS)

Institut de Physique Nucléaire d'Orsay (UMR 8608)

15 rue Georges Clémenceau, Bat. 106  
91406 Orsay Cedex, France

Tel. +33 169157930

Fax +33 169157735

[biarrott@ipno.in2p3.fr](mailto:biarrott@ipno.in2p3.fr)

### Project details

**Project type** // Collaborative Project

**Project start date** // 1.2.2011

**Duration** // 36 months

**Total budget** // EUR 4 869 256

**EC contribution** // EUR 2 926 199

### EC project officer

**Roger Garbil**

European Commission

Directorate-General for Research and Innovation

Directorate Energy

Unit K.4 – Fission

CDMA 1/70

B-1049 Brussels, Belgium

[roger.garbil@ec.europa.eu](mailto:roger.garbil@ec.europa.eu)

## Expected results

The ADS conceptual scheme is shown in Figure 1. The main goal of the MAX project is to deliver a sufficiently detailed, updated and consolidated reference layout of the MYRRHA LINAC that leads to the start of its engineering design in 2015 and a subsequent construction phase.

To reach this goal, advanced beam simulation activities will be carried out as well as a detailed design of the major accelerating components, building on several prototype activities. A strong focus will be put on all the aspects that pertain to the reliability and availability of this accelerator, since the number of beam interruptions longer than three seconds has to be minimised. Such frequently-repeated beam interruptions could indeed induce high thermal stresses and fatigue on the reactor structures, the target or the fuel elements, with possible significant damages especially to the fuel claddings. In this context, the MAX team expects to develop an accurate reliability model of the MYRRHA accelerator by using the methodology applied for nuclear power plants. On the other hand it is planned to experimentally prove the feasibility of the innovative 'fault-tolerance' redundancy scheme by making extensive use of the prototypic accelerating module (see Figure 2) developed during the Sixth Framework Programme (FP6) project EUROTRANS ('European research Programme for the transmutation of high level nuclear waste in an accelerator driven system').

## Societal impact

By supporting the MYRRHA ADS demonstrator project, MAX addresses the need to find sustainable ways of managing high-level, long-lived radioactive waste.

Transmuting them into less toxic, shorter-lived elements would reduce the amount and heat load of radiotoxic material going into deep geological repositories and keep their lifespan at manageable timescales.

The demonstration of the ADS concept in MYRRHA will allow the EURATOM community to extrapolate to the design of an industrial waste burner and evaluate the viability of concentrated transmutation in a double-strata fuel-cycle approach. This extrapolation exercise will be especially valid for the accelerator since its concept remains identical whether it is for a demonstrator or at the industrial level.

Finally, the reliability and availability optimisation brought about by the MAX project should also impact substantially on all emerging and future accelerator projects featuring high-power proton beams.

Figure 2: ADS-type prototypic accelerating module during assembly at CNRS / IPN Orsay © CNRS-IN2P3/IPN Orsay

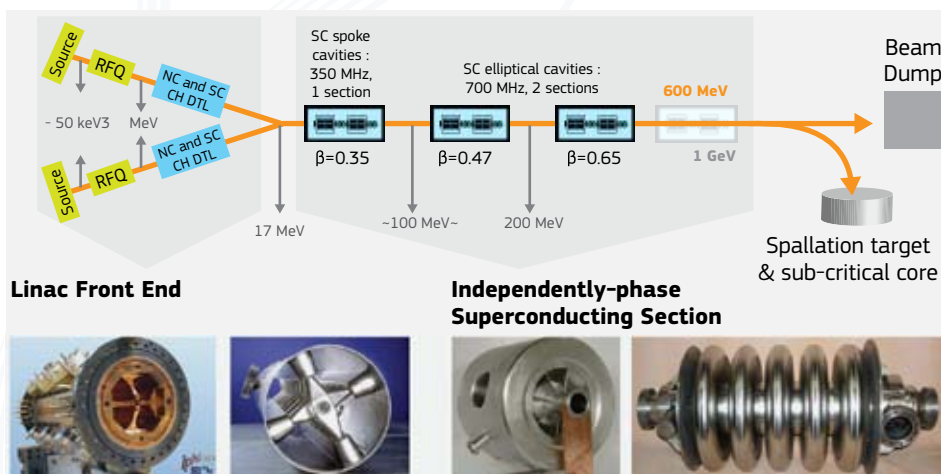


Figure 1: The ADS accelerator conceptual scheme  
© CNRS-IN2P3/IPN Orsay

## Partners

- Centre National de la Recherche Scientifique (CNRS), FR
- Accelerators and Cryogenic Systems (ACS), FR
- Adaptive Predictive Expert Control S.L. (ADEX), ES
- Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), FR
- Empresarios Agrupados Internacional S.A. (EA), ES
- Catholic University of Portugal – Faculty of Engineering (FE-UCP), PT
- Institute für Angewandte Physik (IAP), DE
- Istituto Nazionale di Fisica Nucleare (INFN), IT
- Katholieke Universiteit Leuven (KUL), BE
- Studiecentrum voor Kernenergie – Centre d'études de l'énergie nucléaire (SCK-CEN), BE
- Thales Electron Devices (TED), FR

# MULTIMETAL

In a nuclear power plant's (NPP) structural pressure, components made of different kinds of steel are joined together with dissimilar metal welds (DMWs). Despite extensive previous research carried out within EURATOM projects such as BIMET ('Structural Integrity of Bi-Metallic Components') and ADIMEW ('Assessment of Aged Piping Dissimilar Metal Weld Integrity'), further work is needed to quantify the structural performance of DMWs. MULTIMETAL aims to develop robust experimental methods for toughness measurements and defect assessments procedures in welded components. The project will validate the developed testing procedures through experimental and numerical benchmarks.

## Structural performance of multi-metal component

### An experienced consortium

The MULTIMETAL consortium is made up of 11 organisations from 9 EU Member States. The consortium represents research and engineering institutes, manufacturers, operators and industrial companies playing a long-term and active role in the field of nuclear technology. The project partners possess a plethora of expertise, staff and resources suited to the unique objectives of the project. The consortium is well balanced due to the participation of almost all EU countries involved in the nuclear energy research field. A number of PhD students and faculty members will also contribute to the project.

### Activities

In the project, relevant information will be gathered from field experience: typical locations of DMWs in Western as well as Eastern light water reactors (LWRs) will be identified and their characteristics considered, as well as applicable assessment methods. Micro-mechanical modelling of ductile failure processes will be used as an innovative technique to improve current numerical methods for structural integrity assessment of DMWs. The modelling will take account of ageing-related phenomena and realistic stress distributions in the weld area and support a comprehensive material test programme. A procedure for measuring fracture toughness in DMWs will also be developed.

Overall the project will serve to promote common understanding of structural integrity assessment of DMWs in existing and future NPPs of EU Member States. This will be the technical basis towards the development of harmonised European codes and standards for multi-metal components, which is currently not available.

Efficient management and transfer of knowledge to younger generations is one of the main objectives of the project and to this end a number of PhD students will contribute to the project. In addition, the development of a training seminar on experimental work and exchange of research workers will be developed and the provision of a summary book on the project will be realised.

### Expected results

MULTIMETAL will consolidate the results (see Figure) in the form of best practice guidelines for harmonisation of the procedure for fracture toughness assessment (testing and integrity) of DMWs. A reliable, pan-

#### Coordinator

**Päivi Karjalainen-Roikonen**  
Teknologian Tutkimuskeskus VTT  
Kemistintie 3  
Espoo  
02044 VTT  
Finland  
Phone +358207226844  
Fax +358207227002  
[paivi.karjalainen-roikonen@vtt.fi](mailto:paivi.karjalainen-roikonen@vtt.fi)

#### Project details

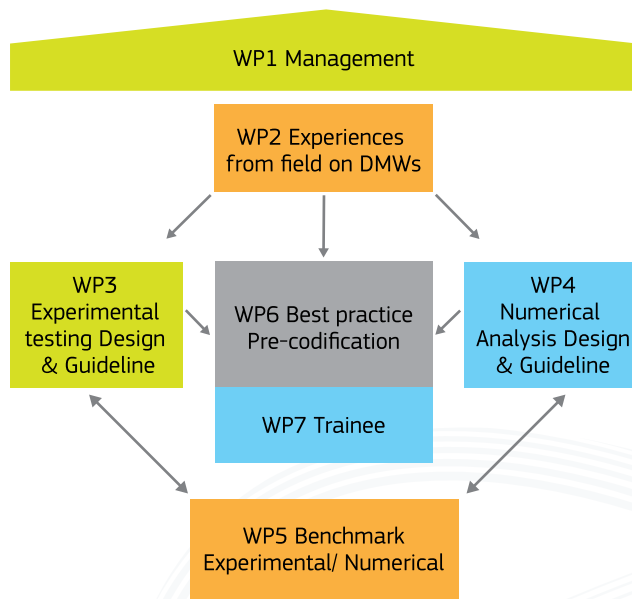
**Project type** // Collaborative Project  
**Project start date** // 1.1.2011  
**Duration** // 36 months  
**Total budget** // EUR 2 004 728  
**EC contribution** // EUR 1 171 470

#### EC project officer

**Mykola Džubinský**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/58  
B-1049 Brussels, Belgium  
[mykola.dzubinsky@ec.europa.eu](mailto:mykola.dzubinsky@ec.europa.eu)



European method for determination of fracture toughness for DMWs will be created, demonstrated and validated. Methods for assessment of residual stresses and structural integrity of the structures containing DMWs in NPP pressure components will be improved.



*MULTIMETAL / Expected output: harmonised procedures for fracture toughness testing and integrity assessment procedure for DMWs.*

## Societal impact

The expected impact of the work in MULTIMETAL is summarised as follows:

- development of a common understanding for structural integrity assessment of DMWs in existing and future NPPs in EU Member States;
- improvements to the design of fracture toughness test specimen;
- contribution to development of an overall strategy within the EU for the harmonisation of European codes;
- dissemination of best practice guidelines on the use of advanced fracture assessment tools for structural integrity assessment of DMWs;
- contribution to improvements to safety assessment of both existing and future NPPs in the EU;
- enhancement of the role of NULIFE in relation to end users and regulators.

## Information about important public events

The project results will be disseminated to the nuclear community in many ways. A website for sharing information throughout the project will be set up and the scientific project results will be made available to the nuclear community through publications in international journals and international conferences. The textbook with the final results of the project will be published and a training course will be organised. In addition, the main project results will be presented at the annual NULIFE network meeting.

## Partners

- Association pour la Recherche et le Développement des Méthodes et Processus Industriels (ARMINES), FR
- Karlsruher Institut Für Technologie (KIT), DE
- Forschungszentrum Jülich GmbH (FZJ), DE
- Svensk Kärnbränslehantering AB (SKB), SE
- AMPHOS 21 Consulting, S.L. (AMPHOS21) ES
- Chalmers University of Technology (CHALMERS), SE
- Stockholms Universitet (SU), SE
- Paul Scherrer Institute (PSI), CH
- Loughborough University (LU), UK
- Peking University (PKU), CN

## PELGRIMM

PELGRIMM contributes to the Sodium Fast Reactor fuel investigations that aim to reduce the actinide content in high level waste and consequently improve disposal requirements. The project hopes to improve proliferation resistance too. The project deals with Minor Actinide bearing oxide fuel developments within two current Minor Actinide transmutation options: homogeneous and heterogeneous recycling, as well as two kinds of fuel shapes: pellets and beads.

## PELlets versus GRanulates: Irradiation, Manufacturing & Modelling

### Nature and scope of the project

PELGRIMM brings together well-respected national and international groups to deploy and complete this challenging and innovative programme. The project consortium includes national as well as European nuclear research laboratories, universities and industry actors in order to significantly progress on fabrication, behaviour under irradiation, modelling and safety primary assessment of fuels related to the current Minor Actinide transmutation options considered feasible from a core physics point:

- the homogeneous recycling mode, where small quantities of Minor Actinides to be transmuted are diluted in the driver fuel (of mixed oxide type);
- and the heterogeneous recycling mode, where Minor Actinides to be transmuted are concentrated in  $\text{UO}_2$  support matrices, loaded in sub-assemblies located at the periphery of the core.

Moreover, synergies will be sought with other ongoing EU-funded Projects such as F-Bridge ('Basic Research for Innovative Fuel Design for GEN IV systems'), ACSEPT ('Actinide reCycling by SEparation and Transmutation'), CP-ESFR (Collaborative project on European sodium fast reactor) and FAIRFUELS ('Fabrication, irradiation and reprocessing of fuels and targets for transmutation'). The PELGRIMM project will contribute actively to EURATOM's contribution to the Generation IV International Forum. Activities carried as part of PELGRIMM will support the Nuclear Material Programme initiated within the European Energy Research Alliance (EERA).

### Activities

Presently, experimental knowledge on Minor Actinide bearing oxide fuels remains limited to laboratory-scale fabrication processes, small amounts of characterisation, and out-of-pile tests, as well as scarce irradiation experiments. Moreover, fuel pelletized forms have been preferred so far in all irradiation tests except in the SPHERE experiment performed as part of FAIRFUELS, where the spherepac form is under investigation too. Indeed, spherepac technology that leads to production of beads is attractive regarding Minor Actinide bearing fuels as it would significantly simplify the fabrication process thanks to the elimination of stages such as milling, pressing and grinding, that involve fuel powders (and dust). Moreover, the compactness of the fabrication process would be increased. Finally, the spherepac fuel performance under irradiation could provide significant advantages too, thanks to better accommodation of solid swelling (compared to pellets) through the re-arrangement of the free inter-particle

### Coordinator

**Fabienne Delage**  
Commissariat à l'Energie Atomique  
Centre de Cadarache  
DEN/CAD/DEC/SESC/LC2I  
Bt 315  
BP 01  
13108 St Paul les Durance Cedex  
France  
Tel. +33 442 256 182  
[fabienne.delage@cea.fr](mailto:fabienne.delage@cea.fr)

### Project details

**Project type** // Collaborative project  
**Project start date** // 1.1.2012  
**Duration** // 48 months  
**Total budget** // EUR 7 211 760  
**EC contribution** // EUR 2 999 999

### EC project officer

**Mykola Džubinský**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/58  
B-1049 Brussels, Belgium  
[mykola.dzubinsky@ec.europa.eu](mailto:mykola.dzubinsky@ec.europa.eu)

areas, and ultimately in better management of the helium generated during irradiation.

The PELGRIMM project partners will:

- make the most of the ground made in the MARIOS and SPHERE irradiation tests carried out as part of FAIRFUELS, providing the very first results respectively on the helium behaviour in (Am,U)O<sub>2</sub> fuels and a comparison between sphere-packed and pelletized (U,Pu,Am)O<sub>2</sub> fuel performances
- take the next step in the (Am,U)O<sub>2</sub> fuel qualification rationale by performing the semi-integral test MARINE in HFR
- extend Minor Actinide bearing fuel fabrication processes to alternative routes in order to limit secondary waste streams
- extend the capabilities of existing calculation codes of fuel behaviour under irradiation
- address a preliminary safety performance assessment of sphere-packed (U,Pu,Am)O<sub>2</sub> fuels in the core of a sodium fast reactor.

PELGRIMM also promotes involvement among European students and young researchers through trainee placements in organisations involved in the project, the development and delivery of training courses and workshops, and contributions to research actions of the project by researchers preparing a doctoral thesis or employed at a post-doctoral position.

## Expected results

Results are expected from a wide range of investigation set to be carried out:

- minor Actinide fuel fabrication process developments as well as fuel property measurements
- an irradiation test of MA-bearing fuels: the MARINE experiment, and Post Irradiation Examinations of already irradiated fuels in the MARIOS and SPHERE tests
- Irradiation behaviour modelling and predictive code developments

Moreover, since implementing Minor Actinide-bearing fuels stacked as spherepacs (i.e. beads of several grain sizes) in pins into a SFR core has not yet been tackled, a preliminary assessment of safety performance is included into the project.

## Societal impact

By developing a new generation of fuels for fast reactor systems, PELGRIMM will:

- reduce the actinide content in high level waste,
- develop low carbon technology,
- optimise natural uranium resources.

Finally, the project is a chance to develop a shared research-application vision, enhanced by both skilled researchers and young researchers and students.



Neutronradiography results on one capsule after the MARIOS irradiation in HFR. © NRG



Fabrication of Am-bearing fuel beads by the Weak Acid Resin technology. © CEA

## Partners

- Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), FR
- AREVA (AREVA), FR
- Electricité De France (EDF), FR
- Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (ENEA), IT
- European Nuclear Education Network Association (ENEN), FR
- Commission of the European Communities
  - Joint Research Center (EC-JRC), EU
- Karlsruhe Institute of Technology (KIT), DE
- Kungliga Tekniska Högskolan (KTH), SE
- LaGrange SARL (LGI), FR
- Nuclear Research and consultancy Group (NRG), NL
- Paul Scherrer Institute (PSI), CH
- Studie Centrum voor Kernenergie
- Centre d'Etude de l'énergie Nucléaire (SCK-CEN), BE

## SARGEN\_IV

The deployment of sustainable nuclear technology is likely to play a key role in future European energy policy considering the European Commission's targets to transform the current energy system based on fossil fuels into a more sustainable one based on a mix of low-carbon energy sources. As part of the Sustainable Nuclear Energy Technology Platform (SNETP) proposed by the EU to coordinate nuclear fission research and development (R&D) at the European level, the European Sustainable Nuclear Industrial Initiative (ESNII) was launched in 2010 to anticipate the development of a fleet of closed cycle fast reactors.

## Proposal for a harmonized European methodology for the safety assessment of innovative reactors with fast neutron spectrum planned to be built in Europe

### Building a proposal

The aim of SARGEN\_IV is to propose a European framework for the safety assessment of Generation (GEN) IV closed cycle reactors as part of the ESNII. To achieve this objective it will be necessary to bring together European designers, Technical Safety Organisations (TSOs), research organisations and utilities companies already involved (or soon to be involved) in innovative reactors, so they can consolidate their work and suggest a harmonised European state-of-art safety methodology representing the Euratom contribution to the Generation IV International Forum (GIF).

### Activities

The project starts with a review of major safety issues concerned with the development of GEN IV concepts: the Sodium-cooled Fast Reactor (SFR), the Lead-cooled Fast Reactor (LFR) and the Gas-cooled Fast Reactor (GFR) with a fast spectrum irradiation facility.

Secondly, information on the safety methodologies proposed by the International Atomic Energy Agency (IAEA), the GIF, the relevant European Seventh Framework Programme (FP7) project consortia and also on national practices has to be gathered including the methodology proposed by WENRA (Western European Nuclear Regulators' Association) for the European nuclear power plant (NPP) 'stress tests'. A harmonised safety methodology must be developed after analysis of these various methodologies.

Thirdly, a set of representative events of initiating will be used as a test of the harmonised safety methodology.

A major task is to identify the topics of future R&D in the safety field with an associated roadmap. This work will help to set out guidelines on the structure and content of the Safety Analysis Report (SAR) for innovative reactors.

### Coordinator

**Daniel Blanc**

Institut de Radioprotection et de Sûreté  
Nucléaire (IRSN)  
Systèmes, nouveaux réacteurs et démarches  
de sûreté  
Pôle Sûreté Nucléaire- Systèmes, nouveaux  
réacteurs et démarches de sûreté  
BP 17 92262 Fontenay-aux-Roses, France  
Tel. +33 158358266,  
Fax +33 146575412  
[daniel.blanc@irsn.fr](mailto:daniel.blanc@irsn.fr)

### Project details

**Project type** // Coordination and support  
action

**Project start date** // 1.1.2012

**Duration** // 24 months

**Total budget** // EUR 1 293 083

**EC contribution** // EUR 999 128

### EC project officer

**Kateřina Ptáčková**

European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/60  
B-1049 Brussels, Belgium  
[katerina.ptackova@ec.europa.eu](mailto:katerina.ptackova@ec.europa.eu)



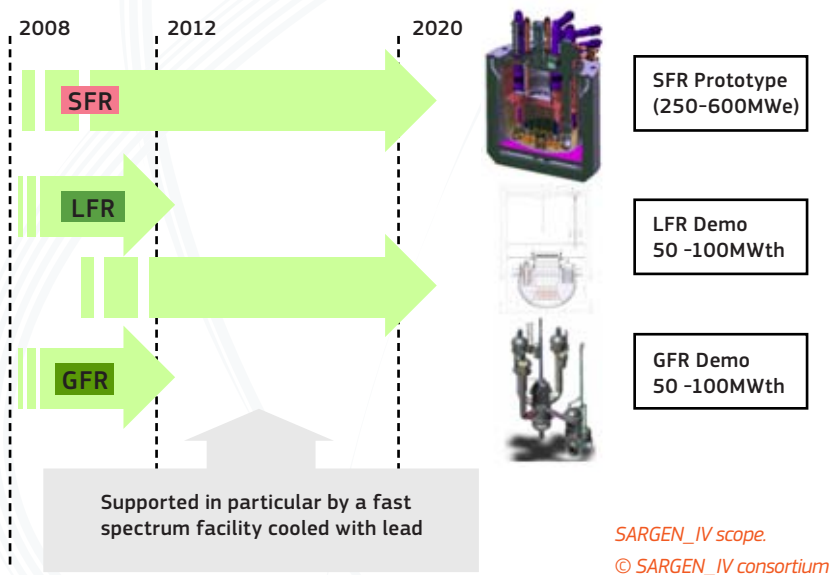
## Expected results

One of the major expected results will be the establishment of working mechanisms for exchange of information between the R&D community, European TSOs and the European Commission, which most probably will be consulted in the development of future legislative processes on safety assessment needed for any future SNETP prototypes/demonstrators. The SARGEN\_IV project will contribute to the practical content of the SNETP Strategic Research Agenda (SRA) providing the means to assess the demonstrable progress towards improved safety and competitiveness of future nuclear installations. In this context it is important to remember that the schedule of the project is built around big milestones such as the SFR prototype construction planned for 2020 and the construction of an alternative technology demonstrator, to be decided around 2012.

SARGEN\_IV will also support the Euratom contribution to the preparation of the GEN IV white paper on nuclear safety for European concept SFRs, LFRs and GFRs.

## SARGEN-IV objective

A harmonized methodology for the safety assessment of SFR, LFR, GFR and also for the fast spectrum irradiation facility



## Societal impact

It is expected that the depth and scope of the R&D needed to demonstrate adequate safety of the ESNII prototypes and demonstrators will be significantly impacted by the safety assessment methodology for these kinds of reactors proposed in SARGEN\_IV and in particular by the lessons learned from events at the Fukushima Daiichi NPP. The harmonisation of the different methodologies is crucial for developing a consistent assessment platform which could be used effectively in the decision-making process and to make the different innovative reactor types publicly acceptable in Europe.

## Information about important public events

A periodic electronic newsletter and a website will provide up-to-date information of the project. All information on the harmonised position issued during the project will be provided to important stakeholders, in particular decision makers like utilities and safety authorities. In addition, several workshops and meetings are planned throughout the project. At the end of 2014, the project partners will organise an information workshop for stakeholders.

## Partners

- Institut de Radioprotection et de Sûreté Nucléaire (IRSN), FR
- Joint Research Centre (JRC) – European Commission, BE
- Gesellschaft für Anlagen- und Reaktorsicherheit mbH (GRS), DE
- Valtion Teknillinen Tutkimuskeskus (VTT), FI
- Ústav Jaderného Vyzkumu Rez a.s. (UJV), CZ
- Bel V (BELV), BE
- Paul Scherrer Institute (PSI), CH

- Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (ENEA), IT
- AtomicEnergyResearchInstitute(MTAEK), HU
- Lithuanian Energy Institute (LEI), LT
- Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), FR
- AREVA NP sas (AREVA), FR
- Electricité de France S.A. (EDF), FR
- AMEC Nuclear UK Limited (AMEC), UK
- The University of Manchester (UNIMAN), UK
- Karlsruher Institut für Technologie (KIT), DE

- Helmholtz-Zentrum Dresden-Rossendorf (HZDR), DE
- Nuclear Power Plant Research Institute (VUJE), SK
- Rheinisch-Westfälische Technische Hochschule Aachen (RWTH), DE
- Ansaldo Nucleare S.p.A. (ANSALDO), IT
- Mol Belgian Nuclear Research Centre (SCK-CEN), BE
- Universidad Politécnica de Madrid (UPM), ES

## SCWR-FQT

Throughout the development of the Supercritical Water Reactor (SCWR), significant progress has been made over the years in terms of the development of basic technologies such as materials for fuel cladding and heat transfer predictions for supercritical water conditions. Core, reactor and plant design concepts have been worked out in substantial detail, as the European High Performance Light Water Reactor (HPLWR) concept. The next step is to carry out a test of a small-scale fuel assembly in a research reactor. Design and licensing of such a small-scale fuel assembly with four fuel pins including the required loop with its safety and auxiliary systems is the aim of the SCWR-FQT project. The design of the facility will be available by 2013 and operational from 2015.

## Supercritical Water Reactor – Fuel Qualification Test

### Cooperation with Chinese sister project

The SCWR-FQT project constitutes the European contribution to an EU-China collaborative project. The SCWR-FQT project aims to make significant progress towards the design, analysis and licensing of a fuel assembly cooled with supercritical water in a research reactor. The SCWR-FQT consortium is made up of seven partners: six research centres and one university. All partners have in the past contributed to the development of the European HPLWR, whether through participating in previous EU Framework Programme-based projects, or as active contributors without direct project funding from the European Commission.

The Chinese contribution is through a project named 'Supercritical water cooled In-Pile Test' (SCRIPT). The Chinese consortium carrying out the complementary project SCRIPT in parallel, is made up of nine partners from universities, national research centres and industry.

### Activities

The objectives of the project are:

- to design a test section, a supercritical water loop and all safety and auxiliary systems required for safe operation of such a fuel assembly test;
- to analyse this test equipment under normal and accidental conditions to demonstrate safe operation;
- to build and operate with supercritical water an out-of-pile test assembly with the same test section geometry, but heated electrically;
- to validate codes for thermal-hydraulic predictions of the flow structure in SCWR fuel assemblies, using the abovementioned out-of-pile test results;
- to focus the material research on those in-core materials which could be licensed in the near future and to prepare a qualified, reliable material database;
- to complete the required licensing documents for this fuel qualification test and thus find out if a nuclear facility operated at supercritical pressure can be licensed or, otherwise, to identify challenges associated with this;
- to teach and train young scientists in licensing procedures of nuclear facilities including the required quality management methods.

### Coordinator

**Mariana Ruzickova**  
Research Centre Rez Ltd.  
Husinec-Rez 130  
25068 Rez  
Czech Republic  
Tel: +420 266 173 513  
Fax: +420 266 172 045  
[ruz@ujv.cz](mailto:ruz@ujv.cz)

### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.1.2011  
**Duration** // 48 months  
**Total budget** // EUR 2 830 750  
**EC contribution** // EUR 1 500 000

### EC project officer

**Georges van Goethem**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/47  
B-1049 Brussels, Belgium  
[georges.van-goethem@ec.europa.eu](mailto:georges.van-goethem@ec.europa.eu)

## Expected results

The measurable result of this project will be the pre-operational safety report required by Czech authorities to build and operate a fuelled loop with supercritical pressure conditions in the LVR-15 research reactor in Rez, Czech Republic.

This joint European project is part of an international collaboration to minimise effort and to maximise the quality of its results. While electrically heated out-of-pile coolant loops for fuel bundles at supercritical pressure are currently not available inside Europe, a suitable facility has just been commissioned at Shanghai Jiaotong University (SJTU) in China. In addition, other Chinese partners intend to share analyses and material tests with the European partners. European partners, on the other hand, contribute with their research reactor LVR-15, as well as with analyses and material autoclave tests. This Chinese–European collaboration is therefore a win-win situation for all. Further collaboration beyond the scope of this project, in particular for performance of the fuel qualification test and results sharing, is envisaged.

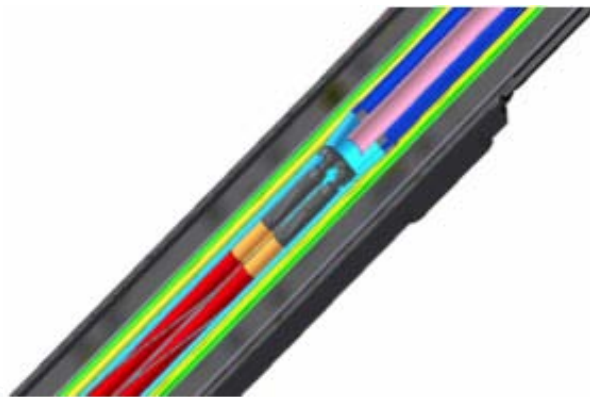
Moreover, as this test is going to be the world's first nuclear facility operated with supercritical water, Japan and Canada as member states of the Generation IV International Forum (GIF) have expressed significant interest in participating in these tests. The European partners are therefore interested in offering this project as a European contribution to the SCWR system development in GIF.

## Societal impact

It is expected that a SCWR will be more economical than conventional light water reactors, as it will be more efficient and have better fuel utilisation, thus producing less radioactive waste per kWh, while still fulfilling the high safety standards. Certain technologies can be used from fossil-fired power plants, where supercritical water is already utilised as a coolant, as well as from experience with operation of light water nuclear reactors.

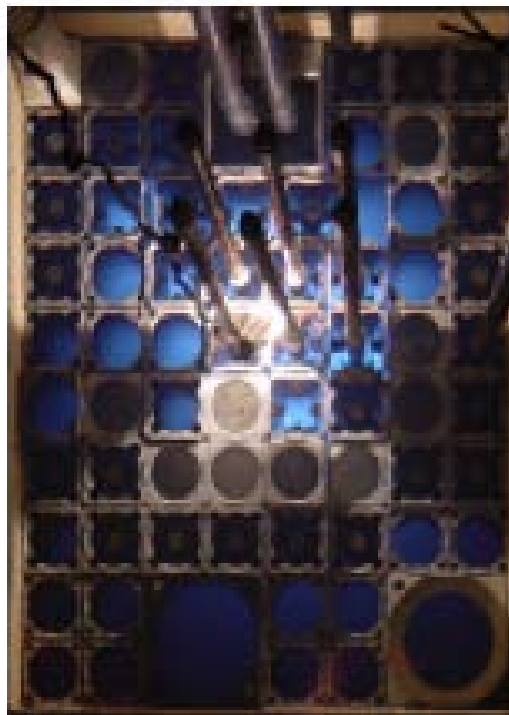
## Important public events

A European–Chinese workshop on SCWR will be organised and take place in China at some point in 2013. The next bi-annual International Symposium on Supercritical Water-cooled Reactors will take place in March 2013.



*Partial cross-section of the test section (fuel rods in red).*

© CV Rez



*LVR-15 core.*

© CV Rez

## Partners

- Centrum vyzkumu rez s.r.o. (CVR), CZ
- Karlsruher institut fuer technologie (KIT), DE
- Nuclear research and consultancy group (NRG), NL
- Magyar tudomanyos akademia kfti atomenergia kutatointezet (KFKI), HU
- Valtion teknillinen tutkimuskeskus (VTT), FI
- Budapesti muszaki es gazdasagtudomanyi egyetem (BME), HU

- JRC-Joint Research Centre-European Commission (JRC-IE), EU

# SEARCH

To improve the safety and sustainability of nuclear energy, scientists and engineers are developing fourth generation (GEN IV) nuclear reactors. One potential type of reactor is one that is cooled with a heavy liquid metal and MYRRHA ('Multi-purpose hybrid research reactor for high-tech applications') will serve as the European Technology Pilot Plant (ETPP). The SEARCH project aims to support the development of MYRRHA by investigating safe behaviour of the fuel and the coolant in the reactor.

## Safe ExploitAtion Related CHemistry for HLM reactors

### Nature and scope of the project

Under previous European Commission Framework Programmes (FPs), design work and research have been performed for the development of heavy liquid metal cooled nuclear systems like the lead fast reactor and the ADS prototype MYRRHA. The SEARCH consortium includes the main actors who helped carry out these previous projects and they will each bring their specific expertise to the table.

SEARCH intends to take the work a step further by using the results of previous projects to study the safe operation of the design. In particular, the researchers will focus on coolability of the fuel pins in all circumstances, the behaviour of the coolant, and the compatibility of the fuel with the liquid metal and the dispersion of the fuel in the reactor in the event of an accident. Finally, the team will look at the possible release of radioactive elements. All these aspects need to be thoroughly studied to ensure the safe operation of these pilot reactors.

### Activities

SEARCH has been split into several technical work packages.

First off the project will investigate the coolability of a fuel bundle in all operational circumstances by measuring heat transfer to the coolant. Numerical simulations will support the interpretation of the results. Secondly, control of the oxygen content and management of impurities in the melt will be studied to ensure that no blockage due to poor coolant chemistry control takes place. The next step in the safety assessment of a nuclear system is the compatibility of the fuel with the coolant should a fuel clad failure occur.

A full analysis of clad failure with computer codes requires experimental data on 'basic' properties of the interactions between the materials involved. For that the researchers will study the chemical behaviour of a mixture of fuel and coolant to determine the energy release, solubility and formation of new chemical compounds. After severe clad failure the fuel pellets could disperse in the coolant. Computer simulations will help the project partners look at the migration of the fuel and the possibilities of fuel accumulation.

To ensure the safety of the general public, risk prevention will be studied by looking into how volatile radioactive elements like Po and Hg escape into the environment. Methods to capture these elements in the covergas and their evaporation from the coolant will also be studied. In addition, this work will address quantum-mechanical calculations.

### Coordinator

**Paul Schuurmans**  
Institute of Advanced Nuclear Systems  
SCK-CEN  
Boeretang 200  
BE-2400 Mol, Belgium  
Tel. +32 14333445  
Fax +32 14323445  
[paul.schuurmans@sckcen.be](mailto:paul.schuurmans@sckcen.be)

### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.11.2011  
**Duration** // 36 months  
**Total budget** // EUR 5 448 120  
**EC contribution** // EUR 2 977 524

### EC project officer

**Roger Garbil**  
European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/70  
B-1049 Brussels, Belgium  
[roger.garbil@ec.europa.eu](mailto:roger.garbil@ec.europa.eu)



## Expected results

Each of the research topics has a clearly defined outcome with a direct impact on the safety assessment of MYRRHA. The heat transfer between the fuel pin and the coolant directly determines the requirements for the coolant flow rate and allows for calculations to be made regarding the maximal temperature that will occur on the fuel clad. In this way it can be demonstrated that a sufficient safety margin is kept. The work package on coolant chemistry control will provide methods to control the oxygen content and impurities in the liquid metal coolant. The results will also put conditions on the sizing of the purification system thus ensuring that the coolant can be kept in the right condition.

The work packages on fuel coolant interaction and fuel dispersion will help build up effective analyses of accident scenarios involving severe clad failure. The aim is to make sure that in the event of an accident the fuel remains within the confinement of the reactor vessel.

Finally, the work package on release and capture of radioisotopes will yield methods to capture volatile radioisotopes in the covergas. By measuring the evaporation rates of these elements from the liquid metal and the efficiency of the capture systems, the project will determine the required filtering installation as well as contribute to assessing the effects of these elements being released into the environment in the event of an accident.

## Societal impact

The search for efficient low-carbon energy has never been more imperative and nuclear energy can play a role in this energy mix. But concerns regarding the complete safety of nuclear energy and the problem of nuclear waste remain. It is clear that any future development of nuclear energy must address both issues. GEN IV systems, in particular the heavy liquid metal cooled types, show promise due to their ability to combine improved passive safety with better fuel sustainability by using fuel more efficiently while producing less waste.

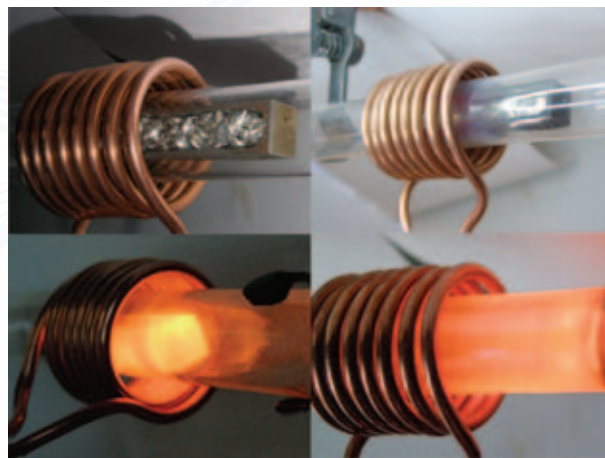
However, it is obvious that the claimed advantages in terms of safety need to be demonstrated before any step towards full deployment of these reactors can be taken. By investigating the safe behaviour of the fuel and the coolant in MYRRHA in its role as the ETPP for the heavy liquid metal cooled reactor, SEARCH is directly tackling this issue.

## Information about important public events

Over the course of the project SEARCH will co-organise two workshops and one lecture series open to all stakeholders. At the end of the project, the results will be presented to the SNE-TP network. The research results will also be published in various scientific journals and presented at conferences.



*A fish eye view of the KALLA lab. © Chalmers University*



*Sample heating for Po evaporation experiments. © Chalmers University*



*Fuel coolant interaction studies in the hot-labs. © Chalmers University*

## Partners

- Studiecentrum voor Kernenergie/Centre d'Etude de l'énergie Nucléaire (SCK-CEN), BE
- Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (ENEA), IT
- Karlsruher Institut Für Technologie (KIT), DE
- Nuclear Research and Consultancy Group (NRG), NL
- Centro di Ricerca, Sviluppo e Studi Superiori in Sardegna (CRS4), IT

- Universiteit Gent (UGENT), BE
- Università di Pisa (UNIP), IT
- Von Karman Institute for Fluid Dynamics (VKI), BE
- Regia Autonoma Pentru Activitati Nucleare Drobeta Tr. Severin Ra Sucursala Cercetari Nucleare Pitesti (INR), RO
- Joint Research Centre (JRC) – European Commission, BE
- Paul Scherrer Institut (PSI), CH

- Chalmers Tekniska Högskola AB (CHALMERS), SE

## SILER

Following the violent earthquakes that struck Japanese nuclear power plants (Kashiwazaki-Kariwa in July 2007 and Fukushima in March 2011) international attention is once again focused on the structural strength of nuclear facilities. This has forced the nuclear engineering community to concentrate significant research efforts on the evaluation and mitigation of risks associated with earthquakes. It was in this context that the SILER project was born.

## Seismic-Initiated events risk mitigation in LEad-cooled Reactors

### Nature and scope of the project

SILER is a Collaborative Project that aims to study the risks associated with seismic-initiated events in Generation (GEN) IV Heavy Liquid Metal reactors, with a view to developing adequate protection measures. Attention is focused on evaluating the effects of earthquakes, with particular emphasis on unexpected (beyond design) events, and on identifying mitigation strategies like seismic isolation, acting on both structures and component design. SILER is expected to have a strong impact on the overall success of the Lead Fast Reactors (LFRs) and Accelerated Driven Systems (ADSs) development programmes, which strongly depend on developing, demonstrating and deploying advanced designs that exhibit, among other things, excellent safety characteristics.

### Activities

The SILER project partners will perform a deep examination of the risks and consequences associated with external loads on LFR and ADS components by analysing the global behaviour of the plant (and its critical components) under seismic conditions. Specific layout solutions will be suggested, and suitable seismic isolators (Figure) and pipeline joints will be designed and manufactured. For the first time, full-scale isolator prototypes will be qualified and tested to failure using real three-directional dynamic excitations, in order to clearly define safety margins in case of unexpected events. Moreover, guidelines and recommendations will be issued based on economic analyses with the aim of extending the use of the technology to other kinds of plants. Finally, particular attention will be paid to the dissemination and exploitation of the results.

SILER activities are linked with the Sixth Framework Programme (FP6) projects ELSY ('European Lead-cooled System') and EUROTRANS ('EUROpean program for TRANSition prediction'), and the Seventh Framework Programme (FP7) projects LEADER ('Lead-cooled European Advanced Demonstration Reactor'), MYRRHA ('MYRRHA Accelerator eXperiment, research and development programme') and CDT ('Central Design Team (CDT) for a fast-spectrum transmutation experimental facility').

SILER will impact on one of the critical issues recognised by the Strategic Research Agenda (SRA): the development path of the next generation nuclear systems.

### Coordinator

**Massimo Forni**  
 ENEA  
 Via Martiri di Monte Sole, 4  
 40129 Bologna, Italy  
 Tel. +39 0516098554  
 Fax +39 0516098544  
[massimo.forni@enea.it](mailto:massimo.forni@enea.it)

### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.10.2011  
**Duration** // 36 months  
**Total budget** // EUR 4 450 851  
**EC contribution** // EUR 2 926 133

### EC project officer

**Mykola Džubinský**  
 European Commission  
 Directorate-General for Research and Innovation  
 Directorate Energy  
 Unit K.4 – Fission  
 CDMA 1/58  
 B-1049 Brussels, Belgium  
[mykola.dzubinsky@ec.europa.eu](mailto:mykola.dzubinsky@ec.europa.eu)

## Expected results

The main expected results are:

- identification of the main features of lead-cooled reactor concepts (LFR and ADS) relevant for evaluation of the risks associated with external damaging events;
- evaluation of the selected system behaviour in the event of a severe seismic accident; in particular, a key objective is the evaluation of the seismic-related movement leading to failure of the primary system (specific consideration is also paid to the study of sloshing phenomena);
- identification of mitigation strategies through the design of adequate components (i.e. vessel supports, core supports, spent fuel storage pools, steam generator tube supports, joints, foundation slab, etc.) and the development of specific devices (i.e. isolation devices) for structural damage reduction, as well as the development of suitable layout;
- evaluation of the economic benefits related to the introduction in the reactor design of measures for reducing the reactor damage due to external events with a consequent increased standardisation in the design;
- transfer of the knowledge gained on the advanced measures for increased safety from external risk mitigation to GEN III Light Water Reactor (LWR) technologies.

## Societal impact

Seismic isolation is a mature technology that is currently used in thousands of buildings all over the world, and this use rate is increasing ever day. Despite this, only two nuclear plants have been seismically isolated (Cruas in France and Koeberg in South Africa) with one currently under construction (Jules Horowitz Reactor in Cadarache, France). The extremely limited number of existing isolated reactors is probably due to the lack of specific standards and the fact that most of them are water reactors, which are characterised by quite stiff structures and rigid components, with an intrinsic robustness sufficient to resist the relatively low seismic inputs assumed as basis design for most of the GEN II reactors (typically  $0.2 \div 0.3$  g peak ground acceleration). However, Liquid Metal Fast Reactors (LMFRs) are more prone to amplifying the seismic motion due to the presence of flexible and heavy components. Moreover, the GEN IV reactors have much higher safety criteria and require a higher level of performance. Thus, seismic isolation is one of the most promising techniques for these kinds of plants and is already foreseen for new designs like ALMR, PRISM, KALIMER and STAR-LM. SILER will certainly demonstrate the feasibility and reliability of seismic isolation for GEN IV nuclear

power plants (NPP) not only with theoretical studies but also through experimental campaigns on full-scale isolation devices and piping joints, something that has never been carried out until now.

It is worth noting that seismic isolation strongly reduces the seismic loads on both structures and components and, consequently, the possibility of failure (and release of radioactivity). Moreover, it also provides full protection in case of unexpected events. Seismic isolation also has positive economic effects because it allows for a deep standardisation of the plant which can be built in sites with different seismicity with no significant changes to the original design. For these reasons, the most important NPP builders (Toshiba-Westinghouse, General Electric-Hitachi, AREVA, etc.) demonstrated great interest in the applicability of seismic isolation to NPP.

## Information about important public events

An international thematic workshop on seismic issues in Heavy Liquid Metal reactors has been arranged for the end of the second year of the project (month 21) to provide an opportunity for dissemination of and feedback on results obtained in the project.

An educational workshop is planned for the end of the project (month 34). PhD students participating in the project's educational programme will have the opportunity to present the results of their research activities.



*Medium-size seismic isolator for civil application during a type test (compression plus one-directional shear loads applied at low velocity, according to the present standards). In the SILER project large-scale isolators developed for nuclear plants will be qualified in threedirectional dynamic conditions up to failure.*

© Massimo Forni

## Partners

- Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile (ENEA), IT
- Areva np sas (AREVA), FR
- Studiecentrum voor Kernenergie/Centre d'Etude de l'énergie Nucléaire (SCK-CEN), BE
- Fip industriale S.p.A. (FIP Industriale), IT
- Maurer Soehne GmbH & Co. KG (MAURER-SOEHNE), DE
- Joint Research Centre (JRC) – European Commission, BE
- Sintec s.r.l. (SINTEC), IT
- Kungliga tekniska högskolan (KTH), SE
- BOA Balg - und Kompensatoren-Technologie GmbH (BOA BKT), DE
- Ingeniería Idom Internacional S.A. (IDOM), ES
- Ansaldo Nucleare S.p.A. (ANSALDO), IT
- Latvijas Universitātes Agentūra Latvijas Universitātes Fizikas Institūts (IPUL), LV
- Numeria Consulting s.r.l. (NUMERIA), IT
- VCE holding gmbh (VCE), AT
- Servizi di Ricerche e Sviluppo società a responsabilità limitata (SRS), IT
- Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), FR
- Empresarios Agrupados Internacionales A.S. (EA), ES
- Nuvia Travaux Speciaux S.A.S. (NUVIA-TS), FR



## STYLE

The safety and reliability of all systems has to be maintained throughout the lifetime of a nuclear power plant. Continual research and development (R&D) work is needed in targeted areas to meet the challenges of the long-term operation of existing and new plants designs.

## Structural integrity for lifetime management — non-RPV components

### Activities

The STYLE consortium consists of 20 organisations from 11 EU Member States and two collaborating non-EU countries (United States and Russia).

The overall objective of STYLE is to assess, optimise and develop the use of advanced tools for the structural integrity assessment of components (RCPB) relevant to ageing and lifetime management, and to support the integration of the knowledge created in the project into mainstream nuclear industry assessment codes. Realistic failure models for some of the key components will be identified within the project based on the operators' experience, supported by an efficient knowledge management database system.

The range of assessment tools considered will include those for assessment of component failure by advanced fracture mechanics analyses validated on small- and large-scale experiments, quantification of weld residual stresses by numerical analysis and by measurements, stress corrosion crack initiation/growth effects and assessment of RCPB components (excluding the reactor pressure vessel) under dynamic and seismic loading. Based on theoretical and experimental results, performance assessment and further development of simplified engineering assessment methods (EAMs) will be carried out, considering both deterministic and probabilistic approaches.

Integrity assessment case studies and large-scale demonstration experiments will be performed on mock-ups of safety-relevant components. These will include a repair weld in an aged butt-welded austenitic pipe, a dissimilar narrow gap tungsten inert gas (TIG) weld (following the EPR design) and a clad ferritic pipe.

### Coordinator

**Elisabeth Keim**

AREVA NP,  
Paul-Gossen-Str. 100,  
91052 Erlangen, Germany  
Tel. +49 913190095218, +49  
913190094023  
[elisabeth.keim@areva.com](mailto:elisabeth.keim@areva.com)

### Project details

**Project type** // Collaborative Project

**Project start date** // 1.1.2010

**Duration** // 48 months

**Total budget** // EUR 5 212 033 00

**EC contribution** // EUR 2 971 757.00

### EC project officer

**Panagiotis Manolatos**

European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/53  
B-1049 Brussels, Belgium  
[panagiotis.manolatos@ec.europa.eu](mailto:panagiotis.manolatos@ec.europa.eu)

### Website address

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



## Societal impact

STYLE will reinforce the competitiveness of the European nuclear industry by obtaining innovative research results in the field of nuclear power plant maintenance. Best practice guidelines titled 'STYLE TOOLS' will consolidate the results on structural assessment and lifetime management of the RCPB in European nuclear power plants. Two training workshops will also be organised. The first consolidation workshop was held in March 2011, and a second final dissemination workshop is planned for October 2013.

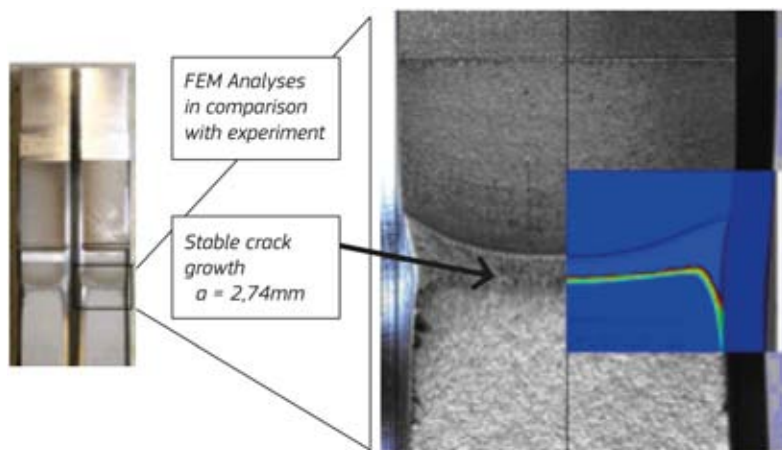


Figure 1.  
© ANP-G

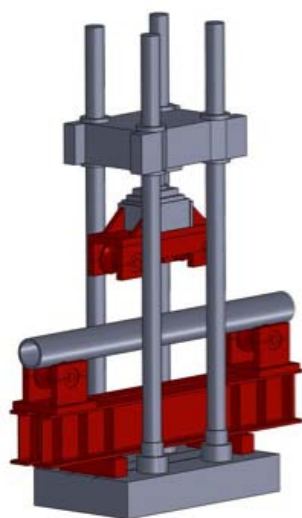


Figure 2.  
© EDF



Figure 3.  
© EDF

## Partners

- AREVA NP GmbH (ANP-G), DE
- EDF Energy Nuclear Generation Ltd. (EDF Energy), UK
- Commissariat à l'Énergie Atomique (CEA), FR
- Commission of the European Communities Directorate General, Joint Research Centre (JRC), EU
- Serco Ltd. (SERCO), UK
- Vattenfall Ringhals AB, RAB, SE
- Centre for Energy Research, Hungarian Academy of Sciences (AEKI), HU
- AREVA NP SAS (ANP-F), FR
- Bay Zoltán Alkalmazott Kutatási Közhasznú Nonprofit Kft. (BZF), HU
- The University of Bristol (BU), UK
- Électricité de France S. A. (EDF), FR
- Institut de Soudure Association (IDS), FR
- Regia Autonoma Pentru Activitati Nucleare Drobeta Tr-Severin R.A.- Sucursala Cercetari Nucleare Pitesti (INR), RO
- Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V. (IWM), DE
- The University of Manchester (UNIMAN), UK
- The Nuclear Research and consultancy Group (NRG), NL
- Ústav jaderného výzkumu Řež A. S. (NRI), CZ
- Studiecentrum voor Kernenergie (SCK), BE
- TECNATOM S. A. (TEC), ES
- Valtion Teknillinen Tutkimuskeskus (VTT), FI

# THINS

The THINS project focuses on cross-cutting issues of thermal hydraulics encountered in innovative nuclear systems. It brings 24 institutions (23 from the European Union) together and synergises Europe's existing infrastructure. The overall objectives of THINS are the development and validation of new physical models, and the improvement and qualification of numerical analysis tools and their application to innovative nuclear systems.

## Thermal-hydraulics of innovative nuclear systems

### Industry involvement

As well as research institutions and universities, the project consortium consists of nuclear industry actors, a commercial software developer (provider) and a nuclear safety regulatory authority. This involvement of industry will help facilitate the exploitation of the project results. The targeted results of the THINS project are new physical models and advanced methodology for more accurate descriptions of thermal hydraulic phenomena, and an experimental and numerical platform for thermal hydraulic research into innovative nuclear systems in Europe. Optimum usage of existing European resources will be achieved by using experimental facilities, numerical tools and research expertise.

### Activities

Thermal hydraulics is recognised as a key scientific subject in the development of different innovative reactor and transmutation systems. Despite the difference in coolants (gas, water and liquid metals) and flow channel structures formed by different fuel lattice arrangements, the THINS project focuses on five crosscutting thermal-hydraulic issues: advanced reactor core thermal hydraulics; single-phase mixed convection; single-phase turbulence; multi-phase flow; and code coupling and qualification. Scientific results from THINS are to be used for education and knowledge-sharing purposes. A large part of the scientific results will be extremely relevant to nuclear thermal hydraulics, nuclear safety and thermal fluid dynamics.

### Expected results

More reliable models will be developed, which are needed in various classes of numerical codes such as heat transfer and flow mixing in complex fuel assemblies, advanced turbulence models for a large range of Prandtl numbers. The project expects to move forward advanced simulation methodology. This includes the methodology for the numerical simulation of liquid metal flow with a low Prandtl number, free surface of windowless targets, solid particle transportation in gas flow and mixed convection in a large liquid pool.

### Coordinator

#### Xu Cheng

Institute of Fusion and Nuclear Technology (IFRT)  
Karlsruhe Institute of Technology (KIT)  
Kaiserstraße 12  
76131 Karlsruhe  
Germany  
Tel. +49 7216085356, +49 7247822561  
[xu.cheng@kit.edu](mailto:xu.cheng@kit.edu)

### Project details

**Project type** // Collaborative Project

**Project start date** // 1.2.2010

**Duration** // 48 months

**Total budget** // EUR 10 454 294 80

**EC contribution** // EUR 5 941 810 80

### EC project officer

#### Michel Hugon

European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/52  
B-1049 Brussels, Belgium  
[michel.hugon@ec.europa.eu](mailto:michel.hugon@ec.europa.eu)

Generic experiments will be performed as part of the THINS project to produce a comprehensive database for code validation purposes. In addition, direct numerical simulation (DNS) will provide a numerical database, which is of crucial for the development of turbulence models.

The THINS project will make optimum use of existing European experimental facilities and expertise, and establish a European experimental platform. The team will further develop advanced measurement techniques such as local velocity measurement in liquid metals and high-resolution laser measurement techniques for boundary flow conditions, and integrate these into the platform.

THINS will develop more reliable and validated codes, based on advanced physical models and numerical methodology. Coupling of code solutions at various scales and the qualification of coupled code solutions will enlarge applicability and ensure simulation reliability of the numerical platform.

## Societal impact

The Generation IV International Forum (GIF) recommended six innovative nuclear energy system concepts for meeting future energy challenges; it set out a technology roadmap with the objective of meeting these challenges by 2030. As Generation IV systems advance, more comprehensive tools and more advanced evaluation methodology will be needed for the assessment of the systems. It is essential that capa-

bility to quantify uncertainty in this evaluation methodology is developed. The THINS project concentrates its technical tasks on the development and validation of more reliable and comprehensive numeric tools. The outcomes of the project can be applied directly by designers and safety regulators for design analysis and system evaluation.

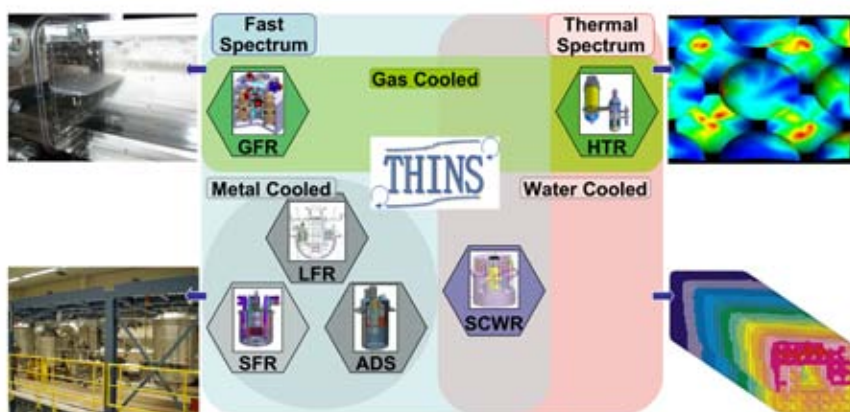
The Strategic Research Agenda (SRA) of the Sustainable Nuclear Energy Technology Platform (SNE-TP) has been organised to address the short-term (around 2012), the medium-term (around 2020) and the long-term (2040–50) research and development challenges and milestones with respect to various innovative nuclear systems. The THINS project, which will run until 2015, has been structured around these SRA milestones.

## Important public events

THINS was present at the International Workshop on Thermal-hydraulics of Innovation Reactor and Transmutation Systems in April 2008 in Karlsruhe. This public event served as an important milestone for the project's preparation.

There are also workshops held at the 12th, 24th and 36th month of the project, for education and results dissemination purposes. As the project draws to a close, there will be a final technical workshop for information exchange.

As using the project results for teaching purposes helps strengthen the basis for maintaining and extending know-how in the field, the THINS partners have also organised a series of student workshops and code-user training courses.



*Generation-IV systems studied in THINS project.*

© THINS Consortium

## Partners

- Karlsruhe Institute of Technology (KIT), DE
- Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), FR
- Studiecentrum voor Kernenergie - Centre d'Etude de l'énergie Nucléaire (SCK-CEN), BE
- Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), IT
- Nuclear Research and consultancy Group (NRG), NL
- Paul Scherrer Institute (PSI), CH
- Forschungszentrum Dresden-Rossendorf (FZD), DE

- Kungliga Tekniska Högskolan (KTH), SE
- Delft University of Technology (DUT), NL
- University of Pisa (UniPi), IT
- Università degli Studi di Modena e Reggio Emilia (UiMore), IT
- University of Bologna (UniBo), IT
- Ansaldo Nucleare SpA (Ansaldo), IT
- Computational Dynamics Limited (CD-adapco), UK
- Jozef Stefan Institute (JSI), SI
- Imperial College of London (ICL), UK
- ASCOMP GmbH (ASCOMP), CH
- Institut de Radioprotection et de Sécurité Nucléaire (IRSN), FR

- Gesellschaft für Anlagen- und Reaktorsicherheit mbH (GRS), DE
- Center for Advanced Studies, Research and Development in Sardinia (CRS4), IT
- Université catholique de Louvain (UCL), DE
- Technical University Munich (TUM), DE
- Lappeenranta University of Technology (LUT), FI
- Texas Engineering Experiment Station (TEES), US



## ANDANTE

Despite decades of research, there is still considerable uncertainty about what risks neutron radiation poses to humans. The ANDANTE project will take a multi-disciplinary approach to investigating the relative risk of induction of cancer from exposure to a range of different energy neutrons compared to photons, the relative biological effectiveness (RBE). A model for predicting risks will be developed using animal and human stem cells and tested in a prospective epidemiological study of second cancers caused following paediatric proton therapy.

## Multidisciplinary evaluation of the cancer risk from neutrons relative to photons using stem cells and the induction of second malignant neoplasms following paediatric radiation therapy

*Better appraising the risk from exposure to low doses of neutron radiation*

### World-leading partners

The ANDANTE project involves 8 participating institutions from 7 different countries, each a world leader in different sub-disciplines of radiation physics, normal tissue radiation biology, stem cell biology, clinical radiation research, and radiation epidemiology. All partners have a track record of active research in the relevant fields. The project work package structure is designed to integrate these disciplines to provide new estimates of the risk of cancer in humans from exposure to neutrons (see diagram).

### Activities

Each task in the project forms an essential component part of the overall objective. The individual task objectives can be split up as follows:

- (i) Physical characterisation, using measurements and modelling, of the neutron fields of various energy spectra to be used for experimental irradiation of cells and also those generated during paediatric proton radiotherapy. The data will provide accurate dosimetry for the radiobiology experiments, and input to biophysical track structure simulation in order to decrease the uncertainty of damage response prediction;
- (ii) Investigation of the damage induction in stem cells as an indicator of the relative carcinogenic effectiveness of low and intermediate doses from neutrons of various energies compared to photons; use of the results to generate provisional values for RBE and explore the dependence on neutron energy and dose;
- (iii) Integration of functional relationships from biophysical simulations and radiobiological stem cell experiments to develop predictive neutron risk models for second primary malignancies following paediatric proton therapy that can be validated using clinical treatment and follow-up data: proof-of-principle pilot study leading to design of a multi-centre prospective study.

### Coordinator

**Andrea Ottolenghi**  
Dipartimento di Fisica  
Università degli Studi di Pavia  
Via Bassi 6  
I-27100 Pavia, Italy  
Tel. +39 0382 987892  
Fax +39 0382 526938  
[andrea.ottolenghi@pv.infn.it](mailto:andrea.ottolenghi@pv.infn.it)

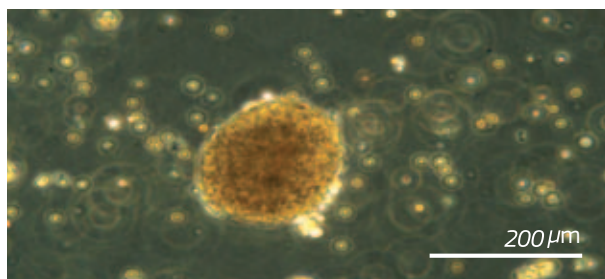
### Project details

**Project type** // Collaborative project  
**Project start date** // 1.1.2012  
**Duration** // 48 months  
**Total budget** // EUR 4204 012  
**EC contribution** // EUR 3 000 000

### EC project officer

**André Jouve**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/78  
B-1049 Brussels, Belgium  
[andre.jouve@ec.europa.eu](mailto:andre.jouve@ec.europa.eu)





Human stem cell mammosphere, isolated from healthy breast tissue of reduction mammoplasty.

© UROS

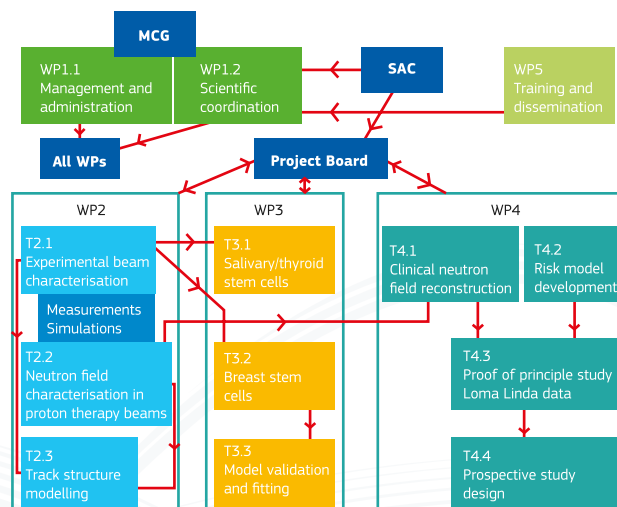
## Expected results

The ANDANTE project is expected to produce results that will have an impact on any aspect of radiation protection where neutrons are a significant factor. The re-evaluation of energy-dependence of the RBE for neutrons will provide information of fundamental importance for taking forward the European regulation of radiation protection. This will have direct implications for any industry where neutrons are produced as a by-product, for example:

- The nuclear power industry (both conventional fission reactors and those with the potential for fusion power in the future). The safety design of work areas, and site safety rules and procedures are all dependent on the knowledge of the risks to health from neutrons.
- High energy medical linear accelerator installations. Any linear accelerator producing x-rays of energy higher than 10MeV generates unwanted neutrons, and the bunker design must include special elements such as a long entrance maze, borated polyethylene wall linings, neutron doors, etc. The level to which safety design must reduce neutron dose rate is determined directly from the estimated risks from neutrons.
- Long-haul air crew. Guidelines for scheduling of high-altitude long-haul air crew are dependent on estimated risks from neutrons.

## Societal impact

Knowledge of the risk from neutrons is particularly important when choosing whether to treat paediatric cancer patients with proton radiotherapy. Depending on the choice of type of machine and treatment plan there will be a greater or lesser exposure of normal tissue to scattered neutrons produced by the protons. A direct result from the ANDANTE project will be a methodology for more accurate prediction of the risks of a second cancer later in life, and hence the treatments can be optimised both for effectiveness and safety.



ANDANTE Workpackage flow chart.

© UniPv

The use of normal stem cells for developing a relative risk model of cancer induction is novel. The investigation of their response to different types and energies of radiation, both in terms of molecular biology and cytology, will contribute significantly to our knowledge of the role of stem cells in carcinogenesis.

## Information about important public events

Dissemination of results from the ANDANTE project will be mainly carried out via specialist scientific journals and conferences. In particular, having ESTRO as the partner taking care of dissemination will mean that ANDANTE can be featured in a dedicated session at any of the annual ESTRO conferences.

Other radiation protection conferences such as the International Ionising Radiation Protection Association (IRPA) will also be targeted.

## Partners

- Università degli Studi di Pavia (UNIPV), IT
- Bundesamt für Strahlenschutz (CUT), SE
- European Society for Therapeutic Radiology and Oncology (ESTRO), BE
- Loma Linda University Medical Center (LLU), US
- Paul Scherrer Institute, Villigen (PSI), CH
- University Medical Centre, Groningen (UMCG), NL
- Universitaet Rostock (UROS), DE

## CEREBRAD

Human brain development is a protracted process that starts in early embryogenesis and continues until nearly two years after birth, and the brain is highly sensitive to ionising radiation during the foetal and early post-natal period.

Data from atomic-bomb survivors show a 40% increase in the occurrence of mental retardation per mGy, with a threshold between 0.06 and 0.31 mGy foetal-dose in the most vulnerable gestational period: between week 8 and 15. The CEREBRAD project aims to identify the potential cognitive and cerebrovascular risks of radiation doses below 100 mGy when delivered during development to a young child (pre or postnatally).

## Cognitive and Cerebrovascular Effects Induced by Low Dose Ionising Radiation

*Providing stronger evidence of radiation induced non-cancer brain diseases*

### Nature and scope of the project

The CEREBRAD consortium is made up of internationally recognised leaders from the relevant fields of radiation and non-radiation research. It combines specialists in the fields of epidemiology, dosimetry, molecular radiation biology, toxicology and neurobiology.

CEREBRAD's aim is to shed light on different areas of limited understanding regarding the cognitive and cerebrovascular effects following exposure to low doses of ionising radiation. Health risks will be assessed in epidemiological studies of patients exposed at a young age to radiotherapy who received low doses to the brain or whose mother was pregnant or a new mother during the Chernobyl accident. Complementary data will be gathered using animal models to uncover key biological mechanisms underlying potential cognitive and cerebrovascular effects induced by low dose radiation.

To reduce fragmentation, the CEREBRAD consortium will work in close collaboration with researchers working on the Seventh Framework Programme (FP7) project PROCARDIO ('Cardiovascular Risk from Exposure to Low-dose and Low-dose-rate Ionizing Radiation').

### Activities

- Increasing the statistical power of epidemiological data about cognitive and cerebrovascular diseases following low-dose exposures by using cancer survivors cohorts as well as cohorts from pre- and postnatally exposed people during and after the Chernobyl disaster, as well as Chernobyl cleanup workers.
- Setting-up appropriate dosimetry calculations for human and animal studies that will allow correct evaluation of the doses to the brain structures.
- Using a systematic approach, the team will analyse the short and long term effects based on animal studies at low and high doses of external radiation and internal contamination as well as synergistic effects with other environmental pollutants. This information will provide experimental evidences on the shape of the dose-response curve for cognitive and cerebrovascular effects.

### Coordinator

**M. Abderrafi Benotmane**

Belgian Nuclear Research Centre (SCK-CEN)

SCK-CEN

Boeretang 200

BE-2400 Mol, Belgium

Tel. +32 14332731

Fax +32 14314793

[abenotma@sckcen.be](mailto:abenotma@sckcen.be)

### Project details

**Project type** // Collaborative project

**Project start date** // 1.10.2011

**Duration** // 36 months

**Total budget** // EUR 4 905 635

**EC contribution** // EUR 2 999 517

### EC project officer

**Andre Jouve**

European Commission

Directorate-General for Research and

Innovation

Directorate Energy

Unit K.4 – Fission

CDMA 1/78

B-1049 Brussels, Belgium

[andre.jouve@ec.europa.eu](mailto:andre.jouve@ec.europa.eu)

- Identifying the molecular pathways and regulatory networks underlying the effects of low-dose irradiation during brain development using an integrated systems biology approach in order to enhance biomarker discovery for the first time, based on experimental and computational omics methodologies.
- Through a targeted communication and dissemination plan stakeholders, decision makers and the general public will be educated on cognitive and cerebrovascular risks at low doses.
- Education and training of young scientists will be the ultimate mission of CEREBRAD to transfer gained knowledge to the next generation of radiation biologists.

## Expected results

CEREBRAD will be able to reduce key uncertainties regarding potential cognitive and cerebrovascular risks induced by low dose radiation (below 100 mGy) by combining sufficient human data to improve the statistical power for an accurate dose-response curve. CEREBRAD will improve dosimetry to reduce the related uncertainties and better evaluate doses to brain structures and improve the protection children exposed to low dose radiation in the range of 20-100 mGy both pre and postnatally, such as those used in medical diagnostic procedures. In addition CEREBRAD will attempt to identify and discover biomarkers of exposure and disease by making use of techniques brought to the consortium by experts in the neurosciences and toxicology fields using animal models. A major effort will be made to unravel the behavioural phenotype and the underlying biological and molecular mechanisms responsible for cognitive and cerebrovascular effects at low-dose radiation.

## Societal

CEREBRAD will improve the protection of pre and postnatally exposed people to low dose radiation in the range of 20-100 mGy such as those encountered in medical diagnostic procedures. Beside daily exposure to natural background doses, we are exposed to continuously increasing doses from the medical sector, nowadays reaching an average of 2.1 mSv per year (in Western Europe). Knowing the effects of these exposure levels is vital. Our results are also expected to help anticipate protection of the most sensitive people to radiation. This could become part of a guidance in managing post

accident situations such as at Chernobyl (Ukraine) or Fukushima (Japan).

So far, our working hypotheses are based mainly on the increase of mental retardations reported from the Hiroshima-Nagasaki A-bomb survivor data in the dose range of 0.06 to 0.3 Gy during the prenatal period (weeks 8-15). Increasing the statistical power of these epidemiological data using cohorts of patients and exposed people in Chernobyl will reduce uncertainties regarding brain-related non-cancer effects at low doses of radiation.

CEREBRAD will provide stronger evidence on whether or not cognitive and cerebrovascular diseases can be caused from exposure to low radiation doses. Thus, this project will help improve European regulations.



© psdesign1, #30178871, 2012. Source: Fotolia.com



© michaeljung, #25486582, 2012. Source: Fotolia.com

## Partners

- Belgian Nuclear Research Center Nucléaire (SCK-CEN), BE
- Erasmus University Medical Center Rotterdam (EMC), NL
- Italian National Agency for New Technologies, Energy and Environment (ENEA), IT
- Helmholtz Center for Environmental Health (HMGU), DE
- Frédéric Joliot-Curie National Research Institute for Radiobiology (NRIRR), HU
- University Rovira I Virgili (URV), ES
- Uppsala University (UU), SE
- Research Centre for Radiation Medicine of the National Academy of Medical Science of Ukraine (RCRM), UA
- Aristotle University of Thessaloniki (AUTH), GR
- University of Birmingham (UBHAM), UK
- Institute Gustave-Roussy (IGR), FR



## DoReMi

The aim of DOREMI is to promote the sustainable integration of low-dose risk research in Europe. The project will help resolve key policy questions identified by the Seventh Framework Programme (FP7) project 'High level expert group on European low dose risk research' (HLEG), that recommended putting in place the 'Multidisciplinary European low dose risk research initiative' (MELODI), a European platform dedicated to low-dose radiation risk research. Although many European countries have national research programmes in this area, beyond the Euratom research programme, little has been done to integrate these programmes.

## Low dose research towards multidisciplinary integration

### *Integrating low-dose risk research in Europe*

#### Low dose health effects

Although much is known about the quantitative effects of exposure to ionising radiation, considerable uncertainties and divergent views remain about the true health effects of low doses of ionising radiation. To this end, the DOREMI project hopes to find out how robust the current system of radiation protection and risk assessment is, and how it can be improved.

The aim is to reduce uncertainty surrounding the magnitude of risks from low and protracted doses of ionising radiation, typical of those encountered in the workplace, the environment and in diagnostic medicine.

The central objective of DOREMI is to provide data to improve quantification of low-dose radiation health risks. This cannot be achieved using the current basis for risk estimates, epidemiology, alone, because the statistical power in the low-dose range is limited. Human population studies need to be accompanied by mechanistic studies to give a fundamental understanding of health risks and identify actual risk factors for humans.

#### Activities

The DOREMI project consortium is made up of 22 partners from Belgium, Finland, France, Germany, Ireland, Italy, Japan, Spain, Sweden, the Netherlands, Norway, and the United Kingdom, and new partners are set to join the network via open calls. The broader scientific community will also be engaged in the project through exploratory workshops, training activities and surveys mapping relevant expertise and infrastructures.

As well as addressing cancer, the DOREMI research activities also look at non-cancer effects such as vascular disease, lens opacities and cognitive effects. The work will examine factors such as the dependence on energy deposition and on dose rate, tissue sensitivities, modification of risk by genetic and epigenetic factors and gender, the effect of age, of lifestyle, of physiological state and of environmental exposures, the possible radiation-induced hereditary contribution, and the role of non-targeted effects.

A substantial part of the DOREMI research programme is devoted to long-term strategic planning; developing a sustainable training and education network is another important DOREMI objective.

#### Coordinator

**Sisko Salomaa**

STUK – Radiation and Nuclear Safety

Authority

P.O.Box 14

FI-00881 Helsinki

Finland

Tel. +358 975988495

Fax +358 975988498

[sisko.salomaa@stuk.fi](mailto:sisko.salomaa@stuk.fi)

#### Project details

**Project type** // Network of Excellence

**Project start date** // 1.1.2010

**Duration** // 72 months

**Total budget** // EUR 21 048 715

**EC contribution** // EUR 12 999 999

#### EC project officer

**André Jouve**

European Commission

Directorate-General for Research and Innovation

Directorate Energy

Unit K.4 – Fission

CDMA 1/78

B-1049 Brussels, Belgium

[andre.jouve@ec.europa.eu](mailto:andre.jouve@ec.europa.eu)



## Societal impact

The magnitude of risks from exposure to low and protracted doses of ionising radiation, typical of those encountered in the workplace, the environment and in diagnostic medicine, is an important policy issue. There are substantial uncertainties as to the magnitude of risks at low doses, as well as the associated social and economic implications. These uncertainties are further exacerbated by evidence that the magnitude of risk may vary considerably between individuals, depending on their genotype.

A cautious assumption has been generally adopted: the risk of radiation increases linearly with increasing dose, with risks at higher doses having been assessed directly from epidemiological studies. However, scientific evidence is equivocal, and supports various interpretations of effects at low doses. These interpretations include a linear relationship between risk and dose, curvilinear relationships of a variety of forms (both supra- and sub-linear), the existence of a threshold, and radiation having a beneficial effect at low doses.

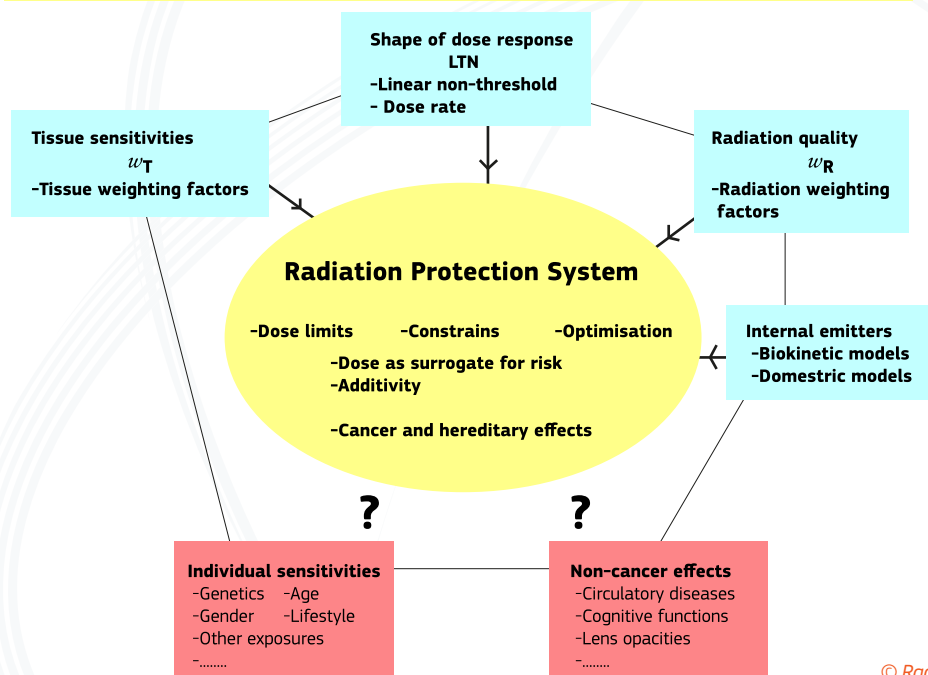
Another dimension in the assessment of risk is the type of health effects which occur at low doses — the current system of radiological protection takes into account cancer and hereditary effects, but not non-cancer effects such as cardiovascular diseases. Better quantification of risks at low doses and how they vary between individuals would have a positive impact on many policy areas.

## Public events

The DOREMI research strategy is accessible via its website, and open calls are organised to bring new beneficiaries into the consortium. The website also provides links to scientific publications as well as a wide range of other information on topics relevant to low-dose research.

DOREMI will engage with the scientific community by organising open and invitational workshops, and will conduct surveys on ongoing research and on infrastructures related to low-dose research.

### How robust is the system of radiation protection and risk assessment?



© Radiation and Nuclear Safety Authority Finland

## Partners

- Radiation and Nuclear Safety Authority (STUK), FI
- Institut de Radioprotection et de Sûreté Nucléaire (IRSN), FR
- Helmholtz Zentrum München (HMGU), DE
- Commissariat à l'énergie atomique et aux énergies alternatives (CEA), FR
- Health Protection Agency (HPA), UK
- University of Pavia (UNIPV), IT
- Istituto Superiore di Sanità (ISS), IT
- Belgian Nuclear Research Centre (SCK-CEN), BE

- Bundesamt für Strahlenschutz (BfS), DE
- University of Stockholm (SU), SE
- Centre for Research in Environmental Epidemiology (CREAL), ES
- Institut Curie (IC), FR
- Universitätsklinikum Erlangen (UKER), DE
- Johann Wolfgang Goethe Universität, Frankfurt am Main (GUF), DE
- Universität Rostock (UROS), DE
- Norwegian University of Life Sciences (UMB), NO
- Norwegian Radiation Protection Authority (NRPA), NO

- Nasjonalt Folkehelseinstitutt (NIPH), NO
- Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (ENEA), IT
- Institute for Environmental Sciences (IES), JP
- Dublin Institute of Technology (DIT), IE
- Erasmus Universitair Medisch Centrum Rotterdam (Erasmus MC), NL

## EPI-CT

The long-term risk of radiation-induced cancer or other effects on health following computerised tomography (CT) scanning have not yet been directly quantified, since no large-scale epidemiological studies of health risks associated with this procedure have ever been carried out.

The EU 'Prospective cohort studies of children with substantial medical diagnostic exposure' (CHILD-MED-RAD) project findings concluded that an international cohort study of paediatric CT procedures was feasible. Now, the EPI-CT project aims put the theory to the test by carrying out such a study; its conclusions will help lift the lid on any potential health risks posed by CT doses.

## Epidemiological study to quantify risks for paediatric computerised tomography and to optimise doses

### The power of statistics

The project consortium, made up of scientists from 10 EU Member States and one associated state, brings together experts from the branches of epidemiology, radiology, molecular biology, biostatistics, clinical medicine and dosimetry. The study uses cohort data from nine European countries: Belgium, Denmark, France, Germany, Spain, Sweden, the Netherlands, Norway and the United Kingdom. This will be the most statistically powerful study of paediatric CT undertaken to date. The study is ideally suited for evaluating factors associated with the use of paediatric CT scans, including indication for CT and the resultant organ-specific doses, and for deriving information to better understand the balance between the risks and benefits of paediatric imaging, so as to optimise the doses delivered from CT procedures.

### Activities

In each country, EPI-CT will assemble cohorts of paediatric patients on the basis of records of radiology departments with large numbers of paediatric populations. The patients' progress will be tracked over time to glean information on the incidence of leukaemia and cancer. Information on CT procedures will be abstracted to calculate individual organ-specific dose estimates. This will allow CT usage comparisons to be made across various regions and countries. Organ-specific radiation dose estimates associated with CTs can be described, and associations with biological endpoints and with cancer incidence quantified.

### Expected results

The project will establish retrospective cohorts in the participating countries, and where they already exist, it will extend them. It will then follow all cohorts prospectively. For leukaemia and cancer incidence, EPI-CT will establish links with national and regional cancer registries.

Using a picture archiving and communication system (PACS), the project will obtain information on technical parameters for dosimetric purposes. As extracting data from individual images is too time-consuming, software developed by the Public Research Centre (CRP) Henri Tudor in

### Coordinator

**Ausrele Kesminiene**

International Agency for Research on Cancer  
150 cours Albert Thomas  
69372 Lyon  
CEDEX 08  
France  
Tel. +33 472738452  
Fax +33 472738054  
[kesminiene@iarc.fr](mailto:kesminiene@iarc.fr)

### Project details

**Project type** // Collaborative Project

**Project start date** // 1.2.2011

**Duration** // 60 months

**Total budget** // EUR 7 245 573

**EC contribution** // EUR 2 998 594

### EC project officer

**André Jouve**

European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/78  
B-1049 Brussels, Belgium  
[andre.jouve@ec.europa.eu](mailto:andre.jouve@ec.europa.eu)

Luxembourg will be used to access data from the Digital Imaging and Communications in Medicine (DICOM) headers. The technical infrastructure of the server is presented in the figure below. Because the expected size of the cohort is quite large, automated dose reconstruction software for estimating individual organ doses for all members of the cohort will be developed. Using the individual radiation dose estimates, EPI-CT will evaluate leukaemia risk per unit (Gray (Gy)) of absorbed dose to the bone marrow.

The project will assess technical reasons for variation in dose and image quality by analysing a sample of CT images collected within the study and linked to CT procedure protocols used in different centres. Existing procedures aiming at reducing patient exposure or at improving image quality will be compared between the same CT machines in different centres; the intention is to harmonise the way optimised image quality is produced, providing the patient with the lowest dose compatible with the 'as low as reasonably achievable' (ALARA) principle.

A report detailing how to develop guidelines and recommendations for the optimal use of CT scans in paediatric patients will be prepared and presented to national and international radiation protection authorities.

## Societal impact

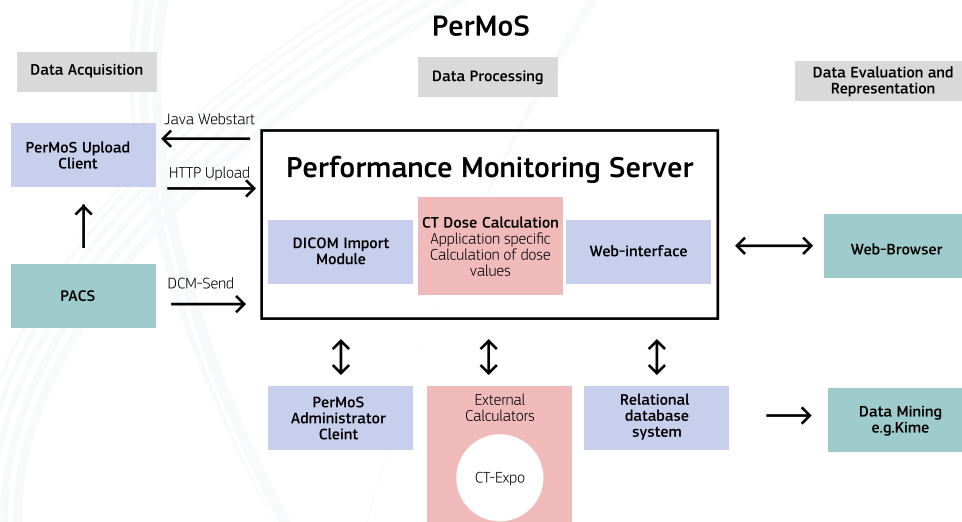
While physicians see benefits of using CT scanning in their clinical practice, concerns about the possible harmful effects of exposure to radiation from diagnostic radiologic procedures have existed for many decades. EPI-CT will help us better understand what these risks actually are.

Evaluating associations between the CT scan types, frequency, estimated bone marrow dose and leukaemia incidence have potentially important implications for the protection of paediatric patients.

Project results could be used as a basis for training radiologists and other technical personnel in how to optimise image quality and lower CT dose by adjusting scanning parameters.

## Information about important public events

A website was set up at the start of the project to inform users about the project and its goals: <http://epi-ct.iarc.fr>. A press release from the Centre international de Recherche sur le Cancer in France will be used to disseminate project results to the international media.



Technical infrastructure of the performance monitoring server (PerMoS).

© Dr Andreas Jähnen, CRP Henri Tudor, Luxembourg

## Partners

- Centre international de recherche sur le cancer (IARC), FR
- Universitaetsmedizin der Johannes Gutenberg-Universitaet Mainz (UMC-Mainz) DE
- Sateilyturvakeskus (STUK) FI
- Karolinska institutet (KI), SE
- University of Newcastle upon Tyne (UNEW), UK
- Centre de recerca en Epidemiologia ambiental (CREAL), ES
- Institut Gustave Roussy (INSERM), FR
- Kraeftens bekaempelse (DCS), DK
- Stichting het nederlands kanker Institut (NKI), NL
- Studiecentrum voor kernenergie-Centre d'etude de l'energie nucléaire (SCK-CEN), BE
- Institut de radioprotection et de Sûreté nucléaire (IRSN), FR
- Centre d'assurance de qualité des applications technologiques dans le domaine de la santé (CAATS), FR
- Centre de recherche public Henri Tudor (CRP), LU
- Norwegian radiation protection authority (NRPA), NO
- Oslo universitetssykehus ht – Cancer registry of Norway (OUS-CRN), NO
- Institut Curie (IC) FR
- Universiteit gent (UGent), BE
- Bundesamt fuer strahlenschutz (BfS), DE

## EpiRadBio

The value of cancer risk from exposures with doses comparable to the dose limits for occupationally exposed workers and its dependence on tissue, radiation type and individual factors is largely unknown. EpiRadBio's innovative approach combines epidemiology and radiobiology to quantify cancer risks after low-dose or low-dose-rate exposures to ionising radiation.

## Combining epidemiology and radiobiology to assess cancer risks in the breast, lung, thyroid and digestive tract after exposures to ionizing radiation with total doses in the order of 100 mSv or below

*Mechanisms down the curve of epidemiological data*

### Nature and scope of the project

EpiRadBio is the integration of genetic, mechanistic and epidemiological approaches that aim to answer some of today's most pressing questions surrounding radiation protection. A central question is 'What is the cancer risk from exposures that correspond to the dose limit of occupationally exposed people and from exposures that occur as a result of the use of ionising radiation in medical diagnostics. The consortium includes world-class modellers of carcinogenesis who have experience in the integration of radiobiological data in the evaluation of epidemiological data.

The main aim of EpiRadBio is to combine epidemiology and radiobiology to assess cancer risks in the breast, lung, thyroid and digestive tract after exposures to ionising radiation with cumulated equivalent doses of the order of 100 millisievert (mSv) or below. Such exposures are of central interest for radiation protection, since they correspond to:

- the dose limit for occupational exposure (100 mSv in 5 years);
- exposures currently occurring due to medical diagnostics, e.g. by a number of computed tomography (CT) examinations.

While most of these exposures are from low linear energy transfer (LET) radiation, exposures to high-LET radiation also occur. EpiRadBio will explore cancer risks arising from important types of low-LET radiation as well as those arising from high-LET.

### Coordinator

**Peter Jacob**

Helmholtz Zentrum München, Deutsches  
Forschungszentrum für Gesundheit und  
Umwelt

Ingolstaedter Landstr.1

85764 Neuherberg, Germany

Tel. +49 8931873022

[jacob@helmholtz-meunchen.de](mailto:jacob@helmholtz-meunchen.de)

### Project details

**Project type** // Collaborative Project

**Project start date** // 1.4.2011

**Duration** // 48 months

**Total budget** // EUR 9 449 020

**EC contribution** // EUR 5 818 073

### EC project officer

**Andre Jouve**

European Commission

Directorate-General for Research and  
Innovation

Directorate Energy

Unit K.4 – Fission

CDMA 1/78

B-1049 Brussels, Belgium

[andre.jouve@ec.europa.eu](mailto:andre.jouve@ec.europa.eu)



## Activities

Key factors of radiation-induced carcinogenesis such as genomic instability will be measured in cancer tissues and blood samples from members of the following radio-epidemiological cohorts: the French Haemangioma Cohort, the Mayak Worker Cohort, and thyroid cancer cases following the Chernobyl accident. Intercellular communication after exposure to low-dose radiation exposure and its influence on apoptosis, cell proliferation, differentiation and genomic instability will be explored with 2D cell cultures and 3D tissue models. This includes research on stem cells; these will be isolated from healthy human breast tissue.

Training will be provided for consortium participants, collaborating institutions and interested young scientists. A committee will be created that collaborates with the Project Management Group on the organisation of training. A student exchange programme will be established that provides support for students and junior scientists to work at participating institutes and to attend workshops. The activities will be coordinated with training activities as part of the European Network of Excellence 'Low dose research towards multidisciplinary integration' (DOREMI). One of the participants in the EpiRadBio consortium is leading DOREMI's Work Package 3, Education and Training.

## Expected results

The results of the radiobiological studies will be integrated into the development of models of carcinogenesis for the evaluation of major epidemiological cohorts: the Atomic Bomb Survivors, the French-Swedish-Italian Thyroid Cancer Cohort, the Mayak Worker Cohort, the Swedish Haemangioma Cohort, the UkrAm Cohort on thyroid cancer after the Chernobyl accident, and the UK National Registry for Radiation Workers. Cancer risk will be determined for the breast, lung, thyroid and the digestive tract after low-dose-rate exposure to low-LET radiation (external gamma radiation and internal radiation from radioiodine) and to high-LET radiation (alpha particles from incorporated plutonium). Lifetime cancer risks including individual risk factors will be calculated, to establish a new basis for deriving dose limits and estimating cancer risks, including those from medical diagnostic exposures.

## Societal impact

The proposed project contributes towards practically all expected impacts listed in the work programme concerning cancer.

- **Contributes to low-dose risk research.**
- The **shape of the dose response** will be elucidated for exposures with equivalent doses in the order of 100 mSv or below, i.e. in the region where the shape of dose response is currently under debate and which is relevant to risks from environmental, occupational and medical exposures.
- EpiRadBio will cover the risk of the most frequent and the most radiosensitive cancer types.
- Individual variability in radiation sensitivity will be addressed by analysing genomic instability.
- Cancer risks of different radiation quality types will be analysed.
- All these **areas/directions** have been **identified and prioritised by the High Level Expert Group on European Low Dose Risk Research (HLEG) as the most promising in terms of addressing/resolving key policy questions.**
- EpiRadBio applies a **multidisciplinary approach** involving clinicians, pathologists, radiobiologists, radiation chemists, radiation physicists, epidemiologists, statisticians, mathematical modellers and dosimetrists.
- EpiRadBio's innovative approach assesses **health effects through integration of radiobiological research and epidemiological studies of groups exposed to low-dose rates by better substantiating computational modelling assumptions.**
- The EpiRadBio consortium **includes non-radiation research biological communities**, e.g. the Microarray core facility at the University of Tübingen in Germany.
- EpiRadBio's approach is based on success and insights gained in earlier projects.



*Dr. Peter Jacob,  
Coordinator of EpiRadBio.  
© Helmholtz Zentrum München*

## Partners

- Helmholtz Zentrum München Deutsches Forschungszentrum für Gesundheit und Umwelt (HMGU), DE
- Commissariat à l'énergie atomique et aux énergies alternatives (CEA), FR
- The Chancellor, Masters and Scholars of the University of Oxford (UOXFH3), UK
- Institut National de la Santé et la Recherche Médicale (INSERM), FR
- Säteilyturvakeskus (STUK), FI
- Università degli Studi di Pavia (UNIPV), IT
- Stockholms Universitet (SU), SE
- Queen's University Belfast (QUB), UK
- Universitaet Rostock (UROS), DE
- Universität Tübingen (UTU), DE
- Federal State Unitary Enterprise Southern Urals Biophysics Institute of Federal Medicobiological Agency (SUBI), RU
- Göteborgs Universitet (UGOT), SE
- Karolinska Institutet (KI), SE
- Health Protection Agency (HPA), UK
- State Institution 'V.P. Komissarenko Institute of Endocrinology and Metabolism of the National Academy of Medical Sciences of Ukraine' (IEM), UA
- Imperial College of Science, Technology and Medicine (Imperial), UK
- Vereniging voor Christelijk Hoger Onderwijs Wetenschappelijk Onderzoek en Patientenzorg (Vumc), NL

## NERIS-TP

Over the past five years, significant progress has been made in the radiological and nuclear emergency management and rehabilitation field. Crucial to this success was the Sixth Framework Programme (FP6) project EURANOS ('European approach to nuclear and radiological emergency management and rehabilitation strategies') which integrated 17 national emergency management organisations with 33 research institutes and brought together best practices, knowledge and technology to enhance Europe's response to any radiation emergency and long-term contamination. Now NERIS-TP builds on this groundwork.

## Towards a self sustaining European Technology Platform (NERIS-TP) on Preparedness for Nuclear and Radiological Emergency Response and Recovery

### Improving national approaches

The project partners all aim to improve current national approaches, identify new and emerging challenges and support a European training programme that maintains and develops expertise. In particular the following important topics have to be addressed:

- improving the effectiveness of current European, national and local approaches;
- promoting a more coherent response to nuclear and radiological emergency throughout Europe;
- identifying gaps and needs for further research and technological developments;
- addressing new and emerging challenges within the field;
- Maintaining and improving technical expertise and know-how among all interested stakeholders in Europe and beyond.

### Five-pronged approach

NERIS-TP project activities will be performed under five distinct work packages:

- support the development and operation of the European Platform on Preparedness for Nuclear and Radiological Emergency Response and Recovery (NERIS Platform) to further improve emergency response and recovery preparedness in Europe;
- improve the early and late countermeasure modules of ARGOS and RODOS for the new International Commission on Radiological Protection (ICRP) approach for emergency and existing situations;
- strengthen preparedness at the local/national level;
- coupling an early notification system with the existing European Decision Support Systems (RODOS/ARGOS);
- test, train and disseminate the new methods and products developed in NERIS-TP.

### Coordinator

#### Wolfgang Raskob

Karlsruhe Institute of Technology  
Institut für Kern- und Energietechnik  
Hermann-von-Helmholtz-Platz 1  
76344 Eggenstein-Leopoldshafen  
Germany  
Tel. +49 72160822480  
Fax +49 72160825508  
[wolfgang.raskob@kit.edu](mailto:wolfgang.raskob@kit.edu)

### Project details

**Project type** // Collaborative Project

**Project start date** // 1.2.2011

**Duration** // 36 months

**Total budget** // EUR 2 333 784

**EC contribution** // EUR 1 455 747

### EC project officer

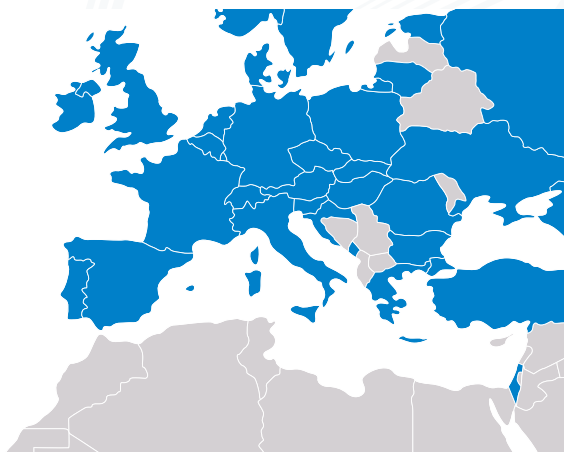
#### Michel Hugon

European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/52  
BE-1049 Brussels, Belgium  
[michel.hugon@ec.europa.eu](mailto:michel.hugon@ec.europa.eu)

## Expected results

The overall goal of the project is to establish a self-sustainable platform where the operational and research community can meet and discuss topics related to emergency response and recovery preparedness with all the relevant stakeholders. The project will also develop how the NERIS Platform will be self sustainable at the end of the three years. Equally, the project also aims to tackle urgent research topics in nuclear emergency response and recovery preparedness, this will strengthen the European dimension of emergency management and rehabilitation by providing new and updated simulation modules for ARGOS and RODOS Decision Support Systems that are used in many European countries. This will contribute to a harmonisation of tools all over Europe.

At the end of the project, both decision support systems ARGOS and RODOS will be enhanced with simulation models taking into account the new recommendations issued by ICRP and International Atomic Energy Agency (IAEA) and coupled to an early notification system with the capability to perform assessments worldwide. In their armoury they also hope to have local/national tools that strengthen response at all levels in the early and late phases of an emergency.



ARGOS and RODOS users group.

© KIT

## Societal impact

The first overall impact of the NERIS-TP project is the establishment of a sustainable European Platform that will build the focal point for improving the effectiveness of current European, national and local approaches for preparedness concerning nuclear or radiological emergency response and recovery. Closing existing gaps, in particular introducing the new international recommendations from ICRP and IAEA by introducing the residual dose as target for the protection of the population will clearly improve the acceptance of measures of the acting organisations.

A further impact is the better preparedness for such an unlikely event. Having defined a strategy a priori and having all relevant stakeholders exchange views on it will allow the acting organisations to complete the strategy in a successful manner in the early phase when top-down approaches are necessary. Further, decision making on longer term aspects will be considerably improved with the new system as the long-term effects require close interaction of local, national and stakeholder organisations in an integrated way.

## Information about important public events

The first large-scale public event was the NERIS workshop 'Preparedness for Nuclear and Radiological Emergency Response and Recovery: Implementation of ICRP recommendations' which took place on 6–8 February 2012 in Bratislava, Slovakia. A second large workshop on preparedness at the local level is planned in the third year of the project.

## Partners

- Karlsruhe Institute of Technology (KIT), DE
- Centre d'étude sur l'Evaluation de la Protection dans le domaine Nucléaire (CEPN), FR
- Norwegian Radiation Protection Authority (NRPA), NO
- VUJE Inc. (VUJE), SK
- Radiation and Nuclear Safety Authority of Finland (STUK), FI
- Universidad Politécnica de Madrid (UPM), ES
- Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT), ES
- MUTADIS (MUTADIS), FR
- Horia Hulubei National Institute of R&D for Physics and Nuclear Engineering (IFIN-HH), RO
- National Centre for Scientific Research "Demokritos" (NCSR), EL
- Risø National Laboratory for Sustainable Energy Technical (Risø-DTU), DK
- Danish Emergency Management Agency (DEMA), DK
- Prolog Development Centre (PDC), DK
- Health Protection Agency (HPA-CRCE), UK
- Norwegian University of Life Sciences (UMB), NO
- Ukrainian Center of Environmental and Water Projects (UCEWP), UA
- Bundesamt für Strahlenschutz (BfS), DE
- Belgian Nuclear Research Centre (SCK-CEN), BE
- University of Western Macedonia (UOWM), EL



## PROCARDIO

For decades the heart was considered a radiation resistant organ, and no special care was taken to avoid irradiation of the heart during radiation therapy or diagnostic imaging procedures such as CT scans and X-rays.

Two large epidemiological studies have now forced us to challenge this notion.

## Cardiovascular Risk from Exposure to Low-dose and Low-dose-rate Ionizing Radiation

*Defining the risks of low-dose radiation on the cardiovascular system*

### Research based on major studies

One of these studies (Darby, S., et al. Mortality from cardiovascular disease more than 10 years after radiotherapy for breast cancer: nationwide cohort study of 90 000 Swedish women. *Br Med J* 2003; 326(7383):256–257) shows us that women receiving radiation therapy for a tumour in the left breast (where the heart was included in the radiation treatment field) were seen to have a higher frequency of cardiovascular death compared to women treated for the disease in the right breast. Another study (Azizova, T.V., et al. Ischemic Heart Disease in Nuclear Workers First Employed at the Mayak PA in 1948–1972. *Health Phys.* 2012 Jul;103(1):3–14) showed that although nuclear industry workers receive considerably less radiation exposure than radiation therapy patients, nevertheless they have a slightly increased risk of cardiovascular disease compared to their non-irradiated colleagues.

Despite these breakthroughs we still do not know what types of radiation close to the heart is liable to cause disease later in life, nor do we have a clear concept of how low doses of radiation damage the tissues of the heart and blood vessels. The aim of the PROCARDIO project is to better understand these phenomena.

### Activities

To understand the degree of risk associated with low-dose radiation exposure the PROCARDIO team will look at cancer patients treated with radiation therapy. In this case, the focus will be on the survivors of childhood cancer. Although these children received radiation doses to tissues some distance from the heart, some exposure to the sensitive organ was unavoidable. In partnership with the Seventh Framework Programme (FP7) project PanCareSurFup ('PanCare Childhood and Adolescent Cancer Survivor Care and Follow-Up Studies') the team are following the health of these cancer survivors, now adults, to monitor changes to their heart and blood vessels.

### Coordinator

**Mike Atkinson**

Institute of Radiation Biology  
Helmholtz Zentrum München  
Ingolstaedter Landstrasse 1  
85764 Neuherberg,  
Germany  
Tel. +49 8931872983  
Fax +49 8931873378  
[atkinson@helmholtz-muenchen.de](mailto:atkinson@helmholtz-muenchen.de)

### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.1.2011  
**Duration** // 36 months  
**Total budget** // EUR 2 004 728  
**EC contribution** // EUR 1 171 470

### EC project officer

**André Jouve**

European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/78  
B-1049 Brussels, Belgium  
[andre.jouve@ec.europa.eu](mailto:andre.jouve@ec.europa.eu)



In parallel, a study of the effects of new radiation treatments that use accelerated sub-atomic particles or even heavy ions to penetrate deep into tissues is being carried out. These new therapies do not deliver a radiation dose to tissues they pass through, but their effects on the heart are unknown.

The third consortium activity is to determine just how radiation damages the heart and circulation. This knowledge is essential for the complex mathematical procedures that allow us to predict the health risks of low-dose radiation, as the mathematical models must describe mechanisms of radiation damage that remain completely uncertain. Together with the EURATOM project CEREBRAD ('Cognitive and Cerebrovascular Effects Induced by Low Dose Ionizing Radiation'), a number of different possible actions of radiation on the heart and blood vessels are being tested, from destruction of the blood vessel lining cells through to injury to the mitochondrial energy factories of the muscle cells.

## Societal impact

Exposure of the heart and vessels to radiation is an almost unavoidable consequence of modern life. Not only do we receive background radiation exposure from terrestrial sources, but we also encounter exposures from medical treatment and especially from diagnostic procedures. For those working in the nuclear industry radiation exposure is strictly limited, but nevertheless some exposure to the heart is unavoidable. Current legislation that is designed to limit the risk of cancer following radiation exposure is believed to offer an effective protection against cardiovascular diseases. However, past experience has shown that the danger to the heart has been consistently underestimated so we can no longer rely upon assumptions that may be erroneous. Through our studies on childhood cancer survivors we will provide one additional source of evidence to assist in determining the risk of heart disease after radiation exposure. Our biological research will begin to unravel the mystery of how radiation actually causes damage. Together these activities will help to make better judgement on the risk of low-dose radiation exposure to the heart and blood vessels.

## Important public events

The PROCARDIO website offers information on the project for stakeholders and policymakers, for academia and regulatory authorities, and for the media and interested members of the public. Updates will show where members of PROCARDIO will be releasing information on our newest findings to the scientific community, and will provide summaries of all new published work. A regular newsletter (available by subscription) will provide opinion and insight into the results of PROCARDIO. The PROCARDIO website offers interactive opportunities to follow the project activities via Facebook and Twitter.



*Measurement of the electrophysiological changes in beating murine heart tissue following exposure to low doses of radiation.*

© GSI HelmholtzZentrum für Schwerionenforschung

## Partners

- Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (ENEA), IT
- Gabo:mi Gesellschaft für Ablauforganisation: Milliarium mbH & Co. Kg (GABO), DE
- Health Protection Agency (HPA), UK
- Helmholtz Centre Munich (HMGU), DE
- Institut Gustave-Roussy (IGR), FR

## RENEB

The RENEB project will coordinate the consolidation of European laboratories with experience in biological dose estimation with the aim of bringing all these laboratories together into a single European Biodosimetry network. At the end of the project, a non-profit international organisation will be established that will guarantee fast and reliable biological dose reconstruction in the event of a large-scale radiological accident.

## Realizing the European Network of Biodosimetry

### Preparing for an emergency

The number of people that may need to be screened for dose estimation after a large-scale radiological incident will easily exceed the capacity of a single or even a number of laboratories. As a result biodosimetry networking has been recognised as a sensible and important emergency response strategy by national and international emergency management organisations. An established European network in biodosimetry will thus guarantee maximum efficiency for the processing and scoring of biological samples in the event of a large-scale radiological event. Integrated into the EU emergency management structures, it will be the sole means of getting a fast and trustworthy biological dose assessment in an emergency situation.

The RENEB consortium brings together leading European scientists in the field of biological dosimetry from 23 organisations and 16 countries. Most of the laboratories have practical experience in the handling of radiation incidences and their authorities have made long-term commitments to contribute to a biodosimetry network.

### Activities

An essential requirement for effective networking is a comparable standard of the procedures applied for dose estimation in the laboratories. It is the aim of RENEB to harmonise the procedures of various assays used within the network. In this regard, requirements of international standards will be developed and regular training exercises will be performed. This education and training programme will be open for both members and non-members of the network. In parallel, a long-term training programme will be established to guarantee consistent high standards within the network. Additionally, a quality assurance and management (QA&QM) programme will be set up within the consortium. This will be an ongoing process and will also comprise methods and members which are newly accepted into the network. The RENEB training programme will be connected to European training courses and international organisations performing training. RENEB will also be linked to national and international emergency and preparedness systems.

### Coordinator

**Ulrike Kulka**

Federal Office for Radiation Protection (BfS)  
Ingolstaedter Landstrasse 1  
85764 Oberschleissheim, Germany  
Tel. +49 30183332210  
Fax +49 30183332205  
[ukulka@bfs.de](mailto:ukulka@bfs.de)

### Project details

**Project type** // Coordination Action and support

**Project start date** // 1.1.2012

**Duration** // 48 months

**Total budget** // EUR 1 614 243

**EC contribution** // EUR 999 182

### EC project officer

**Kateřina Ptáčková**

European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/60  
B-1049 Brussels, Belgium  
[katerina.ptackova@ec.europa.eu](mailto:katerina.ptackova@ec.europa.eu)



## Information about important public events

RENEB will be presented at major scientific conferences, international emergency management meetings and through publications in peer reviewed journals. RENEB-Satellite symposiums held during international congresses will be openly announced on the project's website. Standards and benchmarks for quality assurance will also be openly accessible on the project's website ([www.reneb.eu](http://www.reneb.eu)).

*RENEB\_Kick-off meeting-a 2012.*

© Ulrike Kulka

## Societal impact

It can be presumed that a malevolent attack will occur without any advance warning and will target as many people as possible in order to cause the maximum amount of damage. Following such a scenario, sorting out patients according to their degree of injury and exposure will be one of the most important initial steps. The situation during large-scale accidents may differ, as often an advanced warning allows for precise dose surveillance within the disaster area. However, in order to prevent the healthcare infrastructure being overwhelmed and to minimise socioeconomic harm, in such an event it is important to identify the "worried well" individuals, i.e. people who are extremely distressed but have not actually received radiation doses likely to cause acute health effects.

In both contexts, biological dosimetry is an essential tool for estimating an actual absorbed dose without being influenced by temporal or individual variations in blood counts or confounding factors such as chemical agents or psychogenic reactions. Biological dosimetry will help to distinguish people needing extensive medical care due to severe irradiation from people with injuries who have not received high doses of ionising radiation. In this regard, RENEB will impact on emergency preparedness and management through fast and reliable biological dose estimation in the event of a large-scale radiological incident.

## Partners

- Bundesamt für Strahlenschutz (BfS), DE
- Institut für Radiobiologie der Bundeswehr in Verbindung mit der Universität Ulm (BIR/UULM), DE
- Commissariat à l'Énergie Atomique (CEA), FR
- Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (ENEA), IT
- Helmholtz Centre Munich (HMGU), DE
- Health Protection Agency (HPA), UK
- Instytut Chemii i Techniki Jądrowej (ICTJ), PL
- Institutul National de Sanatate Publica (INSP), RO
- Institut de Radioprotection et de Sécurité Nucléaire (IRSN), FR
- Istituto Superiore di Sanità (ISS), IT
- Instituto Tecnológico e Nuclear (ITN), PT
- Fundacion para la Investigacion del Hospital Universitario La Fe de la Comunidad Valenciana (LAFE), ES
- Leiden University Medical Center (LUMC), NL
- National Centre of Radiobiology and Radiation Protection (NCRRP), BG
- National Centre for Scientific Research "Demokritos" (NCSR-D), EL
- National Research Institute for Radiobiology & Radiohygiene (NRIRR), HU
- Norwegian Radiation Protection Authority (NRPA), NO
- Radiation and Nuclear Safety Authority (STUK), FI
- Stockholm University (SU), SE
- Universitat Autònoma de Barcelona (UAB), ES
- Universiteit Gent (UGent), BE
- University of Tuscia (UNITUS), IT
- Servicio Madrileño de Salud, Hospital General, Universitario Gregorio Marañón (SERMAS), ES



## SOLO

SOLO is a four-year integrated, multidisciplinary project that aims to investigate the risks of radiation exposure. It involves dosimetrists, operational health physicists, statisticians and epidemiologists from nine institutions in the EU (6), Russia (2) and the United States (1).

The project will study the health of two key radiation exposed populations from the Southern Urals of Russia. Its aims are to derive better estimates of the risks of cancer and some non-cancer diseases from long-term exposure to ionising radiation.

## Epidemiological Studies of Exposed Southern Urals Populations

*Exploiting epidemiological data for protecting people against the harmful effects of ionising radiation*

### Exposed populations

The Mayak nuclear facility situated in the Chelyabinsk region of Russia began operating in 1948 to produce plutonium for the Soviet atomic weapons programme. Workers at the plant, who lived in the nearby city of Ozyorsk, were for a number of years exposed to ionising radiation, often at high levels. Residents of villages along the Techa River were also exposed. Techa flows close to the plant and radioactive waste was discharged into it. Both groups were also exposed as a result of an accident at Mayak in 1957.



*Mayak and Ozyorsk also showing the Techa river.*

© NASA World Wind, Landsat Global Mosaic visual layer

Current and former Mayak workers, who are still living in Ozyorsk, have annual medicals in which smoking and alcohol consumption information is recorded. This makes them particularly valuable for studying the effects of radiation on diseases that are affected by smoking and alcohol consumption, such as cancer and circulatory diseases. The project aims to improve the estimates of the risks of long-term health effects associated with protracted external and internal low-dose radiation exposures, through the study of a group of 22 000 current and former Mayak workers and a sub-group of the 43 000 offspring of the local population who lived near the Techa River. Both of these groups were set up under previous projects.

### Coordinator

**John Harrison**

Health Protection Agency  
Chilton, Didcot  
Oxon  
OX11 0RQ  
United Kingdom  
Tel. +44 1235831600  
Fax +44 1235833891  
[john.harrison@hpa.org.uk](mailto:john.harrison@hpa.org.uk)

### Project details

**Project type** // Collaborative Project  
**Project start date** // 1.3.2010  
**Duration** // 54 months  
**Total budget** // EUR 9 million  
**EC contribution** // EUR 5 million

### EC project officer

**André Jouve**

European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/78  
B-1049 Brussels, Belgium  
[andre.jouve@ec.europa.eu](mailto:andre.jouve@ec.europa.eu)



## Activities

SOLO has four complimentary scientific sub-projects that seek to improve estimates of radiation doses and estimates of risks of cancer and non-cancer diseases in relation to exposures to different types of radiation by workers and members of the public.

Estimates of radiation doses will be improved by comparing results between project partners using different measurement techniques, including Electron Paramagnetic Resonance and Fluorescence In Situ Hybridisation techniques.

Project partners will perform epidemiological studies of the incidence of cancer and non-cancer diseases (respiratory and circulatory diseases) among Mayak workers in relation to external radiation exposures and deposition of plutonium in the lungs and other body organs (mainly liver and skeleton). These analyses will make use of smoking and alcohol consumption data that are available for this worker group so that effects attributable to radiation can be distinguished.

The project partners will also develop a joint protocol for the measurement of doses to Mayak workers exposed internally to plutonium and a similar group of workers from the Sellafield nuclear plant in the United Kingdom. Then, subject to a feasibility study, they will perform an epidemiological study of cancer and non-cancer diseases (lung cancer, leukemia and circulatory disease) in these two groups.

Subject to a feasibility study, the team will carry out an epidemiological study of cancer in a group of children born to women from either of the Mayak and Techa River groups who were exposed to radiation while pregnant (approximately 8 000 children in total).

## Expected results

Studies of the Mayak and Techa cohorts provide a unique opportunity to obtain information on risks associated with chronic exposures over many years to external radiation and radionuclides deposited internally in body tissues (internal emitters). There are many challenges to the radiation protection standards recommended by the International Commission on Radiological Protection (ICRP), with arguments that risks at low doses, particularly from internal emitters, are either grossly underestimated or overestimated. These studies will provide directly relevant data that will improve protection. The health of Mayak workers has been followed closely and good information is available on their smoking histories and alcohol consumption so that the effect of these can be taken into account in assessing risks of disease related to radiation exposures (e.g., lung and liver cancers, respiratory and circulatory diseases).

Very limited information is available on radiation risks associated with exposures of the unborn child as a result of exposures of their mothers. Combining information for Mayak and Techa mothers provides a unique opportunity to compare risks for irradiation of the fetus with risks at later ages.

Pooling epidemiological studies increases the statistical power of any observed effects. Initial comparisons of Mayak and Sellafield plutonium workers, and later combinations of results will maximize the potential to obtain meaningful and reliable results.

## Partners

- Health Protection Agency (Coordinator) (HPA), UK
- Southern Urals Biophysics Institute (SUBI), RU
- Urals Research Centre for Radiation Medicine (URCRM), RU
- Helmholtz Zentrum Muenchen - National Centre for Environmental Health GmbH (HMGU), DE
- International Agency for Research on Cancer (IARC), FR
- University of Manchester (UNIMAN), UK
- Istituto Superiore di Sanità (ISS), IT
- Leiden University Medical Centre (LUMC), NL
- University of Florida (UF), US

## STAR

The need for radioecological expertise continues at a high level worldwide. The need is increasing in some countries due to a renewed interest in nuclear energy, and remains a necessity in others because of the associated environmental challenges related to the production of nuclear energy, the presence of contaminated legacy sites, nuclear medical applications, the NORM industry, development of safe storage systems for nuclear waste, and emergency preparedness. Concurrently, educational opportunities in radioecology have steadily declined, leading experts are retiring, and funding for radioecological research is much reduced. STAR, a European Network of Excellence (NoE) in Radioecology, was created to confront these challenges and to encourage integration among radioecological organizations across Europe.

## Strategy for Allied Radioecology

### *European competence in environmental radioactivity*

#### Nature and scope of the project

Radioecology is the science which acquires knowledge and develops tools for assessing the risks of environmental radioactivity to humans and the environment. STAR's goal is to strategically integrate portions of the radioecology programmes of key European organisations by sharing infrastructures, collaborating in research, developing joint educational programmes, and collectively managing and disseminating associated knowledge. STAR is composed of national nuclear research centres in Belgium and Spain, the national radiation protection authorities of Finland, Germany and Norway, universities in Norway and Sweden, the French Nuclear Technical Safety Organisation, and the United Kingdom's National Environmental Research Council. Collectively, these nine organisations retain key radioecological infrastructures, have significant long-term experience in radioecology, and are well equipped to launch associated educational programmes.

#### Activities

STAR has an active research programme that focuses on three main research lines:

- developing methods to integrate environmental and human risk assessments from radiological exposures;
- exploring whether exposures to mixtures of stable chemical contaminants and radionuclides cause interactions that need to be considered within radiological protection criteria; and,
- enhancing the scientific robustness of ecological protection criteria and their applicability as protection benchmarks from chronic exposures to low doses of ionising radiation.

Information generated from STAR's research will be openly exchanged by a fluid, robust knowledge-sharing initiative. Web-2 technology and social networking services will be used to promote radioecology and to engage interested stakeholders. Associated educational programmes will ensure that students acquire the radioecological competences that employers seek. STAR's programmes intend to show students that exciting career paths exist within radioecology.

STAR will also develop a Strategic Research Agenda (SRA) and associated roadmap of long-term goals in radioecology, and will invite consultation and recommendations on the SRA from diverse stakeholders (e.g., international organisations, scientific community, regulators, industries).

#### Coordinator

**Thomas Hinton**

Institut de Radioprotection et de Sécurité  
Nucléaire (IRSN)  
Bat 159 – BP 3  
13115 Saint-Paul-Lez-Durance Cedex  
France  
Tel. +33 0442199532  
Fax +33 0442199145  
[thomas.hinton@irsn.fr](mailto:thomas.hinton@irsn.fr)

#### Project details

**Project type** // Network of Excellence

**Project start date** // 1 February 2011

**Duration** // 54 months

**Total budget** // EUR 7 994 014

**EC contribution** // EUR 3 999 756

#### EC project officer

**André Jouve**

European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/78  
B-1049 Brussels, Belgium  
[andre.jouve@ec.europa.eu](mailto:andre.jouve@ec.europa.eu)

## Expected results

STAR will promote integration, networking and scientific excellence to enhance human and environmental radiation protection. STAR activities will support the radioecological needs of national authorities, non-governmental organisations, industry, scientists and the public. A vital role of STAR is to develop a transition plan of sustainability that invokes a permanent management structure (the European Radioecology Alliance) and acquires long-term funding for radioecological research, infrastructure, training and education.

STAR will develop field Observatories for Radioecological Research. Observatories are select contaminated field sites chosen to enable scientists to test hypotheses and approaches developed within the SRA. Focused research at common sites will maximize improvements in methods and models, leading to an enhanced, more process-based understanding of radionuclide behaviour and effects. Data collected from these sites will be made accessible on the STAR Web portal resulting in a valuable European data compilation. Such a pooled, consolidated effort will facilitate the sharing of data and resources, as well as provide excellent opportunities for training and education. STAR's efforts are state-of-the-art, innovative and multidisciplinary. STAR will make significant contributions to the scientific basis and associated tools that reduce uncertainty and give greater confidence to radiation protection methods and standards.

## Societal impact

Radioecology considers how radioactive substances released to or present in the environment are dispersed by different transfer processes and retained by various environmental components. The quantification of these processes allows determination of the dose from radiation and the assessment of human and environmental risks. STAR will strengthen and secure a sustainable integrated European training and education platform in radioecology that will attract top-level graduates, and maintain a relevant workforce that is in a position to meet future economic and societal needs within the nuclear sciences. STAR will also strategically prioritise research efforts to reduce key data gaps and the uncertainties associated with determining risks from exposure to environmental radioactivity. In doing so, STAR will ensure that Europe maintains its position as a world leader in radioecology.

## Information about important public events

To address stakeholders' needs and policy questions, a strong link with end users will be achieved via dedicated workshops, conferences and advanced dissemination tools. STAR's Web portal, The Radioecology Exchange ([www.star-radioecology.org](http://www.star-radioecology.org)), and other social networks will be used for disseminating information about STAR's activities, outputs and resources (databases, publications, sample archives, analytical methods, models and education materials).



*Isabelle Cavalié, Virginie Camilleri, Simona Al Kassidi Institute of Radioprotection and Nuclear Safety; « Binocular microscopy of zebrafish embryos during a uranium contamination experiment »  
Photographer: IRSN*



*Clare Bradshaw and Maria Thorsson Stockholm University « Sampling plankton and macroalgae »  
Photographer: Erik Wijnblad*

## Partners

- Institut de Radioprotection et de Sûreté Nucléaire (IRSN), FR
- Säteilyturvakeskus (STUK), FI
- Studiecentrum voor kernenergie (SCK-CEN), BE
- Natural Environment Research Council (NERC), UK
- Centro de investigaciones energéticas, medioambientales y tecnológicas (CIEMAT), ES
- Stockholms Universitet (SU), SE
- Bundesamt fuer Strahlenschutz (BfS), DE
- Norwegian radiation protection authority (NRPA), NO
- University of Life Sciences (UMB), NO



# ALICE

The aim of ALICE is to demonstrate access to large irradiation infrastructures in Europe and China for research purposes. The project will develop and validate a flexible design method for irradiation capsules and demonstrate its feasibility in a European material test reactor (MTR) and in the China Experimental Fast Reactor (CEFR). Besides the technical work, the project will also come up with a road map for scientists from Europe and China on how to access large irradiation facilities in both regions.

## Access to large infrastructures in China and Europe

### Nature and scope of the project

The project is undertaken by a consortium of European partners operating or using large irradiation facilities for materials testing. They represent a selection of expertise centres for nuclear material research for advanced applications, as presented below.

- SCK-CEN, the Belgian Nuclear Research Centre, operates the only 100 MW-power material test reactor in Europe, the Belgian Reactor 2 (BR2). The centre is developing the Multi-Purpose Hybrid Research Reactor for High-tech Applications (MYRRHA), a fast spectrum experimental facility representative of liquid lead alloy-cooled fast reactors and accelerator-driven systems.
- CEA, the French Alternative Energies and Atomic Energy Commission, has recognised scientific and technological experience in materials irradiation and testing. It is operating several research reactors and developing a new materials test reactor (the Jules Horowitz Reactor) and the Advanced Sodium Technical Reactor for Industrial Demonstration (ASTRID).
- KIT, the Karlsruhe Institute of Technology, is a leading research institute in Germany in the field of nuclear safety, including materials research and partitioning and transmutation technology.
- CV Řež, the Research Centre Řež, operates the LVR-15 reactor, the Czech research reactor. CV Řež is involved in the development of Generation IV nuclear reactor concepts and has well-established experience with construction and operation of test loops.
- AEKI, the Hungarian Academy of Sciences KFKI Atomic Energy Research Institute, operates the Budapest research reactor and is a member of the Eastern European Research Reactor Initiative.

The European partners will coordinate their efforts with their Chinese counterpart, the Chinese Institute of Atomic Energy (CIAE). CIAE operates several large irradiation facilities, including the CEFR. This reactor is of particular interest for those carrying out research into Generation IV nuclear reactor materials.

The main aim of the project is to demonstrate the accessibility of large irradiation infrastructures in Europe and China for partners from both regions, both in technical and in administrative terms.

### Coordinator

**Steven Van Dyck**  
SCK-CEN  
200, Boeretang  
B2400 Mol  
Belgium  
Tel. +32 14332400  
Fax +32 14320513  
[svdyck@sckcen.be](mailto:svdyck@sckcen.be)

### Project details

**Project type** // Coordination and Support Action  
**Project start date** // to be confirmed  
**Duration** // 48 months  
**Total budget** // EUR 1 101 010  
**EC contribution** // EUR 624 000

### EC project officer

**Panagiotis Manolatos**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/53  
B-1049 Brussels, Belgium  
[panagiotis.manolatos@ec.europa.eu](mailto:panagiotis.manolatos@ec.europa.eu)





Top view of the BR2 reactor at SCK-CEN in Mol, Belgium.

© SCK-CEN in Mol, Belgium

## Activities

The development of new nuclear technologies for Generation IV type reactors requires materials qualification under relevant conditions. Therefore, access to irradiation facilities and the availability of suitable irradiation devices is developed and validated. The project is structured around four main work packages (WPs):

- WP 1: access conditions description, to define access procedures to the facilities in technical and administrative terms;
- WP 2: experimental design method development, in order to construct devices according to a validated methodology to achieve the appropriate irradiation conditions;
- WP 3: validation experiment in the accessible BR2 reactor;
- WP 4: demonstration experiment in the new CEFR reactor.

In WP 0, the management WP, provisions are made for disseminating the project results, publishing calls for participation and sharing the experience of access to irradiation infrastructure in both regions. The design method for experiments is shared between experienced reactor operators and new researchers in the material testing field.

## Expected results

The following key results are expected:

- access manuals to irradiation infrastructures, to lower the threshold for external users of these unique research infrastructures;
- validated experimental design methodologies with flexible applicability between different reactors, to reduce lead time for experiments and enhance utilisation of the infrastructures;
- validation and demonstration of irradiation experiments, to add unique data to the database for irradiation performance of materials.

## Societal impact

- The development of Generation IV type nuclear reactors has the potential to offer a sustainable option for nuclear energy, with minimised amounts of waste, optimised use of natural resources and enhanced safety.
- The improved accessibility of research reactors will broaden their user community, resulting in better and sustained use as well as optimisation of the new builds through a better balance of offer and demand of irradiation services.
- The users of the project results are scientists and industries involved in materials testing, nuclear safety and technology development, and irradiation service providers and users.

## Partners

- Studiecentrum voor Kernenergie – Centre d'Etude de l'énergie Nucléaire (SCK-CEN), BE
- Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), FR
- Karlsruher Institut für Technologie (KIT), DE
- Centrum výzkumu Řež s.r.o. (CV Řež), CZ

- Magyar Tudományos Akadémia KFKI Atomenergia Kutatóintézet (AEKI), HU

# ALISA

The objective of the ALISA project is to provide transnational access to large research infrastructures in Europe and in China to allow for optimal use of the resources in the extremely complex field of severe accident analysis for existing power plants. The facilities involved in the project are designed for the study of severe accident safety issues ranked as high or medium priority by the Severe Accident Research Priorities (SARP) group of the SARNET Network of Excellence.

## Access to Large Infrastructures for Severe Accidents

### Nature and scope of the project

Coolability of a degraded core, corium coolability in the reactor pressure vessel (RPV), melt dispersion to the reactor cavity, and hydrogen mixing and combustion in the containment are extremely complex phenomena that demand specific research involving substantial resources; the research field is too wide to allow the study of all the phenomena by any single national programme. To optimise use of resources, collaboration between nuclear utilities, industry groups, research centres and safety authorities at both European and Chinese levels is very important.

This is the main objective of the ALISA project, which aims to provide these resources and facilitate this collaboration by providing large-scale experimental platforms in Europe and in China for transnational access. ALISA offers the opportunity for European and Chinese partners to get involved in the networks and activities supporting the safety of existing and advanced reactors and it allows European and Chinese researchers to work together as equal partners and develop a common safety culture.

### Activities

The experimental facilities offered as part of ALISA are unique in that they provide the possibility to perform experiments in specific fields of reactor core damage initiation up to hydrogen behaviour. Top-level scientists from two European research organisations (KIT and CEA), two Chinese research organisations (CNPRI and SNPTC) and two Chinese universities (SJTU and XJTU) are participating actively in ALISA, providing the necessary technological competence and scientific excellence to successfully fulfil the objectives of the project. The experiments are designed to be complementary to other experimental facilities and projects to form a coherent nuclear experimental network. They will contribute to better understanding of the core melt sequences and thus improve safety of existing and, in the long term, future nuclear power plants through severe accident mitigation measures and safety installations where required.

### Coordinator

**Alexei Miassoedov**

Karlsruher Institut Für Technologie  
Hermann-von-Helmholtz-Platz 1  
DE-76344 Eggenstein-Leopoldshafen  
Tel. +49 72160822253  
Fax +49 72160824837  
[alexei.miassoedov@kit.edu](mailto:alexei.miassoedov@kit.edu)

### Project details

**Project type** // Coordination and Support Action

**Project start date** // 1.2.2013

**Duration** // 48 months

**Total budget** // EUR 1 644 231

**EC contribution** // EUR 1 000 000

### EC project officer

**Panagiotis Manolatos**

European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/53  
B-1049 Brussels, Belgium  
[panagiotis.manolatos@ec.europa.eu](mailto:panagiotis.manolatos@ec.europa.eu)

## Expected results

ALISA activities will help considerably advance understanding of some of the most important remaining severe accident safety issues, ranked with high or medium priority by the SARP group of the SARNET network. The aim is not only to understand the physical background of severe accidents but also to provide the background knowledge that can help reduce the severity of the consequences. The project will significantly improve understanding of core degradation, melt formation and relocation as well as core coolability in real reactors by scaling up and providing data for the validation of computer codes applied for safety assessment and planning of accident mitigation concepts.

It is crucially important to understand the whole core melt sequences and identify opportunities to lower risk. This can be done by:

- altering the timing or magnitude of reflooding the degraded core;
- in-vessel melt retention in the lower plenum of the RPV;
- ensuring the upper bound of system pressure at vessel failure by dedicated depressurisation valves;
- installation of devices or implementing accident management procedures to mitigate melt dispersion into the containment;
- implementing hydrogen mitigation measures in the containment (ignitors, recombiners, containment-filtered venting, etc.).

## Societal impact

At present, knowledge of various core melt sequences and the consequences of operator actions is not yet sufficient as they are too dependent on specific characteristics of the power plant under consideration. ALISA aims to provide the resources for a better understanding of possible scenarios of core quenching, different core melt sequences and hydrogen behaviour for different reactor designs by offering state-of-the-art experimental facilities for transnational access. This knowledge will lead to improved severe accident management measures, which are essential for reactor safety, and in addition it offers competitive advantages for the nuclear industry. The experimental results will be used for the development of models and their implementation in the severe accident codes such as Accident Source Term Evaluation Code (ASTEC). This helps to capitalise on knowledge obtained in the field of severe accident research in severe accident codes and in scientific databases, thus preserving and diffusing this knowledge to a large number of current and future end users both in Europe and in China.

## Information about important public events

Communicating the ALISA project's objectives and results to the general public will be done via the project's public website. ALISA results will also be disseminated through its user groups and by presentations at international scientific conferences. Topical meetings will be organised once a year with a final workshop scheduled for the end of 2016. The project kick-off meeting will be held at CEA Cadarache in February 2013 in Aix en Provence, France.

## Partners

- Karlsruher Institut Für Technologie (KIT), DE
- Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA), FR
- China Nuclear Power Technology Research Institute (CNPRI), CN
- Shanghai Jiao Tong University (SJTU), CN
- State Nuclear Power Technology Corporation (SNPTC), CN
- Xi'an Jiaotong University (XJTU), CN



# EURACT-NMR

Both the Sustainable Nuclear Energy Technology Platform (SNETP) Strategic Research Agenda (2009) and the Advanced Fuel Cycle Initiative (2008) report of the United States Department of Energy highlight the application and implementation of advanced analytical technologies and computational simulation techniques as an essential part of the future development of nuclear energy around the world. Advances in analytical techniques, computation and modelling have also occurred in the non-nuclear realm. However, while advances in computation and modelling of nuclear materials can be readily adapted to advances in techniques, implementing advanced experiments under radiological constraints is significantly more difficult. Nonetheless, this is essential for validating increasingly sophisticated (and critical) models describing material behaviour under normal and extreme conditions. The aim of this project is to make nuclear magnetic resonance (NMR) facilities for nuclear research available and to establish the technique in European research institutes and organisations.

## Trans-national access to unique actinide and radiological nuclear magnetic resonance facilities

### Nature and scope of the project

NMR has rarely been applied to nuclear materials, and it is only recently that high-resolution experiments on solids have been carried out. However, in the 65 years since its invention, it has been used to produce significant scientific advances. These advances have been awarded three Nobel Prizes (Purcell and Bloch, Ernst, and Mansfield). Milestones include the experimental confirmation of the Bardeen-Cooper-Schrieffer theory of conventional superconductors (these scientists are also Nobel laureates) in physics. In biochemistry/biology, the functional structure and dynamics of biological molecules becomes tractable through Fourier transform multidimensional NMR spectroscopy (awarding Ernst the 1991 Nobel Prize in Chemistry); the rapid methods of magnetic resonance imaging (MRI) (giving Mansfield the 2003 Nobel Prize in Physiology or Medicine) have revolutionised cancer detection and treatment. One of the reasons that NMR can be utilised across so many diverse fields is that it can be equally applied to liquid or solids, and crystalline or amorphous materials. It delivers an element-specific response that greatly simplifies the investigation of compositionally or structurally complex materials. It will now be applied to aspects of nuclear energy, in particular, materials involved in separation, waste and fuel.

### Activities

At the Karlsruhe Actinide NMR Centre of Excellence, state-of-the-art nuclear magnetic resonance facilities have been adapted to carry out advanced nuclear magnetic resonance experiments on radioactive solid and liquid materials. This Coordination and Support Action (CSA) provides support to scientists from Member States and associated states by providing access to this unique facility; in this way, it allows the use and impact of such advanced analytical techniques for actinide and radioactive materials in general to be maximised.

The main focus of the project's activities will be:

- developing actinide separation technologies through the identification of ligand selectivity, intermediates and rates of reaction by multidimensional solution-state NMR spectroscopy;
- determining the local substitution mechanisms of actinide elements into nuclear fuels and waste forms, and the effects of different ordering schemes and radiation damage on physical properties;

### Coordinator

**Ian Farnan**

University of Cambridge  
Department of Earth Sciences  
Downing Street  
Cambridge  
CB2 3EQ  
United Kingdom  
Tel. +44 1223333431  
Fax +44 1223333450  
[if203@cam.ac.uk](mailto:if203@cam.ac.uk)

### Project details

**Project type** // Coordination and Support Action

**Project start date** // 1.2.2011

**Duration** // 30 months

**Total budget** // EUR 634 415

**EC contribution** // EUR 577 517

### EC project officer

**Kateřina Ptáčková**

European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/60  
B-1049 Brussels, Belgium  
[katerina.ptackova@ec.europa.eu](mailto:katerina.ptackova@ec.europa.eu)



- determining the magnetic and superconducting properties associated with actinide elements and actinide compounds, to provide a fundamental test of the accuracy of descriptions of the 5f electron systems, thus underpinning ab initio modelling in nuclear applications.

## Expected results

The programme is expected to deliver details of the mechanisms of lanthanide and actinide separation technologies for future partitioning operations.

The number of atoms displaced by radioactive decay within materials can be measured directly from spin-counting measurements of NMR resonances of damaged material. There will also likely be further testing of radiation damage models that can be combined with adapted and refined modelling to improve our understanding of the effect of radiation damage on the physical properties of nuclear materials.

Atomic distributions of plutonium and other actinides, either as avoidance, clustering or stochastic, within nuclear fuels, will be determined by high-resolution solid-state NMR.

## Societal impact

The long-term aims for nuclear power in Europe depend upon the continued development of actinide separation technologies, and particularly the selectivity of lanthanide and actinide separations, with the goal of minimising the long-term radiotoxicity of nuclear waste. While empirical methods being used to good effect, a fundamental understanding of ligand selectivity is required to give research increased focus. This calls for information on intermediate chemical states and rates of chemical reaction in solution that can be provided by NMR spectroscopy.

New nuclear fuels are being developed as part of the strategic research agenda of the Sustainable Nuclear Energy Technology Platform (SNETP). The reuse of separated plutonium in nuclear fuel and the transmutation of separated minor actinides such as americium require a solid solution of one actinide compound into a matrix of another. The details of this type of substitution are particularly well adapted to investigation using NMR techniques. These are facilitated by the availability of the Karlsruhe Actinide NMR Centre of Excellence and EURACT-NMR access programme.

## Important public events

A workshop in 2013 will present results to industrialists, academics and members of sister FP7 programmes: 'Basic research for innovative fuels design for gen IV Systems' (F-BRIDGE), 'European network for actinide sciences' (ACTINET-13), 'Actinide recycling by separation and transmutation' (ACSEPT), 'Prediction of the effects of radiation for reactor pressure vessel and in-core materials using multi-scale modelling - 60 years foreseen plant lifetime' (PERFORM 60).



*Adaptation of the nuclear magnetic resonance spectrometer for radiological operation with magic-angle spinning. Extra long legs are used to accommodate a glove box beneath the magnet and an additional bore insert isolates the probe operation from the laboratory environment.*  
© JRC-ITU

## Partners

- EC-JRC Institute for Trans-uranium Elements (ITU), BE
- Karlsruhe Institute of Technology (KIT), DE
- Commissariat à l'énergie atomique et aux énergies alternatives (CEA), FR

# LACOMECO

The LACOMECO project aims to give EU research institutions access to four experimental facilities at the Karlsruhe Institute of Technology (KIT): 'Large-scale experiments on the investigation of the quench behaviour of the fuel rod simulator' (QUENCH), 'Large-scale experiments on melt behaviour in the RPV lower head' (LIVE), 'Dispersion of corium and direct containment heating experiments at low pressure' (DISCO-H) and 'Large-scale tests on hydrogen behaviour and mitigation' (HYKA). These have been designed to study severe accident safety issues ranked as high or medium priority by the Severe Accident Research Priorities (SARP) group of the Severe Accident Research NETWORK of Excellence (SARNET).

## Large scale experiments on core degradation, melt retention and containment behaviour

### Nature and scope of the project

Coolability of a degraded core, corium coolability in the reactor pressure vessel (RPV), melt dispersion to the reactor cavity, and hydrogen mixing and combustion in the containment are extremely complex phenomena that call for specific research involving substantial resources; the scope is also too wide for all these phenomena to be studied under any single national programme. Collaboration between different EU institutions at both national and international levels is therefore extremely important for optimising resource use. Facilitating this collaboration by providing severe-accident research facilities at the KIT in Germany is LACOMECO's main objective.

The project focuses on large-scale tests under prototypical conditions. These will help improve understanding of core degradation and quenching, melt formation and relocation, and core coolability in real reactors. This will be achieved in two ways: firstly by scaling up and secondly by providing data for the improvement and validation of computer codes applied for safety assessment and planning of accident mitigation concepts, such as the Accident Source Term Evaluation Code (ASTEC).

### Activities

The experimental facilities this project offers are unique in that they provide the possibility to perform experiments in specific fields of core damage initiation up to hydrogen behaviour, and are like no other existing facility in other Member States. The facilities are operated by a team of experts who have long and recognised experience in nuclear safety research. The experiments are designed to complement other European facilities and experimental platforms such as the Core Degradation Experiments (CODEX), the Versatile UO<sub>2</sub> Lab for Corium Analysis and Observation (VULCANO) and the Platform for Improvements in Nuclear Industry and Utility Safety (PLINIUS) to form a coherent European nuclear experimental network. They will contribute to a better understanding of core melt sequences and will thus improve the safety of existing and future reactors.

### Coordinator

**Alexei Miassoedov**

Karlsruhe Institute of Technology  
Hermann-von-Helmholtz-Platz 1  
DE-76344 Eggenstein-Leopoldshafen  
Baden-Württemberg, Germany  
Tel. +49 72160822253  
Fax +49 72160824837  
[alexei.miassoedov@kit.edu](mailto:alexei.miassoedov@kit.edu)

### Project details

**Project type** // Coordination and Support  
Action

**Project start date** // 1.2.2010

**Duration** // 36 months

**Total budget** // EUR 777 380

**EC contribution** // EUR 500 000

### EC project officer

**Michel Hugon**

European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/52  
BE-1049 Brussels, Belgium  
[michel.hugon@ec.europa.eu](mailto:michel.hugon@ec.europa.eu)

## Expected results

The aim is not only to understand why severe accidents happen, but also to provide the knowledge that can help reduce the severity of the consequences. It is crucially important to understand the entire core melt sequence and identify opportunities to lower the risk.

This can be done by:

- altering the timing or magnitude of reflooding the degraded core;
- in-vessel melt retention in the lower plenum of the RPV;
- ensuring the upper bound of system pressure at vessel failure by dedicated depressurisation valves;
- installing devices or implementing accident management procedures to mitigate melt dispersion into the containment;
- implementing hydrogen mitigation measures in the containment (igniters, recombiners, etc.).

The results of the experiments performed under the 'Large scale experiments on core degradation, melt retention and coolability' (LACOMERA) project will be used for developing models and implementing severe accident codes such as the ASTEC.

## Societal impact

LACOMECO aims to provide the resources for a better understanding of possible scenarios of core quenching, different core melt sequences and hydrogen behaviour for different reactor designs. This knowledge will lead to improved severe-accident management measures that are essential for reactor safety and in addition offer competitive advantages for the European industry.

The project will bring together competent teams from different countries with complementary knowledge, and will establish and maintain links with east European research organisations and utilities companies. Therefore, the project offers a unique opportunity to join up networks and activities supporting water-water energetic reactor (VVER) safety, and for Eastern experts to gain access to large-scale experimental facilities in a Western research organisation. As a result, they will improve their understanding of material properties, core behaviour, and containment safety under severe accident conditions.

## Information about important public events

Communicating the project's objectives and results to the general public will be carried out via the project's website. LACOMECO results will also be disseminated through user groups and by presentations at international scientific conferences. Topical meetings will be organised once a year, with a final workshop scheduled for spring 2013. The first workshop was held together with the PLINIUS severe accident platform of the French Atomic Energy Commission (CEA) Cadarache, in October 2010 in Aix en Provence, France. Results from experiments performed so far and the project's status were presented at a special LACOMECO session at the 16th International QUENCH Workshop at KIT in November 2011 in Karlsruhe, Germany.



*KIT severe accident research facilities QUENCH, LIVE, DISCO and HYKA offered for the transnational access in the LACOMECO project.*

© Karlsruhe Institute of Technology

## Partners

- Karlsruhe Institute of Technology (KIT), DE



## CINCH

The use of nuclear power and the transition to Generation IV (GEN IV) reactors requires a significant number of respective specialists, among others nuclear chemists. CINCH aims to improve education and training in the nuclear chemistry field by developing a long-term Euratom Fission Training Scheme (EFTS) providing a common basis for the fragmented activities in this field.

## Cooperation in education In Nuclear Chemistry

### Nature and scope of the project

The consortium is made up of a network of key players from academia and industry who have expertise in education and training in nuclear chemistry applied to nuclear energy. All the partner universities have a long-standing tradition of delivering courses in nuclear chemistry, and they are among the few universities in the EU where the numbers of students choosing this area of study remain significant. The EU universities are also joined on the project by the Moscow State University.

The project will put in place a set of compact joint modular courses in different branches of modern nuclear chemistry, an e-learning tool available for both education and training, and a long-term sustainable strategy for nuclear chemistry education including a roadmap for its implementation.

As nuclear chemistry education and training in Europe is currently quite fragmented, the main focus of the project is on coordination, both at the PhD and undergraduate levels within the EU and in collaboration with Russia. The project should bring about the establishment of a long-term EFTS. Improving collaboration between academia and industry will also be emphasised by encouraging industry collaboration in the EFTS.

### Results and impact

The development of a system for student and teacher exchange based on common compact modular courses will prepare the ground for a future European Masters in Nuclear Chemistry. The project will also see the realisation of a user friendly e-learning tool that provides access to teaching materials.

Through increased opportunities for students, the project will help promote mobility of young workers and researchers, and there will be more opportunities for teachers and scientists. Thus CINCH will contribute to building the 'European Research Area of knowledge for growth' in the management of spent nuclear fuel and nuclear waste.

CINCH lays the foundations for positive private-public partnerships that have the potential for expansion over the coming years. Through this partnership, the transfer of higher level knowledge and technology will be maximised as young students and experienced research workers will have the opportunity to meet with colleagues from all over Europe. CINCH will increase the attractiveness of careers in nuclear chemistry across the EU.

### Coordinator

**Jan John**

Czech Technical University in Prague  
Brehova 7  
115 19 Prague 1  
Czech Republic  
Tel. +420 224358228  
Fax +420 222317626  
[jan.john@jfj.cvut.cz](mailto:jan.john@jfj.cvut.cz)

### Project details

**Project type** // Coordination and Support Action

**Project start date** // 1.2.2010

**Duration** // 36 months

**Total budget** // EUR 1 047 672

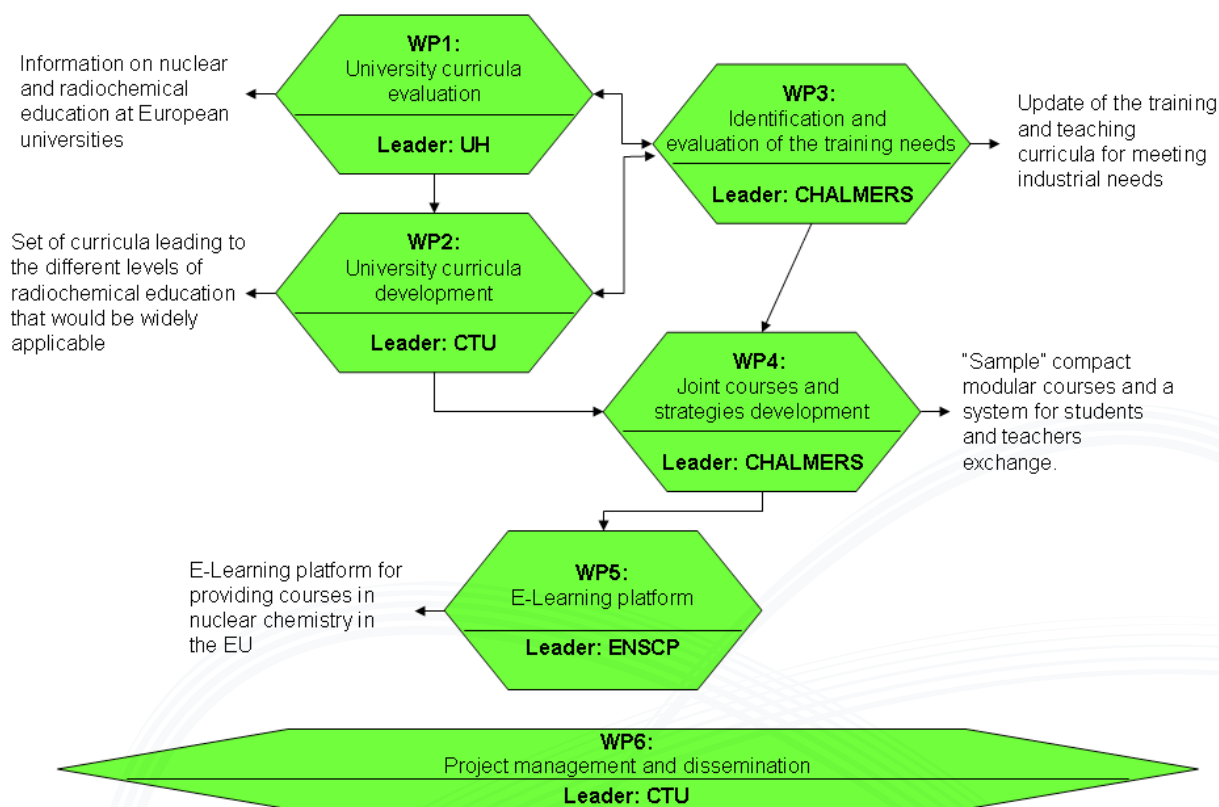
**EC contribution** // EUR 804 304

### EC project officer

**Kateřina Ptáčková**

European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/60  
B-1049 Brussels, Belgium  
[katerina.ptackova@ec.europa.eu](mailto:katerina.ptackova@ec.europa.eu)





Pert diagram of the project

## Information about important public events

A session dedicated to nuclear chemical education with specific emphasis on the results achieved within the project was held during the NRC 8 conference (the 8th International conference on Nuclear and Radiochemistry) in September 2012 in Italy.

Three joint modular demonstration courses will be organised by the CINCH consortium. These are Radio-ecology, Hands-on Training in Nuclear Chemistry, and Chemistry of the Nuclear Fuel Cycle. The first of them took place in October 2012 in Norway.

A final public workshop presenting the results of the project both to the nuclear community and to the general public will be organised before the end of the project. This will take place in France as it is a country that contains all components of a nuclear fuel cycle.

## Partners

- Ceske Vysoke Ucení Technické V Praze (CTU), CZ
- Chalmers Tekniska Högskola AB (CHALMERS), SE
- Helsingin Yliopisto (UH), FI
- Moscow State University (MSU), RU
- Ecole Nationale Supérieure de Chimie de Paris (ENSCP), FR
- Ústav Jaderného Vyzkumu Řež a.s. (NRI), CZ

- National Nuclear Laboratory Ltd (NNL), GB
- Norwegian University of Life Sciences, Aas, in consortium with the University of Oslo (UMB/UiO)

## CORONA

The development of specific training schemes and subsequent establishment of a purpose-built structure for training personnel to operate VVER (or WWER for water-water energetic reactor) technology is the strategic outcome of the CORONA project. The Regional Centre of Competence will provide support and services for preservation and transfer of VVER-related nuclear knowledge as well as know-how and capacity building. Such an approach involves ensuring existing VVER-related training schemes meet International Atomic Energy Agency (IAEA) standards and commonly accepted criteria recognised in the EU.

## Establishment of a Regional Centre of Competence for VVER Technology and Nuclear Applications

*Preservation of VVER technology competencies through harmonization of existing methods and tools and development of specific training schemes*

### Nature and scope of the project

The 11-partner-strong CORONA consortium, made up of 1 international organisation, 4 research centres, 1 university, 4 technical support organisations (TSOs) and 1 nuclear utility company, will work around 3 project themes:

- Putting in place training schemes for different target groups: The team will identify the training needs for all target groups and develop a complete definition of the knowledge and skills required. The training schemes will be for nuclear professionals and researchers, non-nuclear professionals and subcontractors, and students studying nuclear disciplines. Another more general session will cover safety culture and soft skills. Textbooks and adapted courses for distance learning and e-learning will be developed.
- Creating a knowledge management portal for VVER technology to provide a structured system for easy, computer-based access to any VVER-related information, which can be used by staff to maintain and improve their productivity and performance.
- Developing the specialised regional training centre: technical specification for training tools and equipment of general and special assignment for the VVER technology and nuclear applications.

The specific objectives of the project are:

- enhancing safety and performance of nuclear installations with VVER technology;
- emphasis on safety culture enhancing the importance of maintaining an adequate level of safety culture in VVER installations;
- contributing to the development of a Knowledge Management System for VVER technology;
- preserving and further developing nuclear competencies, skills and knowledge related to VVER technology, as a technology used in the EU;
- contributing to research initiatives and education actions as well as to future business opportunities for the nuclear industry;
- catalysing the building of a national network related to the nuclear industry, research and academia, and other communities of practice.

### Coordinator

**Lyubomir Pironkov**  
KNPP Training Center  
Kozloduy NPP  
3321 Kozloduy, Bulgaria  
Tel. +359 973 73391, 2310  
Fax +359 973 73670  
[lipironkov@npp.bg](mailto:lipironkov@npp.bg)

### Project details

**Project type** // Coordination and Support Action  
**Project start date** // 1.12.2011  
**Duration** // 36 months  
**Total budget** // EUR 2 244 178  
**EC contribution** // EUR 969 780

### EC project officer

**Mykola Džubinský**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/58  
B-1049 Brussels, Belgium  
[mykola.dzubinsky@ec.europa.eu](mailto:mykola.dzubinsky@ec.europa.eu)

## Expected results

In the International Convention on Nuclear Safety governments have committed to 'undertaking the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety related activities in or for each nuclear installation, throughout its life.' In this sense the main goal of CORONA is to develop competences and new skills for implementing European Commission decisions and to contribute to improvement of safety and reliability of nuclear installations.

## Societal impact

The development of multinational training schemes will take into account the different approaches applied in education and training in different countries. Thus, significant contribution to coordinating the different training schemes will be made by providing the trainees with broader competences and enhanced flexibility. Methods and activities will be used to encourage access to information sources worldwide.

These trained specialists will aid in the knowledge transfer between senior experts and the new generation whose expertise is essential for managing existing nuclear power plants (NPPs), decommissioning nuclear plants and meeting the needs of next generation reactors. The different approaches and cultural attitudes across the European Union towards education and training will be considered during the development of the programmes, and the training schemes will create an environment where the partners can discuss and evaluate how to integrate the different perspectives as an integral part in the curriculum. The pedagogic framework of the training schemes will encourage social interaction, active engagement and self motivation. The development of the KM portal will integrate the information on VVER web into a single communication system and develop and implement a semantic web structure to achieve mutual recognition of authentication information with other databases, such as the ODIN database (Joint Research Centre - Institute for Energy and Transport (JRC-IET)) and the respective IAEA databases.

## Information about important public events

The project outcomes will be presented at seminars, workshops and conferences of Nuclear Societies in Europe and at special ENS, SMiRT and ISRD'15 events. A workshop for the regulators of the beneficiary countries on the developed training programmes and a special seminar in Turkey, as a VVER 'new-build' country, are planned. CORONA will also have regular articles published in journals.



Winter view of KNPP Training Center.

© KOZLODUY NPP PLC



CORONA kick-off meeting.

© KOZLODUY NPP PLC

## Partners

- Kozloduy NPP Plc. (KNPP), BG
- Magyar Tudományos Akadémia KFKI Atomenergia Kutatóintézet (AEKI), HU
- Fortum Power and Heat Oy (FORTUM), FI
- Institute of Nuclear Research and Nuclear Energy – Bulgarian Academy of Sciences (INRNE-BAS), BG
- Joint Research Centre (JRC) – European Commission, BE

- National Research Nuclear University "MEPhI" (MEPhI), RU
- Centrum vyzkumu Rez s.r.o. (CV Rez), CZ
- PM Dimensions GmbH (PMD), AT
- Risk Engineering Ltd. (REL), BG
- Tecnatom S.A. (TECNATOM), ES
- Intellectual Technologies – Slavutich LLC (IT-S), UA

## ECNET

The ECNET project is a cooperative project carried out between partners from the EU and China with the aim of developing common ground for cooperation in nuclear education, training and knowledge management.

By analysing the current situation in both the EU and China the project consortium aims to define opportunities and barriers for cooperation, carry out pilot exercises and define a road map for long-term cooperation. These activities will offer nuclear researchers and industry a broader basis for further cooperation in nuclear power development. The project aims to put in place postgraduate level education and training for young professionals.

## EU-CHINA Nuclear Education and Training Cooperation

### An experienced consortium

The entire ECNET project for cooperation with China consists of two parallel parts: the ECNET-EU part and the ECNET-CN part. Each part has its own partners and budget, provided by EURATOM and the China Atomic Energy Authority (CAEA) respectively. The European consortium consists of eight organisations, including the ENEN Association (European Nuclear Education Network), four universities, one university network and two research centres, all of which have experience working with China. The ENEN, SCK-CEN and INPL partners will maintain links with work being carried out as part of the Seventh Framework Programme (FP7) projects ENEN III ('European nuclear training schemes in nuclear engineering') on nuclear engineering, ENETRAP II ('European network on education and training in radiological protection - II') on radiation protection, and PETRUS II ('Towards an European training market and professional qualification in Geological Disposal') on waste management and disposal. The Chinese consortium is lead by Tsinghua University and is made up of seven organisations.

### Activities

The project first identifies the needs and strategies of long-term cooperation between the EU and China in education and training on nuclear engineering, radiation protection, and waste management and disposal. Then the analysis follows concerning the compatibility of nuclear education systems in the EU and China, including the credit system (e.g. the Bologna process and the European Credit Transfer and Accumulation System (ECTS) concept in the EU), and promote mutual recognition of the credit system to enhance the exchange of students and young professionals in nuclear education between the EU and China. Finally, nuclear education and training facilities, laboratories and equipment in the EU and in China are expected to be mapped out.

All results, achievements and deliverables of the ECNET project are posted and shared by partners on the ENEN Website and the ENEN Database.

### Coordinator

**Peter Paul De Regge**

European Nuclear Education Network  
Association  
Centre CEA de Saclay - INSTN Bldg. 395  
F-91191 Gif-sur-Yvette Cedex, France  
Tel. +33 169089757  
Fax +33 169089950  
[peter.de-regge@cea.fr](mailto:peter.de-regge@cea.fr)

### Project details

**Project type** // Coordination and Support  
Action

**Project start date** // 1.3.2011

**Duration** // 24 months

**Total budget** // EUR 602 500

**EC contribution** // EUR 480 000

### EC project officer

**Georges Van Goethem**

European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/47  
B-1049 Brussels, Belgium  
[georges.van-goethem@ec.europa.eu](mailto:georges.van-goethem@ec.europa.eu)





*ECNET Kick-off meeting in Beijing, March 2011.*

© ENEN/Peter Paul De Regge

## Societal impact

In light of the dearth of high level graduates educated in the nuclear field combined with the looming retirement of many existing nuclear sector professionals, in December 2008 the EU Council issued its conclusions and recommendations on the 'Need for Skills in the Nuclear Field', where, in addition to needs in the EU, the relevance of skill requirements in the international context was also considered. ECNET contributes to enlarging recruitment areas and enhancing career opportunities beyond the EU.

## Information about important public events

A workshop dedicated to the compatibility of nuclear education systems in the EU and China, including the credit system, will be organised for spring 2012 or 2013. The ENEN PhD Event 2012, a competition among PhD students, is another event planned to be used for the project. In addition to the internal project meetings, the ENEN holds a General Assembly meeting every March and publishes a report. This is an opportunity for further discussion among its members and relevant project partners.

## Partners

- Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA), FR
- European Nuclear Education Network Association (ENEN), FR
- Studiecentrum voor Kernenergie (SCK CEN), BE
- Institut National des Sciences et Techniques Nucléaires (CEA-INSTN), FR
- Institute National Polytechnique de Lorraine (INPL), FR
- Karlsruhe Institute of Technology (KIT), DE
- Consorzio Interuniversitario per la Ricerca Tecnologica Nucleare (CIRTEN), IT
- Universidad Politecnica de Madrid (UPM), ES
- Imperial College London (ICL), UK

## ENEN-RU

The ENEN-RU project is for cooperation between the EU and Russia that aims to develop common grounds for cooperation in nuclear education, training and knowledge management. The work starts with an analysis of the present situation in both Europe and Russia. After defining existing cooperation opportunities and barriers, the partners carry out pilot exercises and define a road map for expanding cooperation beyond the project. The project leads to the mutual recognition of education and training programmes that will offer nuclear research and industry a broader basis of human resources as well as foster cooperation in nuclear power development.

## Development of Common Ground for Cooperation with the Russian Federation in Nuclear Education, Training and Knowledge Management

### Scope of project

The entire ENEN-RU project for cooperation with Russia consists of two parallel parts: the ENEN-RU project on the European side and a parallel project on the Russian side. Each part has its own partners and budget. The European consortium is made up of eight organisations – the ENEN (European Nuclear Education Network) Association, four universities, two research centres and an industry partner, all of which have had experiences working with Russia. The Russian consortium is lead by ROSATOM (State Atomic Energy Corporation) and consists of five organisations. The scope of the project is education in nuclear engineering for postgraduates and training for young professionals.

### Activities

The project first analyses the implementation and the compatibility of the Bologna Process and the European Credit Transfer System (ECTS) concept in Russia as a basis from which to enhance future exchanges of lecturers and students, and promotes the implementation of the Bologna Process within the new National Research Nuclear University (NRNU) in Russia. Then recommendations for long-term cooperation in terms of nuclear education and training are to be developed, from which pilot education and training exercises will be carried out in the second phase of the project. Rules and procedures to get access to relevant nuclear facilities and equipment in the EU and Russia will be clarified and tested out during the pilot sessions.

The results, achievements and deliverables of the ENEN-RU project are posted and shared by the partners on the ENEN Website and the ENEN Database.

### Coordinator

**Ryoko Kusumi**

European Nuclear Education Network  
Association  
Centre CEA de Saclay - INSTN - Bldg 395  
Pe 34  
F-91191 Gif-sur-Yvette Cedex, France  
Tel. +33 169089757  
Fax +33 169089950  
[ryoko.kusumi@cea.fr](mailto:ryoko.kusumi@cea.fr)

### Project details

**Project type** // Coordination and Support

Action

**Project start date** // 1.1.2011

**Duration** // 24 months

**Total budget** // EUR 595 503

**EC contribution** // EUR 467 155

### EC project officer

**Mykola Džubinský**

European Commission  
Directorate-General for Research and  
Innovation  
Directorate Energy  
Unit K4 – Fission  
CDMA 1/58  
B-1049 Brussels, Belgium  
[mykola.dzubinsky@ec.europa.eu](mailto:mykola.dzubinsky@ec.europa.eu)

## Societal impact

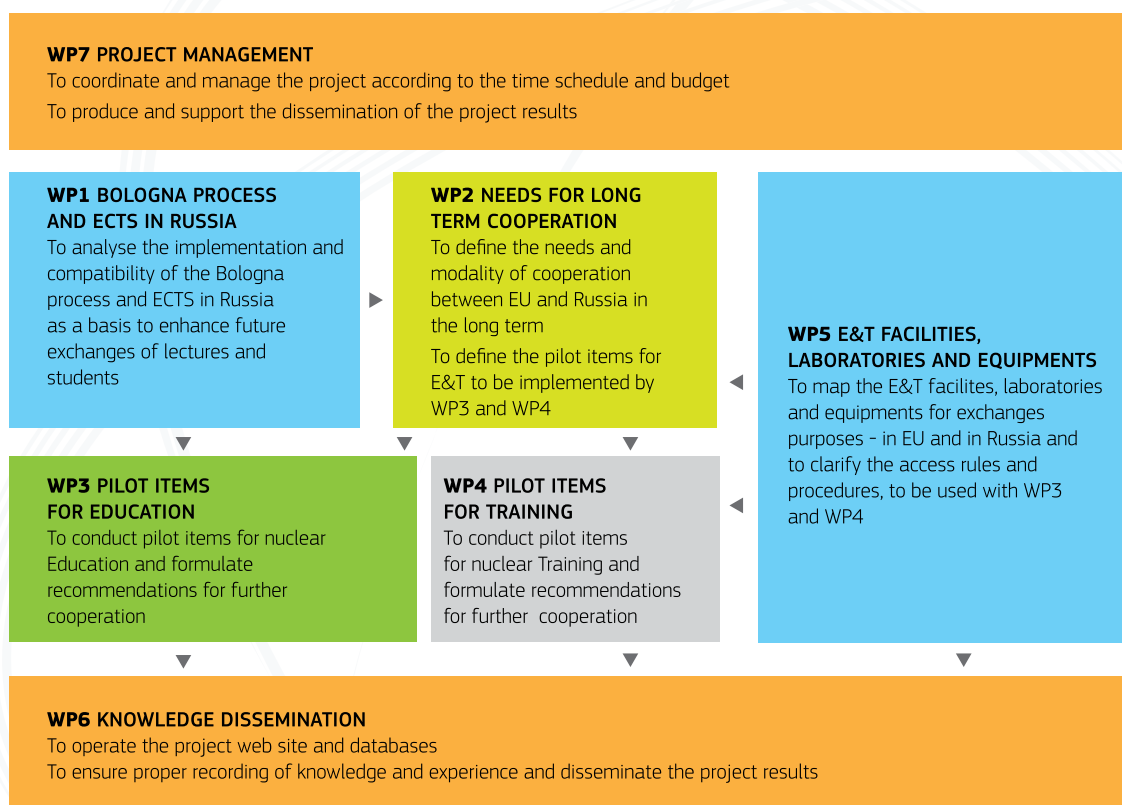
In light of the shortage of high level graduates educated in the nuclear field combined with the looming retirement of many existing nuclear sector professionals, in December 2008 the EU Council issued its conclusions and recommendations on the 'Need for Skills in the Nuclear Field' where, in addition to needs in the EU, the relevance of skill requirements in the international context was also considered. ENEN-RU contributes to enlarging recruitment areas and enhancing career opportunities beyond the EU.

## Information about important public events

In addition to the project meetings, the ENEN Association organises the annual General Assembly meeting every March to report on the project's progress. This is also an opportunity for further discussion among all ENEN Members and relevant partners. The ENEN annual PhD Event, a competition among PhD students at the European level, is also another opportunity for cooperation with Russia.

ENEN-RU WP structure.

© Ryoko Kusumi



## Partners

- European Nuclear Education Network Association (ENEN), FR
- Studiecentrum voor Kernenergie (SCK CEN), BE
- Ceske Vysoke Ucení Technické V Praze (CTU), CZ
- Ustav Jaderného Vyzkumu Rez a.s. (UJV), CZ
- Universität Stuttgart (IKE), DE
- University Politehnica of Bucharest (UPB), RO
- Slovenska Technická Univerzita V Bratislave (STUB), SK
- Tecnatom (TECNATOM), ES

## EURECA!

The aim of the EURECA! project is to establish a European-Canadian education and training (E&T) programme in the field of fourth generation (GEN IV) Super Critical Water-cooled Reactors (SCWR) research. Moreover, the EURECA! project paves the way for long-term collaboration between the EU and Canada in the field of education, training, research and development of nuclear energy generation in general.

## Cooperation between EU and Canada in Education, Training and Knowledge Management on Super-Critical Water Reactors

*The establishment of an Education and Training programme on the Super Critical Water-cooled Reactor. A European-Canadian initiative*

### A mutual European-Canadian education and training programme

Nuclear power in general requires highly qualified, skilled and well trained professionals in order to assure the supply of energy and to secure safe operation and the development of reliable technology. The recent Fukushima nuclear accident in March 2011 confirmed these requirements.

However, as noted by the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA), a specialised agency within the Organisation for Economic Co-operation and Development (OECD), there exists a shortage of high level graduates educated in the nuclear field and increasing levels of retirement by professionals in the nuclear sector; these trends represent a worrying skilled labour shortage.

EURECA! will enhance the skills of current professionals in the nuclear sector and attract graduates and professionals from other sectors to work in the nuclear field. Moreover, a platform will be created with Canada to enhance the exchange of knowledge between the EU and Canada in the field of nuclear energy.

### Focusing on Super Critical Water-cooled Reactors

The Super-Critical Water-cooled Reactor (SCWR), being one of the most promising and feasible reactor concepts selected by the Generation IV International Forum (GIF), has been put under great spotlight in both the EU and Canada and continues to be subject to a number of research projects.

EURECA! focuses on the SCWR for three reasons: (i) the SCWR is an attractive reactor concept to young graduates and professionals; (ii) the level of knowledge and skills regarding this new type of nuclear reactor will be ensured in the future; and (iii) the level of knowledge and skills regarding current water-cooled reactors will be improved and ensured, since the concepts and technology of the SCWR are close to the ones of conventional water-cooled nuclear plants.

### Coordinator

**Martin Rohde, Assistant Professor**  
Delft University of Technology  
Physics of Nuclear Reactors  
Mekelweg 15, 2629 JB, Delft  
The Netherlands  
Tel. +31 15 2786962  
[m.rohde@tudelft.nl](mailto:m.rohde@tudelft.nl)

### Project details

**Project type // Coordination and Support Action**  
**Project start date // 1.8.2012**  
**Duration // 24 months**  
**Total budget // EUR 582 916**  
**EC contribution // EUR 471 706**

### EC project officer

**Panagiotis Manolatos**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/53  
B-1049 Brussels, Belgium  
[panagiotis.manolatos@ec.europa.eu](mailto:panagiotis.manolatos@ec.europa.eu)



## EURECA! activities

The EURECA project is subdivided into two core activity areas:

1) The establishment of an Education and Training programme in a specific scientific/technical field.

The specific scientific and technical fields are thermal-hydraulics, neutronics and fuels, water-chemistry and materials, and mechanical design and analysis. The safety aspect will be reflected throughout all four fields. The entire programme comprises training courses and practical exercises.

The main aims are:

- (i) to identify professional competences with the help of (future) employers;
- (ii) to identify courses and practical exercises in the EU and Canada;
- (iii) to compose an excellent, coherent and well balanced education and training programme; and
- (iv) to assure mobility of students and professionals in terms of crediting systems and legal procedures.

2) The second core activity area is the organisation and implementation of a small pilot programme. The aim of the pilot will be to acquire more experience and, consequently, to enhance the entire programme.

## Societal impact

The expected impact on society can be summarised as follows:

- securing and consolidating knowledge and skills level of graduates and professionals required for current and future nuclear power plants;
- enhanced exchange of high level knowledge;
- increased attractiveness of nuclear research careers;
- increased mobility of researchers between Europe and Canada;
- stronger link with Canadian SCWR research and development network;
- promotion of European know-how at the international level;
- better career opportunities;
- enhanced coherence between EU research groups in the field of SCWR and current (PWR/BWR) water-cooled reactors;
- increased confidence in the use of safe nuclear power.

## Public events

The progress of the project will be reported on in seminars, workshops and conferences. Important meetings and project achievements will be reported on in press releases and in articles in widely available non-technical magazines.

## Partners

- Atomic Energy of Canada Limited (AECL), CA
- Delft University of Technology (DELFT), NL
- École Polytechnique de Montréal (EPA), CA
- European Nuclear Education Network Association (ENEN), FR
- Kungliga Tekniska Högskolan (KTH), SE
- McMaster University (MU), CA
- Materials Technology Laboratory (MTL), CA

- Research Centre Rez Ltd. (REZ), CZ
- Universität Stuttgart (USTUTT), DE
- University of Pisa (UP), IT
- University Network of Excellence in Nuclear Engineering (UNENE), CA

# TRASNUSAFE

Nuclear safety culture is the result of a continuous effort and commitment to maintain high safety standards at all stages of nuclear installation design, construction, operation and dismantling, including during the transport of fuel, waste and other radioactive materials like medical radioisotopes. It includes the requirement to meet the ALARA (As Low As Reasonably Achievable) goals for the radiological protection of people. Nuclear safety culture is based on knowledge and understanding, research, experience-based feedback, training and communication, management commitment and assessments, as well as regulation and regulatory processes.

## Training Schemes on Nuclear Safety Culture

### Training for safety

The TRASNUSAFE consortium is made up of 18 partners from 10 European countries. It brings together expertise from many relevant areas such as training providers from public and private organisations active in both industrial and radiological safety, members of the European ALARA Network (EAN) and universities. The consortium is also supported by potential users grouped into two user groups: one involving companies of the electro-nuclear sector, coordinated by TRACTEBEL Engineering S.A., and another involving other companies, coordinated by the Romanian regulator CNCAN (Comisia Nationala pentru Controlul Activitatilor Nucleare).

TRASNUSAFE aims to design, develop and validate two training schemes on nuclear safety culture, with a common basis:

- a training scheme related to the nuclear industry;
- a training scheme related to installations making use of ionising radiation-based technology.

The two training schemes being developed are aimed at high level professionals who hold managerial responsibilities in nuclear installations or in the radiotherapy departments of hospitals. It includes the design of the installations, their construction, operation and dismantling, the transport of fuels, waste and radioisotopes. All types of nuclear installations are concerned: nuclear power plants (NPPs), research reactors, waste treatment units, etc. The project is thus aimed at addressing the needs of managers responsible for safety in the industrial as well as the medical sector.



© sonap, #41131687, 2012. Source: Fotolia.com

### Coordinator

**Michel Giot**

Université catholique de Louvain

Louvain-la-Neuve, Belgium

Tel. +32 10472200

[michel.giot@uclouvain.be](mailto:michel.giot@uclouvain.be)

### Project details

**Project type** // Coordination Action

**Project start date** // 1.11.2010

**Duration** // 48 months

**Total budget** // EUR 1,926,948.40

**EC contribution** // EUR 974,133.88

### EC project officer

**Georges Van Goethem**

European Commission

Directorate-General for Research and Innovation

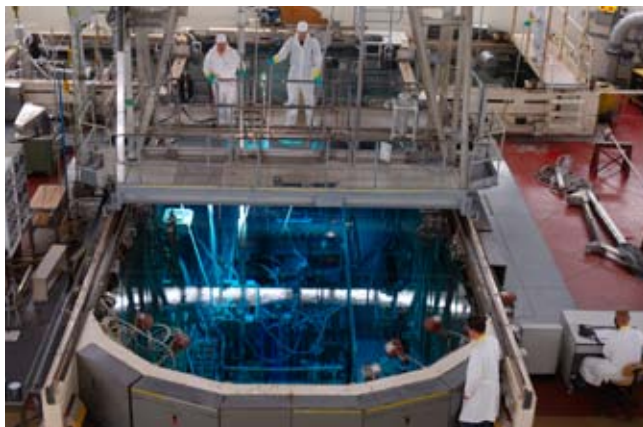
Directorate Energy

Unit K.4 – Fission

CDMA 1/47

B-1049 Brussels, Belgium

[georges.van-goethem@ec.europa.eu](mailto:georges.van-goethem@ec.europa.eu)



*Inside the containment.*

©SCK-CEN

## Activities

Nuclear safety harmonisation is the subject of a Council Directive issued on 25 June 2009: 'Member States shall ensure that the national framework in place requires arrangements for education and training to be made by all parties for their staff having responsibilities relating to the nuclear safety of nuclear installations in order to maintain and to further develop expertise and skills in nuclear safety.'

In addition, the idea of a 'European Passport' acquired through training using the ECVET (European Credit system for Vocational Education and Training) system is increasingly gaining interest.

Although industrial companies and users of ionising radiations in hospitals may seem very far from each other with respect to nuclear safety culture, it appears that many skills and attitudes share some basic principles, such as the ALARA principle. This is why a common basic training module seems feasible and desirable. Such a module does not exist yet and will be designed as the common root for the two planned training schemes. Two reflection groups have been set up to define the core contents of this common module, one with the EUTERP (European Training and Education in Radiation Protection Foundation) and the other with the EAN.

Training schemes for professionals with a high level of responsibilities have to be very interactive and concentrated. This is fully compatible with the particular character of nuclear safety culture, which is based not only on competence but also on skills and attitudes, both individual and collective.

## Expected results

The results of the project will be five training modules that have been fully designed, developed and validated through pilot sessions, and thus ready for use across Europe. In addition, since the first step of this project involves identifying the needs qualitatively and also to some extent quantitatively, it is expected that the five modules will really correspond to the identified needs.

## Societal impact

A high degree of nuclear safety culture is a key issue for the safe use of nuclear energy, and the safe use of ionising radiations for medical and industrial applications. Managers have to create and continuously maintain and improve conditions for a widely spread nuclear safety culture in their organisations and operations, whether they are NPPs, radiotherapy services in hospitals or during the transport of medical radioisotopes.

The training schemes designed, developed and validated at the European level will also help harmonise nuclear safety in Europe, and help the mobility of professionals.

## Partners

- Université catholique de Louvain (UCL), BE
- Tractebel Engineering S.A. (TRACTEBEL S.A.), BE
- Studiecentrum voor Kernergie (SCK-CEN), BE
- Tecnomat (TECNATOM), ES
- Instituto Tecnológico e Nuclear (ITN), PT
- Jožef Stefan Institute (JSI), SI
- University Politehnica of Bucharest (UPB), RO

- The University of Manchester (UNIMAN), UK
- Centre d'étude sur l'Evaluation de la Protection dans le domaine Nucléaire (CEPN), FR
- European Nuclear Education Network Association (ENEN), FR
- European Isotopes Transport Association (EITA), BE
- European ALARA Network (EAN), FR
- Societatea Nationala Nuclearelectrica S.A. (SNN), RO

- Slovak University of Technology in Bratislava (STUBA), SK
- Consorzio Interuniversitario per la Ricerca Tecnologica Nucleare (CIRTEN), IT
- Slovenske Elektrarne, a.s. (SEAS), SK
- Universidad Politécnica de Madrid (UPM), ES
- Comisia Nationala pentru Controlul Activitatilor Nucleare (CNCAN), RO



# MATTER

The structural components of the various Generation (GEN) IV reactors will need to be able to deal with high temperatures, high neutron doses and aggressive environments.

However, the available standards and rules are not appropriate for the behaviour of materials operating in such conditions. The MATTER project aims to tackle this problem by updating the testing rules by developing and establishing new best practice guidelines and updating the design rules by revising databases and performing new tests.

## Materials Testing and Rules

### Nature and scope of the project

The MATTER consortium is made up of 26 partners: 24 from Europe, 1 from Korea and 1 from Australia. Almost all the atomic energy research agencies in Europe are represented, together with eight industrial partners and one university. This wide participation means a large consensus at the European level on design rules and testing methods can be achieved.

The first part of the project involves activities related to materials characterisation. This means identifying the material properties essential for lifetime assessment, the qualification of several screening techniques for testing small-size specimens, and the harmonisation of testing and evaluation procedures that will be used to characterise the materials for sustainable nuclear systems.

The second part is dedicated to the revision and update of the design rules in order to give answers to the design teams, namely the adaptation of existing design rules to additional steels, the extension of materials characterisation to 60 year's lifetime in liquid metals, the identification of negligible creep limits, the update of weld coefficients, and the identification of additional design factors such as ageing and corrosion.

The third aspect to the project guarantees strong coherence with the EERA (European Energy Research Alliance) Joint Programme on nuclear materials (NM) by supporting both the short-term programme and the long-term programme. The short-term studies address the structure and clad materials issues in favour of ESNII (European Sustainable Nuclear Industrial Initiative) and the development of CO-free hard surfaces. The long-term research includes modelling and more innovative materials which are at the development stage such as ODS (Oxides Dispersed Strengthened) steels, refractory metals and ceramics.

### Expected results

MATTER will report on the current state of play and lay the groundwork for successive updates. This is made possible by access to a large amount of data previously generated by national laboratories and European industries.

The project researchers will publish a wide materials database on creep and creep-fatigue interaction which stems from the project's scientific reviews. The results will also show the reliability and the scientific valid-

### Coordinator

**Pietro Agostini**  
 ENEA C.R. Brasimone  
 40032 Camugnano (Bologna)  
 Tel. +39 0534801170  
 Fax: +39 0534801225  
[pietro.agostini@enea.it](mailto:pietro.agostini@enea.it)

### Project details

**Project type** // Collaborative project  
**Project start date** // 1.1.2011  
**Duration** // 48 months  
**Total budget** // EUR 12 263 835  
**EC contribution** // EUR 5 993 919

### EC project officer

**Mykola Džubinský**  
 European Commission  
 Directorate-General for Research and  
 Innovation  
 Directorate Energy  
 Unit K.4 – Fission  
 CDMA 1/58  
 B-1049 Brussels, Belgium  
[mykola.dzubinsky@ec.europa.eu](mailto:mykola.dzubinsky@ec.europa.eu)



ity of as many unconventional materials screening methods, such as indentation and small punch, which are easily useable in protected areas such as hot labs. An example of an original screening device under qualification is shown in Figure 1.

The remaining qualifications are referred to in the results of direct materials testing which is performed in MATTER about corrosion, welds performances, CO-free hard surfaces, ODS production and performances, ceramics performances and benchmarking of materials' numerical models. Six deliverables are referred to in the development of testing procedures, devices and recommendations. This is the most specific product of the MATTER consortium which is able to achieve wide comparability of results/data and is able to achieve a large consensus at the European level. These regard creep tests, fracture toughness in heavy liquid metals (HLMs), creep testing for fuel cladding tubes, corrosion in liquid metals. A significant example of output is the testing device for HLM corrosion which is shown in Figure 2.

MATTER will also come up with new or updated design rules and recommendations on ratchetting of grade 91 steels, creep and creep-fatigue, welds coefficients and welding consumables.

## Societal impact

The development of materials testing procedures and of qualified design rules will provide useful and up-to-date standardisation tools for research and industry laboratories for materials qualification and for reactor designers in view of nuclear applications. The adoption of the specific rules, developed in MATTER, will foster the European industrial initiative that aims to construct two sustainable nuclear reactors in Europe by 2025. Aside from the direct advantages in safety and sustainability, MATTER will also inspire original development of the European industry in a promising new field as development in the nuclear industry is closely linked with the development of nuclear design rules. The accomplishment of new technologies for the development of ODS and other innovative materials as part of MATTER and EERA NM represents a promising long-term solution to withstand high neutron flux, high temperature and aggressive coolants, the current limiting factors for sustainable reactors.

## Information about important public events

Two international workshops and two training courses for students and graduates have been organised.

The first workshop 'Key material issues for MYRRHA and ASTRID' was held in Rome from 7 to 9 March 2012. The first training course was the joint MATTER/GETMAT Summer School MUNECO (Materials Under Extreme Conditions) which was held in Spain from 11 to 15 June 2012.



Figure 1: Small punch device for 500 °C.

© Pietro Agostini ENEA

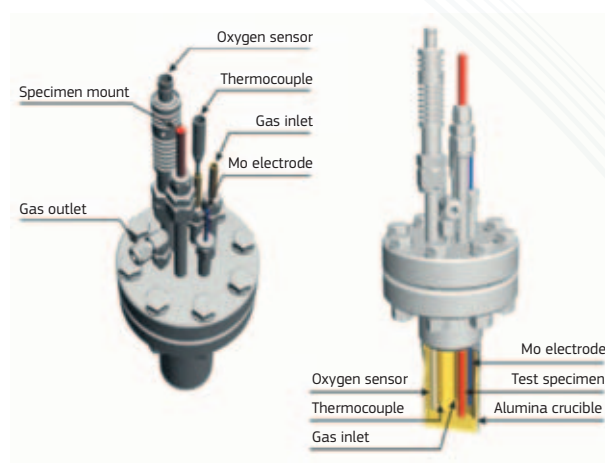


Figure 2: Testing device for corrosion in liquid metals.

© Pietro Agostini ENEA

## Partners

- Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (ENEA), IT
- Centre for Energy Research, Hungarian Academy of Sciences (BNC AEKI), HU
- Australian Nuclear Science and Technology Organisation (ANSTO), AU
- AREVA NP sas (AREVA), FR
- EDF Energy Nuclear Generation Limited (BE), UK
- Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA), FR
- OCAS – Onderzoekscentrum Voor Aanwending Van Staal N.V. (OCAS), BE
- Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas (CIEMAT), ES
- Consiglio Nazionale delle Ricerche (CNR), IT
- Centro Sviluppo Materiali S.p.A. (CSM), IT
- Electricité de France S.A. (EDF), FR
- Helmholtz-Zentrum Dresden-Rossendorf (HZDR), DE
- Industeel Creusot S.A.S. (INDUSTEEL), FR
- Regia Autonoma Pentru Activitati Nucleare Drobeta Tr. Severin Ra Sucursala Cercetari Nucleare Pitesti (INR), RO
- Joint Research Centre (JRC) – European Commission, BE
- Karlsruher Institut Für Technologie (KIT), DE
- Lithuanian Energy Institute (LEI), LT
- Nuclear Research and Consultancy Group (NRG), NL
- Paul Scherrer Institute (PSI), CH
- Centrum vyzkumu Rez s.r.o. (CV Rez), CZ
- Studiecentrum voor Kernenergie (SCK-CEN), BE
- Serco Limited (SERCO), UK
- The Chancellor, Masters and Scholars of the University of Oxford (UoxfDJ), UK
- Valtion Teknillinen Tutkimuskeskus (VTT), FI
- Groupe Böhler Soudage France S.A.S. (Bohler GBSF), FR
- Korea Atomic Energy Research Institute (KAERI), KR

## NEWLANCER

Despite European Commission efforts to facilitate and attract broad participation of New Member States (NMS) in the Euratom programme, their involvement in terms of number of projects and budget is still low. NEWLANCER will pave the way for the sustainable participation of research institutes and universities from NMS in nuclear energy research as outlined by European policies and initiatives such as the SET-Plan (Strategic Energy Technology Plan), SNETP (Sustainable Nuclear Energy Technology Platform), IGD-TP (Implementing Geological Disposal Technology Platform), ESNII (European Sustainable Nuclear Industrial Initiative), EERA (European Energy Research Alliance) and MELODI (Multidisciplinary European Low Dose Initiative).

## New Member States Linking for an Advanced Cohesion in Euratom Research

### Bringing together old and new

Over the last decade the EU's eastern frontier has expanded significantly through the accession of a large number of Central and Eastern European countries which share similar historical roots: a socialist past and a centralised regime that was responsible for issuing funding and guidelines to research and development (R&D) institutes. With the transition to the market economy the mechanisms used to fund research have changed and responsibility for defining the institutes' role and strategy has shifted to the institutes themselves. At the beginning of the last decade, the International Atomic Energy Agency (IAEA) noted that the nuclear R&D institutes had failed to adapt to this science and technology (S&T) paradigm shift, and consequently risked 'lagging behind' in management, structure, planning and funding, all of which directly affect the sustainability of the institution. In light of this and the low NMS participation in the Euratom research programme, assisting top managers and senior scientists in nuclear research to improve their management practices and improve access to national and international funding opportunities is vital.

The NEWLANCER consortium is made up of 15 partners representing nuclear research institutes, universities, implementers and small and medium-sized enterprises (SMEs) from both New and Old Member States (OMS). The NMS partners are active organisations in nuclear research and education with some previous experience in collaborative research, and the ability to crystallise and structure national expertise as well as increase regional cohesion. The OMS participants with extended and long-standing participation in the Euratom programme will guide the NMS partners to a better understanding of their opportunities, and to a better use of their research potential. All will identify together the best applicable solutions to increase future participation of NMS in Euratom research, exploring three directions: strengthening and catalysing the full R&D potential at national level, increasing cohesion among NMS and improving cooperation with OMS research centres.

### Coordinator

**Daniela Diaconu**  
Institute for Nuclear Research  
Campului 1  
Mioveni  
115400 Romania  
Tel. +40 248213400  
Fax +40 248262449  
[daniela.diaconu@nuclear.ro](mailto:daniela.diaconu@nuclear.ro)

### Project details

**Project type** // Coordination and Support Action  
**Project start date** // 1.11.2011  
**Duration** // 24 months  
**Total budget** // EUR 946 708  
**EC contribution** // EUR 900 033

### EC project officer

**Kateřina Ptáčková**  
European Commission  
Directorate-General for Research and Innovation  
Directorate Energy  
Unit K.4 – Fission  
CDMA 1/60  
B-1049 Brussels, Belgium  
[katerina.ptackova@ec.europa.eu](mailto:katerina.ptackova@ec.europa.eu)



*Newlancer Kick-off.*

© Institute for Nuclear Research, Pitesti, Romania

## Expected results

NEWLANCER will analyse NMS participation in the Euratom Framework Programmes (FPs) and compare and contrast this with the actual research potential of nuclear research organisations, taking into consideration the Strategic Research Agenda (SRA) and other energy policies. This comprehensive review will give a clear picture of the obstacles and difficulties that must be overcome. A catalogue will list the research skills and infrastructure existing in the NMS that should be further promoted.

Best practices and recommendations extracted from the Euratom success stories will reflect the findings of all project partners (both specialists and managers), and be communicated to a large spectrum of end users interested in better integration of the research potential across EU. These will be applied inside the project in a pilot exercise for the elaboration of a new project proposal intended to integrate consortium organisations not yet involved in Euratom projects and coming from either NMS or from OMS with a low level of participation.

The main outcome of NEWLANCER will be a complex and dynamic network able to interact at the European and national levels in order to improve the harmonisation of nuclear research policies in each participating NMS with European objectives. National expert groups created in each Euratom research field will interact at regional level, creating regional expert clusters. The network will explore current research capabilities in the NMS, identify opportunities for future project proposals, and produce working plans for long-term cooperation and advanced cohesion at the regional level. This network will come up with proposals at the institutional level, aligned to national strategies and distilled into a regional perspective.

## Societal impact

European nuclear R&D is oriented to developing future reactors, which should significantly improve nuclear safety and the use of mineral resources as well as strongly reduce waste radiotoxicity, particularly regarding high level and long-lived wastes. Research also aims to continually improve the level of reactor safety of existing nuclear power plants (NPPs) as well as ensure sustainable management of radioactive materials and waste. Special concerns of the nuclear field are long-term education and training for new qualified personnel and knowledge preservation and management. NEWLANCER will facilitate advances in all these areas by bringing NMS research and education up to higher standards, and therefore the overall European research capacity to a higher level.

## Partners

- Regia Autonoma pentru Activitati Nucleare – Sucursala Cercetari Nucleare Pitesti (INR), RO
- Magyar Tudományos Akadémia Energiatudományi Kutatóközpont, (MTA EK) HU
- Agencija Za Radioaktivne Odpadke (ARAO), SI
- Commissariat à l’Energie Atomique et aux Energies Alternatives (CEA), FR
- Ente per le Nuove tecnologie l’Energia e l’Ambiente e lo Sviluppo Economico Sostenibile (ENEA), IT
- Institute of Nuclear Chemistry and Technology (INCT), PL
- Institute for Nuclear Research and Nuclear Energy (INRNE-BAS), BG
- Jožef Stefan Institute (JSI), SI
- Lithuanian Energy Institute (LEI), LT
- Agenzia per la Promozione della Ricerca Europa (APRE), IT
- Studiecentrum voor Kernenergie – Centre d’Etude de l’énergie Nucléaire (SCK-CEN), BE
- Institut SYMLOG de France (SYMLOG), FR
- Technical University of Sofia – Research and Development Sector (TUS), BG
- University of Ljubljana (UL), SI
- Universitatea Politehnica din Bucuresti (UPB), RO



## SMILE

Since its launch in September 2007 the Sustainable Nuclear Energy Technology Platform (SNETP) has supported technological developments in nuclear fission as part of a safe, sustainable, low-carbon mix. Its 100+ members share a common vision and work together to optimise European scientific and engineering resources. The aim of SMILE is to provide professional support for managing the Platform's diverse operations.

## SNETP Management, Implementation, Liaison and Evolution

### Diverse partners

SMILE ensures both continuity and additional support to the growing requirements of the SNETP, in particular to its Technology Working Groups. The SMILE consortium is led by LGI Consulting – an innovation management consultancy with thorough experience in European projects related to the nuclear field. They are supported by research centres from France (CEA) and the Czech Republic (UJV Rez), as well as the German utility company E.ON and European association FORATOM (European Atomic Forum).

### Activities

SMILE provides secretariat support to the Platform and its governing bodies, thus ensuring efficient management processes. The partners also help with implementation by supporting the activities of the Platform's Working Groups, with secretariat and operational assistance. Through liaison and communication they ensure maximum impact and dissemination of the activities of the SNETP and its Working Groups, and organise continuous interaction with different stakeholders. Professional publication of the SNETP documents and continuous management of web-based information contribute to maximising the efficiency and impact of the work produced by the Platform.

The SMILE team also monitors and plans further SNETP activities by setting out a consolidated roadmap of planned research and development (R&D) activities. The dynamic nature of this tool means that it can be shared throughout the whole research community, and keep stakeholders up-to-date on technological achievements and plans for nuclear fission R&D in Europe.

In particular, SMILE supports the following major events in the evolution of the SNETP:

- the implementation of strategic documents (Strategic Research Agenda (SRA) and Deployment Strategy (DS)) – in particular through the operation of European industrial initiatives, under the EU's Strategic Energy Technology Plan (SET-Plan);
- the update of the SRA;
- the implementation of the Education, Training and Knowledge Management strategy.

### Coordinator

**Vincent Chauvet**

Lagrange (LGI Consulting)

Rue de Marivaux, 13

F-75002 Paris

Tel. +33 67539 8727

Fax +33 97231 8187

[vincent.chauvet@lgi-consulting.com](mailto:vincent.chauvet@lgi-consulting.com)

### Project details

**Project type** // Coordination & Support

Action

**Project start date** // 1.6.2011

**Duration** // 36 months

**Total budget** // EUR 1 017 203

**EC contribution** // EUR 800 000

### EC project officer

**Michel Hugon**

European Commission

Directorate-General for Research and

Innovation

Directorate Energy

Unit K.4 – Fission

CDMA 1/52

B-1049 Brussels, Belgium

[michel.hugon@ec.europa.eu](mailto:michel.hugon@ec.europa.eu)



SMILE helps to further enhance the visibility of the Platform and improve communication between SNETP and the general public, EU and national decision makers, as well as the nuclear industry and the nuclear scientific and engineering research communities.

## Communicating and engaging with the community

More than ever, effective communication is essential for demystifying the nuclear industry, as well as for engaging stakeholders in meaningful public dialogue and decision making. Wide dissemination of SNETP publications is envisaged, both electronically and through physical copies, in order to reach as wide an audience as possible and maximise impact.

The project's communications strategy comprises a complete 'toolkit', from a continuously updated public website to newsflashes, newsletters and participation in significant international events. In particular, the SNETP factsheets target a non-expert public and specifically address issues of general concern such as carbon dioxide (CO<sub>2</sub>) emissions, sustainability, nuclear safety and economic aspects.

SMILE started with the organisation of a kick-off meeting of the Platform's Nuclear Cogeneration Industrial Initiative (NC2I) Task Force, in Warsaw, June 2011. The secretariat also organised SNETP's participation in events such as the EURELECTRIC Workshop on Nuclear Perspectives after Fukushima (Brussels, September 2011). SNETP was also represented in GRED 2011 (Global Renewable Energy Development, Brussels, October 2011).

The Platform's Third General Assembly took place in November 2011, as a side event of the SET-Plan conference organised by the Polish Presidency of the Council of the European Union. The SMILE team will also organise the Fourth General Assembly, currently planned for 2013.



© Courtesy of LGI Consulting

## Partners

- Lagrange SARL (LGI Consulting), FR
- Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA), FR
- E.ON Kernkraft GmbH (E.ON), DE
- Ústav Jaderného Vyzkumu Rez. a.s. (UJV), CZ
- Forum Atomique Européen (FORATOM), BE



## GLOSSARY

Many of the entries in this glossary are reproduced courtesy of the International Atomic Energy Agency (IAEA; see <http://www.iaea.org>).

### ► Ageing

General process in which characteristics of a structure, system or component gradually change with time or use. Although the term ageing is defined in a neutral sense – the changes involved in ageing may have no effect on protection or safety, or could even have a beneficial effect – it is most commonly used with a connotation of changes that are (or could be) detrimental to protection or safety, i.e. as a synonym of ageing degradation.

### ► Accident management

The taking of a set of actions during the evolution of a beyond design-basis accident:

- to prevent the escalation of the event into a severe accident;
- to mitigate the consequences of a severe accident;
- to achieve a long-term, safe and stable state.

### ► Decommissioning

- 1) Administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a facility (except for a repository which is closed and not decommissioned).
- 2) All steps leading to the release of a nuclear facility, other than a disposal facility, from regulatory control. These steps include the processes of decontamination and dismantling.

### ► Disposal

Emplacement of waste in an appropriate facility without the intention of retrieval (c.f. storage with intent to retrieve).

Some countries use the term disposal to include controlled discharges of effluents to the environment.

- Direct disposal: Disposal of spent fuel as waste.
- Geological disposal: Disposal in a geological repository.

### ► Dose

- 1) A measure of the energy deposited by radiation in a target.
  - 2) Absorbed dose, committed equivalent dose, committed effective dose, effective dose, equivalent dose or organ dose, as indicated by the context.
- Committed dose: Committed equivalent dose or committed effective dose.

### ► Engineered barrier system

The designed or engineered components of a repository, including waste packages and other engineered barriers.

## ► Exposure

The act or condition of being subject to irradiation.

- External exposure: Exposure due to a source outside the body. Contrasted with internal exposure.
- Internal exposure: Exposure due to a source within the body. Contrasted with external exposure.
- Natural exposure: Exposure due to natural sources. Natural exposure is often excluded exposure, but in some cases may be occupational exposure or public exposure.

## ► Fission product

A radionuclide produced by nuclear fission. Used in contexts where the radiation emitted by the radionuclide is the potential hazard.

## ► Generations of nuclear reactors

Generation-I reactors were developed in the 1950s and 1960s as prototypes. Only a few are still running today. Most reactors operating now are generation-II reactors, developed on the basis of the most successful generation-I prototypes. Generation III reactors are considered to be 'advanced reactors'. Examples include the European Pressurised Water Reactor (EPR) and the AP1000 of Westinghouse. These focus on improving safety, economics and severe-accident management scenarios. More than a dozen generation-III advanced reactor designs are in various stages of development. Some have evolved from existing designs, while others are more radical. The best-known radical new design is the 'pebble-bed modular reactor', or high-temperature reactor, which uses helium as coolant at very high temperatures to drive a turbine directly.

Generation-IV designs are still on the drawing board and will not be operational on a commercial basis for at least two or three decades. Presently, six different systems are being developed in the framework of the Generation IV International Forum (GIF), which brings together countries with interest in these developments. Euratom is also a member of GIF. Three of the generation-IV systems are fast reactors using sodium, lead or gas as coolant. One is an advanced HTR, one is a supercritical water-cooled reactor and one is a molten-salt reactor concept.

## ► Geological repository

A facility for disposal of radioactive waste located underground (usually several hundred metres or more below the surface) in a geological formation, to provide long-term isolation of radionuclides from the biosphere.

## ► High-level waste (HLW)

The radioactive liquid containing most of the fission products and actinides present in spent fuel – which forms the residue

from the first solvent-extraction cycle in reprocessing – and some of the associated waste streams; this material following solidification; spent fuel (if it is declared a waste); or any other waste with similar radiological characteristics. Typical characteristics of high-level waste are thermal power above about 2 kW/m<sup>3</sup> and long-lived radionuclide concentrations exceeding limitations for short-lived waste.

## ► IAEA

The International Atomic Energy Agency (IAEA) is an independent international organisation that is related to the United Nations. The IAEA reports to the UN Security Council regarding non-compliance in terms of both safety obligations and matters relating to international peace and security.

## ► Ionising radiation including $\alpha$ , $\beta$ , $\gamma$ , etc.

For the purposes of radiation protection, radiation capable of producing ion pairs in biological material(s).

Ionising radiation can be divided into low-LET (linear energy transfer) radiation and high-LET radiation (as a guide to its relative biological effectiveness), or into strongly penetrating radiation and weakly penetrating radiation (as an indication of its ability to penetrate shielding or the human body).

## ► ISTC

The International Science and Technology Center (ISTC) was set up in Moscow, Russia and is an intergovernmental organisation that works to prevent the proliferation of expertise related to weapons of mass destruction. To learn more, visit <http://www.istc.ru>.

## ► Minimisation, waste

The process of reducing the amount and activity of radioactive waste to a level as low as reasonably achievable, at all stages from the design of a facility or activity to decommissioning. This is done by reducing waste generation and also by means such as reuse of certain fuel components and treatment of the waste, with due consideration for secondary as well as primary waste.

## ► Model

A representation of a system and the ways in which phenomena occur within that system, used to simulate or assess the behaviour of the system for a defined purpose.

- Transport model

A mathematical representation of mechanisms controlling the movement of finely dispersed or dissolved substances in fluids.



## ► Nuclear fuel cycle

All operations associated with the production of nuclear energy, including:

- mining and milling, processing and enrichment of uranium or thorium;
- manufacture of nuclear fuel;
- operation of nuclear reactors (including research reactors);
- reprocessing of nuclear fuel;
- any related research and development activities;
- all related waste management activities (including decommissioning).

## ► Nuclear safety

The achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards.

## ► OECD/NEA

The Nuclear Energy Agency (NEA) is a specialised agency within the Organisation for Economic Co-operation and Development (OECD). To learn more, visit <http://www.nea.fr>.

## ► Partitioning

Separation, usually by chemical methods, of minor actinides from the reprocessing stream, for the purpose of appropriate further processing, storage and/or disposal.

## ► Performance assessment

An assessment of the performance of a system or sub-system and its implications for protection and safety at a planned or an authorised facility. This differs from safety assessment in that it can be applied to parts of a facility and does not necessarily require assessment of radiological impacts.

## ► Radiation protection

The protection of people from the effects of exposure to ionising radiation and the means for achieving this. The International Commission on Radiological Protection (ICRP) and others use the term radiological protection, which is synonymous. The accepted understanding of the term radiation protection is restricted to protection of humans. Suggestions of extending the definition to include the protection of non-human species or the environment are controversial.

## ► Radioactivity

The phenomenon whereby atoms undergo spontaneous random disintegration, usually accompanied by the emission of radiation. A nucleus (of an atom) that possesses properties of spontaneous disintegration (radioactivity). Nuclei are distinguished by their mass and atomic number.

## ► Radioactive species

Either single radioactive atoms, molecules, molecular fragments or ions containing one or more radioactive atoms.

## ► Redox

Various definitions exist for redox reactions (oxidation and reduction chemical reactions) in terms of the transfer of oxygen, hydrogen and electrons between the chemical elements involved in the reaction.

- Redox phenomena and conditions: Phenomena involving redox reactions and the physio-chemical conditions in which they take place. In the geochemical field in particular, redox reactions determine the mobility of many radioactive species.

## ► Repository

A nuclear facility where waste is emplaced for disposal.

- Geological repository: A facility for radioactive waste disposal located underground (usually several hundred metres or more below the surface) in a stable geological formation to provide long-term isolation of radionuclides from the biosphere.
- Near-surface repository: A facility for radioactive waste disposal located at or within tens of metres of the Earth's surface.

## ► Reprocessing

A process or operation, the purpose of which is to extract radioactive isotopes from spent fuel for further use.

## ► Safety Case

An integrated collection of arguments and evidence to demonstrate the safety of a geological disposal facility.

## ► Severe accident

Accident conditions more severe than a design-basis accident and involving significant core degradation.

### ► Spent nuclear fuel

- 1) Nuclear fuel removed from a reactor following irradiation, which is no longer usable in its present form because of depletion of fissile material, build-up of poison or radiation damage.
- 2) Nuclear fuel that has been irradiated in and permanently removed from a reactor core.

### ► STCU

The Science and Technology Center in Ukraine (STCU) is an intergovernmental organisation that works to prevent the proliferation of expertise related to weapons of mass destruction. To learn more, visit <http://www.stcu.int>.

### ► Storage

The holding of spent fuel or of radioactive waste in a facility that provides for its containment, with the intention of retrieval.

### ► Transmutation

The conversion of one element into another. Transmutation is under study as a means of converting longer-lived radionuclides into shorter-lived or stable radionuclides. The term actinide burning is used in some countries.

### ► Underground research laboratory

Tests conducted within a geological environment that is essentially equivalent to the environment of a potential repository. A special underground laboratory, called an underground research laboratory (URL), may be built for in situ testing or tests may be carried out in an actual repository excavation. Only in such a facility can the full range of repository environment properties and waste repository system interactions be measured.

### ► Very high temperature reactor (V/HTR)

A graphite-moderated nuclear reactor that uses a 'once-through' uranium fuel cycle. This generation-IV reactor concept is designed to produce an outlet temperature of 1 000°C (see Generations of nuclear reactors, above).

### ► Vitrified waste

The vitreous product that results from incorporating waste into a glass matrix.

### ► Waste, radioactive

For legal and regulatory purposes, waste that contains or is contaminated with radionuclides at concentrations or activities greater than clearance levels as established by the regulatory body.



## Index of projects

ADRIANA	36	HeLiMnet	58
ADVANCE	38	HPMC	60
ALICE	106	InSOTEC	20
ALISA	108	IPPA	22
ANDANTE	86	JASMIN	62
ANDES	40	LACOMEKO	112
ARCHER	42	LEADER	64
ASGARD	44	LOGLIFE	66
BELBaR	12	LUCOEX	24
CATCLAY	14	MATTER	126
CEREBRAD	88	MAX	68
CINCH	114	MULTIMETAL	70
CORONA	116	NERIS-TP	96
CROCK	16	NEWLANCER	128
DoReMi	90	PEBS	26
ECNET	118	PELGRIMM	72
ENEN-RU	120	PROCARDIO	98
EPI-CT	92	REDUPP	28
EpiRadBio	94	RENEB	100
ERCOSAM	46	SARGEN_IV	74
ERINDA	48	SCWR-FQT	76
EURACT-NMR	110	SEARCH	78
EURECA!	122	SecIGD	30
EVOL	50	SILER	80
FIRST-Nuclides	18	SITEX	32
FREYA	52	SKIN	34
GoFastR	54	SMILE	130
HARMONICS	56	STYLE	82



SOLO	102
STAR	104
THINS	84
TRASNUSAFE	124



**European Commission**

EUR 24859 — **Euratom FP7 Research & Training Projects Volume 3**

Luxembourg: Publications Office of the European Union

2012 — 140 pp. — format 29.7 x 21.0 cm

ISBN 978-92-79-20029-8

doi:10.2777/65063

## **How to obtain EU publications**

### **Free publications:**

- via EU Bookshop (<http://bookshop.europa.eu>);
- at the European Commission's representations or delegations. You can obtain their contact details on the Internet (<http://ec.europa.eu>) or by sending a fax to +352 2929-42758.

### **Priced publications:**

- via EU Bookshop (<http://bookshop.europa.eu>);

### **Priced subscriptions (e.g. annual series of the Official Journal of the European Union and reports of cases before the Court of Justice of the European Union):**

- via one of the sales agents of the Publications Office of the European Union ([http://publications.europa.eu/others/agents/index\\_en.htm](http://publications.europa.eu/others/agents/index_en.htm)).

This brochure describes the third batch of research projects (60 in total) funded through the specific programme for 'Research and Training on Nuclear Energy (2007-2011)' under the Seventh Euratom Framework Programme for Nuclear Research and Training Activities (FP7 Euratom). The projects described here all involve research activities in the general area of nuclear fission and radiation protection. Research and training activities in nuclear installation safety, innovative nuclear reactor designs, approaches to the management of radioactive waste and radiation protection are all major themes of the programme. Euratom activities on research and development for nuclear fusion are not covered here.



Publications Office

ISBN 978-92-79-20029-8



9 789279 200298