Spent Fuel Characterization and Evolution Until Disposal

Joaquin Cobos/CIEMAT, on behalf of the WP coordination team

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Coordination team for the development of the proposal

	Name	Organisation	Country	Type (WMO, TSO, RE)
Main coordinator	Peter Jansson	Uppsala University	SE	RE
Subcoordinator	Stefano Caruso	NAGRA	CH	WMO
Subcoordinator	Joaquin Cobos	CIEMAT	ES	TSO

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SFC - Main Objectives

- **Experimental procedures** to estimate the isotopic content of SNF & uncertainties.
- Establish **characterization techniques** for SNF during its evolution from reactor to disposal .
- **Uncertainty quantification** on the evolution of SNF in pre-disposal activities.
- **Performance of the SNF** during **pre-disposal**, to build basis for safety concepts/culture.
- **Ageing effect & behavior** of fuel, cladding, fuel-cladding interaction under normal and accident conditions.
- Contribute to the operational safety concepts for **fuel handling at SNF packaging facilities**.
- **Education, training** and building **competences** in the subject.

WP Expected impacts

- Radiactive Waste Management implementation needs
  - Reduced uncertainty of the decay heat ➡ economical savings DGR.
- Safety Analysis and Assesment
  - Reduced uncertainties on safety.
  - Guidance on operational safety of interim storage & fuel packaging facilities.
  - Safety assessment on pre-disposal technologies could predict the consequences of design changes.
- Increasing scientific and technical Knowledge in RWM
  - Fuel & cladding: thermomechanical/chemistry degrading mechanisms.
  - Identification gaps and propose beyond the SOTA.
  - Increase knowledge to the European concept/strategy.
  - Models and experimental understanding of the SNF-rod behavior .
- Radioactive waste management routes
  - WP will meet WMO´s, regulatory bodys, RE´s and TSO´s Stategy.
  - Contribute to implement EU directives and comunications. ➡

SFC Participants

Organisations
✓ **CEA,** France (RE)
✓ **CHRDI**, Ukraine (WMO)
✓ **CIEMAT**, Spain (TSO) ▪ IDOM, Spain ▪ UPM, Spain
✓ **CNRS**, France (RE) ▪ Umontpellier, France
✓ **ENRESA**, Spain (WMO) ▪ ENUSA, Spain
✓ **CPST**, Lithunia (TSO)
✓ **FZJ**, Germany (RE) ▪ HZDR, Germany
✓ **IRSN**, France (TSO) ▪ NTW, France
✓ **JRC,** Belgium (RE)
✓ **JSI**, Slovenia (TSO) ▪ EIMV, Slovenia

Organisations
✓ **KIT**, Germany (RE) ▪ BAM, Germany ▪ PEL, Germany
✓ **LEI**, Lithuania (RE)
✓ **MTA EK**, Hungary (RE)
✓ **NAGRA,** Switzerland (WMO)
✓ **PSI**, Switzerland (RE)
✓ **SCK-CEN**, Belgium (RE)
✓ **SKB**, Sweden (WMO) ▪ UU, Sweden
✓ **SSTC NRS**, Ukraine (TSO)
✓ **SURAO**, Czech Republic (WMO) ▪ CTU, Czech Republic
✓ **TUS,** Bulgaria (RE)
✓ **VTT**, Finland (TSO)

Interested external parties

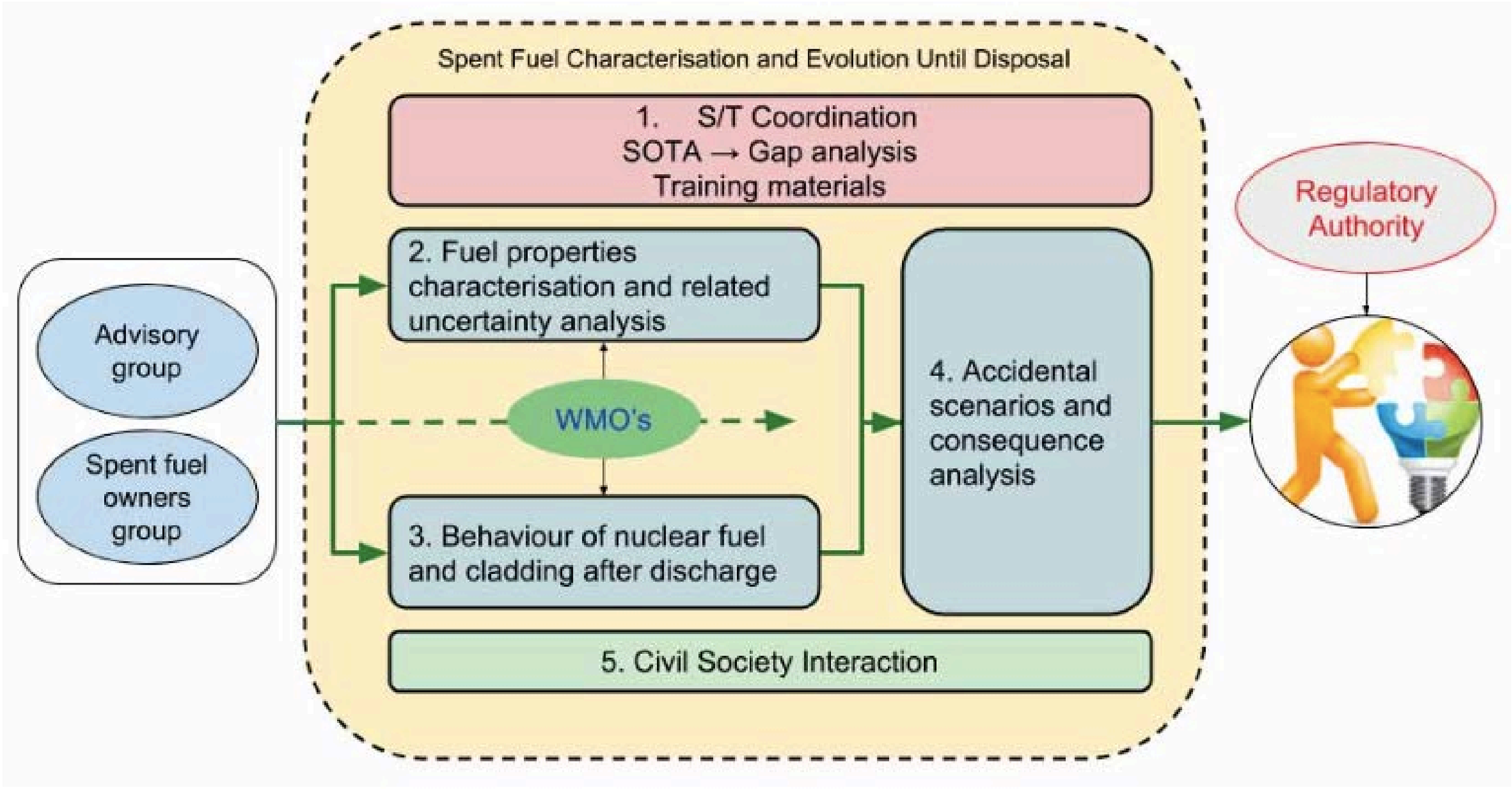
Organisation	Country
Chalmers University of Technology	SE
Czech Radioactive Waste Repository Authority (SÚRAO)	CZ
Electric Power Research Institute (EPRI)	USA
Endesa	SP
Gesellschaft für Anlagen- und Reaktorsicherheit (GRS)	DE
Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)	IT
Kharkov Institute of Physics and Technology	UA
Lawrence Livermore National Laboratory	USA
National Nuclear Laboratory	UK
Oak Ridge National Laboratory	USA
OECD NEA Data Bank	OECD
Pacific Northwest National Laboratory	USA
Radioactive Waste Management (RWM)	UK
Studsvik (SCIP project)	SE
Swedish Academic Initiative on Nuclear Technology Research (SAINT)	SE
TS Enercon	HU
University of Bristol	UK
Tokyo Institute of Technology	JP

WP – Task Breakdown and WP Board

- Main coordinator, Peter Jansson, Uppsala University
- Contact info: peter.jansson@physics.uu.se, +46184715841

- **Task 1 – S/T coordination, State-of-the-art and training material.**
  - Task Leader (SKB/UU)
- **Task 2 - Fuel properties characterisation and related uncertainty analysis Start.**
  - Task Leader (JRC Geel/SCK-CEN)
- **Task 3 - Behaviour of nuclear fuel and cladding after discharge.**
  - Task Leader (KIT/BAM)
- **Task 4 - Accident scenario and consequence analysis**
  - Task Leader (CIEMAT/NAGRA)
- **Task 5 – Civil Society (CS) interaction**
  - Task Leader (JSI/EIMV)

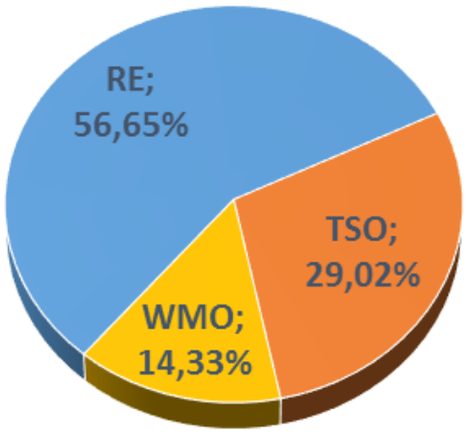
Structure of the SFC WP



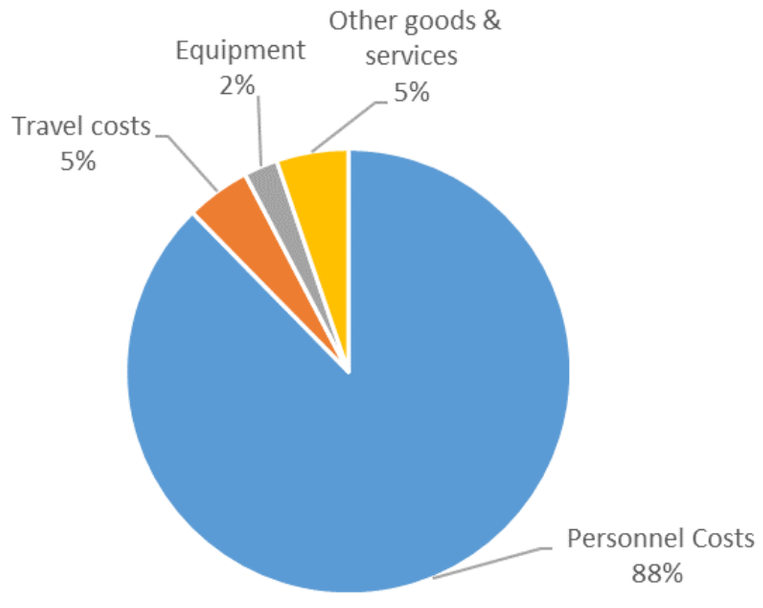
WP – Planned resources

TOTAL BUDGET	5,8M€
EC requested contribution	2,9M€

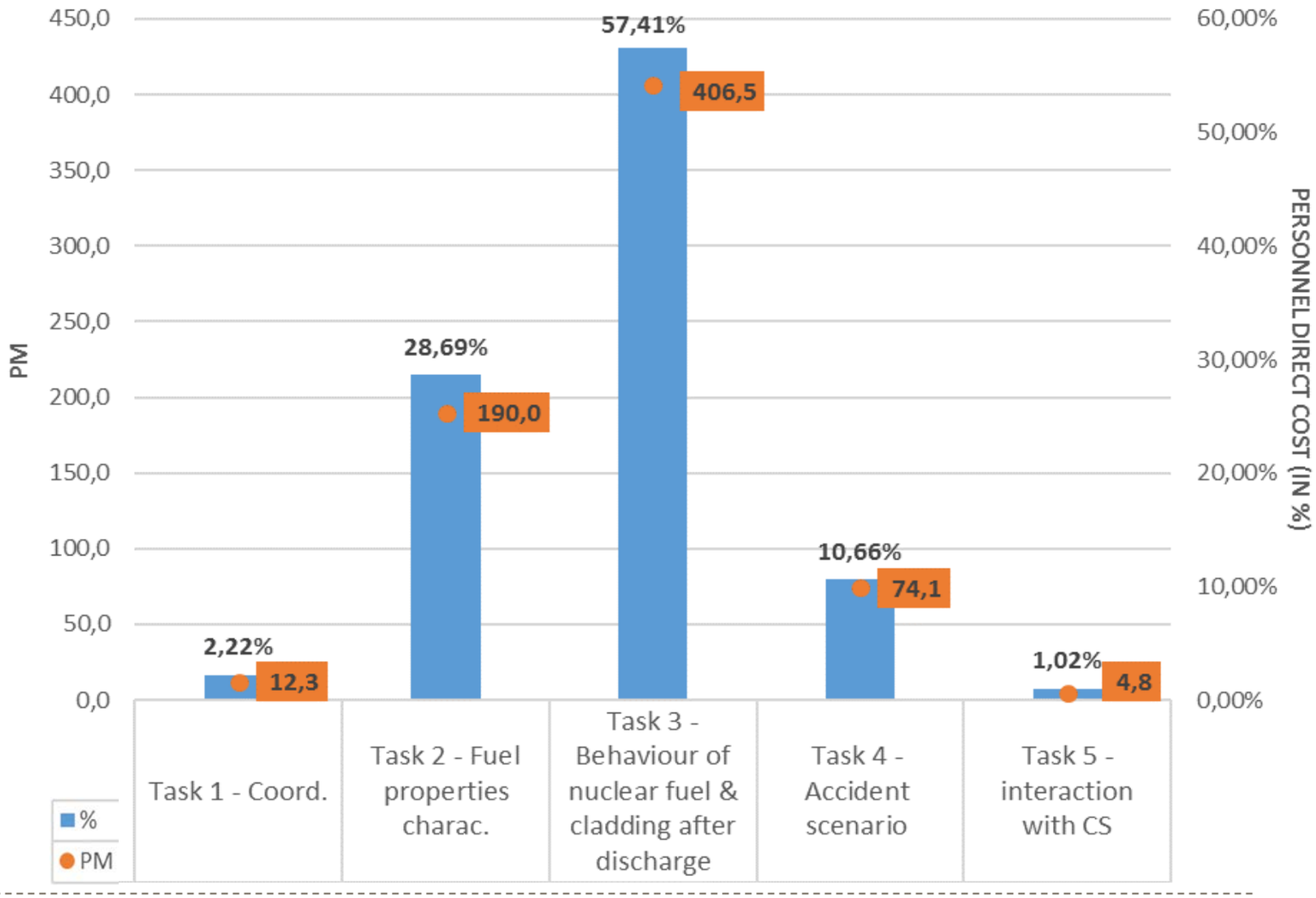
SFC WP:
Distribution of EC Contribution between categories of Actors



SFC WP - Budget distribution between categories of direct costs



SFC WP:
Personnel costs breakdown per task (in % and in PM) - Total PM: 687,6



WP – Task 1 – S/T coordination, State-of-the-art & training material

- **Task Leader**: SKB (UU)
- **Objective**:
  - Provide efficient management and administration of the work package
  - Identify potential problems at an early stage and provide timely and effective solutions.
  - Developing/updating SOTA and training materials as an input to KM.

- Subtask 1.1 – S/T coordination
- Subtask 1.2 – State-of-the-art and Gap analysis
- Subtask 1.3 – Training materials

WP – Task 2 - Fuel properties characterisation and related uncertainty analysis

- **Task Leader**: JRC- Geel
- **Objective**: Produce experimentally verified procedures to determine reliable source terms of spent nuclear fuel (SNF), including realistic uncertainties.
  - Subtask 2.1 – Theoretical study of SNF source terms: Timescale 48 months. Subtask Leader PSI
  - Subtask 2.2 – Develop, improve and demonstrate NDA methods/systems for SNF characterisation. Timescale 48 months. Subtask Leader SCK.CEN
  - Subtask 2.3 – Determine the inventory of activation and fission products in cladding material. Timescale 48 months. Subtask Leader VTT.
  - Subtask 2.4 – Define and verify procedures to determine the source terms of SNF assemblies with realistic confidence limits. Timescale 35 months. Subtask Leader KIT.

WP – Task 3 - Behaviour of nuclear fuel and cladding after discharge

- **Task Leade**r: KIT (BAM)
- **Objective**: Understand and describe numerically the behavior of SNF, irradiated cladding, fuel/cladding chemical interaction (FCCI) and ageing effect under conditions of extended interim storage, transportation and emplacement in a final disposal system.
  - Subtask 3.1 – Thermo-mechanical-chemical properties of the SNF rods and cladding Timescale 48months. Subtask Leader CIEMAT (UPM).
  - Subtask 3.2 – Behaviour of SNF pellets under interim storage conditions. Timescale 48 months. Subtask Leader CIEMAT.
  - Subtask 3.3 – Pellet-cladding interaction under conditions of extended storage, transport and handling of SNF rods. Timescale 48months. Subtask Leader CIEMAT

WP – Task 4 - Accident scenario and consequence analysis

- **Task Leader**: CIEMAT (NAGRA)
- **Objective**: Study SNF behaviour under accident conditions which may lead to a potential loss of confinement during storage, transport and pre-disposal activities.
  - Subtask 4.1 – Accident scenario for fuel under dry interim storage conditions Timescale 48 months. Subtask Leader NAGRA.
  - Subtask 4.2 – Consequence analysis of accident scenarios 35 Months. Subtask Leader ChRDI.

WP – Task 5 – Civil Society (CS) interaction

- **Task Leader**: JSI (EIMV).
- **Objective**: To follow by the CS the work conducted in the WP by using a CS interaction framework developed and established for EURAD, facilitating the translation of results and other output of the WP to the civil society. Finally the task 5 will enhance the possibilities of CS participation in future situations where there are consultation processes as a part of safety case review.
  - Subtask 5.1– Scoping of SFC tasks 2-4, initial input from the CS experts and development of Interaction with Civil Society (ICS) action plan. Timescale 12 Months. Task Leader [JSI (EIMV)].
  - Subtask 5.2– Implementing ICS action plan. Timescale 24 Months. Task Leader [JSI (EIMV)].
  - Subtask 5.3– Synthesis work and dissemination. Timescale 24 Months. Task Leader [JSI (EIMV)].

Key challenges & objectives for Year 1

- Task 1:
  - S/T coordination startup.
  - Focus on gap analysis as well as literature research, aiming to collect and summarise SOTA research activities
    - **Deliverable**: State-of-the-art report – M6
- Task 2
  - Definition of the different necessary quantities to perform the code-to-code.
  - A selection of a number of representative assemblies will be made.
  - Currently used NDA techniques for SNF to be described.
  - Preparation of irradiated sub-samples of cladded UO_2 and MOX pellets to be measured.

Key challenges & objectives for Year 1

- **Task 3:**
  - Preparation of irradiated and unirradiated samples of spent nuclear fuel rod segments and cladding.
  - Start of experiments to identify the behaviour of irradiated fuels and simulated spent nuclear fuel pellets.
- **Task 4:**
  - Identification and first analysis of credible accident scenarios related to transport/storage of SNF.
  - Activities devoted to link this task to the Task 2 and 3 are also foreseen.
    - **Deliverable:** state-of-emergency radioactive waste - M3
- **Task 5:**
  - Scoping of the objectives and actions in SFC tasks 2-4 in order to identify issues that are deemed of more specific interest in the perspective of developing interactions between civil society and EURAD partners along the course of the WP.
    - **Deliverable:** ICS action plan - M11