



*Towards European Licensing of
Small Modular Reactors*

ELSMOR

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The VTT logo consists of the letters 'VTT' in a bold, sans-serif font. The 'V' is orange, and the 'TT' is blue.

ELSMOR

towards European licensing of SMRs

- Project aiming to investigate selected safety features of LW-SMRs
- Part of projects funded by EURATOM 2014-2018 Research and Training Programme
 - Safety focus of H2020 EURATOM Programme calls
- 3.5 year research project started on 9/2019

Contents of the presentation

- Concept of ELSMOR
- ELSMOR consortium
- Project description

Growing interest in SMRs



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Romania to explore NuScale SMR deployment

19 March 2019



An agreement between US small modular reactor (SMR) developer NuScale Power and Romanian energy company Societatea Nationala Nuclearelectrica SA (SNN SA) to explore the use of SMRs in Romania has been welcomed by the US Department of Energy (DOE).



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Russia gets operating licence for floating plant

27 June 2019



Russia's Rosenergoatom has received an operating licence for its floating nuclear power plant, *Akademik Lomonosov*, from the country's regulator Rostekhnadzor. The facility is 144 metres in length, 30 metres wide and has a displacement of 21,000 tonnes. It has two 35 MWe KLT-40S reactors.



The newly-painted Akademik Lomonosov in Murmansk (Image: Rosenergoatom)



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ČEZ and NuScale to explore Czech SMR deployment

26 September 2019



NuScale Power has signed a Memorandum of Understanding with ČEZ, to explore applications for its small modular reactor in the Czech Republic.



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GE Hitachi, Fermi Energia sign small modular reactor MoU

03 October 2019



GE Hitachi Nuclear Energy (GEH) and Fermi Energia have agreed to collaborate on potential deployment applications for GEH's BWRX-300 small modular reactor in Estonia. In a Memorandum of Understanding they have agreed to examine the economic feasibility of constructing a BWRX-300 in Estonia, to review siting requirements and to assess nuclear regulatory requirements.



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NuScale SMR enters first manufacturing phase

26 September 2018



NuScale Power has selected BWX Technologies Inc (BWXT) as the first manufacturer of its small modular reactor (SMR). This marks the transition to the manufacturing phase and represents major progress in bringing the technology to market, NuScale said yesterday.

French-developed SMR design unveiled

17 September 2019



A new small modular reactor (SMR) design has been announced by the French Alternative Energies and Atomic Energy Commission (CEA), EDF, Naval Group and TechnicAtome. The Nuward - with a capacity of 300-400 MWe - has been jointly developed using France's experience in pressurised water reactors (PWRs).



SMRs in EURATOM 2014-2018 training&research programme

- To acknowledge the interest in SMRs in total of 4 projects are funded by the EURATOM programme
 - GEMINI+
 - ELSMOR
 - McSAFER
 - EEC SMART

ELSMOR answer to NFRP-2018-3

Scope of the action

This action should **investigate improved safety features of Light Water SMRs** and provide a set of fundamental technical specifications, against which compliance of SMRs with Directive 2009/71/Euratom could be tested by safety regulators. **The research should also propose the methodology** for the performance of these tests, including the experimental validation of essential items of the proposed models of safety demonstration as well as **their effects on the SMR licensing process** under various typical fields of application. Due account should be taken of safety features for the refuelling and spent fuel management of SMRs in the above safety demonstration as well as to decommissioning. To increase the impact of the action, **particular attention should be paid to Light Water SMR concepts deployable in the short-term.**

ELSMOR concept

- To investigate selected safety features of LW-SMRs
 - Safety focus of H2020 EURATOM Programme calls
 - Prevention of early release
 - Core cooling functions
 - Containment
- Research on methods for robust safety assessments
 - Several prior proposals / methodologies developed for both currently operating plants as well as non-conventional, e.g. for GenIV, fusion...
- Demonstration of the applicability of developed tools and methods
 - Test case
- Dissemination to stakeholders

Project consortium

- 15 partners
- 8 countries represented
- Initial consortium building by Nugenia T.A. 6



Collaboration with European SMR developers

- Collaboration with French SMR developer consortium
 - 3 out of 4 partners in ELSMOR
- Earlier conceptual development version of Nuward (F-SMR) provides some reference cases for investigation
 - Passive core cooling
 - Submerged containment cooling
 - Similar features in various designs

French-developed SMR design unveiled

17 September 2019

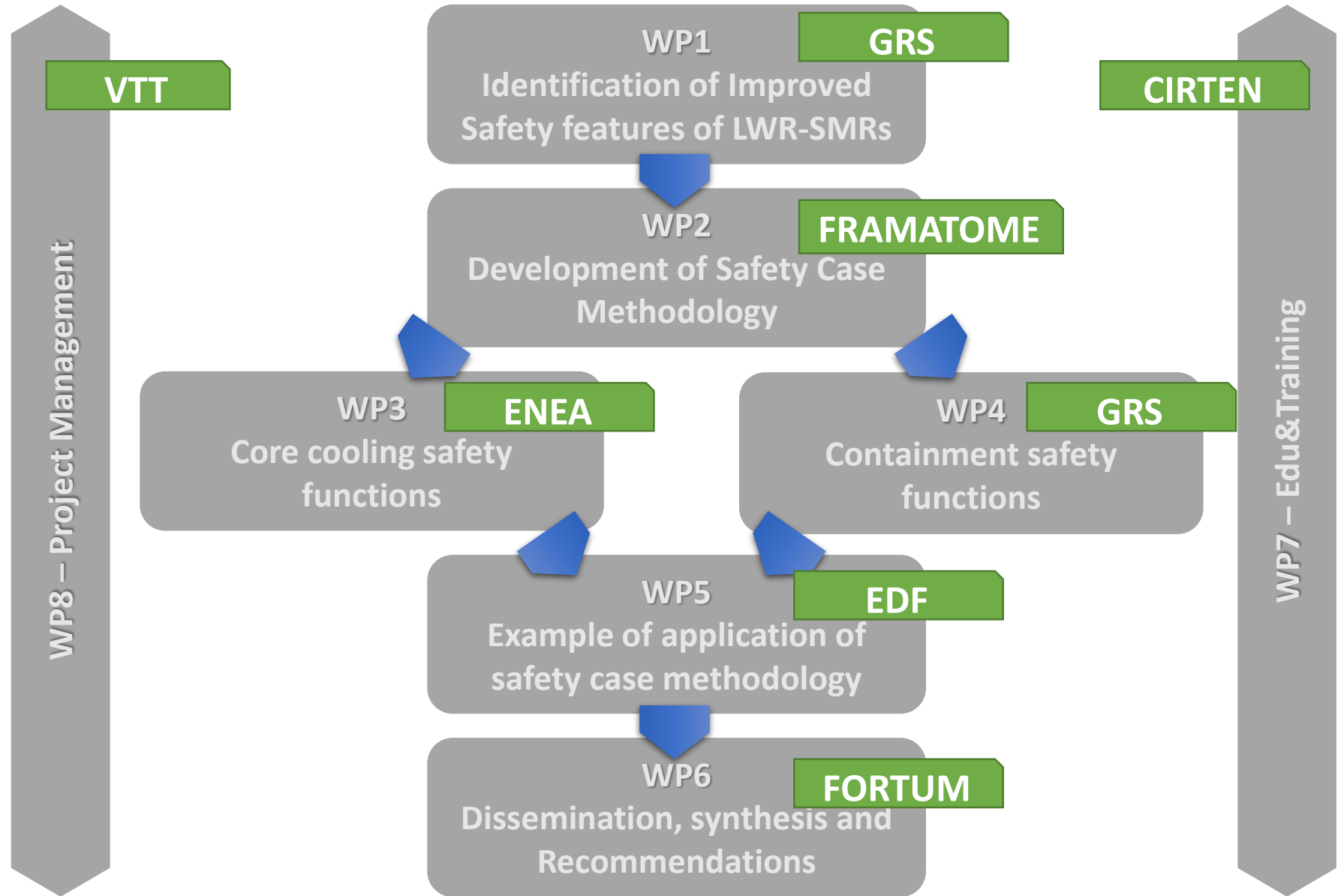


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Project overview



WP1: Identification of improved safety features of LW-SMRs

WP1 will focus on the identification of advanced or innovative safety features of LW-SMRs that potentially pose challenges to established safety demonstration approaches.

- Review of the European nuclear safety directive(s) and good practices on the safety assessment of LWR reactors,
- Screening of current LW-SMR designs (based on available material) related to improved or innovative safety features
- Summary of safety challenges for further consideration in the project

SMR concepts at different maturity stages

- A lot of information about the safety systems for decay heat removal, reactivity control as well as severe accident mitigation publicly available
 - Information about refuelling, fuel management and decommissioning or human factors lacking

Some common challenges

Main features which can challenge the current methodologies are

- The use of passive safety systems affecting reliability assessment, consideration of single and common cause failures and requiring a consideration of uncertainties,
- Multi-unit sites, e.g. when only a single control room with reduced staff is provided,
- High burn-up cores leading to new materials due to burnable absorbers with no boron systems and
- Severe accident mitigation affecting practical elimination and emergency planning zones.

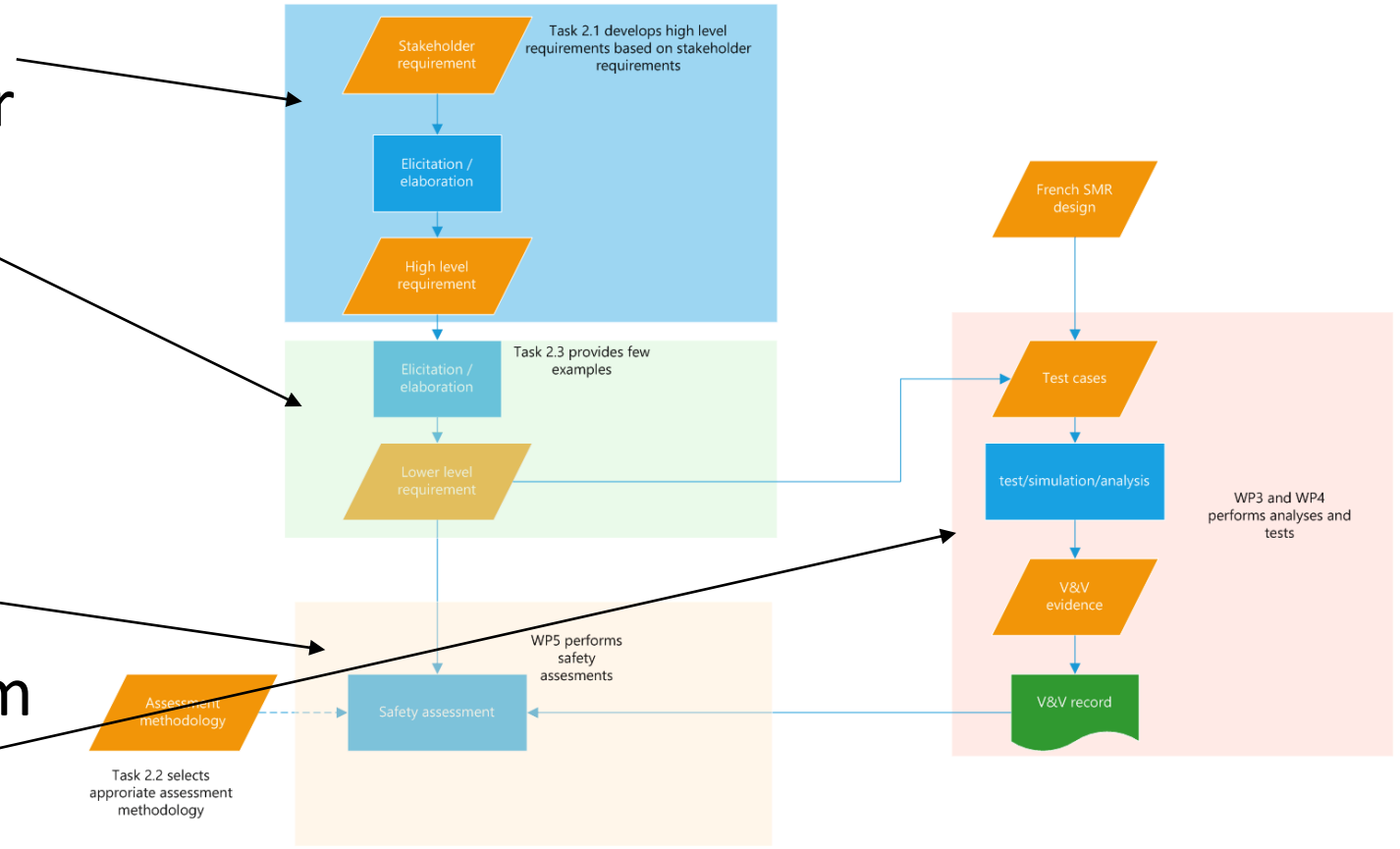
WP2: Development of safety analysis methodology for LW-SMRs

WP2 will focus on developing a methodology with qualitative and quantitative recommendations to support the safety demonstration of LW-SMRs.

- Complementary methodology development
 - Assessing the applicability of technology neutral Integrated Safety Assessment Method (ISAM) developed by GenIV International Forum
 - Systems engineering approach
- Various aspects of SMRs
 - High-level objectives (reactivity control, core cooling, containment)
 - Multi-unit plants, human factors, decommissioning, fuel management

Example of ELSMOR work flow: Development of requirement management approach (T2.3)

- Task 2.1 determines high-level safety requirements (or safety goals) and Task 2.3 defines a process to elaborate few examples to lower-level requirements
- Later in WP5 these requirements are compared to the results of safety analyses using feedback from WP3 and WP4



ELSMOR: Development of requirement management approach

- SMR safety follows the same Defence-in-Depth principle as large power reactors, but with stronger emphasis on passive safety features
- It is practical for SMR to present requirements on (at least) following three different, hierarchical, levels:
 - 1) Plant / System Architecture Level
 - 2) System Level
 - 3) Phenomena Level
- In each level, it is important to recognise potential uncertainties for passive safety features in order to ensure smooth licensing of SMR

WP3: Core cooling safety functions

Work Package 3 will focus on core cooling safety functions of integral LW-SMRs.

- Work to be performed is associated with safety analysis, development and assessment of codes and models
- Experimental investigations at SLET facility
 - Heat exchanger mock-up tested
 - Blind and post test modelling, model development

WP4: Improved Safety Analysis Methods and Tools for Containment Safety Functions

The objective of this WP is the development, assessment, and validation of analysis methods and tools for the safety demonstration of improved or innovative **containment safety function features** of integral LW-SMRs.

WP 5: Example of application of safety case methodology

An application of the developed safety case methodologies and models with a chosen reference design will be performed in order to demonstrate their applicability for real cases. The approach will focus on the safety features of the global design, but with special attention and effort on safety systems that differ from large PWRs.

- the application of the high-level methodologies developed in the Work Package 2,
- the working of the safety functions in an accident scenario, and
- the working of the safety functions in a severe accident scenario.

WP6: Synthesis, Recommendations and Dissemination

WP6 will focus on stakeholder interaction and dissemination results of the project to recommendations to stakeholders. This will be performed throughout the lifecycle of the project.

- Identifying important stakeholders and analysis of their needs
 - Different dissemination strategies towards different stakeholders
 - Industry, general public, academia, decision makers
- Development of recommendations to stakeholders and future R&D work based on project outcomes
- The organisation of an International Workshop
- Dissemination of the project results

WP7: Education & Training

WP7 will target the Education & Training of students and young researchers.

- Involvement of MSc and PhD students and young researchers in the ELSMOR R&D activities, the preparation and implementation of an International Summer School
- Design and broadcasting of Open Educational Resources (e.g. MOOC-like videos) on SMR concepts and ELSMOR findings

Thank you for your attention

- Project website:
 - www.elsmor.eu

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