SESAME

thermal hydraulics Simulations and Experiments for the Safety Assessment of MEtal cooled reactors

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Summary

This document presents the nature, the activities, the expected results as well as the societal impacts of the SESAME project.

Approval

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Introduction

The thermal-hydraulics Simulations and Experiments for the Safety Assessment of MEtal cooled reactors (SESAME) project supports the development of European liquid metal-cooled reactors. It will make available new experimental results and improved numerical approaches, allowing system designers to improve the safety of equipment, which will lead to enhanced safety standards and culture.

1 Nature and scope of the project

The European Sustainable Nuclear Energy Technology Platform (SNETP) and the European Sustainable Nuclear Industrial Initiative (ESNII) give an important role to the future application of fast reactors for the production of sustainable nuclear energy.

In Europe, three demonstration projects currently have a promising outlook: ASTRID, a Sodium cooled Fast Reactor (SFR) prototype, launched by CEA and gathering European and international public and private partnerships; MYRRHA, a multipurpose fast neutron spectrum irradiation facility proposed to operate as a European large research infrastructure, and to serve as an experimental pilot plant for the lead technology; and ALFRED, a programme targeting the construction of a Lead cooled Fast Reactor (LFR) demonstrator in Central/Eastern Europe.

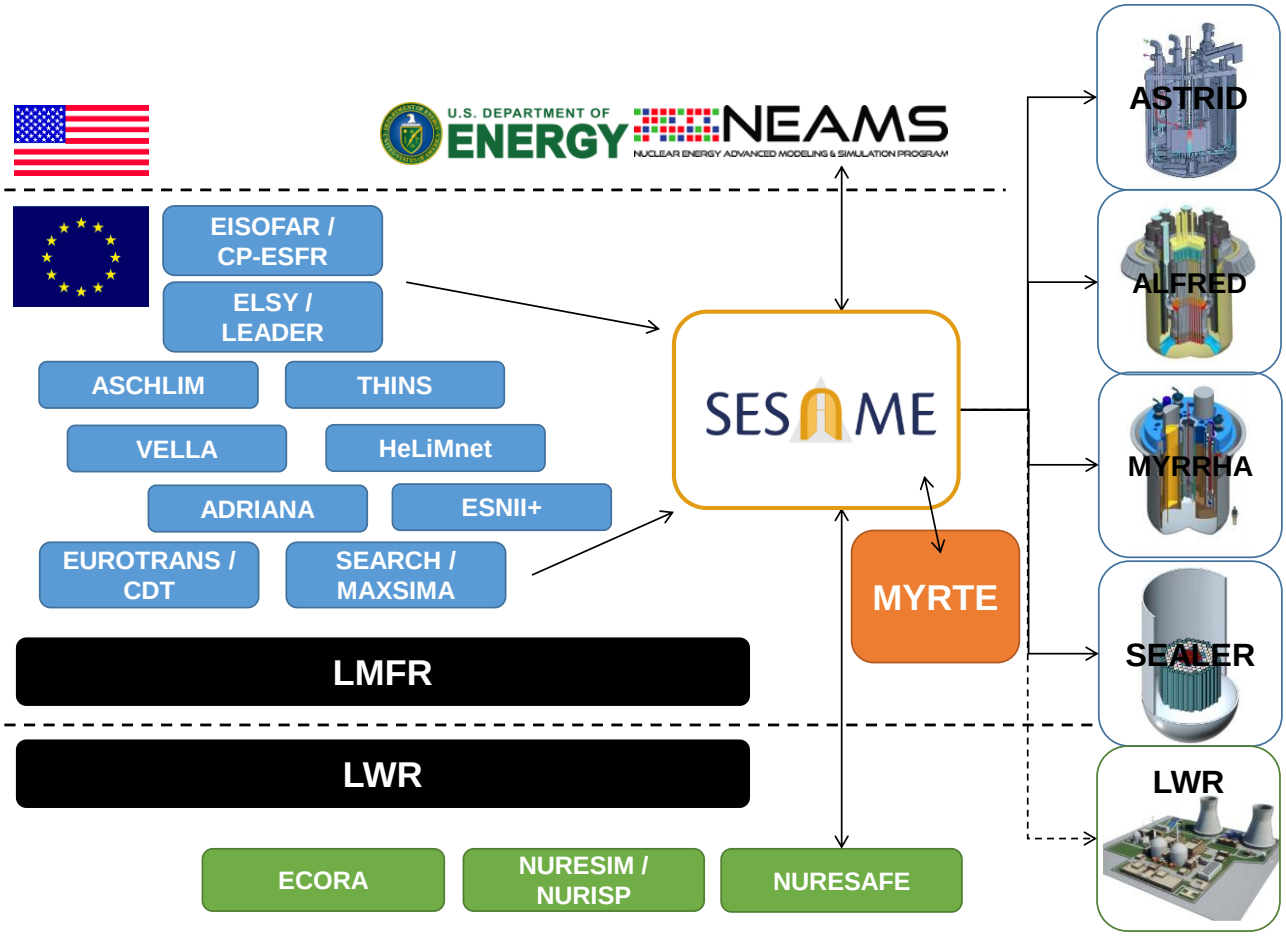
In addition, SEALER is a small lead cooled reactor under development by the Swedish company LeadCold, with the aim to ensure reliable and safe production of power for sites where evacuation is not an option, such as a number of arctic communities in Canada, the US, and Greenland.

SESAME supports the development of these reactors by addressing their pre-normative, fundamental and safety-related challenges through:

- the development and validation of advanced numerical approaches for the design and safety evaluation of advanced reactors
- the achievement of a new or extended validation base by creating new reference data
- the establishment of best practice guidelines, verification & validation methodologies, and uncertainty quantification methods for liquid metal fast reactor thermal hydraulics

The fundamental and generic nature of the SESAME project will also provide results of relevance to the safety assessment of contemporary light water reactors. By extending the knowledge base, it will contribute to the development of robust safety policies in EU member states. At the same time, SESAME will maintain and further develop the European experimental facilities and numerical tools.

23 partners from 8 EU countries (The Netherlands, Belgium, France, Germany, Italy, Slovenia, Czech Republic, Sweden), and Switzerland comprise the consortium. They have a long-standing experience in the field of nuclear technology and nuclear thermal-hydraulics and most of them have successfully cooperated in related projects. SESAME will also interact closely with the European liquid metal cooled reactor design teams, who will actively advise on the content of the project. As the prime end-users, the results stemming from the project will ensure that their innovative reactor designs reach the highest safety standards using frontier scientific developments.



2 Activities

The technical topics to be addressed in SESAME were defined following a thorough identification and prioritization process. This process selected the topics most relevant to the designers and to the safety assessment activities in ESNII. The experience and knowledge gained from previous and continuing EU framework projects, roadmaps, reports and strategic documents from international organizations and open (scientific) literature and conference proceedings were first identified. Feedback was then collected from ESNII representatives and designers in order to prioritize the topics.

Complemented by several meetings, this process set the focus of the work to be carried out in SESAME. Activities cover: the assessment of thermal fluctuations, vibrations, core thermal-hydraulics, pool thermal-hydraulics and integral system thermal-hydraulics, as well as the establishment of best practice guidelines, improved V&V methodologies and uncertainty quantification.

The SESAME project is complementary to the thermal-hydraulic work package in the European MYRTE project. While SESAME focuses on pre-normative, fundamental, safety-related, generic challenges, MYRTE will focus on MYRRHA specific challenges. Both projects will benefit from the developments undertaken in each project and will interact closely as many partners are involved in both.

The scientific and experimental knowledge and findings stemming from SESAME will be shared with the research and scientific community, industry, universities, international and European projects and initiatives, and the general public. Publications are planned and Best Practice Guidelines, improved V&V methodologies for liquid metal flow simulation and a Nuclear Liquid Metal Thermal-hydraulics Textbook will be developed for the industry and research communities interested in liquid metal cooled fast reactors. Training courses and material for CFD code training will be also developed for universities and student networks.

In addition, a Senior Advisory Committee was established to participate in the dissemination and exploitation of the foreground results. This Senior Advisory Committee includes representatives of the fast reactor designs and a representative from the US Nuclear Energy Advanced Modelling and Simulation (NEAMS) program. Its main objectives will be to:

- provide independent opinion on progress achieved
- ensure tight interaction between the project and system designers, who are the end-users of the project results (i.e. new models, simulation tools and reference databases)
- assess the project's performance, allowing to adjust dynamically the project according to designer requirements, if necessary and possible
- exchange on international knowledge and practical experience

3 Expected results

SESAME will serve as a coordinated R&D programme for nuclear thermal-hydraulics reactor safety, supporting both future reactors and the continued safe operation of existing nuclear plants, which provide one third of the EU's electricity and two thirds of its low-carbon energy today.

SESAME will maintain and develop the necessary supporting research infrastructures, such as experimental facilities and numerical tools. In particular, it will collect and use available liquid metal laboratories and facilities in Europe, such as the existing facilities from KALLA, KASOLA, CIRCE, TALL, NACIE, and the Phenix sodium fast reactor. In addition, new facilities will be built within the project.

In the short term, SESAME will improve the thermal hydraulics knowledge base for liquid metal fast reactors and for contemporary light water reactors. This basis will support European reactor designers and regulatory bodies and technical support organisations, and allow the EU and its member states develop strong policies with respect to nuclear reactor safety. The new experimental data and the advanced simulation approaches to be developed within SESAME will also further support interactions with stakeholders at large and the civil society on nuclear reactor safety.

In the medium term, the project will improve the safety of liquid metal fast reactors and contemporary light water reactors in Europe, and in a second step globally, by making available new safety related experimental results and improved numerical approaches. They will allow system designers to improve the equipment safety of their reactors, leading to an enhanced safety culture.

4 Societal impacts

The European Union is a leader in the nuclear field. SESAME will contribute to the reinforcement of this leadership through two main aspects:

First, the enhanced knowledge on nuclear system thermal-hydraulics and the better understanding of the mechanisms occurring in nuclear reactors will contribute to the reinforcement of the technological leadership of the EU. This enhanced knowledge will become an asset for the EU to remain at the forefront of the development of innovative reactor designs with even higher safety characteristics. It will also allow to make wiser decisions on the future safety systems in SFR & LFR. In doing so, cost reductions could be reached thanks to more efficient designs of future reactors. Finally, SESAME will reinforce the development of Gen IV reactors, allowing the use of uranium resources to be 50 to 100 times more efficient, entailing great supply chain cost savings.

This knowledge will help decrease environmental risks of existing nuclear power plants. By supporting the development of the ASTRID, MYRRHA, ALFRED and SEALER reactors, SESAME will contribute to taking a step towards the transmutation of waste, and thus towards clean and sustainable nuclear energy. SESAME will ultimately help reaching the EC's objective to achieve a low carbon economy by cutting its CO2 emissions to 80% below 1990 levels by 2050 (EC, 2011).

As SESAME will allow the main stakeholders to work together in the field of system thermal-hydraulics, this project will act as a catalyst to strengthen the research network in the field. The research performed during the project will also drive the training of new young scientists who will be able to secure the leadership of the European Union in the field for the years to come.

Lastly, achievements in the project will provide the technical background to contribute to changing the negative opinion on nuclear energy following the Fukushima accident. It will help bring about positive change, which is essential for future developments.

5 Information about important public events

The research community gathered in SESAME will actively participate to international conferences. In particular, three main conferences were identified: the bi-annual NURETH (Nuclear Reactor Thermal-hydraulics) series with the 16th conference in September 2015, , the IAEA FR (Fast Reactor Conference) in 2017, and the SESAME international workshop to be organized near the end of the project in the Netherlands.

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13	CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE FONDATION D'UTILITE PUBLIQUE	SCK	BE
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18	UNIVERSITA DI PISA	UNIPI	IT
19	UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA	URom	IT
20	ASCOMP GmbH	ASC	CH
21	INSTITUT VON KARMAN DE DYNAMIQUE DES FLUIDES	VKI	BE
22	CENTRUM VYZKUMU REZ S.R.O.	CVR	CZ
23	TECHNISCHE UNIVERSITAET MUENCHEN	TUM	DE