NuSTEM: Nuclear Science, Technology and Education for Molten Salt Reactors

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Program: NE-1 Grand Challenge

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ABSTRACT:

Nuclear energy has played an important role in the last fifty years. It currently accounts for about 11% of the world's electricity generation (IEA, 2014). For nuclear energy to continue to play a prominent role and to help in the transition to a carbon-thrifty economy, it needs to become a more widely accepted energy source. This will require more efficient, safer, and cheaper advanced reactor designs. Molten salt reactors have been identified by multiple parties, and most noticeably by numerous private entities, as one of the most likely advanced reactor concept to be able to achieve all objectives described above in a relatively short time frame. The scope of this project is to tackle some of the recognized challenges that remain towards the deployment of molten salt reactors.

This Integrated Research Project is another step in that advancement. NuSTEM The project will contribute to the molten salt fast reactor concept with its combination of very attractive safety characteristics and the unique ability to reduce the inventory of long-lived transuranic wastes. The integrating nature of the project cuts across many dimensions. These include the technical diversity of the research and collaboration across international boundaries. Also as implied by the title of the project, NuSTEM will not only contribute this advanced technology, but it will be critical to the development of young professionals and the human capacity to successfully and safely utilize nuclear technology over the next several decades and it will be used to excite and stimulate young people to pursue STEM fields while gaining a knowledge and understanding of the potential and contributions of nuclear energy to meet society's needs.

The program involves Five Technical and One Educational Mission areas. A brief description of each area is given below with more detailed information provided in Section 3.

Technical Mission 1: Material and Corrosion Science will deal with material characterization and optimization, corrosion assessment, and will development a fundamental understanding of failure mechanisms

Technical Mission 2: Optical/Chemical Sensor Development will deal with the development and demonstration of chemical and thermal sensors employing optical and electrochemical techniques. Manufacturing methods and materials will be explored for miniaturization of the probe for use in-reactor, and in-loop (ex-core). A sensor prototype will be built and tested.

Technical Mission 3: Modeling, Multiphysics Simulation, and Uncertainty Quantification will deal with the modeling and computational challenges in MSRs assessment. Specific models will be developed

for effective delayed neutrons fraction calculations; the impact of bubble formation in the slat will be investigated. Reduced-order models will be developed to allow for rapid design optimization.

Technical Mission 4: Thermal hydraulic science will study pumps and compact heat exchangers for MSRs. An additional thrust will be the investigation of passive heat removal.

Technical Mission 5: 35cl(n,p) cross-section measurements will correct a deficiency in evaluated nuclear data files for the (n,p) reaction on Cl-35 in the fast spectrum range.

Educational Mission: After being dormant for the longest time, the molten salt reactor concept has seen a resurgence of interest mostly guided by the private sector. This rapid growth is partially being hindered by the lack of human capital with the basic knowledge of molten salt systems. An increasing demand is to be expected from multiple sources: DOE will require to hire or educate current personnel to be able to assess MSR technologies underdevelopment nationally and internationally, some start-up companies will progress to more advanced stages and will need to expand their work force, regulatory bodies will need to acquire capabilities in order to evaluate MSRs licensing. The educational mission of this project is to bring the research experience in MSR of the partner institutions into educational tools of various nature (summer school, video lectures, etc.) The educational mission will draw upon research, incorporate results into courses and curriculum, and utilize it to engage with young students to encourage them to produce studies in science, technology, engineering and mathematics. The outcomes will be an increasing number of young professionals with a strong basis in advanced nuclear technologies, and large number of students familiar with nuclear power.

These mission will be completed in collaboration with our International Partners, the EURATOM SAMOFAR (Safety Assessment of MOlten salt FAst Reactor) project.