Overview

The strategic approach of the Institute in the division of Nuclear Technology is to perform high quality applied R&D, sustaining and developing the respective know-how and infrastructure. Further strategic aims are related to:

- the need to conserve and expand the accumulated know-how in Nuclear Engineering in order to keep the Nuclear option open for Greece;
- the need to refurbish and restart the research reactor, upgrade its safety, increase its longevity and improve its capabilities under the highest security standards;
- the need to deeply reorganize the Nuclear- and Radio- Infrastructure in Greece, centered around the GRR-1 infrastructure in order to perform state-of-the-art R&D in a variety of topics that include Computational and Experimental Nuclear Technology, Nuclear Safety and Security, Material Characterization and Research, Analytical Techniques comprising Neutron Activation Analysis (NAA), Prompt-gamma NAA and large sample analysis (including archaeological), Radiation Protection, Radiopharmacy, Radiation Protection and Radioecology.
- coordination and development of fusion technology research activities within the European Fusion Program.

Major objectives / Activities

- Re-start GRR-1 operation
- Organize the Greek Nuclear- & Radio-Infrastructure
- Perform High-level Research in Computational Nuclear Technology
- Perform High-level Research in Reactor Safety
- Implement Neutron Transmutation Technique
- Fusion Technology
- Provide specialized services, education and training
- Develop and re-enforce international collaboration

Resources – Critical mass assembly

Participating Laboratories / Groups:

- Research Reactor Laboratory
- Thermal Hydraulics & Multiphase Flow Laboratory
- Environmental Radioactivity Laboratory
- Systems Reliability and Industrial Safety Laboratory
- Environmental Research Laboratory

Major accomplishments in this thematic area can be found in the latest Scientific Report of INRASTES.

Re-start GRR-1 operation (short-to-medium term)

Five scenarios have been elaborated to this aim with their cost, time schedule, positive points and weaknesses. The high-end scenario that includes complete reactor modernization requires 2 M€. Upon selection of an option, the Research Reactor Laboratory personnel will proceed to the following actions:

- Preparation of a new contract with the Architect Engineer (KEPCO)
- Approval receipt from the regulatory authorities (the Greek Atomic Energy Commission - GAEC) for specific works
- Partial or complete replacement of the Primary Cooling System (depending on the option selected)
- Modernization of the fire-extinguishing installation
- Replacement of the radiation protection monitors that are out-of-service or obsolete
- Updating of the Safety Analysis Report according to IAEA's standards and submission to GAEC for approval:

- Re-training of the GRR-1 personnel in a similar research reactor
- In-depth checking of all systems and components
- Receipt of GAEC authorization for GRR-1 re-start

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Organize the Greek Nuclear- & Radio-Infrastructure (medium term)

The establishment of a significant Research Infrastructure (RI) for the Greek nuclear and radiological community, based on the scientific excellence, innovation potential and international reputation of multiple research performers (from the academia, research centers and private companies) dispersed around the country will be sought. With this aim, a 28.5 M€ proposal has been submitted to the General Secretariat of Research and Technology (GSRT) in the framework of the 2013 call for the National Roadmap of RIs. In addition to the 15 Laboratories from 3 NCSRD Institutes, the project encompasses 25 partnering organizations from 10 regions of Greece, including the vast majority of the research community of Nuclear and Radiological Sciences. The project will significantly increase the high added value and spill-over effects as well as impacts to interrelated scientific disciplines by gathering knowledge and experimental feedback. More specifically, the project aims to:

- Upgrade safety, increase longevity and improve GRR-1 capabilities thus, creating a unique high performance research reactor (RR) while the closest European RR facility that is comparable to the GRR-1 is located in Budapest at a distance of 1500 km from Athens
- Maintain state-of-the-art scientific expertise by increasing the research potential of researchers, engineers and operators while training a new generation thus, sustaining a critical mass of researchers and benefiting industrial partners
- Build a sustainable strategic partnership and cooperation between the Greek Nuclear – Radiological community and relevant Laboratories and internationally prominent Organizations ensuring better integration in the European Research Area
- Support a scientific leadership with up-to-date instrumentation, capabilities and competences in core research areas of national importance
- Provide increased benefits to the society (e.g. radiopharmaceuticals, biological tissues, radiation protection, radioecology, nuclear and radiological emergency response)
- Pursue long-term self-sustainability based on the establishment of appropriate, effective mechanisms (service level agreements) that will ensure financial support for the entire spectrum of engaged research activities
- Support strategies in Greece for areas of national priority: materials science, medical and biological applications through a defined mechanism to speed up the “research--industry” process and boost regional innovation

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Perform High-level Research in Computational Nuclear Technology (indicative activities, short-to-medium term)

Analysis of reactor cores with deterministic and stochastic methods. Investigation of alternative fuel cycles such as Th/U including breeding regimes. Development of innovative computational tools for assessing the control rod absorber depletion, the gamma heating of samples. Development of a dynamic stochastic neutronic code for conventional and innovative reactor cores including Accelerator Driven Systems. Improvement of the computational coupling procedures between neutronics and thermal hydraulics in multiphysics/multiscale reactor core analyses. Optimization of research reactors capabilities. Neutron spectrum tailoring for special irradiations using neutron screens.

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Perform High-level Research in Reactor Safety (indicative activities, short-to-medium term)

Event sequences encountered in nuclear reactor safety may be studied with numerical simulations that are safer and less costly than actual experiments. State-of-the-art computational means have been developed to support the exploration of open issues which are hard to investigate experimentally. On the other hand, accurate numerical models may provide guidelines for designing safety related experiments. In this framework, nuclear reactor safety activities take advantage of the sustained evolution in information technology to develop realistic models of the complex physical phenomena taking place in nuclear reactor facilities with the intention to improve the overall system safety and performance. According to the Strategic Research Agenda elaborated by the EU Sustainable Nuclear Energy Technology Platform (SNETP) modeling and simulation activities contribute to all phases of a reactor lifecycle i.e., design, safety assessment, licensing and issue resolution during operation. It has become industry practice to:

- analyze the thermal-hydraulic behavior of small scale facilities and extrapolate the outcome to the actual plant size

- employ established codes to accurately model the physical phenomena taking place in a system

The Research Reactor Laboratory (RRL) that hosts GRR-1 is a suitable environment to foster nuclear reactor safety activities since it may accommodate both approaches listed above. Experiments are symbiotic with numerical computations and the performance of a computational tool needs to be verified and validated against experimental data. Thus, successful GRR-1 upgrade will render the facility available to support the developments in nuclear engineering modeling and simulation. Data availability will accommodate analysis and validation of computational tools. Along this line, GRR-1 best-estimate models have already been developed to simulate the system response under various transient conditions.

The SNETP Deployment Strategy in 2010 has identified key R&D topics for Gen III reactors in the areas of upgraded human system interfaces and simplified operation of reactor systems, while for Gen IV it embraces improved safety as well as advanced instrumentation and in-service inspection capabilities. Thus, development of physical models using energy, momentum and mass balance equations has been a motivation for the Research Reactor Laboratory activities to expand into the realm of data modeling. In this area, empirical data sets are used to estimate the underlying system function with little or no knowledge of the function form. Applying sophisticated machine learning algorithms in a nuclear facility, data modeling has been proven a powerful tool for monitoring, diagnostics and control tasks. Advanced tools – from the computational intelligence realm – are developed at RRL for (i) identifying non-linear system dynamics, (ii) predicting rapidly evolving transients, (iii) signal validation, (iv) enhanced man-machine interfaces and (v) plant-wide monitoring.

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Implement Neutron Transmutation Technique (medium-term)

Neutron Transmutation Doping (NTD) is the most promising method for producing high quality silicon-based semiconductors. Since the international market for doped silicon is foreseen to substantially increase in the near future, the RRL will exploit various methods to accomplish axially and radially uniform irradiation of the ingots to improve homogeneity. A ratio as-high-as-possible between the thermal and fast neutron fluxes will be sought for limiting the defects in the silicon crystal generated by fast neutrons.

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Fusion Technology Group

Overview

The Fusion Technology Group (FTG) was formed in 1999 when Greece joined the EURATOM Thermonuclear Fusion Project.

FTG is the co-ordinator of the Fusion Technology Program of the National Program of Controlled Thermonuclear Fusion. Fusion research at NCSR "Demokritos" is jointly conducted by a collaborating team of 10 researchers from three Institutes: INRaSTES, Institute of Nuclear and Particle Physics (INPP) and Institute of Advanced Materials, Physicochemical Processes, Nanotechnology and Microsystems (IAMPPNM). The relevant research facilities of these Institutes are integrated in the research activities of FTG. The research expertise and infrastructure of FTG include

Objectives

- Competitive Research in Fusion Technology
- Co-ordinating Demokritos' participation in the European Fusion Technology Programme
- Utilization of FTG's multidisciplinary expertise in new technological and research areas
- Attracting European and National Funding
- Establishing common research activities within Demokritos, Greece, Europe and the World
- Development of new innovative research infrastructure in areas in which FTG and Greece have the competitive advantage
- Participation in Universities educational activities, training of young professionals and students
- Focusing toward Societal Value-Added Research

For more information please visit FTG's website.

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Provide specialized services, education and training (indicative, short and medium-term)

RRL will continue to provide support to GAEC for situation assessment and decision making actions in case of nuclear or radiological emergencies. It will further expand its advisory services and already established preliminary contacts with important stakeholders to provide technical advice in the field of nuclear propulsion. Once GRR-1 becomes operational usual education and training courses to students will be supplemented with specialized education and training services to reactor operators of nuclear ships.

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Develop and re-enforce international collaboration

The advancement of already existing links with several key European Large Scale Infrastructures will pave the way for smoother integration of the community into the European Research Area (ERA). The aim is to foster close ties of cooperation and knowledge exchange with distinguished international organizations such as the ESRFI JHR, NMI3 and MYRRHA, the OECD's IFE/Halden, the East European Research Reactors Infrastructure etc.

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Resources – Critical mass assembly

- The recently started LENSER (“Less nuclear waste and safer utilization of research reactors”) project awarded to RRL with the aim of enhancing its R&D potential is fully utilized to train high-level young Researchers in NT and develop advanced computational tools.
- Proposal submitted to the General Secretariat for Research and Technology for the establishment (and inclusion in the national Research Infrastructure roadmap) of an advanced integrated Infrastructure for Nuclear- and Radio-Research in the Country.
- Continued funding from the European Fusion Program (INRASTES coordinates the relevant activities at National scale). Participation in Horizon 2020 projects related to Nuclear Technologies and provision of relevant services to interested parties of the public and private sectors.
- It is noted that as a result of personnel leave or retirements over the last years, there is a strong need for immediate hiring of two high-level Collaborators, i.e. a Mechanical Engineer with MSc in Nuclear Engineering to be involved in R&D activities in Thermal Hydraulics and a Security Expert to be engaged in the rapidly growing area of nuclear security that holds significant promise for attracting external collaboration and funding to the Institute.

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