Recent OECD/NEA Activities in EGSMR (Expert Group on Small Modular Reactor) and CCVM (CSNI Code Validation Matrix) for the Safety of Small Modular Reactors

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1. Introduction

Recently, there is a growing interest in the use of Small Modular Reactors (SMRs), which are seen as promising technology for providing safe and cost-effective energy systems. Proponents argue that SMRs offer several advantages, including shorter construction times and costs, more autonomous operation, greater reliance on smart technologies, and inherent safety features. However, these advantages come with diverse design concepts, encompassing a range of sizes, various coolants, and different fuels. Despite the diversity in design approaches, certain commonalities exist among SMRs, such as increased use of passive systems and reduced core inventories within each module.

OECD/NEA CSNI (Committee on the Safety of Nuclear Installations) is tasked with advancing scientific and technical knowledge to enhance nuclear safety. This mandate can also be applied to ensure the safety of SMRs.

Several initiatives aimed at safely integrating SMRs are underway. This paper will specifically focus on recent OECD/NEA activities related to EGSMR (Expert Group on Small Modular Reactors) [1] and CCVM (CSNI Code Validation Matrix) [2].

2. EGSMR Activities

2.1 EGSMR Overview

In June 2021, OECD/NEA CSNI established EGSMR (Expert Group on Small Modular Reactors), given the growing importance of small modular reactors (SMRs). The EGSMR comprises 23 organizations from 15 NEA member countries, as well as two international organizations (IAEA and EC), including research institutions, national laboratories, technical support agencies, regulatory bodies, suppliers, and utility companies.

The chairman of EGSMR is Andrew Morreale from Canada's CNL, with Vesselina Rangueleva from OECD NEA providing additional support.

EGSMR's primary functions include:

1) Prioritizing SMR-related activities within NEA CSNI.
2) Providing systematic methods for coordinating NEA efforts.
3) Supporting the placement of SMRs through safety assessments and licensing reviews at both organizational and national levels.

2.2 EGSMR Activities Areas

The primary areas of focus for EGSMR include:

1) Promoting international regulatory coordination and standardization in the licensing process for small modular reactors (SMRs).
2) Supporting an understanding of comprehensive, cross-disciplinary SMR safety issues.
3) Reviewing and defining new international experiment campaigns to enhance phenomenological understanding and experimental verification of SMR designs.
4) Facilitating international benchmarking activities aimed at validating computer models used in the design validation of SMRs.

The key safety-focused activities prioritized by EGSMR, aligned with CSNI's work, include:

1) Collecting Phenomena Identification and Ranking Tables (PIRTs) specific to SMRs.
2) Updating and revising Validation & Verification (V&V) activities, such as the Comprehensive Code Validation Matrix (CCVM), tailored for SMRs.
3) Collaborating on projects to gather and produce data essential for enhancing SMR safety analysis.

These initiatives aim to strengthen international coordination and standardization in licensing, foster deeper safety understanding, advance experimental validation, and enhance model validation for emerging SMR designs.

2.3 EGSMR Activity Overview

EGSMR meetings are held biennially. The first and second EGSMR meetings were conducted virtually via conference in 2022. Subsequent meetings took place in Paris, France; Copenhagen, Denmark; and Ottawa, Canada. Most recently, the sixth and seventh meetings occurred from March 26-28, 2024, in Prague, Czech Republic, and from October 29-31, 2024, at INL in the United States.

The upcoming eighth meeting will be held from March 4-5, 2025, at the OECD NEA headquarters in Paris, France.

As a significant initial outcome of EGSMR, a report summarizing the group's evaluation results has been prepared. This report includes major recommendations for common safety research and assessments that NEA member countries should conduct to support the safe and timely deployment of SMR technology worldwide [3].

In accordance with CSNI's decision, a collaborative project on SMR safety research is planned. The project involves evaluating the novelty of SMR technology in collaboration with nuclear technology stakeholders, supported by various working groups under NEA CSNI, including WGAMA (Working Group on Analysis and Management of Accidents), WGRISK (Working Group on Risk Assessment), WGHOF (Working Group on Human and Organizational Factors), and WGEV (Working Group on External Events).

The author participates as a Korean expert in EGSMR. In previous meetings, introductory content related to SMART has been presented, and future plans include introducing domestic SMRs such as i-SMR and BANDI-60.

2.4 Future Plans for EGSMR

EGSMR plans to host an upcoming workshop in October 2025. In preparation for this event, a CAPS has recently been prepared.

The EGSMR-NEA Workshop: "SMR Safety Assessment: From Challenges to Achievements" is currently under development.

Future activities include:

1) PIRT Collection, led by Peter Yarsky (USNRC, USA).
2) The CCVM SMR initiative, which will be carried out in collaboration with WGAMA, and led by Fulvio Mascari (ENEA, Italy).
3) Collaboration with other working groups such as WGRISK, WGHOF, WGEV, WGFS (Working Group on Fuel Safety), and WGFCS (Working Group on Fuel Cycle Safety).
4) Preparation of procedures for a pilot review of advanced technology SMRs to support the PIRT Review process.
5) Review and revision of the Cross-Cutting Issues List.

These plans aim to address various aspects of SMR safety assessment and foster international collaboration within the EGSMR community.

3. WGAMA CCVM

2.1 CCVM Overview

For Anticipated Operational Occurrences (AOOs), Design Basis Accidents (DBAs), Beyond Design Basis Accidents (BDBAs), and Severe Accidents (SAs) as postulated accidents in nuclear reactors, computer codes are relied upon for safety analysis. These codes must undergo a thorough Verification and Validation (V&V) process to ensure their accuracy. Additionally, they require Uncertainty Quantification (UQ) to account for potential uncertainties.

The codes' predictive capabilities are validated by comparing them with data from scaled-down experimental facilities, both Separate-Effect Test Facilities (SETFs) and Integral-Effect Test Facilities (IETFs). These experiments play a crucial role in providing necessary knowledge and data. For decades, the WGAMA under OECD/NEA CSNI has been pivotal in identifying key phenomena relevant to reactor safety analysis, comparing them with experimental facilities available in NEA member countries, and assessing the suitability of these facilities for code assessment.

The summarized information is presented in several CSNI Code Validation Matrices (CCVMs), each accompanied by Phenomena Identification Ranking Tables (PIRTs) that list SETFs and IETFs relevant to different types of reactors. The CCVM aims to collect the most comprehensive set of openly available data for code validation, including uncertainty assessments of the constitutive models and calculated results.

Access to this suggested data in the CCVM is essential for developing reliable safety assessed codes and supporting knowledge management. It also facilitates the transfer of expertise to young experts and newcomers [2].

2.2 Recent Efforts on CCVM

The CSNI is actively engaged in developing Code Validation Matrices (CCVMs), which serve as a crucial tool for advancing the safety analyses of thermal-hydraulic (TH) and severe accident (SA) phenomena in nuclear reactors.

Experiments play a pivotal role in providing the necessary knowledge for assessing computational tools, which are essential for ensuring reactor safety. Constructing CCVMs involves collecting the best available test data to validate these codes, thereby contributing significantly to both knowledge management and expert training. However, despite repeated emphasis on periodic updates, this critical task has been neglected.

A recent research paper by F. Mascari et al. [2] summarizes previous NEA activities and underscores the need for extending CCVMs to cover advanced LWR designs, including SMRs. An expanded CCVM covering relevant phenomena will enable stakeholders to evaluate their codes using high-quality data, thereby enhancing confidence in safety analyses methods. This extended matrix will also serve as a comprehensive

database of experimental facilities and test data, providing an entry point for young experts and newcomers to learn about these resources while preserving valuable experimental data in the NEA data bank.

This activity will identify any significant gaps between CCVMs and the underlying experimental databases. These gaps can be prioritized to determine the specific needs for additional research and code validation work.

Recently, a new CSNI Activity Proposal Sheet (CAPS) has been issued regarding CCVM activities. The aim of this initiative is to update and extend existing CCVMs to incorporate recent experimental data related to current and advanced LWRs (PWR, BWR, and VVER) and PHWRs, including Water Cooled Small Modular Reactors (WC-SMRs). These new designs share common features with current reactors but introduce innovations such as passive safety systems, novel operational behaviors, and extended boundary conditions. This CCVM update focuses on thermal-hydraulic (TH) research related to behaviors of Reactor Coolant System (RCS) and containment.

4. Conclusions

The recent OECD/NEA activities of EGSMR and CCVM are introduced in this paper. These activities could support and advance the technical knowledge base for the safe installation of SMRs including many passive safety features. A comprehensive evaluation and review of the SMR design is necessary to determine the adequacy of safety attained by the passive safety systems and it could be supported by sufficient experimental data for the assessment.

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