DIRECTION OF NUCLEAR CONSEQUENCE ANALYSIS OF SMR IN THAILAND

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EXTENDED ABSTRACT

The rising interest in Small Modular Reactors (SMRs) among newcomer countries underscores the significance of understanding consequence analysis as a means of effective communication across governmental, public, and private sectors. Key inquiries from these stakeholders revolve around the anticipated impacts of SMRs, the scope of emergency planning zone requirements, and the existence of strategic frameworks for nuclear fallout management, including sheltering and evacuation protocols. Drawing on Thailand's recent experience in atmospheric dispersion analysis for large-scale Nuclear Power Plants (NPPs), insights have been leveraged to delineate the Emergency Planning Zone (EPZ) for SMRs through Level 3 Probabilistic Safety Assessment (PSA) methodologies.

In Level 3 PSA concept for SMR, radiological releases from Design-Basis Accidents (DBAs) and Beyond-Design-Basis Accidents (BDBAs) must be analyzed to determine the required Exclusion Area Boundary (EAB) and Low Population Zone (LPZ) boundaries [1, 2]. In 2019, NuScale Power submitted a report to the U.S. Nuclear Regulatory Commission outlining their methodology for evaluating source terms and radiological consequences of DBAs and BDBAs in Light Water Reactor-SMR (LWR-SMR) [3]. NuScale requested approval for using the ARCON program to estimate offsite atmospheric dispersion in hourly releases, instead of using PAVAN for longer release periods from 2 hours to 30 days [4]. In 2023, X-Energy, LLC used the US NRC's ARCON program to estimate atmospheric relative concentration (χ/Q) values at the EAB and LPZ boundaries up to 1,200 meters from the power block area's nearest building edge [5]. Recently, Thailand has also experienced developing atmospheric dispersion codes for Large NPPs [6, 7, 8] and approach estimate Emergency Planning Zone (EPZ) of LWR-SMR [9].

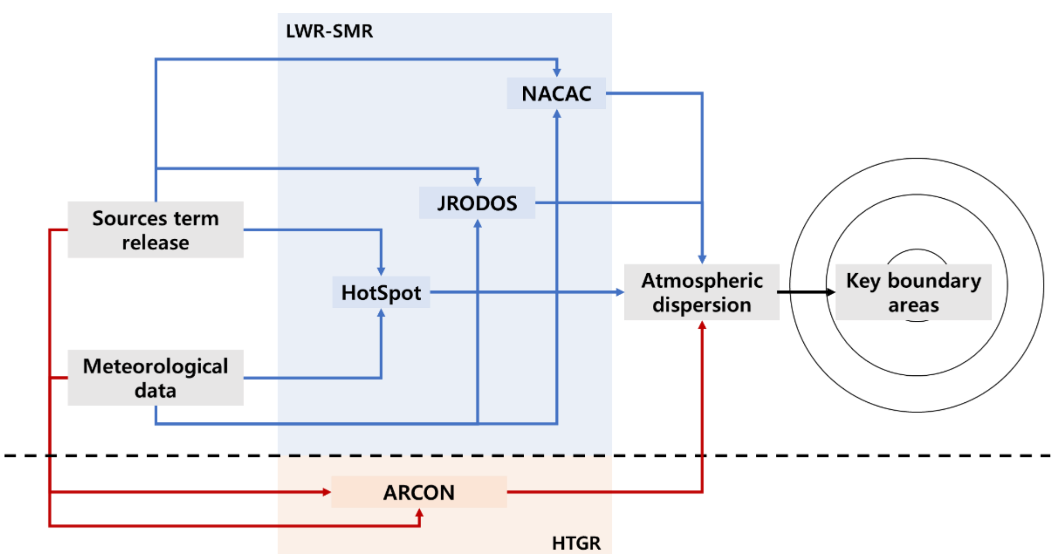

FIGURE 1. Thailand strategy for nuclear consequence analysis of Level 3 PSA for LWR-SMR and HTGR

In Thailand, SMR technology, including LWR-SMRs and HTGRs is considered a potential candidate, aligning with the strategies of other countries. Consequently, to meet regulatory requirements, it is essential to estimate the radiological consequences in the EAB and LPZ. This task is vital for plant owners and related entities to submit to the regulatory body for emergency planning and to assist government sectors in public communication. This research elucidates the evolving landscape of nuclear consequence analysis within the context of Level 3 PSA for prospective SMR technologies in Thailand.

Fig. 1 shows the Thailand strategy for nuclear consequence analysis of Level 3 PSA for LWR-SMR and HTGR. The direction of nuclear consequence analysis of SMRs is divided into two parts. The upper part (blue zone) is the consequence analysis scheme of LWR-SMR. At first, HotSpot and JRODOS that are validated tools, were selected to assess dose for emergency response. The authors started with the quick HotSpot code simulation which is the basic atmospheric dispersion code to estimate the direction of the release and dose assessment. Then, JRODOS that is a more comprehensive system, was used to simulate the results for real-time decision support in nuclear emergencies. Then in 2023, the authors together developed NACAC code that simply the meteorological grad use for atmospheric dispersion. The results of HotSpot and JRODOS can well verify the NACAC code. Thus, all three codes for LWR-SMRs are generally used for atmospheric dispersion analysis based on the time and existing resources. As for the lower part (red zone), since X-Energy and U.S. NRC co-develop and recommended the ARCON program to estimate atmospheric relative concentration (χ/Q) values for HTGR having specific core inventory and radioactive material release. ARCON source code is modeled to cover the high pressure and temperature conditions affecting radioactive material behaviors. Thus, the authors planned to use ARCON to help explain the atmospheric dispersion analysis and identify the key boundary areas for emergency planning in the future.

Noteworthy contenders such as the LWR-SMR and HTGR hold promise in advancing the country's green and sustainable energy agenda as outlined in the national energy strategy. The envisioned trajectory of nuclear consequence analysis for these SMRs is poised to address pertinent concerns of governmental, public, and private entities while furnishing a robust, secure, and economically viable framework for Thailand's forthcoming nuclear energy initiatives.

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