Keynote Lecture

Exploring Appropriate Risk Metrics for Advanced Nuclear Energy System

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Core Damage Frequency (CDF), Large Early Release Frequency (LERF) and Large Release Frequency (LRF) are commonly used as standard output indicators of Probabilistic Risk Assessment (PRA) for nuclear facilities such as nuclear power plants(NPPs). But we have found that it is increasingly difficult for these indicators to demonstrate their proper roles in supporting design and operations.

One observation is that the estimates of these PRA indicators are getting smaller and smaller. Some designs claim they can do 1E-7 and even lower. Yes, the whole nuclear industry is working very hard so that the safety level of operating nuclear units is definitely improving. And the new nuclear units have learned a lot from existing fleets and also have taken many additional safety measures. We thus see the record of CDF estimates being refreshed from time to time, at least for internal event power operating mode. Unfortunately, But these very low claimed values are not as effective in improving public acceptability as might be expected. On the other hand, they greatly limit the flexibility of advanced nuclear energy systems in terms of design and operational optimization, because the space left for these advanced designs is below 1E-7, while the space left for currently operating units is at least of the order of 1E-6.

There are a number of innovative non-LWR nuclear energy systems that are making good progress in recent years. The fact is that the concepts of Core Damage and Large Early Release don't really apply to these reactor types. For example, the HTR-PM demo project in China, the demonstration NPP Project for High Temperature Gas-Cooled Reactor with Pebble bed and Modular design, has demonstrated the success practice of using the cumulative frequency of accident sequences with the dose exceeding 50mSv at the site boundary as an indicator for PRA. Neither CDF nor LERF are adopted in HTR-PM. Experts and the authority could not accept this breakthrough at first, but the practice has shown that this approach is in line with the PRA theory and also the characteristics of HTGR. Therefore, it works. The story also hints at this possibility: must water reactors stick to CDF and LERF? Are there better metrics?

In addition, there is another driving force for thinking about the appropriate risk indicators for advanced nuclear energy systems.The demand for the integrated use of nuclear energy is increasing significantly, i.e. the co-generation of electricity, heat, steam, water and hydrogen in the community of HTGR and SMR development. In such application scenarios, risk assessment practitioners have been asked that they should be able to provide more appropriate output indicators to characterize the extent to which these co-generation outputs are accomplished safely and reliably.

This talk will present a pilot initiative to explore the feasibility of non-CDF indicator for advanced LWR reactor.