Sustainability assessment of SMART in terms of safety by using the IAEA INPRO methodology

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1. Introduction

From 2001 to 2008, with the support of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), the International Atomic Energy Agency (IAEA) developed a methodology for assessing the sustainability of nuclear energy systems (NESs). The INPRO methodology covers seven issues that influence NES sustainability: safety, competitiveness, proliferation, waste, environmental stressors, resources and infrastructure.

The INPRO methodology has been applied to NESs based on large reactors and sodium-cooled fast reactors several times, but not to small and medium-sized modular reactors (SMRs). Some initial attempts to evaluate SMRs have failed to fully consider design-related criteria, mainly due to lack of input data. For a summary of these initial efforts, refer to IAEA-TECDOC-1636 [1].

SMRs, even with the same technology as large pressurized light water reactors, can provide significant benefits in terms of system sustainability, e.g., simplified infrastructure requirements, and smaller source terms if they are likely to be inadvertently released into the environment.

Therefore, it is necessary to apply the updated INPRO methodology for SMR designs. Application of the INPRO methodology is normally organized as a self-assessment exercise performed in a country developing a strategic plan for introduction / expansion / modification of the NES.

In the present study, a newly launched task regarding application of INPRO methodology to SMART, especially in the area of reactor safety, will be briefly explained.

2. Details of the task

In this section, background and necessity of the task are briefly described. Then the goals, utilization, and expected outcomes are also provided.

2.1 Background of the task

The INPRO methodology consists of issues affecting the sustainability of NESs, such as economics, reactor safety, safety of fuel cycle facilities, infrastructure, waste management, environmental impacts, and nuclear

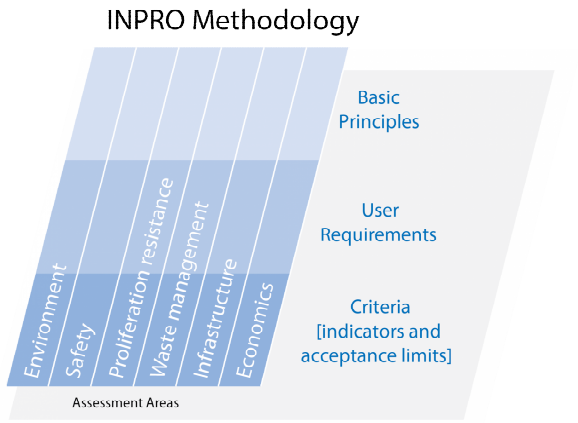

Fig. 1. Summary of IAEA INPRO methodology (Courtesy of IAEA)

proliferation resistance. It consists of basic principles, user requirements, and evaluation criteria, which are then divided into evaluation indicators and acceptance limits. Avoiding commercially sensitive information, evaluation criteria requiring detailed knowledge of the design consists of up to 100 (less number may be chosen depending on the scope of the evaluation). Figure 1 shows the summary of the methodology.

From 2013 to 2020, all areas of the INPRO methodology, except for the IAEA-TECDOC-1575, rev.1, vol.5 [2], were amended and published to the IAEA Nuclear Energy Series No. NG-T-3.12 [3], NG-T-3.13 [4], NG-T-3.15 [5], NG-T-4.4 [6] and IAEA-TECDOC-1901 [7], -1902 [8], -1903 [9].

In April 2020, IAEA requested the participation of the Korea Atomic Energy Research Institute in the following meeting: "INPRO Methodology for Sustainability Assessment of NESs Based on SMRs." The purpose of the meeting is to encourage SMR developers in different countries to self-evaluate their country's SMR design using INPRO methodology for evaluating the sustainability of NESs. While the USA, Russia and China, which are leading the development of SMRs, have already expressed their intention to participate, ROK has also expressed her willingness to actively participate the meeting.

2.2 The necessity of the task

Until now, IAEA member states have not applied the latest version of INPRO methodology to specific SMR

designs, but in 2019 several member states expressed their interests in conducting INPRO sustainability assessment on different SMR designs.

It is also expected that INPRO sustainability assessment studies focused on designing one or more specific SMRs will help determine whether new versions of INPRO methodologies are performing as intended.

Therefore, cooperation between evaluator and designer organizations is critical to achieve high quality results of the task.

2.3 The goal and objectives of the task

The final goal of the task is to apply the INPRO methodology to SMART for sustainability assessment in the area of reactor safety. The technical challenges, if any, will be identified through the task when applying INPRO methodology to SMART.

Detailed objectives are as follows:

1) Confirm satisfaction with basic principles of INPRO methodology
2) Confirm satisfaction with user requirements of INPRO methodology
3) Confirm satisfaction of evaluation criteria (indicators and acceptance limit) of INPRO methodology
4) Comparison with domestic regulatory requirements (if necessary)

The basic principles require that the innovative NES enhances the concept of defence-in-depth, with an increased emphasis on inherent safety characteristics and passive safety features resulting in a health and environmental risk of an innovative NES that is comparable with that of industrial facilities used for similar purposes.

2.4 The utilization of the task results

The INPRO methodology for SMRs will be firstly applied to SMART in the area of nuclear reactor safety. The INPRO methodology can be further applied and utilized in areas such as safety of fuel cycle facilities, infrastructure, radioactive waste, environmental and nuclear proliferation resistance.

SMART is often cited as the best practice for applying INPRO methodology to SMRs that are being developed competitively around the world, and it can be used as a way to enhance the international competitive-ness of SMART and seek export channels.

2.5 Expected outcomes

By applying updated INPRO methodology to SMART design, it can contribute to sustainable technological innovation to SMRs and is expected to play a leading role in applying INPRO methodology to SMRs.

By using INPRO methodology to evaluate the sustainability of SMART design, it is expected that the sustainability of SMART will be objectively evaluated and it contributes to promoting overseas exports.

It can also contribute greatly to increase awareness of the need for INPRO methodology in IAEA member states and the nuclear power plant industry, and contribute to cooperation among IAEA member states.

3. Conclusions

The present study is intended to evaluate whether SMART designs meet the basic principles, user requirements, and evaluation criteria, using INPRO methodologies for evaluating the sustainability of NESs. In particular, evaluation will be carried out in the reactor safety sector among several areas related to sustainability. Through this task, the technical challenges will be identified when applying INPRO methodology to SMART.

By using the INPRO methodology to assess the sustainability of SMART designs, it is expected that SMART will be objectively evaluated and the results will contribute to promoting overseas exports. It will also raise the awareness of the need for INPRO methodologies in IAEA member states and the nuclear power plant industry and contribute to cooperation among IAEA member states.

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