# PSA for New and Advanced Reactors: The Current Status and Prospect

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## 1. Introduction

Probabilistic Safety Assessment (PSA) for new and advanced reactors has been recognized as useful probabilistic approaches to achieve improved nuclear power plant safety and performances comparing to the existing plants. An international effort to clarify the current issues and to assess applicability of PSA for new and advanced reactors has been conducted by the WGRisk (Working Group on Risk Assessment) of CSNI, OECD/NEA. As part of the foregoing activity, recently, a joint workshop entitled "OECD/NEA CSNI workshop on PSA for new and advanced reactors" was held at OCED Headquarter during June 20-24, 2011 [1].

The purpose of this paper is to introduce the current status of PSA for new and advanced reactors and relevant insights, based on the foregoing workshop.

## 2. Background

While PSA has a chance to contribute the safety improvement of new and advanced reactors, but issues and challenges have been raised in its applicability to new and advanced reactors, especially for both technical and regulatory aspects. These challenges are mainly coming from slight differences between new and advanced reactors due to their development phases.

New reactors which are in the last phases of design and in commissioning stage typically within five to ten years of commencing power operations, are being faced with challenges (including a lack of design detail, a lack of empirical data, and the possibility of failure scenarios that differ in character from those treated in current PSAs) for which standards and guidance may be needed.

Advanced reactors which are in research stage or in the early phases of conceptual design also take into account application of PSA approaches to their design and safety evaluation stages. However, the ability of current PSA technology to support such design decisions, and the potential value of advanced methods have not been internationally assessed.

Moreover, the lack of plant-specific operating experience data and operations procedures at the design stage may lead to PSA results that do not reflect the future as-built, as-operated plant. This may lead to an impediment to the implementation of risk-informed regulatory initiatives. One way to help ensure quality in the PSAs for new reactors and for advanced reactors, and eventually lead to better guidance/standards, would be to share lessons and best practices.

In order to address the above issues, the WGRisk is currently conducting two coordination tasks: on "PSA for Advanced Reactors" and on "PSA in the frame of Design and Commissioning of New NPPs." In order to support two tasks objectives, the WGRisk directed a joint workshop entitled "OECD/NEA CSNI Workshop on PSA for new and advanced reactors" held at OCED Headquarter during June 20-24, 2011. Both tasks are still in progress under the auspice of WGRisk.

As shown in Table 1, fifty experts from 13 countries (including UAE) and one international organization (IAEA) participated in the workshop, and 35 technical papers and two OECD WGRisk task activities on new and advanced PSA were presented in the workshop.

Table1: Summary of National Contribution to the Workshop

**National contributions** (35 papers from 12 countries & IAEA)

| | France | USA | Korea | China | Japan | Germany | Others | Total |
|---|---|---|---|---|---|---|---|---|
| Papers | 8 | 9 | 4 | 3 | 2 | 2 | 7 | 35 |

(*) Others (1 paper per country) : Belgium, Finland, Italy, Russia, UK, India, IAEA

| Category | France | USA | Korea | China | Japan | Germany | Others | Total |
|---|---|---|---|---|---|---|---|---|
| New | 3 | 4 | | 3 | | | 3 | 13 |
| Advanced | 4 | 3 | 3 | | 2 | 1 | 1 | 14 |
| Common | 1 | 2 | 1 | | | 1 | 3 | 8 |

(*) **New:** Gen-III/III+ (EPR/AP1000/ABWR...); **Advanced:** Gen-IV (HTGR/VHTR/FBR/SMR...)

| Category | France | USA | Korea | China | Japan | Germany | Others | Total |
|---|---|---|---|---|---|---|---|---|
| Level 1 | 7 | 1 | 2 | 2 | 1 | 1 | 2 | 16 |
| Level 2 | 1 | 1 | | | 1 | 1 | 1 | 5 |
| Common | | 7 | 2 | 1 | | | 4 | 14 |

## 3. Summary and Conclusion of the Workshop [1-3]

A wide spectrum of presentations and discussions on the PSA for new and advanced reactors were made during the workshop. The topics were including current practices among member countries (e.g., analysis methods, tools and relevant data), efforts to improve technical problems, and potential challenges to the use of the risk-informed decision makings in design improvements of new and advanced reactors and related potential regulation processes, and technical practices according to the basis of these challenges.

In the workshop, the participants shared and discussed their respective practices of PSA applications for new and advanced reactors. Participants recognized that there is currently a wide spectrum of the current practices of PSA applications, key technical and regulatory issues requiring further works, and potential areas for future international collaboration.

There were some degrees of difference in interesting areas and gaps in technical practices among the participants, and it is not easy to reach specific consensus on the PSA of new and advanced reactors.

However, the workshop participants paid particular attentions to the necessity of formal guidance to ensure technical acceptability on the PSA for new and advanced reactors (like ASME/ANS LWRs and non-LWR standard) and formalized peer review process, capability of the current PSA technologies in implementing the PSA for new and advanced reactors, technology applicable commonly for new and advanced reactors (e.g., passive safety system reliability, human reliability, and digital system reliability), advanced reactors-specific risk assessment methodology and relevant computational tool (e.g., risk metrics and severe accident analysis for non-LWRs), and applicability of PSA in addressing the safety-security interface, etc.

Although any consolidated consensus and conclusion on the aforementioned topics were not made among the participants, the workshop played a great role in sharing the current state-of-the art on the PSA of new and advanced reactors, and points of interest among member countries. Main findings obtained from the workshop are as follows:

- For new reactors, PSAs are being used in the design of new reactors for purposes such as balance between accident prevention and mitigation features of the design, demonstration of safety, identification of design vulnerabilities and improvements, and comparison with the risk of existing plants, etc. Nevertheless, guidance for using PSA in the design process needs to be improved and standardized.
- For advanced reactors, PSAs are limitedly using for the conceptual or preliminary design stages and there seems to not currently exist any consensus on how to take into account several technical issues discussed in the workshop and on what level of depth to take into account them. Nevertheless, efforts are currently being focused on indentifying and resolving the PSA issues for designer and regulatory bodies.

General conclusions and recommendations made within the context of the workshop are as follows:

- Periodic survey on further activities among member countries will be helpful in finding and clarifying further issues related to the PSA of new and advanced reactors;
- More consolidated guidance and peer review process on PSA of new and advanced reactors should be developed for both industry and regulation aspects, together with development of the relevant technologies;
- Regarding high-priority technical issues related to the PSA of new and advanced reactors, pilot study and international collaboration will provide more insights into the underlying issues. Such kind of technical issues and common areas of interest among member countries were raised and discussed in the workshop.

## 4. Concluding Remarks

In this paper, the current status of PSA for new and advanced reactors was introduced, based on the recent OECD/NEA CSNI workshop. Although there are still some degrees of difference in the interesting areas and gaps in technical practices between the applications of PSA to new and advanced reactors, it was recognized that all the findings and insights obtained in the workshop will be contributed to the future improvement and development of PSA technologies related with the applications to new and advanced reactors. In addition, the participants empathized that the outcomes of the workshop could play a great role in developing the relevant guidelines and future plans to apply PSA technologies to new and advanced reactors.

In near future, it is expected that key issues related to the PSA of new and advanced reactors will be more clarified in parallel with the realization of new and advanced reactors and through further activities to consolidate technical and regulation aspects of the PSA on new and advanced reactors.

## Acknowledgements

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## REFERENCES

[1] OECD/NEA Workshop on PSA for New and Advanced Reactors: Summary Report, Draft, 2011.
[2] K.I. Ahn et al, OEDC/NEA WGRisk CAPS on PSA for advanced Reactors: A Summary of Questionnaires and Answers Report, OECD/NEA Workshop on PSA for Advanced Reactors, Paris, June 20-24, 2011.
[3] G. Georgescu et al, OEDC/NEA WGRisk CAPS on PSA for new Reactors: A Summary of Questionnaires and Answers Report, OECD/NEA Workshop on PSA for New Reactors, Paris, June 20-24, 2011.