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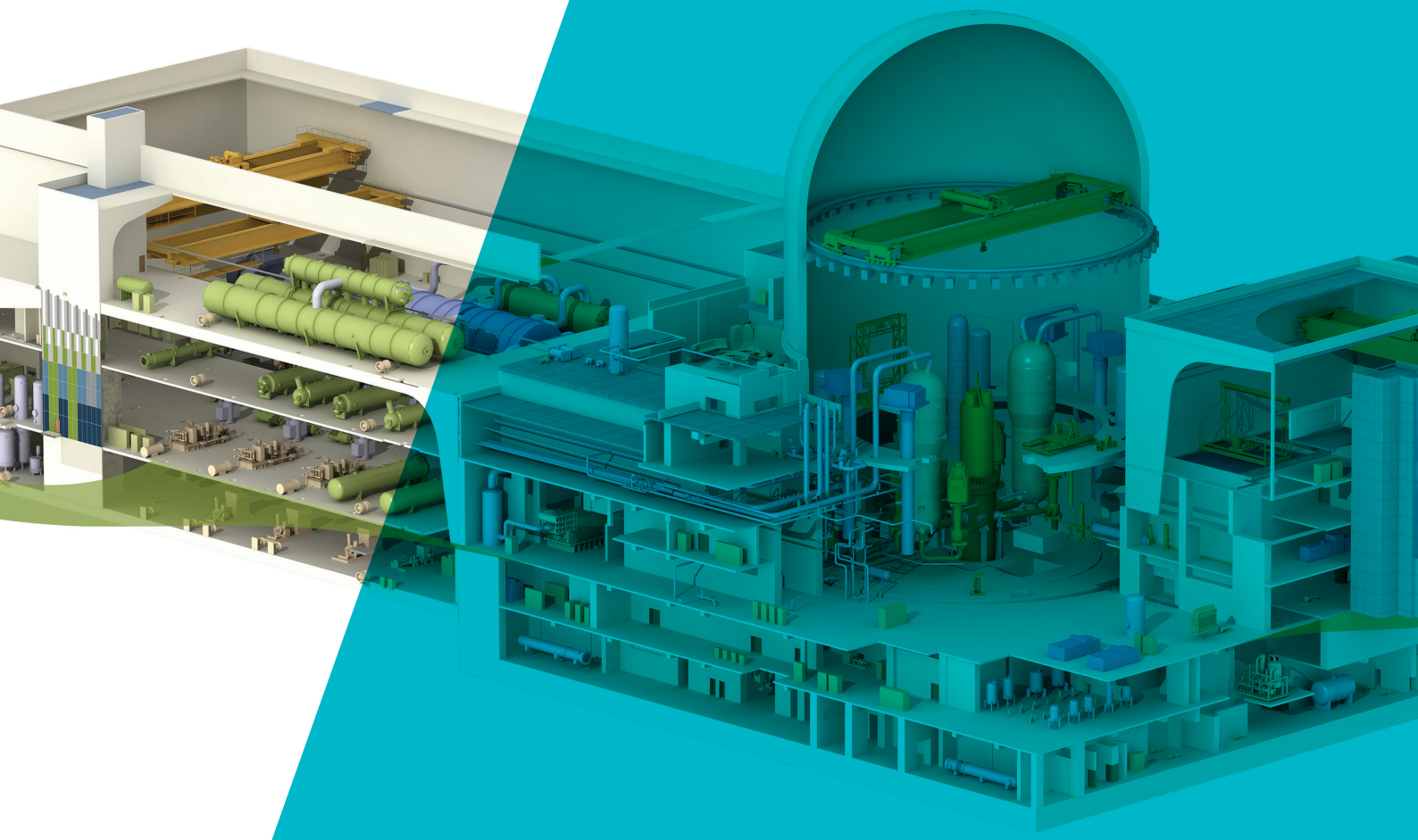

Making Use of the Reference Plant Concept for Licensing New Nuclear Units

Cooperation in Reactor Design Evaluation and Licensing Working Group

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Foreword

The concept of a reference plant has been used for many years in the safety assessment and licensing of nuclear power plants, as well as for contractual purposes between vendors and future operators. This report by the Licensing and Permitting Task Force (LPTF) of the World Nuclear Association's Cooperation in Reactor Design Evaluation and Licensing (CORDEL) and Law Working Groups defines and explores the issues associated with the reference plant concept used for regulatory purposes.

The appropriate use of a reference plant for regulatory purposes is consistent with the main aims of the *CORDEL Roadmap*[1], *i.e.* to take advantage of licensing that has already been carried out in other countries. This necessitates increased cooperation between the regulators of the recipient country and those of the country that has already licensed the plant.

This report looks into the number of issues that should be thoroughly investigated from the very beginning of a nuclear plant project in order to derive the maximum benefit from the concept of a reference plant. It draws on the lessons and experiences of countries with nuclear power programmes, and is primarily aimed at organizations involved in the implementation of nuclear power programmes (*i.e.* NEPIO[2], regulatory body, operator) in emerging nuclear countries, where licensing processes, strategies, and related regulations are not yet fully established.

The LPTF, one of six CORDEL task forces, was set up in 2011 by the Law and CORDEL Working Groups of the World Nuclear Association to identify good practices in licensing and permitting for nuclear new build. The LPTF aims to facilitate communication on these aspects between the global nuclear industry and regulators, as well as to propose new approaches and solutions to licensing and permitting of nuclear facilities.

The CORDEL Working Group's mission is to promote the international standardization of nuclear reactor designs and harmonization of regulatory requirements. CORDEL is working to support the dialogue between relevant stakeholders and to identify areas where convergence can be achieved. The goal is to gradually reduce the changes a reactor design must undergo to meet different national regulatory frameworks. Thus each step taken toward harmonization and convergence of regulatory requirements and of Codes and Standards is also one taken in the direction of increasing the pace at which nuclear power can be deployed to be part of the solution to our climate and energy challenges.

The Law Working Group's mission is to provide a forum for discussion for nuclear industry lawyers and to raise awareness amongst the broader World Nuclear Association membership of the legal issues and developments affecting the nuclear industry.

The LPTF has previously published a report on Licensing and Project Development of New Nuclear Plants and was a major contributor to one on Facilitating International Licensing of Small Modular Reactors.

The World Nuclear Association would like to acknowledge the leadership of Claude Mayoral, Co-Chair of the LPTF as well as the main author of this report. We would also like to thank members of the LPTF, of the CORDEL Steering Committee and of the Law Working Group for their active support and input into the report.

[1] The Roadmap is outlined in the CORDEL Strategic Plan 2019-23.

[2] Nuclear energy programme implementing organization

1 Introduction

The concept of a reference plant has been used for in several countries over many years. The main purposes are to:

- Provide a reference that has already been validated by an experienced nuclear regulatory body for the implementation of safety concepts and related design features, thus ensuring high confidence in the level of nuclear safety.
- Provide guidance on the development of a nuclear project based on the experience gained from a similar nuclear project at a more advanced stage.
- Minimize the risk of a nuclear project schedule slipping, by using established plant designs with existing manufacturing and construction experience.
- Reduce the capital cost by adhering closely to an already established design, and manufacturing and construction techniques.
- Especially in newcomer countries, allocate regulatory resources in the most efficient manner by focusing on site-specific and country-specific conditions.

However, it should be noted that exact replication of the reference plant is usually not possible nor desirable. Site-specific conditions and differences in national regulations may lead to deviations from the reference plant design. Moreover, in some cases, the reference plant project might not itself be completed, so the point of reference needs to be clearly defined and correspond to a coherent status of the project (*e.g.* the design and plant configuration as submitted in the construction licence application). In this situation there might be differences between the reference plant and the reference plant as-built. For this reason, a reference plant may only be a baseline for the licensing review of a new nuclear project with a number of differences that will have to be identified, justified and documented.

In cases where a vendor/designer proposes a new reactor design, even if the design is innovative, it is likely to be evolutionary, i.e., based on previous reactor designs that have been modified to improve safety and economics. In such cases, the 'reference design' of the new nuclear project is derived from one or several nuclear power plant models that can be called 'parent design(s)'.

The Table in Appendix 1 gives examples of the use of the reference plant concept for both regulatory and contractual purposes.

1.1 Reference plant in IAEA publications

The International Atomic Energy Agency's (IAEA's) *INSAG-22* [1] report published in 2008 introduced the reference plant concept, which new entrant countries were encouraged to base their first construction on. It states:

Many mature nuclear countries used a so-called "reference plant" concept for their first nuclear units. Under this approach, an imported plant has the same design and safety features as a plant already licensed by the regulatory body of the exporting country. However, care should be taken to ensure that the selected site and the reference plant site have similar characteristics or that any significant differences have been taken into account.

Also any construction by a new entrant will likely be based on the well proven technologies of an exporting country. It might be expected that the design has been licensed by the regulatory

body in the exporting country, perhaps with the benefit of analysis by other regulatory bodies… It is highly recommended that the regulatory body in the importing country establish and maintain a knowledge transfer relationship with the regulatory body in the exporting country.

Then, in 2012 *INSAG-26* [2] indicated that, where possible, when a new entrant country chooses as its first power plant a design that is essentially the same as one already licensed by an experienced regulator, the use of the reference plant concept would be advisable:

During the design safety review process for issuance of the construction licence for the first nuclear power plant, use of the design safety review conducted earlier by an experienced regulator for the reference plant could be appropriately made. However, it is essential that the regulatory body has a good understanding of the design and due attention is paid to the design differences on account of factors such as site related parameters, plant layout and incorporation of new design features based on operating experience and advancement in technology. This strategy is proposed primarily to ensure a high level of safety which incidentally, may also help expediting the licensing process.

Further development of the reference plant concept as discussed below may lead to it being included in IAEA safety standards. So far, this concept was not included in Specific Safety Guide SSG-12 [3], *Licensing Process for Nuclear Installations*, nor in General Safety Guide GSG-13[3] [4], *Functions and Processes of the Regulatory Body for Safety*, which superseded it.

1.2 Proposed definitions

Reference plant for regulatory purposes

The reference plant concept used for regulatory purposes can be defined as: *a plant of the same design as the one to be built or of a similar design with justified limited modifications (including but not limited to those related to safety), and which has already been licensed or certified by an experienced regulatory body in the vendor (or another) country.*

The reference plant concept for regulatory purposes helps to de-risk the licensing process and to minimize the chances of encountering 'dead ends' during the safety evaluation process. In fact it is likely that a reactor could be licensed within a reasonable timeframe if it is of the same or similar design as the one that has already been through a thorough safety evaluation process carried out by an experienced regulatory body in another country. Especially in newcomer countries, the existence of a reference plant would facilitate the licencing process as the regulatory body (which has never licensed a nuclear power plant before) could greatly benefit from the exchange of information and safety assessments that were performed as part of the licensing process of the reference plant.

[3] GSG-13 has been approved by the Commission of Safety Standards but not yet published. At the time of writing, it is still considered as a draft standard (DS473).

2 Insights on the Reference Plant Concept

2.1 Advantages

Relying on a reference plant (for regulatory purposes) has many benefits for both the operator as well as for the regulatory body of the recipient country. These include:

- Greater confidence in a timely licensing process as the reference plant design and safety options have already been assessed by another regulator.
- Knowledge transfer between the regulators, alleviating the workload of the recipient country regulator.
- The opportunity to focus on the country- and site-specific concerns that require thorough assessment.
- Allows the owner to assess projected plant performance – for example, what capacity factor it should achieve (how long refueling outages take, what is the typical forced outage rate) and what amount of O&M is expected. These performance parameters may be helpful in obtaining financing for the project.

The reference plant concept also creates the potential for the personnel of the operating organization and the regulatory body in the host country to have access to training facilities of the vendor country (e.g. full scope simulator and mock-ups) before these facilities become available in the recipient country. This is particularly important for newcomer countries which need such experience to better understand operator training programs and qualify the shifts of operators that will be needed.

Finally, the reference plant concept has the strong potential to expedite the licensing process, which has multiple benefits, including:

- Allowing faster deployment of new nuclear units in order to meet electricity needs and climate change related goals
- Instilling confidence in the licenseability of new reactors in an efficient manner, while observing the highest safety standards
- Reducing the financial costs of licensing new build

2.2 Selection of a reference plant

A number of questions should be addressed before selecting a reference plant:

- Which stakeholders would benefit most from a reference plant for regulatory purposes?
- What kind of intellectual property agreement should be implemented?
- What should be the required plant's design, licensing and/or construction status for it to qualify as a reference plant?
- Which factors are needed to realise the advantages of a reference plant?

Stakeholders

INSAG-22 [1] focuses on newcomer countries and a first nuclear power plant as well as how the safety assessment can draw on the safety evaluation reports of the regulator of the country of origin. Further plants could then be licensed without relying so heavily on assessments made in the country of origin.

Nevertheless, even for experienced regulators and operators, using a reference plant could benefit projects by reducing the amount of time and resources required to license a new plant.

Depending on the country where the plant is intended to be built, a reference plant can be either a prerequisite under national regulations, or just a recommendation by the national regulatory body, or simply a request from the future licensee to the vendor.

Intellectual property agreements

In order to benefit as much as possible from the reference plant, intellectual property aspects need to be carefully managed.

Safety evaluation reports are the property of the licensee and of the regulatory body of the reference plant. The future operator and the regulator of the recipient country should therefore identify at least the main parts of the safety evaluation reports they would need to access, and establish agreements with the relevant parties in the country of origin.

Also, in order to ensure smooth cooperation, the regulatory bodies of the country of origin and recipient country should put agreements in place that take account of intellectual property issues.

Translation into one or several foreign languages of the related documentation may also be considered early in the process in order to avoid running into difficulties later.

Reference plant licensing, design and construction status

There are a number of possible requirements that the host country or the new plant owner could establish with respect to the reference plant. Such requirements may be part of the national regulatory framework, requested or recommended by the regulatory body, or included by the future operator in the bid specification as mandatory or favourable criterion. For example the host country or the new plant owner may require or recommend that the reference plant to be already licensed, certified or formally reviewed by an experiencedregulatory body (but not yet under construction), for the reference plant to be in the construction phase, or already in operation.

The conditions required for a plant to qualify as a reference plant may have a major influence on technology selection; if these requirements are too strict, the technology selection process may inadvertently disqualify vendors or even lead to an unsuccessful procurement. In particular, where the concept of a reference plant is included in the regulatory framework, it is advisable to adopt a flexible approach in order for the future plant owner to be in a position to choose the most suitable technology and reference plant to meet the owner's and/or host country's goals.

Factors for successful implementation

The selection of a reference plant for regulatory purposes is dependent on several factors that could facilitate the implementation of a nuclear project in the recipient country. Given the number of mature Generation III and III+ technologies on the market, there may be a wide selection of reference plant candidates from several countries.

Some important considerations that could significantly affect the success of the project include:

- Access to the safety evaluation report of the reference plant.
- The support from the regulatory body of the country of origin regarding the reference plant and the similarities and differences between the regulatory requirements in the country of the reference plant and those of the recipient country.
- The similarities between the site conditions of the reference plant and those of the planned plant.
- The specific safety options, methods and calculation codes chosen for the reference plant.
- The overall safety approach adopted for the reference plant.
- The similarities between the codes and standards used for the reference plant and the most commonly used ones in the recipient country.
- The similarities and differences in the design and operation of the reference plant and the planned plant, and the associated impact on the applicability of the safety demonstration.

For different possible contractual schemes (*e.g.* open bid with competition between vendors, or bilateral agreement with a technology provider) the selection of the reference plant can take place at different stages, *i.e.*: during the review of the possible technologies before the bidding process; during the bidding process itself; or after the selection of the vendor. If it seems likely that the reference plant concept will be adopted, interested vendors should be informed at the early stages of the feasibility studies and the reference plant concept should be addressed in the request for information or bid specification.

The participation of the regulators, their availability and quality of their exchanges are key aspects of the process.

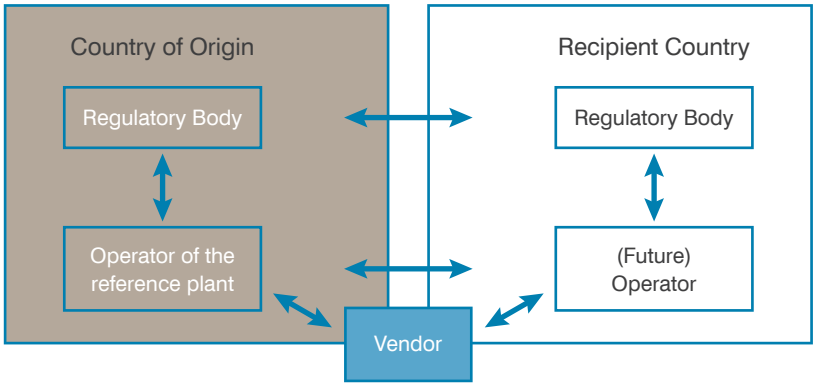
3 Next Steps

Given that the prime responsibility for safety rests with the (future) operator [5] and that the regulatory body in the recipient country is currently responsible for reviewing and assessing relevant safety information in order to determine whether the design meets that country's safety requirements [6], the concept of reference plant should neither be considered as a substitute for the licensing process nor a guarantee that the process will be straightforward. Nevertheless, through collaboration between the regulatory bodies of the recipient country and country of origin, the use of the reference plant concept for licensing purposes has for many years proven to be efficient at transferring knowledge between regulators and facilitating the licensing process.

Host countries developing and implementing new nuclear programs and new build projects should consider the reference plant concept at the outset of the program and/or project and incorporate that concept in a manner that derives the most benefit from that concept. A flexible approach should therefore be adopted in the recipient country in order to find the most suitable approach to an effective use of the reference plant concept.

Open discussions should be conducted between the regulators and stakeholders from the very beginning of a new nuclear plant program and/or project in order to reach a common understanding of regulatory expectations on the one hand and of the capabilities of the (future) licensee on the other hand. Such an approach will maximise the level of predictability of the licensing process, facilitate the implementation of the project, and benefit safety goals. Finally, also it is important to highlight that the licensing process is not limited to pre-construction steps: the concept of the reference plant is also intended to provide insights to the regulatory body in the recipient country regarding the oversight of the construction and commissioning phases of the NPP to be built. These aspects may be explored by the LPTF in future discussions.

Further cooperation between the World Nuclear Association and the regulatory community via the IAEA and/or of the OECD/NEA is needed to continue sharing experiences and foster the use of the reference plant concept for regulatory purposes. This may also contribute to harmonizing regulatory practices between countries and thereby facilitate the deployment of standardized designs.



Appendix 1

Name	Operator	Type	Reference plant
Ostrovets	Belarus NPP	4-loop PWR	Leningrad II (Rosatom design – VVER-1200/V-491)
Qinshan Phase III	TQNPC (China)	PHWR	Wolsong 3&4 (CANDU design)
Daya Bay 1&2	CGN (China)	3-loop PWR 2905 MWth	Gravelines 5&6 3-loop PWR, 2785 MWth
Sanmen phase I and Haiyang phase I	Sanmen: CNNC; Haiyang: SPIC: (China)	2-loop PWR	Westinghouse AP1000
Taishan 1&2	CGN (China)	4-loop PWR 4590 MWth	Flamanville 3 (Areva EPR design)
Tianwan 1 to 4	JNPC (China)	4-loop PWR 3000 MWth	Rosatom design Standard VVER-1000/V392
El Dabaa	(Egypt)	PWR	Leningrad II (Rosatom design)
Olkiluoto 3	TVO (Finland)	4-loop PWR, 4 loops 4300 MWth	N4 & Konvoi (Siemens/KWU design)
Hanhikivi 1	Fennovoima (Finland)	4-loop PWR	Leningrad II (Rosatom design – VVER-1200/V-491)
Fessenheim 1&2 (CP0 type)	EDF (France)	3-loop PWR 2660 MWth	Beaver Valley (Westinghouse design)
Bugey 2 to 5 (CP0 type)	EDF (France)	3-loop PWR 2785 MWth	Fessenheim 1&2 & North Anna 1 (Westinghouse design) for the power uprate compared to Fessenheim
Tricastin 1 to 4 (CPY type)	EDF (France)	3-loop PWR 2785 MWth	Bugey 4&5
Paluel 1 to 4 (P4 type)	EDF (France)	4-loop PWR 3817 MWth	South Texas Project 1 (4-loop PWR, Westinghouse design)
Chooz B-1&2 and Civaux 1&2 (N4 type)	EDF (France)	4-loop PWR 4250 MWth	Previous French 4-loop PWR
Flamanville 3 (EPR type)	EDF (France)	4-loop PWR 4500 MWth	Framatome N4 & Siemens/KWU Konvoi design
Paks II	MVM Paksi Atomeromu (Hungary)	4-loop PWR	Leningrad II (Rosatom design – VVER-1200/V-491)
Kudankulam 1 to 4	NPIC (India)	PWR	Balakovo (Rosatom design)
Bushehr 1	(Iran)	PWR	Balakovo 4 (Rosatom design)
Chashma	Pakistan	PWR	Qinshan Phase I (CNNC design)
Koeberg 1&2	Eskom (Republic of South Africa)	3-loop PWR 2785 MWth	Tricastin 1
Hanbit (formerly Yonggwang) 3&4	KHNP (South Korea)	2-loop PWR 2825 MWth	Palo Verde (Combustion Engineering design)
Hanul (formerly Ulchin) 1&2	KEPCO (South Korea)	3-loop PWR 2785 MWth	Le Blayais 3&4 – EDF operator 3 loops-PWR, 2785 MWth
Akkuyu 1 to 4	JSC Akkuyu Nuclear (Turkey)	4-loop PWR 3200 MWth	Kudankulam (Rosatom design AES92 – VVER-1000)
Barakah 1 to 4	ENEC (United Arab Emirates)	2-loop PWR 3983 MWth	Shin Kori 3 (KEPCO design)

References

[1] Nuclear Safety Infrastructure for a National Nuclear Power Programme Supported by the IAEA Fundamental Safety Principles, INSAG-22, A Report by the International Nuclear Safety Group, International Atomic Energy Agency (September 2008)

[2] Licensing the First Nuclear Power Plant, INSAG-26, A Report by the International Nuclear Safety Group, International Atomic Energy Agency (September 2012)

[3] Licensing process for Nuclear Installations, Specific Safety Guide No. SSG-12, IAEA Safety Standards, International Atomic Energy Agency (October 2010)

[4] Functions and Processes of the Regulatory Body for Safety, General Safety Guide No. GSG-13, IAEA Safety Standards, International Atomic Energy Agency (September 2018)

[5] Fundamental Safety Principles, Safety Fundamentals No. SF-1, IAEA Safety Standards, International Atomic Energy Agency (November 2006)

[6] Governmental, Legal and Regulatory Framework for Safety, General Safety Requirements No. GSR Part 1 (Rev. 1), IAEA Safety Standards, International Atomic Energy Agency (February 2016)

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