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# Welcome to the Webinar

# Technical Safety Review (TSR): a key IAEA Peer Review mission for current nuclear power reactors and SMRs

## 13 December 2023

As soon as you join Ms Teams, please stay muted

## Meeting will start at 14:00 Vienna Time

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# Opening remarks

**Ana Gomez Cobo**
**Head of the Safety Assessment Section**
**Division of Nuclear Installation Safety**
**International Atomic Energy Agency**

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# Overview of the IAEA Technical Safety Review Service

**IAEA Webinar on the Technical Safety Review (TSR): a key IAEA Peer Review mission for current nuclear power reactors and SMRs**
**Vienna, Austria**
**December 13, 2023**

**Martin GAJDOS**
Technical Safety Review Service Coordinator
Safety Assessment Section
Division of Nuclear Installation Safety
Department of Nuclear Safety and Security
International Atomic Energy Agency

# Technical Safety Review (TSR) Service

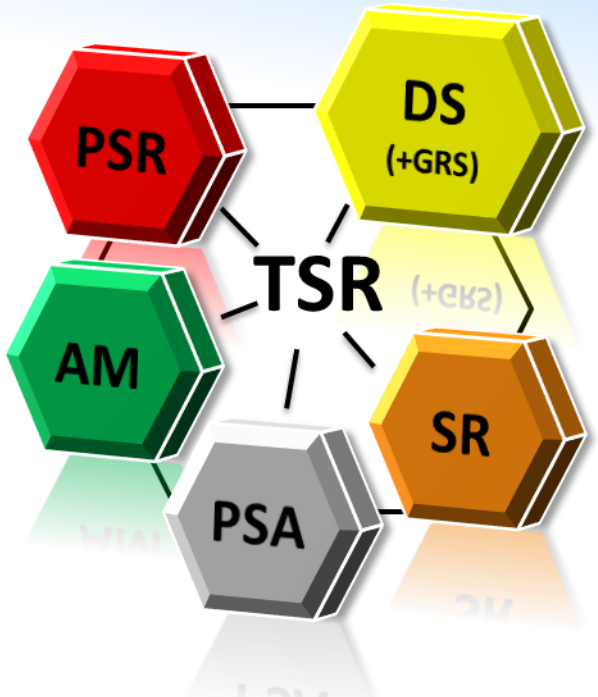
The TSR Peer Review encompasses safety reviews of several technical subject areas to address the needs of Member States at most stages of development and implementation of a nuclear power programme

# TSR Service

The TSR services encompass six technical subject areas dedicated to:

- Safety Requirements (SR)
- Probabilistic Safety Assessment (PSA)
- Accident Management (AM)
- Periodic Safety Review (PSR)
- Design Safety (DS)
    - Generic Reactor Safety (GRS)

    … and we are now adding “Safety, Security and Safeguards by design” (3S)!!




Technical Safety Review (TSR) | IAEA

# TSR Objectives


- Provide the Requesting Party with:
  - an objective review of the documentation presented to the peer review team **with respect to IAEA safety standards**
  - recommendations in those areas needing improvements to be consistent with IAEA safety standards
- Contribute towards harmonization of safety assessment standards worldwide
- Promote use of IAEA safety standards
- Gather feedback to identify areas where IAEA safety standards could be further strengthened

# TSR Review Basis

## IAEA Safety Fundamentals and Requirements

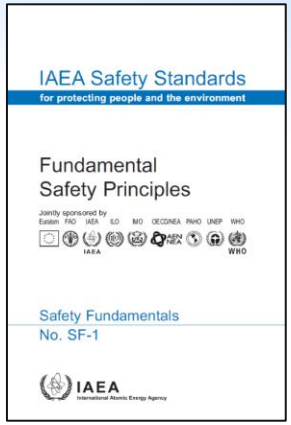
Exclusively used as review criteria

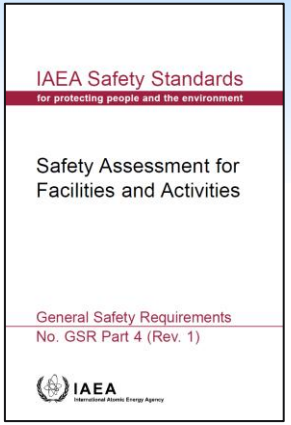
## IAEA Safety Requirements

Adjusted to scope of technical subject areas

## IAEA Safety Guides

supporting information only for purposes of clarification of the requirements used as the basis for review




# Design Safety (TSR-DS)

**DESCRIPTION**

- NPP design safety review at different reactor design stages (i.e. conceptual design, generic design, detailed design)
- Against SSR-2/1 (Rev. 1) - Safety of Nuclear Power Plants: Design
- Supported by the Safety Guides for NPP design
- This review can be limited to specific technical areas


**OBJECTIVE**

- To assist the Requesting Party in review the safety documentation for NPPs and to make recommendations in order to enhance safety.

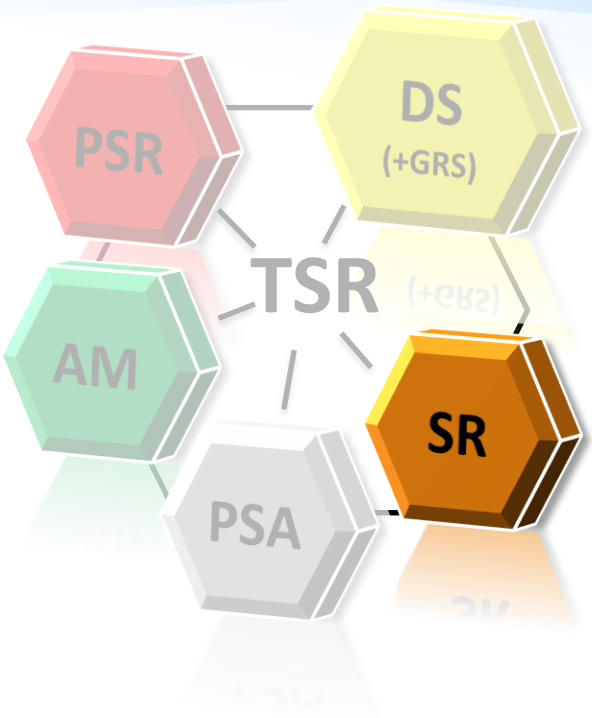
# Safety Requirements (TSR-SR)

**DESCRIPTION**

- Review the national safety requirements for NPPs
- Against SSR-2/1 (Rev. 1) - Safety of Nuclear Power Plants: Design and GSR (Part 4) (Rev.1) Safety Assessment of Facilities and Activities
- The review can be limited to specific requirements of interest.

**OBJECTIVE**

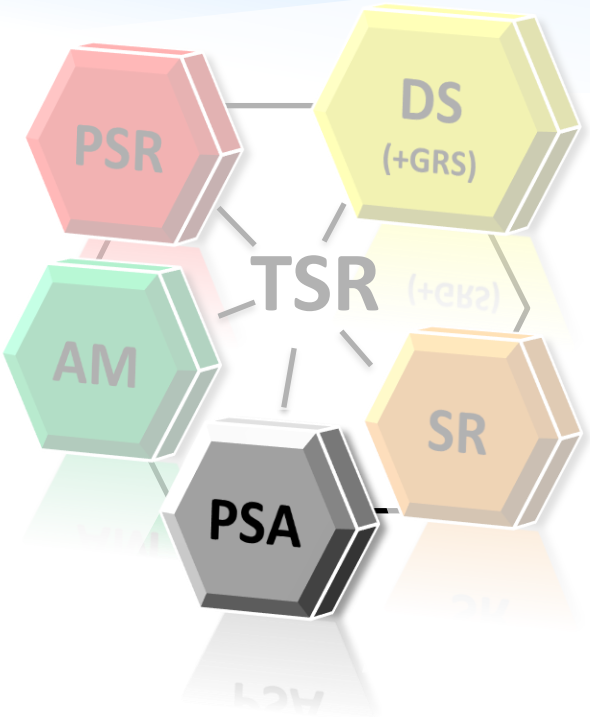
- To assist the Requesting Party in the process of issuing or revising national safety requirements for NPPs to enhance safety.



# Probabilistic Safety Assessment (TSR-PSA)

**DESCRIPTION**

- Review the probabilistic safety assessment documentation
- Against GSR Part 4 (Rev. 1)) Safety Assessment for Facilities and Activities supported by the Safety Guides on Level 1 and Level 2 PSA
- Scope could be limited to specific hazards, operational states or PSA applications
- Documentation includes the electronic models




**OBJECTIVE**

- To assist in the review of the technological and methodological aspects modelled in the PSA, as well as PSA applications to enhance safety.

# Accident Management (TSR-AM)

**DESCRIPTION**

- Review Accident management arrangements
- Against the IAEA General Safety Requirements on Safety Assessment for Facilities and Activities (IAEA Safety Standards Series No. GSR Part 4 (Rev. 1)) supported by the Safety Guide on Accident Management Programmes for Nuclear Power Plants (IAEA Safety Standards Series No. SSG-54)
- Observing the AM drills could be a part of review

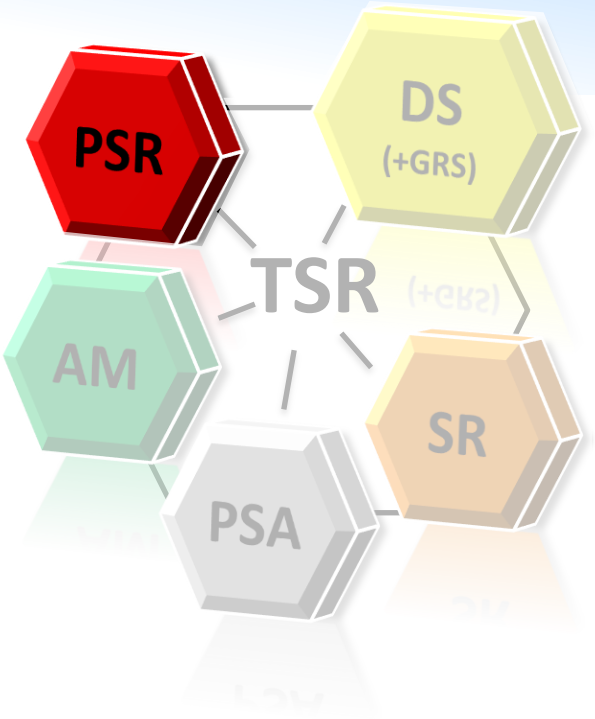

**OBJECTIVE**

- To assist in the development and implementation of an accident management to enhance safety.

# Periodic Safety Reviews (TSR-PSR)

## DESCRIPTION

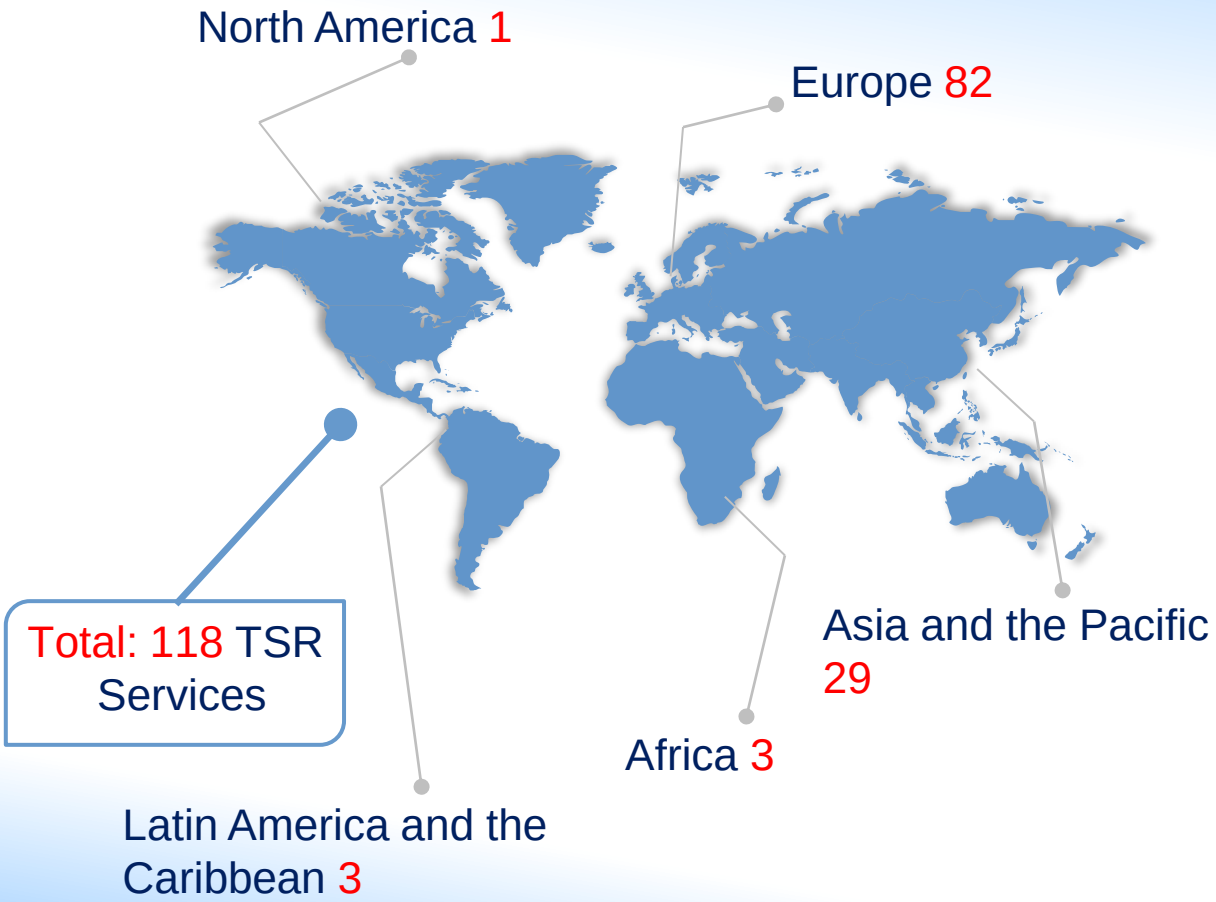
- Review the periodic safety review programme against
- Against GSR Part 4 (Rev.1) Safety Requirements on Safety Assessment for Facilities and Activities and SSR-2/2 (Rev. 1) Safety Requirements on Safety of Nuclear Power Plants: Commissioning and Operation
- Supported by the Safety Guide on Periodic Safety Review of Nuclear Power Plants (SSG-25)




## OBJECTIVE

- To assist the Requesting Party in establishing and implementing PSR programmes consistent with the IAEA Safety Standards to enhance safety throughout the operating lifetime of the NPP.

# TSR Services Conducted



# TSR Completed and Inquired

| Number | Subject Area | Member State | Status |
|---|---|---|---|
| 1 | Probabilistic Safety Assessment (PSA) | Netherlands | Formal request received |
| 2 | Follow-up Probabilistic Safety Assessment (FU-PSA) | Bulgaria | Expected completion Q3 2024 |
| 3 | Generic Reactor Safety (GRS) | UK | Ongoing, expected completion Q4 2024 |
| 4 | Design Safety (DS) | USA | Formal request received |
| 5 | Design Safety – Conceptual (DS) | Republic of Korea | Formal request received |
| 6 | Design Safety (DS) | Turkey | Formal request received |
| 7 | Probabilistic Safety Assessment (PSA) | Turkey | Formal request received |
| 8 | Probabilistic Safety Assessment (PSA) | Bulgaria | Completed Q3 2023 |
| 9 | Probabilistic Safety Assessment (PSA) | Mexico | Completed Q3 2022 |
| 10 | Periodic Safety Review (PSR) | RSA | Completed Q1 2022 |
| 11 | Design Safety (DS) | Hungary | Completed Q3 2021 |
| 12 | Probabilistic Safety Assessment (PSA) | Hungary | Completed Q3 2021 |
| 13 | Safety Requirements (SR) | Nigeria | Completed Q1 2020 |

# TSR Review Sheet Template

| Review Sheet No. XX |
|---|
| 1 TOPIC REVIEWED<br><br>*This is the main aspect for which the review sheet is developed.* |
| Safety Documentation Reviewed:<br><br>*The exact PSAR chapter number and title that has been evaluated by the reviewer.* |
| Review Area:<br><br>*The exact PSAR section number and title together with the document ID of the documentation provided for review that has been evaluated by the reviewer.* |
| Observation Title:<br><br>*A short statement summarizing the reviewer's observation.* |
| 2 OBSERVATIONS/REVIEW RESULTS<br><br>*This is the section were all the information needed to identify and understand the aspect being evaluated will be included.* |
| 2.1 DESCRIPTION<br><br>*(a succinct description of the observation).*<br><br>2.1.1 Statement in the Safety Documentation<br><br>*Quotes of the statements made in the documentation provided for review (this information should be accurate and factual, not an interpretation).*<br><br>*This information should include the exact location of the statement in the documentation, i.e. title and the ID of the document reviewed, section and page number.*<br><br>2.1.2 Assessment by Reviewer<br><br>*The reviewer's assessment describing the nature of the aspect being evaluated, the criteria used to judge it and the potential safety impact of the aspect on the documentation provided for review.* |

| |
|---|
| 2.2 REFERENCE TO IAEA SAFETY STANDARDS<br><br>*The exact title of the IAEA safety standard as well as its applicable requirements/paragraphs for the topic being reviewed should be provided in this section.* |
| 2.3 RECOMMENDATION<br><br>*Clearly formulated recommendations on ways to adhere to the IAEA safety standards.* |
| 3 REQUESTING PARTY'S RESPONSE<br><br>*This section of the review sheet is reserved for the Requesting Party to provide, if necessary, comments on the specific observations made by the IAEA review team. The Requesting Party's comments should refer to the documentation that was provided for review and not to additional documents the Requesting Party might have that were not part of the review* |
| 3.1<br><br>3.2 |
| 4 RESOLUTION BY THE IAEA REVIEW TEAM<br><br>*This section of the review sheet is reserved for the respective review team members to evaluate the comments received from the Requesting Party and provide the resolution of the comments. The evaluation of the comments will be done solely based on the documentation originally provided for review and not con sidering any additional documents mentioned by the Requesting Party.* |
| 4.1<br><br>4.2 |
| 5 FINAL RECOMMENDATION<br><br>*The final recommendation might be different from the original recommendation if the comments (referring to the documentation submitted for review) from the Requesting Party are sufficient to clarify the topic, or it might be the same as the original recommendation if the review sheet receives no comments or the comments are not sufficient to clarify the topic in accordance with the IAEA safety standards.* |
| |

# TSR Review Report Template

TSR peer-review report content:

Executive Summary

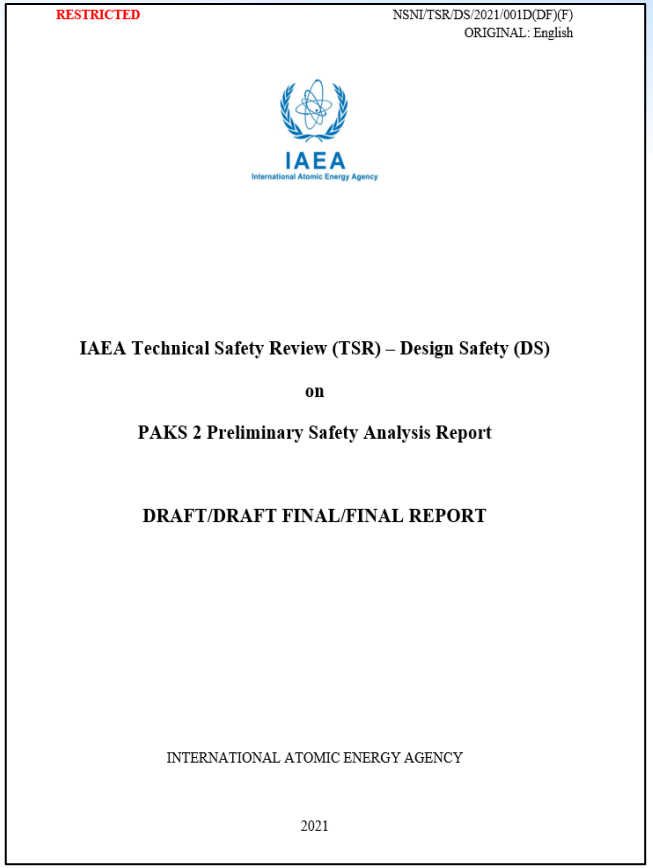
Introduction and Main Conclusions

Results of the review

- Cross-cutting issues
- Summaries of review of topical areas reviewed

Appendices

- Review sheets



RESTRICTED

NSNI/TSR/DS/2021/001D(DF)(F)
ORIGINAL: English

IAEA
International Atomic Energy Agency

**IAEA Technical Safety Review (TSR) – Design Safety (DS)**

**on**

**PAKS 2 Preliminary Safety Analysis Report**

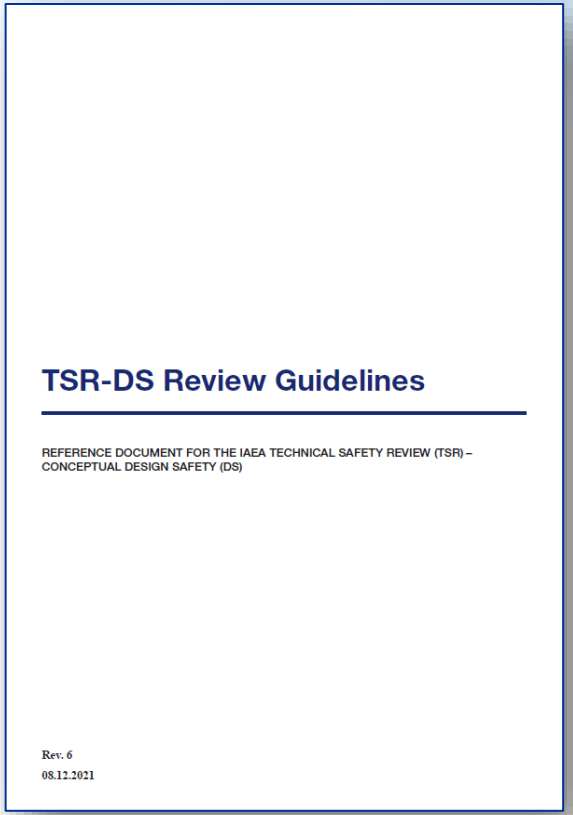
**DRAFT/DRAFT FINAL/FINAL REPORT**

INTERNATIONAL ATOMIC ENERGY AGENCY

2021

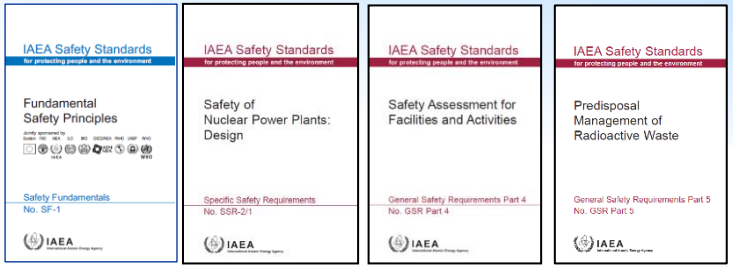
# TSR - Design Safety (DS) - Conceptual Design Review

- The emergence of innovative reactor designs led IAEA to expand its TSR Services to incorporate design safety (DS) review of conceptual design documentation
- New review guidelines for the conceptual design safety provide:
  - The Requesting Party with information on conceptual design documentation, scope of the review, criteria for review and documentation of the review
  - Reviewers with guidance to review conceptual design documentation (against what review criteria, what and how)



# Basis for TSR-DS Review of Conceptual Design Documentation

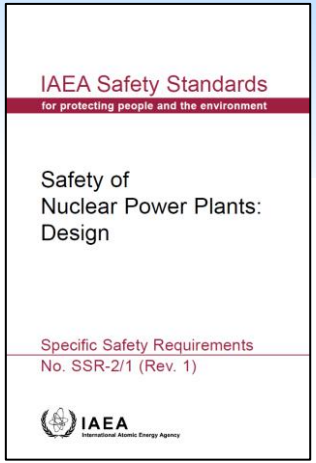
- SF–1 Fundamental Safety Principles
- Safety requirements
  - SSR-2/1 (Rev.1)
  - GSR Part 4 (Rev.1)
  - GSR Part 5
- Supporting safety guides
  - SSG-61: Format and Content of the Safety Analysis Report for Nuclear Power plants
  - Safety Classification of Structures, Systems and Components in Nuclear Power plants, IAEA Specific Safety Guide SSG-30
  - Deterministic Safety Analysis for Nuclear Power Plants, IAEA Safety Standards Series No. SSG-2 (Rev. 1)
  - SSG-69 Equipment qualification
  - ….




# Consideration of 3S interfaces in design

**Requirement 8: Interfaces of safety with security and safeguards**

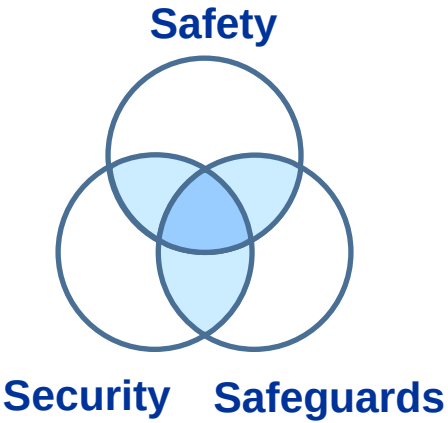
**Safety measures, nuclear security measures and arrangements for the State system of accounting for, and control of, nuclear material for a nuclear power plant shall be designed and implemented in an integrated manner so that they do not compromise one another.**




- **There are interfaces** between 3S (conflicts, potential synergies)
- Interfaces are currently **not considered systematically**
- **Hard to address** (or impossible) when design is finalized
- **Unique time window** while the reactors are in design stage
- **Getting more complex** in light of the innovative reactors, e.g. SMRs (novelties lead to several challenges for all 3S)

# TSR review guidelines on 3S

- **Objective:** provide detailed guidelines to review the interfaces between safety, security and safeguards (3S) for a specific NPP design
- **Contains:** actionable items to review 3S interfaces
- **Focuses** on FSAR chapters (mainly)
- **Allows:** to evaluate and document the review against requirement 8 of SSR-2/1 (Rev.1)
  - *whether safety measures, security measures and safeguards related arrangements have been designed and **implemented in an integrated manner so that they do not compromise one another***



# TSR 3S review guidelines

**1. INTRODUCTION**

**2. GENERAL CONSIDERATIONS**
- 2.1. PREPARATION OF THE REVIEW SERVICE
- 2.2. GENERAL OVERVIEW OF 3S INTERFACES
- 2.3. SECURITY BY DESIGN CONSIDERATIONS
- 2.4. SAFEGUARDS BY DESIGN CONSIDERATIONS

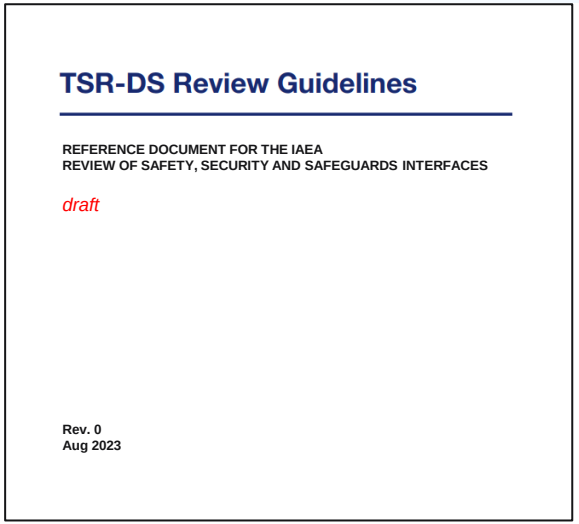
Specific considerations in design stage (general)

**3. SAFETY, SECURITY AND SAFEGUARDS INTERFACES**
- 3.1. SCOPE AND STRUCTURE OF THE DOCUMENTATION SUBMITTED FOR REVIEW
- 3.2. REVIEW OF 3S INTERFACES
  - 3.2.1. Management System
  - 3.2.2. Site selection and justification
  - 3.2.3. Procedures
  - 3.2.4. Reactor design and safety systems
  - 3.2.5. Irradiated fuel storage system
  - 3.2.6. Fuel design, manufacturing and management
  - 3.2.7. I&C systems design
  - 3.2.8. Human factors engineering
  - 3.2.9. Access control

Actionable items (what to review)

**4. DOCUMENTATION OF THE REVIEW RESULTS**

**REFERENCES**



# Guest Speakers

**Emil Stefanov**

Head of Risk
Management Section
Kozloduy NPP, Bulgaria

**Bravance Mashele**

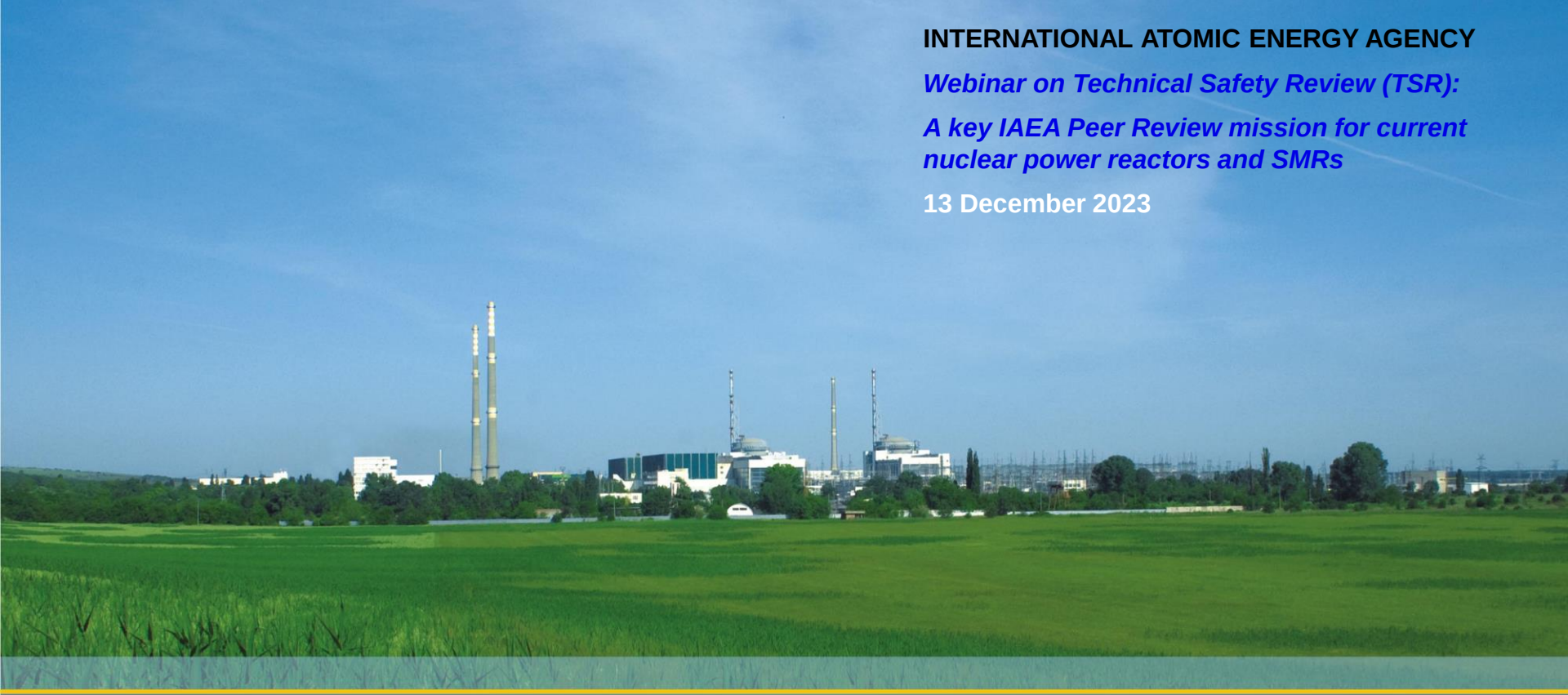
Senior Manager
Nuclear Engineering
Koeberg NPP
Eskom, South Africa

**Ramon Lopez Morones**

Director
Division of Technology
CNSNS, Mexico

**Mark Salisbury**

Head of Regulatory Affairs
Rolls-Royce SMR Ltd.
United Kingdom



INTERNATIONAL ATOMIC ENERGY AGENCY

*Webinar on Technical Safety Review (TSR):*

*A key IAEA Peer Review mission for current nuclear power reactors and SMRs*

**13 December 2023**

# KOZLODUY NPP, BULGARIA

# TSR-PSA as a tool for independent review of the updated Probabilistic Safety Assessment for Kozloduy NPP Unit 5 and 6

# PSA History of the Kozloduy NPP

**1992–1995**

The first PSA Level 1 for VVER-1000 at full power (FP) for internal initiating events (IE), floods, fires and seismic impacts was performed in 1992-1995;

**2002–2005**

In the period 2002-2005 FP PSA L1 was updated by:

- ✓ new FP PSA L1 - 2003
- ✓ implementation of PSA L1 for low power and shutdown (LP&S) - 2004.
- ✓ implementation of FP PSA L2 - 2005.

**2006**

Risk Monitoring (RM) Model for PSA L1 with Safety Monitor - 2006

**2007**

Full-scale PSA L1 after the Modernization Program I (2001-2007)

**2010–2013**

- ✓ Updating PSA L1 (2010) and full-scale PSA L2 with completely integrated model "PSA L1 - PSA L2" (2013) after the Modernization Program II - 2011-2013
- ✓ IPSART of PSA L1 (2010) – 2013
- ✓ RM Model for PSA L1 with RS Risk Watcher – 2013

**2020–2023**

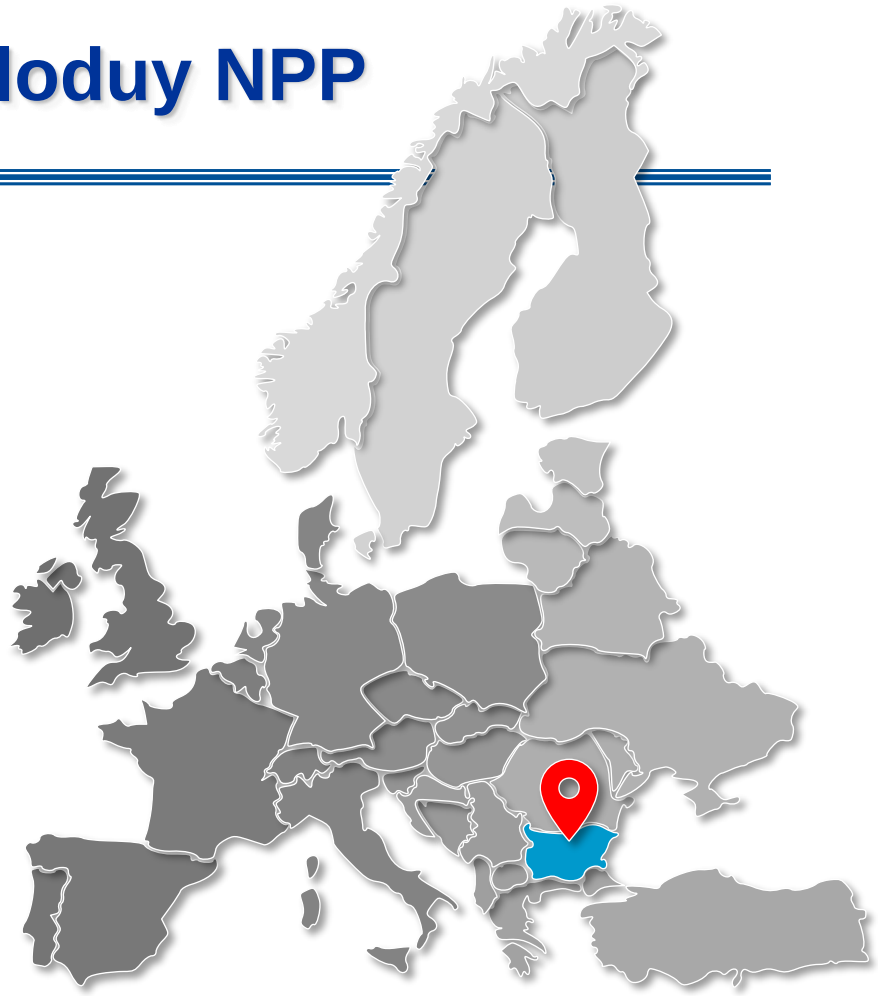
**Updating of full-scale PSA L1 (2020-2022);**

**TSR-PSA of PSA L1 (2020) - 2023**

**2023**

# TSR-PSA for Kozloduy NPP

- TSR-PSA Mission to Kozloduy NPP Units 5&6 full scope Level 1 PSA
- March 20 – 31, 2023 - Kozloduy NPP, Bulgaria



# Technical Safety Review (TSR-PSA)

- The purpose of the TSR-PSA mission was to provide an independent review of Level 1 PSA documentation (including the electronic PSA model) for Units 5 and 6 of KNPP against the relevant IAEA Safety Standards and make recommendations for further improvements.
- The outcome of this TSR-PSA was the IAEA TSR-PSA Final Report which consists of an executive summary, and the review sheets which identify the specific observations made, the related IAEA safety standards, and a final recommendation of how the observation could be resolved. Each observation will be provided via Review Sheets in the report.

The TSR service is based on the IAEA's **Safety Standards** and covers the following subject areas:

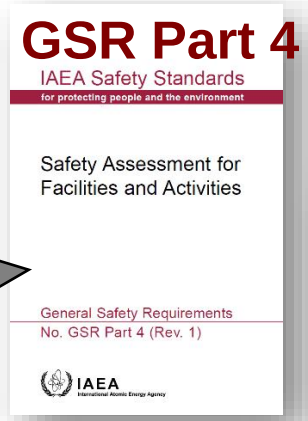
- Design Safety (DS);
- Generic Reactor Safety (GRS);
- Предели и условSafety Requirements (SR);
- **Probabilistic Safety Assessment (PSA);**
- Accident Management (AM);
- Periodic Safety Review (PSR).

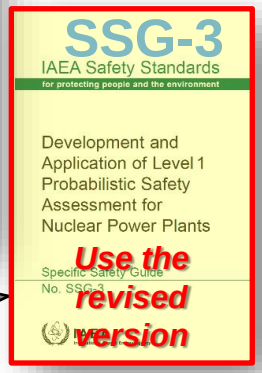
# Review basis: IAEA Safety Standards on PSA

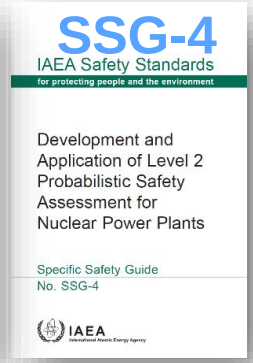

***MUST***
**Safety objectives and safety principles**

***SHALL***
**Functional conditions required for safety**

***SHOULD***
**Guidance on what should be done to fulfil the requirements**




** For specific issues other standards were applied (e.g. SSR-1 for hazard assessment)*

# Inviting the TSR-PSA mission

1. Updated PSA L1 for units 5&6 in Kozloduy NPP (the scope is extended for the site external hazards and MUPSA)

2. Requirements of Regulatory Guide on use of PSA to support the safety management of nuclear power plants - To confirm that the overall implementation of PSA is adequate and meets the established good practices and international standards, it is recommended that the licensee provide for the performance of independent verification.

3. The Bulgarian Nuclear Regulatory Agency (BNRA or the Requesting Party) has requested the IAEA to perform a TSR-PSA of the Updated Probabilistic Safety Analysis Level 1 for Units 5 and 6 in Kozloduy NPP (Kozloduy 5&6 PSA L1).

# TSR-PSA Mission stages

**02**

OPTION

**Discussion meeting** to preliminary discuss the preliminary set of review sheets and concerns of the reviewers (9-10 February 2023, virtual mode)

**04**

OPTION

**Exit meeting** to hand over the final TSR-PSA report (31 March 2023, in-person)

**01**

OPTION

**Kick-off meeting** on TSR-PSA of updated Probabilistic Safety Analysis Level 1 for Units 5 and 6 of the Kozloduy NPP (12-14 December 2022, Vienna, Austria hybrid mode)

**03**

OPTION

**TSR-PSA review mission** to finalize the review sheets and develop the draft TSR-PSA report (20-31 March 2023, Kozloduy, Bulgaria, in-person)

# TSR-PSA Mission preparation

**01**
OPTION

Terms of Reference for IAEA TSR – PSA

**02**
OPTION

Kozloduy NPP submitted to the IAEA the PSA L1 documentation and model.

Reports are available in English and Bulgarian (translation is possible – limited)

**03**
OPTION

A Kick-Off Meeting was organized at the IAEA Headquarters and started with a presentation by the Requesting Party on the Kozloduy 5&6 PSA L1 and the Kozloduy 5&6 NPP design followed by a general discussion with involvement of external experts. Thereafter, the Team Leader and Deputy Team Leader discussed with the assigned 6 external experts to present the scope of the review and review process, the assignment of work, the schedule for performing the review as well as the expected deliverables.

# TSR-PSA Mission at the Kozloduy site

## Objectives

Familiarization with the plant site (mainly for multi-unit interactions and external hazards related aspects).

**Familiarization with the plant design and operation (mainly for modelling assumptions in PSA)**

**Assure that all facts are accurately captured.**

**Assure that the content of the review sheets is clear to the Requesting Party.**

**Carry out the review in areas that need intensive interaction with the Requesting Party.**

Clarify questionable aspects related to the PSA study (if needed).

**Respond and discuss to the preliminary review observations.**

**Finalization of the review process** and observations (including information from the walkdown)

**Discussion of the review sheets** with Bulgarian counterpart

Providing final resolutions

Development and handover of the final report

# TSR-PSA mission agenda

| time | Monday 20 March | Tuesday 21 March | Wednesday …… Monday 22 March ….. 27 March | Tue.- Wednesday, 28-29 March | Thursday, 30 March | Friday, 31 March |
|---|---|---|---|---|---|---|
| 9AM-1PM | **Opening session**<br><br>**S1. Preliminary review results** (Review team) | **S3. Split work:**<br><br>**Review Team:** PSA review and write review sheets<br>**Bulgarian CP:** provides support, written responses | **Technical Walkdown**<br><br>• SG feedwater<br>• AC/DC, DGs, MCR and ECR<br>• HVAC<br>• Spray ponds<br>• Site related (MU&EE)<br>• Etc. | **S6. Finalizing the review sheets**<br><br>**Review Team:** summaries and final resolutions<br>**Bulgarian CP:** final written responses *(by 28 March end of the day)* | **S7. Final report**<br><br>**IAEA:** Final report<br>**Review Team:** slides for Exit meeting and Master Table | **Exit meeting**<br><br>**IAEA:** overview of mission results<br>**Review team:** specific findings short presentation<br><br>Final Report |
| 1PM-4PM | **S1. Preliminary review results** (Review team)<br><br>**S2. KNPP feedback** | (cont.) | **S5. Split work** (like S3)<br><br>*Last review sheet: 27 March, Monday (noon)* | (cont.) | (cont.) | |

# Technical walkdowns

- **Two walkdowns** (review-focused)
  - SG emergency feedwater system
  - Electrical switchgear
  - MCR and ECR
  - Spray ponds
  - Diesel generators (including mobile)
  - MZ areas (row A, B, etc.)
  - Site related (MU&EE)
  - Example of the operator action
  - HVAC
- **Important info -** spatial interactions
- **KNPP staff** assistance and flexibility

# Review sheets summary

| # | Expert name | Organisation | Country | Field | RS | Total |
|---|---|---|---|---|---|---|
| 1 | Tamas SIKLOSSY | NUBIKI | HUN | POS and LPSD PSA | 5 | **15** |
| | | | | Initiating Events Analysis | 6 | |
| | | | | External hazards | 4 | |
| 2 | Jan HUSARCEK | UJD | SVK | Accident Sequence Analysis | 12 | **12** |
| 3 | Ivan VRBANIC | APOSS | CRO | Data analysis and CCF | 13 | **19** |
| | | | | Human Reliability Analysis | 6 | |
| 4 | Gurgen KANETSYAN | NRSC | ARM | Internal fire and flood PSA | 10 | **12** |
| | | | | Other internal hazards | 2 | |
| 5 | Bert COMMANDEUR | PALLAS | NED | System analysis | 4 | **8** |
| | | | | Quantification, Imp&Sen&Unc. | 4 | |
| 6 | Andrea MAIOLI | Westinghouse | USA | Seismic hazard | 14 | **16** |
| | | | | Multi-unit PSA | 2 | |
| | | | | | | **82** |

- All review sheets were discussed with Bulgarian counterpart
- Responses, resolutions and recommendations drafted

# Final report

**EXECUTIVE SUMMARY**

**1. INTRODUCTION AND MAIN CONCLUSIONS**

- 1.1. Objective and Scope
- 1.2. Project Organization and Conduct
- 1.3. Main Conclusions
- 1.4. Future Outlook

**2. REVIEW RESULTS**

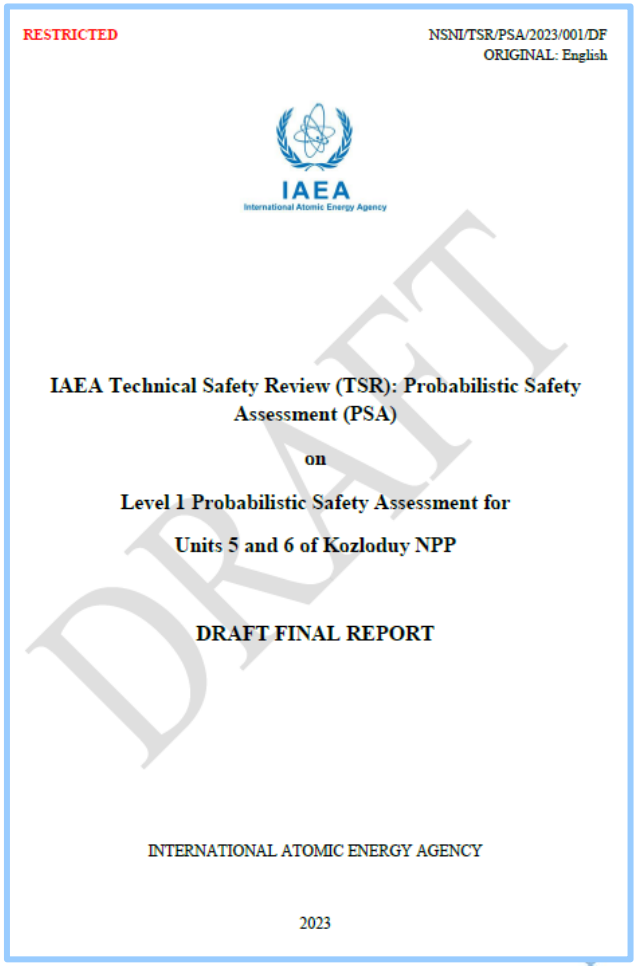
- 2.1. PSA scope and plant operating states
- 2.2. Initiating Events Analysis
- 2.3. Accident Sequence Analysis (including thermal-hydraulic support)
- 2.4. System Analysis
- 2.5. Data Analysis
- 2.6. Analysis of dependencies
- 2.7. Human reliability analysis
- 2.8. Level 1 PSA Quantification (including sensitivity and importance analyses)
- 2.9. Internal Hazards (fires, floods, other internal hazards)
- 2.10. External hazards (seismic, other external hazards)
- 2.11. Low power & shutdown
- 2.12. Multi-unit considerations

**REFERENCES**

**APPENDIX I. Review Team and Requesting Party's Team composition**

**APPENDIX II. Review areas and review area codes**

**APPENDIX III. Complete set of the Review Sheets**



RESTRICTED

NSNI/TSR/PSA/2023/001/DF
ORIGINAL: English

IAEA
International Atomic Energy Agency

DRAFT

IAEA Technical Safety Review (TSR): Probabilistic Safety Assessment (PSA)

on

Level 1 Probabilistic Safety Assessment for

Units 5 and 6 of Kozloduy NPP

DRAFT FINAL REPORT

INTERNATIONAL ATOMIC ENERGY AGENCY

2023

# Next steps and future outlook

Follow Up TSR-PSA 01

Risk Monitoring - Updating of RiskWatcher model based of new PSA model 02

PSA level 2 updating 03

# Conclusions

- The Review Team concluded that Kozloduy Units 5&6 L1 PSA study generally follows the requirements provided in the relevant IAEA Safety Standards.
- The review identified some areas that need further enhancement to improve alignment of the reviewed PSA study with the IAEA Safety Standards.
- KNPP expressed their understanding of the results of this review and the importance of their resolution to fully comply with the IAEA Safety Standards, as these constitute the global reference for safety.
- The Kozloduy NPP will use the results of this review to enhance nuclear safety in areas that may need improvements to adhere to the IAEA Safety Standards - Bulgarian counterpart updated PSA model and documentation based on the comments, recommendations and resolutions in TSR-PSA final report
- TSR is used as an independent review of PSA performed by operating organization before the safety analysis is submitted to BNRA for approval.

# Thank you for your attention!

# Experiences from the IAEA TSR-PSR of Koeberg NPP Periodic Safety Review Documentation in Support of LTO

Presented by: B Mashele

Date: 13 December 2023

# Purpose of the presentation

**Aim:** To share Koeberg NPP experiences on the IAEA TSR of third PSR documentation that is used to support LTO

## Outline

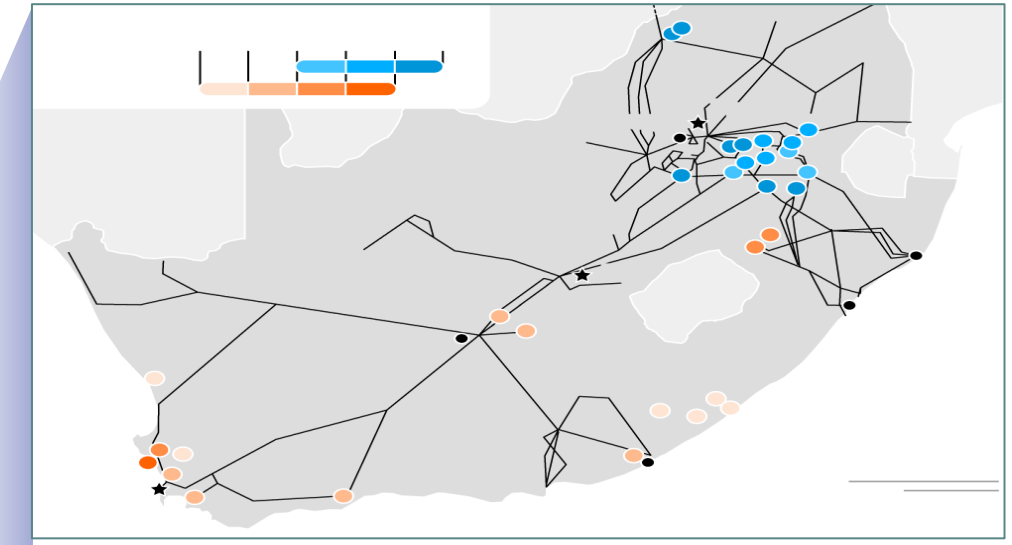
1. Overview of the nuclear programme in South Africa
2. Koeberg's PSR-TSR requirement and process
3. PSR-TSR journey and outcome
4. Conclusion

# Overview of the Nuclear Programme in South Africa

- How many nuclear power plants are in commercial operation in South Africa?
- What technology is employed for the Koeberg design?
- How many years has Koeberg been in operation, and what has the reliability been like?
- Are there future new nuclear build for South Africa?

# KNPP is an essential source of energy for South Africa and the only baseload power supply in the Western Cape.

- The only nuclear power plant in South Africa (SA), which employs pressurised water reactor technology with an annual energy contribution of 4.5%.
- The only base load power station within the Western Cape grid of SA.
- The Western Cape grid connects to the Mpumalanga Generation pool (mainly coal) in north-eastern part of SA via transmission lines which are more than 1000 km away (400 kV and 765 kV lines).
- Current operating license expires in July 2024, Eskom has applied to extend the operating license by 20 years.



**Lifecyle of the units**

| | | | |
|---|---|---|---|
| Unit 1 | Unit 1 commenced commercial operation 1984 | Operating license expires in 2024 after 40 years | 20-year life extension, i.e., LTO period |
| Unit 2 | Unit 2 commenced commercial operation 1985 | Operating license expires in 2024 after 39 years | 20-year life extension, i.e., LTO period |

# Koeberg boasts a track record of safe and reliable operation since its commissioning in 1984 (39 years)

- Safe operation since commissioning with no major nuclear accidents or major incidents.
- No suspension of the operating license by NNR.
- Multiple breaker to breaker operations, resulting in KNPP being one of the most reliable stations on the Eskom fleet.
- Aligned with the nuclear industry good practices through international benchmarking and peer reviews, e.g., WANO, INPO, IAEA, peer stations, etc.
- Currently in the process of license renewal, with major safety assessments to support long term operation (LTO), such as PSR and SALTO, concluded.
- SA government's Integrated Resource Plan indicates "…a nuclear build programme to the extent of 2 500 MW at a pace and scale that the country can afford…".

# Koeberg's periodic safety review (PSR)-Technical Support Review (TSR) requirement and process

- What were the key reasons that the IAEA TSR was requested?
- What were the main expectations from the TSR?
- What was the scope of the TSR?
- How was the TSR conducted?
- How long did the TSR take to conclude?
- How many documents (pages) were reviewed?
- How many external experts were utilised?
- Implication of Koeberg NPP staff and other national experts (discussions, presentations, answers provided).

# KNPP's third PSR is the major input into the LTO safety case

## PSR-TSR Purpose

- Provide guidance on conducting PSR utilizing IAEA SSG-25 – **first of kind project for KNPP.**
- Verify the **adequacy of the preparation and review phases** – Independent review by industry experts to ensure Koeberg is on par with requirements that should be addressed in PSR in order to produce a robust justification for the suitability of continued operations to support the LTO safety case.

## Expectations

1. 
   - Obtain input and guidance on the inclusion of international safety standards and requirements,
   - Verify based on operating experience whether the PSR documentation adequately incorporates these safety requirements.
2. Verify that the PSR adequately evaluates the safety requirements and especially those needed to support LTO.
3. Conduct review within stringent limited period due to timelines provided by the Regulator.
4. Conduct review virtually due to covid-19 intercontinental travel restrictions.

# The scope of PSR-TSR

**List of input documentation from Koeberg and IAEA- TSR deliverable documents**

## Input into TSR

- Basis document: > 200 pages.
- Three safety factors requirements and review methodology documents as pilots: SF-1, SF-2 and SF-6: ~550 pages.
- All 14-safety factor review reports: average of ~1 000 pages per safety factor – **September 2021.**
- Global assessment report: ~800 pages – **November 2021.**

## Output of the TSR

- ❑ Terms of reference agreed: May 2021.
- ❑ Review sheets with IAEA comments: ~410 pages (November and December 2021 for SFs and GA, respectively).
- ❑ Meetings/discussions/clarification emails and technical meetings.
- ❑ TSR-PSR report: ~26 pages.
- ❑ Draft report transmitted: **December 2021.**
- ❑ Exit meeting: May 2022.

**Total duration of TSR = 6 months**

# TSR-PSR initially agreed schedule on the ToR

| No. | Task Name | Duration |
|---|---|---|
| 0 | Agreed Terms of Reference | 12 May 2021 |
| 1 | Recruitment of Experts | 1 June – 30 June 2021 |
| 2 | Submission of Koeberg PSR documentation (Safety Factors) | 1 August 2021 |
| 3 | Kick-Off Meeting (virtual) | 5 August 2021 |
| 4 | Review of documentation | 9 August – 31 August 2021 |
| 5 | Discussion Meeting with experts (virtual) | 1 – 3 September 2021 |
| 6 | Delivery of Review Sheets | 6 September 2021 |
| 7 | Intermediate Meeting with Requesting Party (virtual) | 27 September 2021 |
| 8 | Requesting Party provides comments | 11 October 2021 |
| 9 | Submission of Koeberg PSR documentation (Global assessment) | 1 November 2021 |
| 10 | Review of Global assessment documentation | 2 - 10 November 2021 |
| 11 | Delivery of all Review Sheets (Final Safety Factors, draft Global Assessment) to Requesting Party | 17 November 2021 |
| 12 | Preparation of the TSR-PSR Draft Report | 19 November – 8 December 2021 |
| 13 | Delivery TSR-PSR Draft Report with all review sheets | 8 December 2021 |
| 14 | Requesting Party provides comments on TSR-PSR Draft Report and remaining review sheets on global assessment | 12 January 2022 |
| 15 | Resolution of Requesting Parties comments | 19 January 2022 |
| 16 | Requesting Party receives draft TSR-PSR Final Report | 21 January 2022 |
| 17 | Exit Meeting to discuss draft TSR-PSR Final Report | 26 – 27 January 2022 |
| 18 | Finalize TSR-PSR Final Report | 1 – 18 February 2022 |
| 19 | Deliver TSR-PSR Final Report to Koeberg NPP | 18 February 2022 |

Left Tab

# TSR-PSR teams and teams' effectiveness

**IAEA Team**

- Team leader
- Deputy team leader
- IAEA staff members
- Industry experts from Czech Republic, Netherlands, Slovakia, and United States of America

**Eskom Team**

- Team leader
- Deputy team leader
- Safety factor leads - Eskom experts
- Safety factor leads – industry experts
- Global assessment industry experts

**Results of effective teams**

- Both teams collaborated well with open robust engagements.
- Two iterations of review sheets and the main report.
- Professional and technical/process focused discussions were held for clarifications.
- Good guidance in general.
- TSR identified weaknesses that resulted in updating most PSR documents.
- Both teams worked tirelessly to conclude the TSR within the agreed timelines.
- TSR ensured PSR documentation produced was of high quality.
- As a result, several safety factors' reports had no comments from the Regulator's reviews.
- Less significant comments were received from the Regulator on the remainder of the safety factors and global assessment reports.

# TSR-PSR journey and outcome

- What and how was the outcome?
- Was the TSR-PSR worthwhile?

# Summary of the TSR outcomes

- In general, good alignment of the Koeberg reviewed documentation with the IAEA safety standards.
- The scope of review of PSR documentation was comprehensive and generally followed the recommendations provided in SSG-25, which are similar to SA PSR regulation guidelines.
- The key TSR recommendations associated with the most significant issues identified during the review are the following:
  - Several IAEA specific safety requirements were not included in KNPS PSR basis among the review criteria. Justification, why specific safety requirements were not included in the review was not provided when KNPS PSR documentation was submitted to IAEA. **This was corrected.**
  - Description of the scope setting process for identification of SSCs to be considered for the periodic safety review should include justification of the representativeness of the SSC sampling process used. **The justification was documented in the SF-2 requirements and review methodology document.**
  - The equipment qualification programme should consider the full spectrum of conditions arising from external natural hazards relevant for the site, including climate change considerations. **This was considered where relevant.**

# Summary of the TSR outcomes

- All deviations included in global assessment should be consistent with deviations identified during the safety factors' evaluation. **Safety factors and global assessment documents were reviewed and aligned in terms of deviations.**
- There were two safety factors' reports that were identified to be largely inconsistent with IAEA safety standards. **These safety factors' reports were re-written following IAEA guidance.**

- Eskom senior management:
  - Commended the IAEA on conducting the TSR under several constraints and expressed the understanding that the results of this review are important to achieve high levels of safety.
  - Expressed that the resolution of the identified issues on the results will contribute to enhancing nuclear safety in areas that may need improvements in accordance with the IAEA safety standards.
- The IAEA team appreciated:
  - The openness and transparency of the KNPP staff and acknowledged their technical knowledge and excellent preparation for the review service.
  - The KNPP management for their commitment to safety and continuous improvement.

# Conclusion

# Salient points

- It was a worthwhile exercise; Eskom considers the service as value for money.
- IAEA experts were ready for the reviews and always delivered unambiguous quality review comments in accordance with the agreed timelines.
- All comments were objective and always referred to the relevant IAEA safety requirement that is not adequately addressed or missed, and highlighted evidence in the KNPP PSR's documentation.
- Covid-19 travel restrictions were identified as a risk at the beginning, but remote work ended up producing good results.
- Even though there were constraints such as limited time and travel restrictions leading to different time zones, both IAEA and Eskom teams were committed and always delivered what the other party requires within the agreed timelines to minimise the adverse impact on another's schedule.
- Most PSR documents were revised because of IAEA TSR review comments.

# Salient points

- Almost half of the safety factor reports had no comments from the Regulator's review.
- The other safety factors and the global assessment reports had less significant comments from the Regulator (in line with their review comments criteria).
- The TSR was a success and resulted in acceptable quality of PSR reports.
- This ensured high quality work, in the form of PSR outcomes formed a significant input into the LTO safety case, which is currently under review by the SA Regulator.

# End.

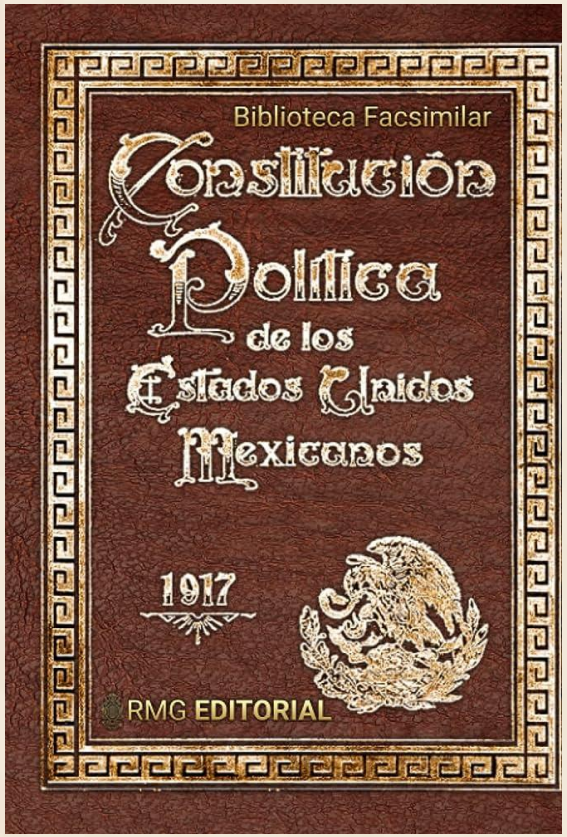
# IAEA Technical Safety Review (TSR-PSA):

## Experiences with and the usage of results from the TSR-PSA Probabilistic Safety Assessment Study for Laguna Verde NPP to enhance regulatory body's capabilities

GOBIERNO DE MÉXICO | SENER SECRETARÍA DE ENERGÍA | CNSNS COMISIÓN NACIONAL DE SEGURIDAD NUCLEAR Y SALVAGUARDIAS

# The Nuclear Program in Mexico:

## The CNSNS




- Article 27, establishes that nuclear energy must be only used for pacific applications and that the exploitation of nuclear fuels for the generation of nuclear energy as well as the regulation of its application to all areas corresponds to the Nation.
- Federal Executive, through the Secretariat of Energy, regulates and supervises compliance with the provisions on matter of nuclear safety and radiological protection.
- The creation of the CNSNS. It operates as Regulatory Authority responsible for overlooking nuclear and radiological safety, physical security, as well as safeguards.
- Mexico is committed to apply and to comply with the Basic Safety Standards of the IAEA and with the safety conditions recommended in the IAEA's practical guides.
- At the beginning of the design and construction of the LVNPP, by agreement between the Mexican government and the IAEA, the regulatory process conforms as far as possible to the guidelines and standards applicable in the country of origin of nuclear reactors. Being both reactors of the General Electric, all activities related to licensing are conducted in compliance with the applicable regulation in the USA, with the prior approval of the National Regulatory Body, the National Commission for Nuclear Safety and Safeguards (CNSNS).
- For this reason, Title 10 "Energy" of the Code of Federal Regulations of the United States of America was established as a regulatory requirement as well as all industrial standards and guides deriving from such Title.

# LAGUNA VERDE NUCLER POWER PLANT

- **The commercial operation**
  **(initial operation licensee for 30 years)**
  - **Unit one began in 1990 and unit two followed in 1995.**

**1931 MWt original power**

- **first uprate 5% (2027 MWt)**
  - **In 1995 the 105% of the power up rate proyect was initiated. Increasing the steam flow to the turbine Mantaining the Pressure in a constant value.**
  - **Increase the feed water flow in combination with a higher control rod pattern**

- **2317 MWt second uprate (20%)**
  - **In 2008 it was submitted the Extended Power up Rate of 120% (2317 MWt)**
  - **Redesign of BOP including an extra condensate pump**
  - **No pressure modification**

## Electric BWR/5,Two units, with a MARK II Containment

# PSA in Mexico, Background

- First models developed in a joint efforts between Regulator, Utility and research institutes (CNSNS, CFE, ININ and IIE)
  - Familiarization with the methodology to develop fault and event (WASH 1400)
  - Familiarization with codes for PSA and severe accidents
  - Initial efforts to develop Fault tress for some of the front-line systems
  - Use generic data base for component failure rate
  - Very preliminary models for event trees
- After that initial efforts, each institution start to work on their own side
  - CNSNS to acquire more skill to review PSA developments
    - Develop their own model for regulatory applications
  - CFE (utility) to star the development of the Individual Plant Examination (IPE)
  - ININ to increase their skill to collaborate with CFE

Regulatory PSA for Laguna Verde NPP

Mexican Nuclear Regulatory Authority developed an independent PSA

PSA level 1 for full power operation

- First model in cooperation with Utility, research institutes (CNSNS, CFE, ININ and IIE)
- Complete model in SETS with generic data (Full documentation, general review for Sandia National Laboratories)
- Conversion to SAPHIRE platform and first updating
- Updating process to include among others: plant specific data

PSA level 2

- Accident Progression Event Tree, 131 Questions about possible events, EVNTRE computer code
- MELCOR code was used to support the APET
- Event Progression Analysis Code, NUREG/CR-5174, Sandia National Laboratories
- LVSOR (series XSOR), parametric equation based on mass conservation
- Timing
  - Early (before 6 hours)
  - Intermediate (6 to 24 hours)
  - Late (after 24 hours)
- A mount of fission product releases
  - High (more than 10% of Cs-I)
  - Moderate (1% to 10%)
  - Low (less than 1%)

A preliminary PSA level 1 for one POS for LP&SD

- Developed for the National University (UNAM) using the Utility models

ISL a contractor from NRC perform a review of the PSA level 1 and 2

**IPE for Laguna Verde NPP**

The Utility (CFE) developed

**Individual Plant Examination (IPE), internal events and full power operation**

Updating process to include plant specific data was completed for PSA Level 1

Codes: CAFTA and MAAP

**PSA Level 2 updating in process**

Methodology of EPRI NSAC-159 (Small event trees and large fault trees)

Internal Flooding developed for the Research Institute (ININ)

**Risk Monitor**

# Performing the TSR

- The purpose of the TSR-PSA mission was **to provide an independent review of the CNSNS PSA Study** using as a basis the IAEA Safety Standards and make recommendations for further documentation improvements.

- The mission was coordinated by an IAEA Team Leader was composed of experts from : regulatory body, utility, design organisation and academia (from Finland, Spain, and Russian Federation) and IAEA staff members.

- This TSR-PSA mission reviewed documentation on CNSNS Level 1 and Level 2 PSA report, severe accident analysis and corresponding supporting documentation, which mainly included system descriptions, Event Tree descriptions, equipment reliability data, description of Containment Event Trees and MELCOR supporting analyses. In addition, the electronic PSA model was made available for the review team.

- **A key factor was the availability of the information (Short plant description, PSA models and results, severe accident simulations, etc) three months in advance of the mission. Therefore, a detail revision was achieved.**

# Main results

- The TSR Review Team concluded that CNSNS PSA Study in general follows the overall PSA framework reflected in the IAEA Safety Standards. The Review Team also noted the high level of understanding and knowledge of the PSA Study and applied software tools.
- However, the review identified some areas that need further enhancement to improve alignment of the reviewed PSA documentation with the IAEA Safety Standards. The key recommendations associated to the most significant issues identified are the following:

- The documentation of CNSNS PSA Study should be enhanced to ensure sufficient scope and level of details to support the PSA conclusions
- The process of systematic identification of all potential risk contributing factors should be implemented in particularly in the context of initiating event, human failure events and common cause failures.
- The process should be established to ensure the reliability data used in a PSA Study are regularly updated to account for operating experience available at both units of Laguna Verde NPP.
- The Level 2 PSA model should be revisited to clarify (and revise if needed) the differences revealed between the results presented for PDSs and CETs and to systematically address the calculation of success paths for each functional event.

# Feedback of the TSR-PSA:

- Opportunity to discussion with experts on the different modeling techniques,
- Feedback on specific areas to how to improve, modify, update and maintain our models.
- Peer-review of Probabilistic Safety Assessment

**Usefulness and applicability of obtained results**

- Peer review is a very important activity.
- we will increase the technical quality of our PSA model and documentation, and therefore of regulatory applications, to support risk-informed decision making.
- Detail report on the activities and recommendation

# Foreseen Benefits of the TSR-DS Service in Support of the Development and Licensing of the Rolls-Royce SMR

Mark Salisbury

13th December 2023

# SMR A technology vendor offering a complete SMR power plant on a turnkey basis

**Rolls-Royce SMR Ltd Shareholders**

**Rolls-Royce Group**
60 years designing, manufacturing, supporting and operating nuclear technology

**Constellation Energy (previously Exelon Generation Ltd)**
Operates the largest U.S. fleet of zero-carbon nuclear plants with over 18.7GW from 21 reactors at 12 facilities

**BNF Resources UK Ltd**
Extensive investments in the energy space and represented and advised by BNF Capital Limited, an FCA regulated UK-based investment advisory

**Qatar Investment Authority**
Invests in the energy transition and funds technologies that enable low carbon electricity generation

**UK Government Grant Funding**

Department for Business, Energy & Industrial Strategy

UK Research and Innovation

**UK Department of Business Energy and Industrial Strategy**
Rolls-Royce SMR Ltd received the Low-cost nuclear (LCN) grant award by UK Research and Investment (UKRI)

# Turning nuclear into a product, not a one-off mega infrastructure project

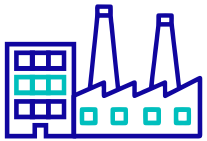
✘ **EPC (mega project)**

**Conventional EPC (e.g. Large nuclear)**

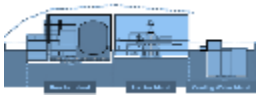
- Mega project GBP10bn+
- Reactor only, *not* whole plant
- Government driven
- Commercially complex

**Designed for LCOE and simplicity of deployment**

**Factory product**



**Standardization**



**Schedule certainty**

**Commercial simplification**

Reducing Project Risk

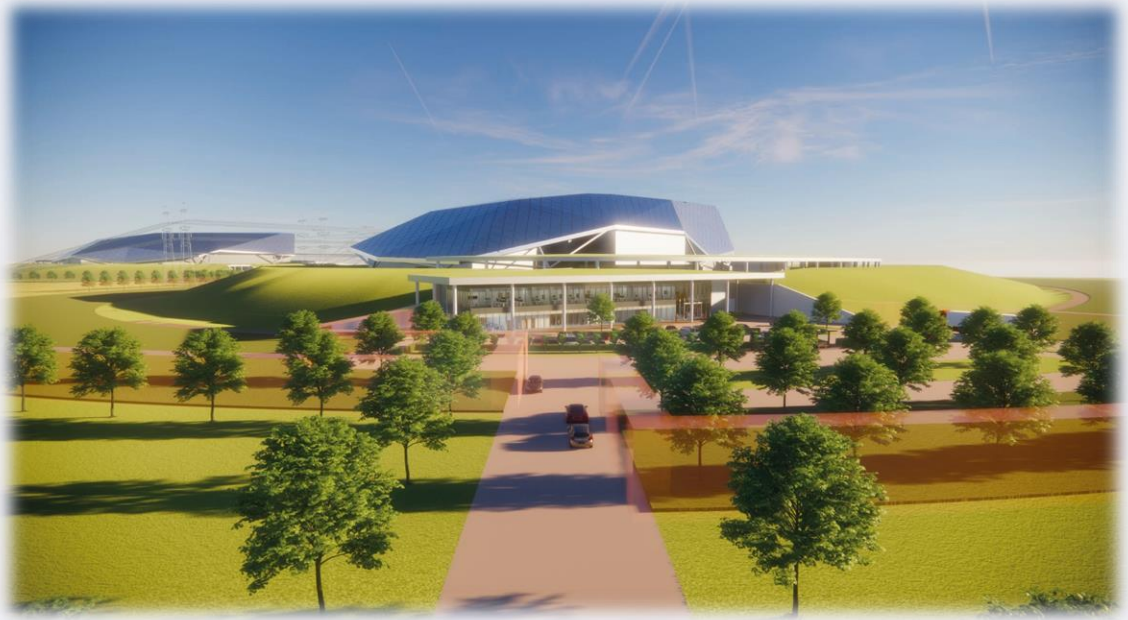
✓ **EMA (factory product)**

Engineering
Manufacturing
Assembly

- **Much lower risk**
- **Reduced capital**
- **Shorter time to build**

**= Reduced financing cost**

# Power Station Overview

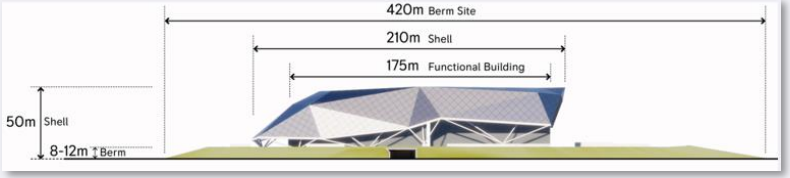


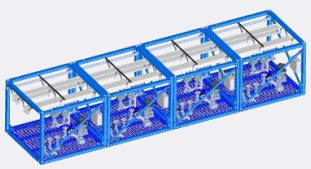
**An integrated whole power station approach focused on standardisation, repeatability and commoditisation**

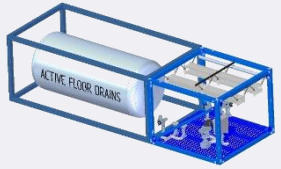
| MAJOR TECHNICAL PARAMETERS: | |
|---|---|
| **Parameter** | **Value** |
| **Reactor Type** | Pressurised Water Reactor |
| **Electrical Capacity (MWe)** | 470 |
| **Thermal Capacity (MWth)** | 1358 |
| **Expected Capacity Factor (%)** | >90 |
| **Design Life (years)** | 60 |
| **Plant Footprint ($m^2$)** | 45,000 |
| **Power Conversion Process** | Rankine cycle |
| **Cogeneration Capability** | Possible configuration |
| **Passive Safety Features** | Yes |
| **Active Safety Features** | Yes |
| **Fuel Type / Assembly Array** | Industry Std $UO_2$ in 17x17 array |
| **Fuel Cycle (months)** | 18 – 24 |
| **Emergency Safety Systems** | Passive |
| **Refuelling Outage (Days)** | 18 |
| **Seismic Design (g)** | 0.3 |
| **Core Damage Frequency (per yr)** | $<1 \times 10^{-7}$ |

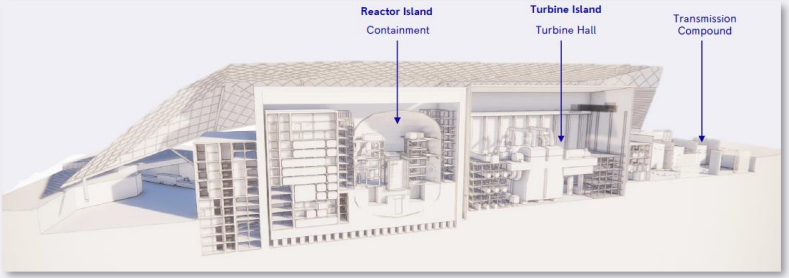
# Not all SMRs are the same

- **S**mall
  - Maximise power for physical constraints around manufacturability and transportability
  - Not about designing around an arbitrary power level
- **M**odular
  - Standardisation, factory repeatability in a production line approach.
  - Avoidance of large modules that must be disassembled for transportation - defeats the benefits of modularisation
  - Modules tested in factories to reduce site activity
- **R**eactor
  - RR provides the power plant, not just the reactor
  - Reactor is ~20-25% of the power plant by capital
  - Modularisation of the full power plant including civil construction
  - Enables delivery, by Rolls-Royce SMR under single EMA contract

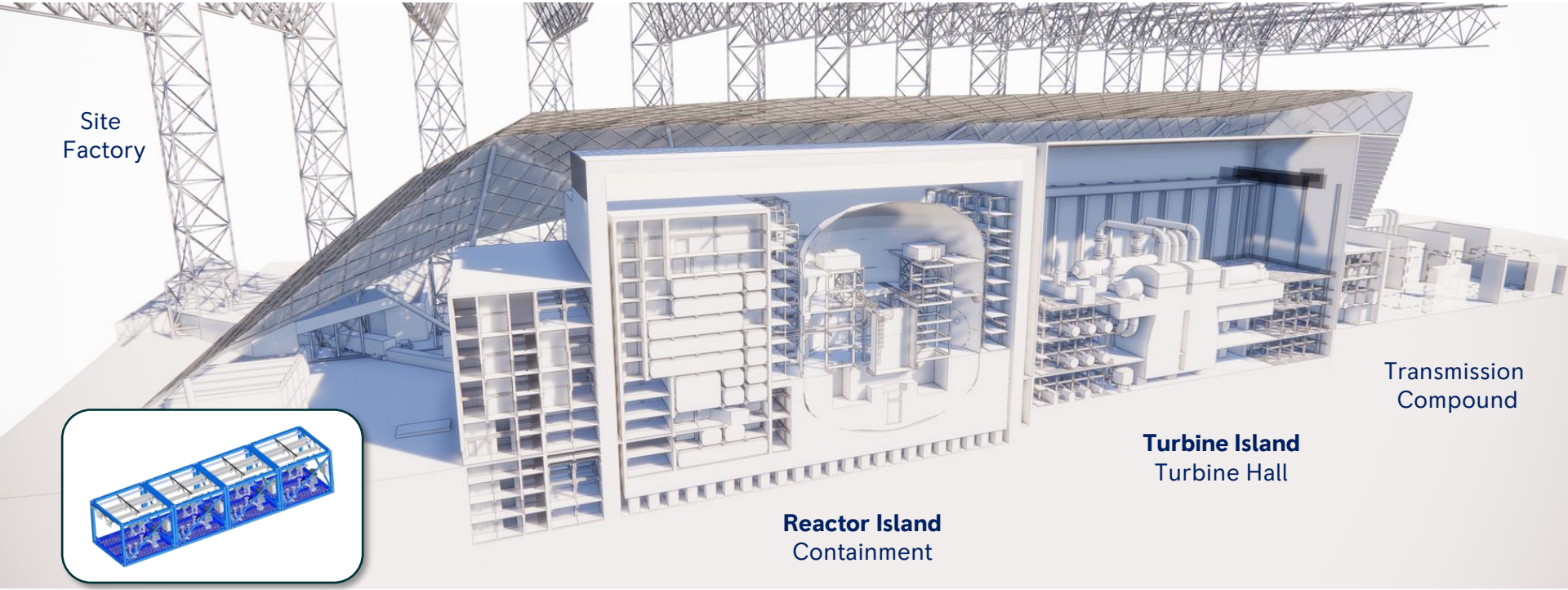




# A whole power plant approach focused on standardisation, repeatability, commoditisation



# Plant Development and Design

- Power Station is designed to international standards such as IAEA,
- Includes compliance with UK legislation and regulation,
- UK regulatory regime is goal setting and non-prescriptive,
- We must demonstrate the design reduces risk to As Low As Reasonably Practicable (ALARP),
- We must demonstrate the design uses Best Available Techniques (BAT) to reduce impact on the environment.

# Generic Design Assessment

- 3 Step process to assess a generic design,
- Joint assessment by Office for Nuclear Regulation (ONR), Environment Agency (EA) and Natural Resources Wales (NRW),
- Commenced in April 2022, currently in Step 2,
- Design assessed through our integrated Environment, Safety, Security and Safeguards (E3S) Case,
- gda.rolls-royce-smr.com

# IAEA TSR-DS

- Design is aligned with IAEA Safety Standards,
- Described in our E3S Case (all tiers),
- IAEA TSR-DS provides an opportunity to confirm and guide our team,
- Independent, expert demonstration of our alignment with IAEA Standards,
- Mission mid 2024.


ROLLS
ROYCE
SMR

IAEA
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# IAEA Technical Safety Review Service Process

## How to Request the TSR Service?

**IAEA Webinar on the Technical Safety Review (TSR): a key IAEA Peer Review mission for current nuclear power reactors and SMRs**
**Vienna, Austria**
**December 13, 2023**

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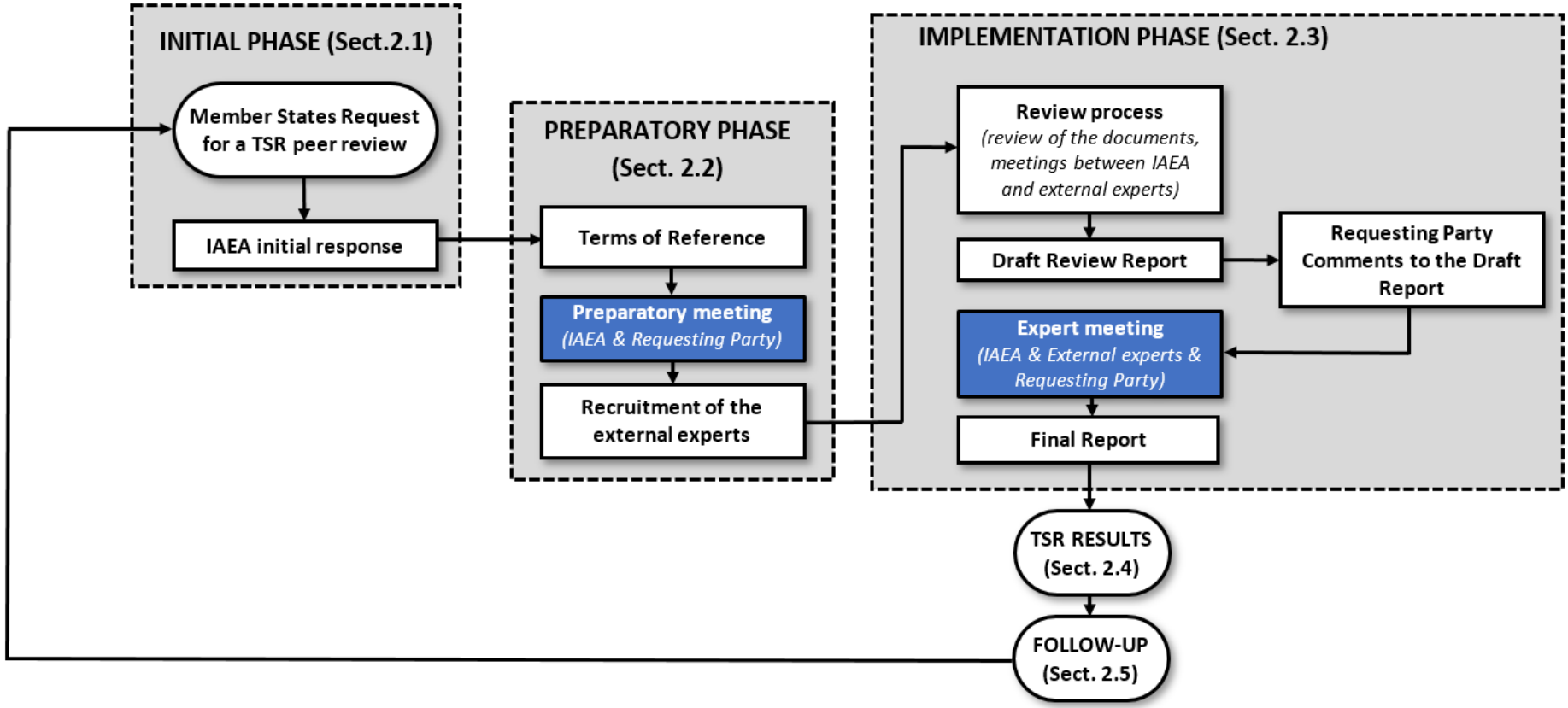
Senior Nuclear Safety Officer
Safety Assessment Section
Division of Nuclear Installation Safety
Department of Nuclear Safety and Security
International Atomic Energy Agency

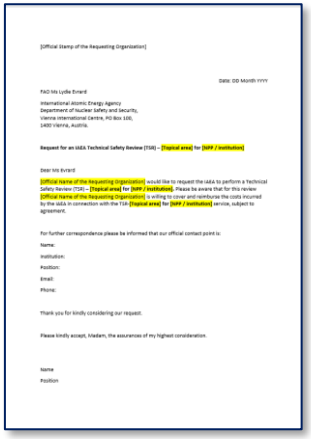
# TSR Peer Review Process



# How does the Requesting Party request a TSR service?

Official letter addressed to the Deputy Director General, Department of Nuclear Safety and Security: Ms. Lydie Evrard

- Identifying:
  - Topical area for the TSR
  - Name of the NPP / institution subject of the TSR
  - Proposed dates [optional]
  - Contact point details
  - Modality for covering the costs



[Official Stamp of the Requesting Organization]

Date: DD Month YYYY

FAO Ms Lydie Evrard

International Atomic Energy Agency
Department of Nuclear Safety and Security,
Vienna International Centre, PO Box 100,
1400 Vienna, Austria.

**Request for an IAEA Technical Safety Review (TSR) – [Topical area] for [NPP / Institution]**

Dear Ms Evrard

[Official Name of the Requesting Organization] would like to request the IAEA to perform a Technical Safety Review (TSR) – [Topical area] for [NPP / Institution]. Please be aware that for this review [Official Name of the Requesting Organization] is willing to cover and reimburse the costs incurred by the IAEA in connection with the TSR [Topical area] for [NPP / Institution] service, subject to agreement.

For further correspondence please be informed that our official contact point is:

Name:
Institution:
Position:
Email:
Phone:

Thank you for kindly considering our request.

Please kindly accept, Madam, the assurances of my highest consideration.

Name
Position

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*Thank you!*
*Questions?*

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