Advanced Reactor Codes and Standards Collaborative Workshop

November 30, 2023 I 9:00 a.m. to 4:30 p.m. EST
Electric Power Research Institute
Washington, D.C.

The Advanced Reactor Codes and Standards Collaborative (ARCSC) held its second workshop on November 30, 2023, at the Electric Power Research Institute (EPRI) offices in Washington, D.C. The hybrid workshop had just over 200 participants, including representatives from standards development organizations (SDOs), EPRI, the Nuclear Energy Institute (NEI), national laboratories, government agencies, vendors, advanced reactor designers, consultants, as well as representatives from other U.S. industry and international organizations including the International Atomic Energy Agency (IAEA) and World Nuclear Association (WNA).

1. **Welcome**
   Andrew Sowder with EPRI welcomed all to their offices in Washington, D.C. Safety information for those attending and other administrative logistical information were provided.

2. **NEI/EPRI North American Advanced Reactor Roadmap Support of ARCSC**
   Mark Richter with NEI provided attendees background on the NEI/EPRI North American Advanced Reactor Roadmap (NAARR). Consensus codes and standards (C&S) is included in the third pillars ("Technical Readiness") of the "Roadmap." The Roadmap recognizes the need for timely development of C&S as an essential component of advanced reactor strategy for large-scale deployment and to meet the U.S. national energy, climate, economic, and security goals. The need to support SDOs and subject matter experts that volunteer their time to support standards programs is essential. Funding and in-kind support are both critical to ensure C&S are available in the requisite timelines. Stakeholder engagement, especially from advanced reactor designers, is vital. NEI and EPRI are facilitating the operation of the ARCSC (or "Collaborative") to implement the C&S actions in conjunction with the Roadmap Implementation Board (RIB) and identified in the NAARR action plans.

   ARCSC has engaged advanced reactor designers and other sector representatives through a recent survey to identify and prioritize needed C&S, expanding on the work of NEI 19-03 (Rev.1), "Advanced Reactors Codes and Standards Needs Assessment." The Collaborative is comprised of U.S. and Canadian organizations to streamline the use of C&S in designs deployed in both countries. The Collaborative also looks to facilitate harmonization of U.S. and international C&S to support the export of advanced reactor designs, offering potential participation with organizations in other countries partnering with the U.S. and Canada on advanced reactors.

   Richter briefly reviewed the ARCSC charter and goals and where they fit into the Roadmap. C&S are one of the elements in the "Technology Readiness" pillar of the Roadmap to achieve successful deployment of advanced reactors through a shared industry strategy. The execution of the Roadmap is supported by the RIB which includes representation from 8 non-government organizations, 2 government organizations, 7 utilities, 6 Original Equipment Manufacturers, and 1 Engineering, Procurement, Construction organization. The purpose of the workshop was to address and discuss how the Collaborative was working to meet its charter objectives to
   - facilitate information sharing between SDOs and industry
   - identify and gather advanced reactor developer standards needs
   - inform and complement international and national C&S efforts
   - align actions with the NAARR

3. **Advanced Reactor International Activities**
ARCSC co-chair Kate Hyam with the American Society of Mechanical Engineers (ASME) provided an introduction of the three international speakers. Presentation titles and speaker information are listed below with their presentations attached and linked.

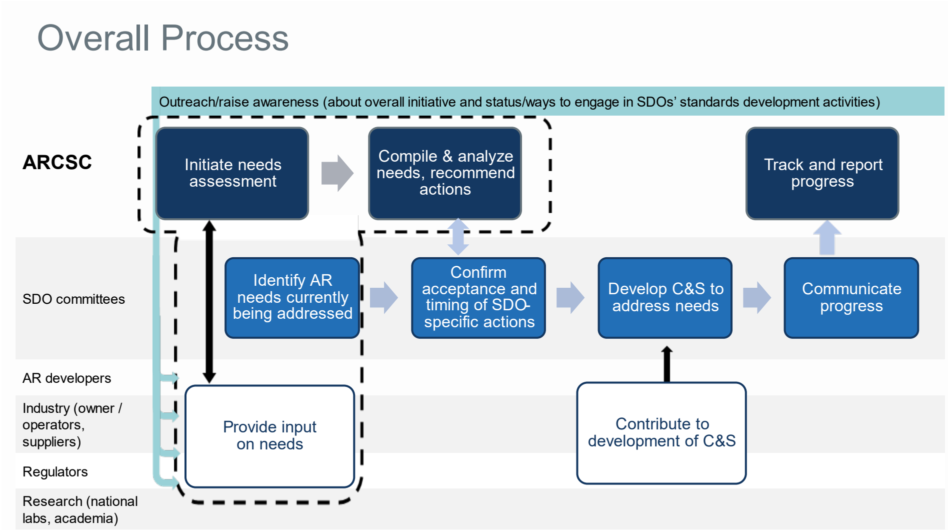
The Nuclear Harmonization and Standardization Initiative (NHSI): Common Approaches on Codes and Standards presented by Pekka Pyy, Division of Nuclear Power, IAEA
(See Attachment 1)

Activities of SDO Convergence Board – by Seiji Asada, Mitsubishi Heavy Industry, SDO Convergence Board chair
(See Attachment 2)

Overview of CORDEL Codes & Standards initiatives by Ronan Tanguy Safety & Licensing Programme Lead at WNA
(See Attachment 3)

Feedback was solicited via a survey from workshop attendees to find out what the advanced reactor community wanted to know about these international initiatives going forward, how the advanced reactor community wanted to contribute to these initiatives, and if there were other initiatives that ARCSC should be aware of.

4. **ARCSC Standards Development Roadmap Process**
Kate Hyam reviewed the Collaborative's activities since the December 1, 2022, kickoff meeting. Since that time, a charter and process document were developed, a list of nuclear-related standards was collected, and a survey was issued in September 2023 to collect industry feedback on advanced reactor standards needs. As of the workshop date, the survey had received over 100 responses and would remain open for any further responses. The ARCSC team members' names and positions were shared. Kate Hyam (ASME) and Larisa Logan (CSA Group), share the co-chair role of the ARCSC team. Others include representatives from NEI, EPRI, ASME, American Nuclear Society (ANS), Institute of Electronic and Electrical Engineers (IEEE), American Society of Civil Engineers (ASCE), and American Institute of Steel Construction (AISC). The Collaborative team also includes observers from the U.S. Department of Energy, International Society of Automation, Institute of Nuclear Power Operations, and U.S. Nuclear Regulatory Commission (NRC).
Hyam revisited the ARCSC charter and goals shared earlier by Mark Richter. The four key objectives are to 1) share information, 2) identify needs, 3) inform and complement, and 4) align actions. She walked everyone through the overall process the ARCSC will use to identify advanced reactor C&S needs, where they currently are in the process, and what conclusions will be drawn using the below diagram.



She explained that the top swim lane is the ARCSC, which is responsible for the Roadmap C&S actions through the RIB and where needed through engagement with the other stakeholders. The band at the top represents the ongoing objective for ARCSC to raise awareness and share information about the ARCSC, specific standards activities, how to engage, etc. The dashed black line represents the needs assessment process (2^{nd} objective) which is the current activity of the Collaborative.

SDO processes must be respected, so two-way communication between ARCSC and SDO committees will be critical to validate the input received from stakeholders regarding gaps and needs. Each SDO will be asked to evaluate then determine whether to accept any actions to address gaps. Each SDO will also continue to develop and approve their own content but will be requested to provide feedback to the ARCSC on their progress. Hyam stressed that the Collaborative needs collaboration and coordination from the stakeholders, especially advanced reactor designers, and contribution to the development of C&S to achieve the objectives.

Pat Schroeder, ANS, explained the process for creating a list of ~1000 nuclear-related standards and projects. The ARCSC team felt that the community would benefit from knowing what standards are currently available and to leverage existing work. Eighteen SDOs were asked to provide a list of their standards and projects. This includes the following:

- American Concrete Institute (ACI)
- American Institute of Steel Construction (AISC)
- American Nuclear Society (ANS)
- American Society of Civil Engineers (ASCE)
- American Society of Mechanical Engineers (ASME)
- ASTM International (ASTM)
- American Society for Quality (ASQ)
- American Welding Society (AWS)
- CSA Group (CSA)
- Health Physics Society (HPS)
- Institute of Electrical and Electronics Engineers (IEEE)
- Institute of Environmental Sciences and Technology (IEST)
- Institute of Nuclear Materials Management (INMM)
- International Society of Automation (ISA)

- Manufacturers Standardization Society (MSS)
- National Fire Protection Association (NFPA)
- National Electrical Manufacturers Association (NEMA)
- Nuclear Information and Records Management Association (NIRMA)

ASQ and IEST acknowledged that they did not have any of their standards used by the nuclear power community. As of the date of this workshop, no response was received from NEMA and NIRMA. The remaining 14 SDOs contributed to the list of ~1000 standards and projects. Information collected includes the designation, title, and status of the standard or project. Also requested was whether the SDO believes their standards are applicable to advanced reactors and to categorize the use of the standard into one of the six topical areas included in the recent industry survey. Some of the SDOs only had a handful of nuclear-related standards while others had hundreds. The list reflects the many disciplines needed to design and operate nuclear power plants.

Feedback was solicited via a survey from workshop attendees to find out if any SDOs are missing from the list, if the list of all identified nuclear-related standards and projects is needed, whether the community needs access to the spreadsheet, and whether the spreadsheet should be maintained, and if so, what frequency.

5. Needs Assessment Survey – Preliminary Statistics and SDO Committee Engagement Process

Larisa Logan reviewed the structure of the industry survey. The survey was structured around six topical areas and questioned what standards are being used and whether these standards have any gaps. The survey was launched September 14, 2023, with the announcement at the September NRC Standards Forum and further distributed through ARCSC members. As of November 1, 2023, the survey received 103 responses. The responses reflected a good representation of the industry and reactor type. The majority of standards currently being applied fall into the design and construction topical area; however, twenty-five comments were received on the lack of standards in design and construction. Although the requested response date of November 1 has passed, the survey link would remain live, and there was an ongoing invitation for stakeholders to provide further input which would be monitored periodically.

Donald Eggett, immediate past chair of the ANS Standards Board, provided a high-level summary of the preliminary evaluation of ARCSC survey responses on ANS standards. ANS grouped its responses by standard to get a better understanding of the industry's use and need. The majority of ANS standards in use by advanced reactor designers are in the design and construction area. Twelve of ANS's standards were recognized in use by more than five responders. Feedback on whether these standards had gaps were mixed. ANS will likely need to contact responders for more information. As a start, ANS will explore the following comments:

- a revision of ANSI/ANS-2.26-2004 (R2021), *Categorization of Nuclear Facility Structures, Systems, and Components for Seismic Design,* to be consistent with the License Modernization Project (NEI 18-04), ASCE 43, *Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities*, and with both NRC and DOE requirements
- a revision of ANSI/ANS-6.4-2006 (R2021), *Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power,* to interface (harmonize) with ASCE standards
- a revision of ANSI/ANS-15.8-1995 (R2023), *The Quality Assurance Program Requirements for Research Reactors*, to be applicable to advanced reactors
- a resurrection of withdrawn standard ANS-54.8-1988, *Liquid Metal Fire Protection in LMR Plants*

- a revision of ANSI/ANS-58.14-2011 (R2022), *Safety and Pressure Integrity Classification Criteria for Light Water Reactors*, to incorporate risk-informed and/or performance-based methods
- a revision of ASME/ANS RA-S-1.4-2021, *Probabilistic Risk Assessment Standard for Advanced Non-Light Water Reactor Nuclear Power Plants*, to include releases resulting from purposeful human-induced security threats and address NRC staff positions in RG 1.247 (for trial use), "Acceptability of Probabilistic Risk assessment Results for Non-Light-Water Reactor Risk-Informed Activities."

Eggett closed with explaining the process that ANS will use to evaluate its survey comments which will be led and include a review by its Priority Task Group that he will chair and engagement from its consensus committees, subcommittees, and their working groups using similar ranking criteria used in NEI 19-03 (Rev. 1) to establish priority. This process will be initially shared with other SDOs to gain their "buy-in" so all SDOs will be working to the same process when evaluating the comments received for their standards.

6. Advanced Reactor Industry Insights

The ARCSC welcomed five advanced reactor designers to provide additional insight into their survey responses. Presentations from the following are attached and linked:

GE Hitachi Nuclear Energy by Dennis Henneke, Consulting Engineer
(See Attachment 4)

TerraPower by Steven Unikewicz, Natrium Design Authority
(See Attachment 5)

X-Energy by Jon Facemire, Licensing Manager
(See Attachment 6)

Terrestrial Energy by William Smith, Senior Vice President Operations & Engineering
(See Attachment 7)

Holtec International by Jodine Jensen Vehec, Probabilistic Safety Analysis Engineer - SMR
(See Attachment 8)

7. ARCSC Future Actions – Discussion

The ARCSC next steps and future actions followed. The industry survey will continue to be evaluated to identify specific actions, gaps, and comments. The process to extract each SDO-specific responses to analyze cross-cutting themes will be defined by ARCSC over the coming months. The Collaborative will share responses with the responsible SDOs in spring 2024. A two-way dialogue will be established with each SDO to provide responses back to the Collaborative by the summer 2024. Subsequent steps include compiling overall resource needs and seeking prioritization input from the RIB in fall 2024.The next ARCSC workshop is tentatively scheduled to be held in September 2024 to provide current progress and the next set of actions moving forward. An ARCSC website is also being created and should be available soon to provide public access to survey response information, reference files, contact information, and events with meeting presentations.

Feedback was solicited via a survey from workshop attendees to find out what the industry would like to see on the webpage, what types of updates are needed, and what the preferred meeting platform is.

8. **Conclusion and closing**

Of great interest to the community is the harmonization of terminology both nationally and internationally. A suggestion was made for the ARCSC to form a subcommittee on terminology. While there was broad agreement on the need and importance, the challenge to harmonize terminology within one SDO is difficult much less harmonizing among multiple SDOs world-wide. The ARCSC will need to determine whether this activity falls within the current scope and resources of the Collaborative. Ronan Tanguy (WNA) shared a 2019 report that evaluated terminology along with notable challenges to harmonize, particularly from one country to the next. The report is available at https://world-nuclear.org/our-association/publications/online-reports/safety-classification-for-iandc-systems.aspx

A recap of key points from advanced reactor designer presentations during the workshop included the following:

- Ensure C&S provide cost-effective, risk-informed/performance-based options (e.g., the lower the plant risk, the lower the cost to meet code requirements). A specific example that was discussed was that structural costs (e.g., concrete, steel) are driving the overall business case for ARs and there is a desire to optimize the associated requirements to reflect lower risk and to credit functional containment, where applicable.
- Continue to support IAEA and WNA standards harmonization activities but try to minimize overlap and burden on advanced reactor designers. It was suggested that the ARCSC establish a sub-group to develop basic principles of harmonization.
- Completion of new standards or revisions to existing standards in the following areas are needed:
  - liquid metal fire protection,
  - decay heat power for non-light water reactors to minimize effort and regulatory risk,
  - advanced light water reactor probabilistic risk applications (PRA),
  - PRA for low power and shutdown methodology, and
  - PRA for advanced non-light water reactors.
- C&S should allow for a graded approach in quality assurance requirements for different functions of the same component.
- Industry alignment on key philosophies for mapping of licensing basis event categories to code service levels/stress analysis could ease regulatory approval.
- C&S language could benefit from an update to be consistent with the terminology on the License Modernization Project.
- High-quality data sufficient to meet code requirements is needed for graphite.

The Nuclear Harmonization and Standardization Initiative (NHSI)

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Common Approaches on Codes and Standards

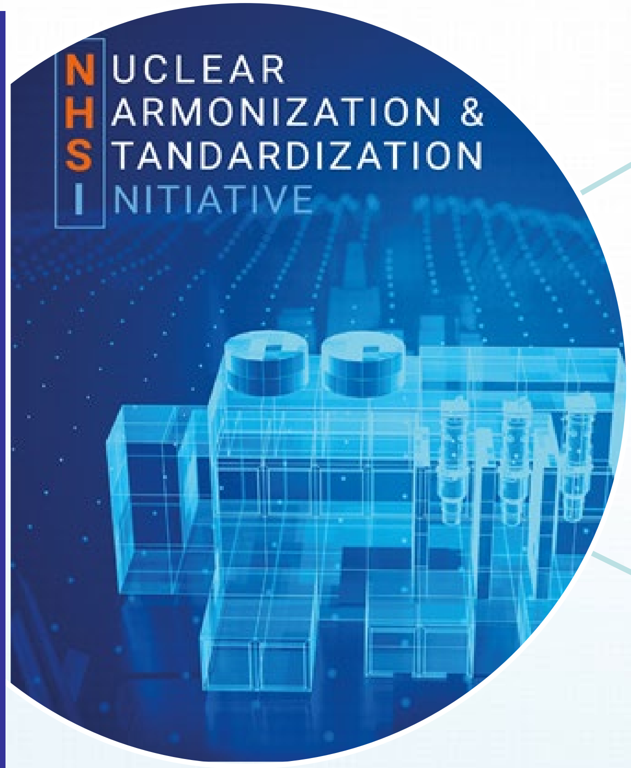
Dr. Pekka Pyy
Division of Nuclear Power, IAEA

NUCLEAR HARMONIZATION & STANDARDIZATION INITIATIVE

NHSI

IAEA

Effective Global Deployment of **Safe and Secure** Advanced Nuclear Reactors



Harmonization of Regulatory Approaches Track

- **WG1:** Framework for information sharing
- **WG2**: Towards harmonization - multinational pre-licensing review process
- **WG3:** Two processes increasing cooperation – building on current initiatives

IAEA as facilitator

within and between the tracks

Harmonization and Standardization of Industrial Approaches Track

- **Topic 1:** Harmonization of high-level user requirements
- **Topic 2**: Common Approaches on Codes and Standards
- **Topic 3:** Experimental Testing and Validation for Design and Safety Analysis Computer Codes
- **Topic 4:** Accelerating the implementation of nuclear infrastructure for SMRs

- Regulators
- Governments
- Technology Holders
- Operators and other end-users
- International Organizations and Associations

Topic 2 Objectives

Topic 2 - Common Approaches on Codes and Standards

Mission & Vision with approaches on C&S:

- **Identify** similarities and differences
- **Understand** why they exist
- **Share** information on the findings
- **Develop** common approaches
- **Harmonize** where possible

For "**Nuclear without Borders**"

26 companies from 13 Member States so far with **WNA** as a strategic partner

Topic 2 Programme of Work

NHSI Topic 2 Scope

I. Codes & Standards

A. QUALITY AND MANAGEMENT SYSTEM STANDARDS USED WIDELY IN THE MEMBER STATES (APPLICABLE TO SMRS)

B. ENGINEERING STANDARDS FOR THE DESIGN AND CONSTRUCTION OF SMRS (WNA LEAD)

C. EQUIPMENT QUALIFICATION STANDARDS FOR NUCLEAR (SMRS) FACILITIES

D. C&S USED IN VARIOUS SMRS (AND THEIR PROJECTS)

E. C&S FOR ADVANCE MANUFACTURING TO BE USED FOR SMRS (AND THEIR PROJECTS)

II. Oversight & Acceptance

A. A USE OF STANDARD, PROVEN SERIALLY MANUFACTURED INDUSTRIAL GRADE ITEMS

B. NON-NUCLEAR CODES, STANDARDS, LAW AND REGULATIONS RELEVANT TO SMR DEPLOYMENT

C. OVERSIGHT ACTIVITIES REQUIRED BY CODES, STANDARDS, LAW AND REGULATIONS

NHSI Industry TG2 2 Platform

NUCLEAR HARMONIZATION & STANDARDIZATION INITIATIVE

IAEA

Nuclear Harmonization Topical Group 2 Common Approaches on Codes & Standards

I. Codes & Standards

I.A. QUALITY AND MANAGEMENT SYSTEM STANDARDS USED WIDELY IN THE MEMBER STATES

I.B. ENGINEERING STANDARDS FOR THE DESIGN AND CONSTRUCTION OF SMRs

I.C. EQUIPMENT QUALIFICATION STANDARDS FOR NUCLEAR (SMR) FACILITIES

I.D. C&S USED IN VARIOUS SMRs (AND THEIR PROJECTS)

I.E. C&S FOR ADVANCED MANUFACTURING (AM) TO BE USED FOR SMRs (AND THEIR PROJECTS)

II. Oversight & Acceptance

II.A. USE OF STANDARD, PROVEN SERIALLY MANUFACTURED INDUSTRIAL/COMMERCIAL-GRADE ITEMS

II.B. NON-NUCLEAR CODES, STANDARDS, LAW AND REGULATIONS RELEVANT TO SMR DEPLOYMENT

II.C. OVERSIGHT ACTIVITIES REQUIRED BY CODES, STANDARDS AND REGULATIONS

Meetings

Technical Meeting 12-15 December 2023

Consultancy Meeting 14-15 September 2023

Consultancy Meeting 10-11 July 2023

Consultancy Meeting 12-14 April 2023

1 December 2022

Consultancy Meeting 27-28 February 2023

MSCQ

and NHSI TG2 membership)

First NHSI deliverables (TG2) coming out …

"I am pleased to report that, since we started work a year ago, progress has been made on the two tracks of this key initiative, including the recent publishing of a [working] paper outlining why serially manufactured industrial products are crucial for the reliable deployment of SMRs," **DG Grossi** said in his opening remarks to the General Conference in Vienna, Austria.

On the industrial side, a group of key players in the nuclear sector reached a general agreement on moving forward with SMR manufacturing. Their working paper proposes using serially manufactured or "off the shelf", commercially available parts rather than bespoke designs to speed up procurement, reduce production delays and costs and ensure reliable supply chains compliant with safety requirements. "The steps outlined in the paper can facilitate the timely deployment of safe and secure SMRs to address the climate crisis and the security of energy supply," said **Aline des Cloizeaux, Director of the IAEA Division of Nuclear Power.**

Related IAEA TECDOC 2034 will be published these days:
Suitability Evaluation of Commercial-Grade Products for Use in Nuclear Power Plant Safety Systems

IAEA Showcases Progress in Nuclear Harmonization and Standardization Initiative to Facilitate Deployment of SMRs

Lucy Ashton, IAEA Department of Nuclear Energy

SEP 28 2023

IAEA Director General Rafael Mariano Grossi (second from right) spoke at a side event on the IAEA Nuclear Harmonization and Standardization Initiative (NHSI), held on the margins of the 67th IAEA General Conference in Vienna, Austria, on 27 September 2023.

Related stories

- IAEA Initiative Advances Efforts to Support the Safe, Secure Deployment of SMRs
- IAEA Initiative Sets Ambitious Goals to Support the Safe an Secure Deployment of SMRs
- Robust Safety Demonstration and International Harmonization - Key to Strengthening the Safety of Reactors Designs, TIC Concludes
- Accelerating SMR Deployment: New IAEA Initiative on Regulatory and Industrial Harmonization

NUCLEAR HARMONIZATION & STANDARDIZATION INITIATIVE

Topic 2 - Way Forward

IAEA

Topic 2 - Common Approaches on Codes and Standards

Phase 1– Planning and Alignment	Phase 2 – Developing Contents & Deliverables	Phase 3 – Harvesting the Fruits	Phase 4 – Long-Term Collaboration

2022 — 2023 — 2024 — 2025

Phase 1
- **Kick-off** (1-2 Dec 2022) Virtual
- Scoping and beginning to plan
- Ad-hoc planning meetings on need basis
- **First Working Meeting** ("February 2023" CM –date based on Doodle poll) Virtual

Phase 2
- **Workshop (12-14 April 2023), IAEA/Vienna, Hybrid**
- 18 May, NHSI Ind Track call
- **NHSI plenary, 27 June 2023**
- **10-11 July CM 2023, Hybrid**
- **14-15 Sept CM 2023, Hybrid**
- **Technical Meeting, 11-15 December 2023 (nominations)**

We are here!

Phase 3
- **CM 25-26 March 2024**
- **CM 10-11 June 2024**
- **CM 12-13 September 2024**
- **CM 20-21 November 2024**
- **-> NHSI II planning**

Other meetings on need basis for different Topic 2 activities

Phase 4
- **Platform Operation**
- Spin-offs (TBD)
- Recurring meetings (TBD)
- What else (TBD)

CONTACT: Mr. Pekka PYY, P.T.Pyy@iaea.org

Technical Meeting on the Harmonization and Use of Industrial Codes and Standards for Small Modular Reactors in December 2023

Timeline and Expected Outcomes

2022

- Work plans and outline of publications for each working and topical group
- Key inputs, experience available, cooperation with ongoing projects
- Start development of publications
- Define interface between tracks

2023

- WG/TG meetings and continue developing publications
- NHSI Plenary June 2023
- First Industry Track Deliverables coming out
- Targeted interface meetings between tracks

2024

- Completion of more deliverables
- NHSI Plenary June 2024
- Interface meetings between Industry and Regulatory Track
- Recommendations for future work

The success of this Initiative will require **clear commitment** and **support** from governments, regulatory bodies, operators and nuclear industry

Meetings – Past and Future

Visit our Portal for up-to-date information on IAEA SMR related events and its NHSI pages

https://smr.iaea.org

NUCLEAR HARMONIZATION & STANDARDIZATION INITIATIVE

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C&S conformance approaches

ATTACHMENT 2

Activities of Standard Development Organization (SDO) Convergence Board

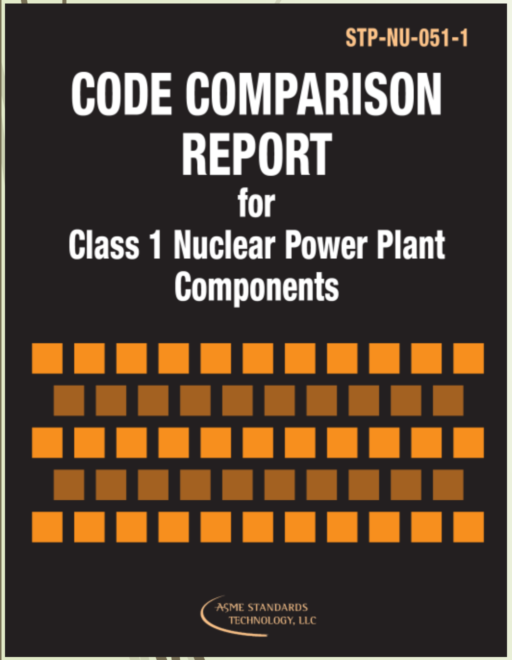
1

Chair: Seiji Asada

Co-Chair: Paul Donavin

Technical Secretary: Ronan Tanguy

Introduction



- The Multinational Design Evaluation Programme (MDEP) Code Comparison Project was initiated in late 2006 in response to a request by the MDEP Codes and Standards Working Group (CSWG) consisted of international nuclear regulatory bodies.
- The CSWG requested the various Standard Development Organizations (SDOs) to develop a comparison of their codes & standards for Nuclear Power Plant Class 1 components.
- “Code Comparison Report for Class 1 Nuclear Power Plant Components” (STP-NU-051-1) was published in 2012.
- The SDOs understood the necessity of their collaboration through this project.

Introduction: Sample of Code Comparison Report

Appendix B1: JSME vs ASME Comparison Table

Summary Table of Difference on Technical Requirements between JSME and ASME

ASME B&PV Code 2007 Edition	JSME Code 2008 Edition	Classification
NB-1100 SCOPE		
NB-1110 ASPECTS OF CONSTRUCTION COVERED BY THESE RULES	PVB-1110 does not contain rules for marking, stamping and preparation of report by Certificate Holder. Not required by MITI.	B-2
NB-1120 TEMPERATURE LIMITS	PVB-1120	A-2
NB-1130 BOUNDARIES OF JURISDICTION APPLICABLE TO THIS SUBSSECTION		
NB-1131 Boundary of Components	GNR-1230 does not require that the Design Specification define the boundary of a component. JSME does not define the first threaded joint in screwed connections as the boundary of a component, as does NB-1131(c). Not required by MITI.	B-2
NB-1132.Boundary Between Components and Attachments NB-1132.1 Attachments NB-1132.2 Jurisdictional Boundary	GNR-1230 does not distinguish between different types of attachments. It treats all attachments the same, regardless of their function. JSME does not address fasteners used for attachment or optional expansion of the component boundary. Other Japanese standards are used to impose welding qualification and NDE requirements for important attachments, such as what ASME calls structural attachments.	B-2
NB-1140 ELECTRICAL AND MECHANICAL PENETRATION ASSEMBLIES	GNR-1110 is equivalent.	A-2
NB-2100 GENERAL REQUIREMENTS FOR MATERIAL		
NB-2110 Scope of Principal Terms Employed	JSME does not define these terms in detail compared to ASME	B-1

Comparison Scale

A1 = Same

A2 = Equivalent

B1 = Different – Not Specified

B2 = Technically Different

SDO Convergence Board

- started from February 2013.
- Members: AFCEN (France), ASME (U.S.A), CSA (Canada), ISNI (China), JSME (Japan), KEPIC (KOREA), NIKET (Russia), NTD (Czech), WNA CORDL, R5/R6 (UK)
- Meetings: Basically held during ASME BPV Code Week
  (Sometimes; AFCEN Conference, KEPIC-Week)
- Charter
  - The Standards Development Organizations (SDO) Convergence Board will facilitate the following objectives for Nuclear Power Plant Codes and Standards:
    - ✓ **Limit divergence on individual requirements**
    - ✓ **Achieve harmonization on individual requirements, where realistic and practical**
  - The SDO Convergence Board will collaborate with Working Group on Codes and Standards (WGCS in CNRA of OECD/NEA), CORDEL and other global stakeholders to identify and facilitate implementation of activities leading to nuclear code harmonization and minimization of code divergence.

1st- 3 year Work Plan (2018-2020)

- From 2018, the SDO CB started “3 year Work Plan” to discuss potential topics.
- The 1st “3 year Work Plan” for 2018 – 2020 is;
  - ✓ **1: Pressure Testing**
    - Understand reason for differences in Codes and propose alternatives to pressure tests
  - ✓ **2: Welding residual stresses**
    - mitigation and minimization, e.g. peening etc.
    - consequences in degradation evaluation (corrosion, fatigue, rupture…)
  - ✓ **3: Verification and validation in Codes**
    - V&V of finite element calculations
  - ✓ **4: Heterogeneities in thick section forgings and flocking**
    - If prompted by MDEP
    - Recognized by the SDOs that very little exists currently in the Codes
  - ✓ **5: Alternatives to radiography**

2nd- 3 year Work Plan (2021-2023)

- The SDO CB developed the following 2nd "3 year Work Plan" at the meeting dated February 8, 2021.

- **1. Advanced Manufacturing Techniques**: [PM: Asada]
  - ✓ to follow-up and discuss the latest AM techniques in the world for application to nuclear components
- 2. **UT in lieu of RT** [PM: Paul Donavin]
  - ✓ to have common understanding for requirements in code and applicable UT technique
- 3. **Transition from construction stage to operating stage** [PM: Claude Faidy]
  - ✓ RT is required in construction stage, but UT is required in operating stage. Should we apply UT at construction stage? If a flaw is found in PSI, what should we do? We should have international consensus for the transition.

3rd- 3 year Work Plan (2024-2026)

- The SDO CB developed the following 3rd "3 year Work Plan" at the meeting dated November 12, 2023.

◆ **1. Advanced Manufacturing Techniques**: [PM: JSME]
- ✓ In the 2nd Three-year Plan, we have shared our status for development AM codes.
- ✓ In the 3rd Three-year Plan, we should prepare comparison of requirements for our AM codes to make harmonization.

◆ **2. Protection against SCC** [PM: Asada]
- ✓ SCC was found in welds of SS piping in France and Japan.
- ✓ We should share requirements for protection against SCC in our codes

◆ **3. Codes and Standards for SMRs** [PM: Tanguy]
- ✓ TG2 in NHSI is "Common Approaches to Codes and Standards" for SMRs.
- ✓ We should follow TG2 and the other TGs/WGs in NHSI.

◆ **4. Code Comparison of High Temperature Design** [PM: AFCEN]
- ✓ ASME, RCC-MRx, JSME, KEPIC, UK

Communication

- **WNA** (World Nuclear Association) **CORDEL** (Cooperation in Reactor Design Evaluation and Licensing)
  - ✓ CORDEL is making great contribution to SDO CB as a technical secretary and a member.
  - ✓ CORDEL is preparing and has been published valuable reports for codes, and they are good inputs for SDO CB.
  - ✓ WNA CORDL Non-Linear Analysis Workshop was held on August 4th 2019 in the ASME Code Week as an activity of SDO CB.
    - Typical benchmarks based on nozzles
    - Share the results, review the methodologies and agree to a consistent analysis methodology
    - Discuss common challenges, opportunities for cooperation, concerns and issues

Communication

- The MDEP CSWG moved to the OECD/NEA, and Working Group on Codes and Standards (WGCS) in Committee on Nuclear Regulatory Activities (CNRA) was established in 2018.
  - ✓ WGCS invited the SDO CB to their meetings, and we had good communication with each other.
  - ✓ WGCS held "International Workshop on Mechanical Codes and Standards: In-Service Inspection" on 11-14 April 2022, and CNRA held "Workshop on Ageing Management Considerations in Mechanical Codes and Standards" on 28-29 June, 2023. Several SDOs joined these workshops, and made presentations.
- The SDO Convergence Board will collaborate with global stakeholders to identify and facilitate implementation of activities leading to nuclear code harmonization and minimization of code divergence.

Thank you for your attention!

ATTACHMENT 3

WORLD NUCLEAR ASSOCIATION

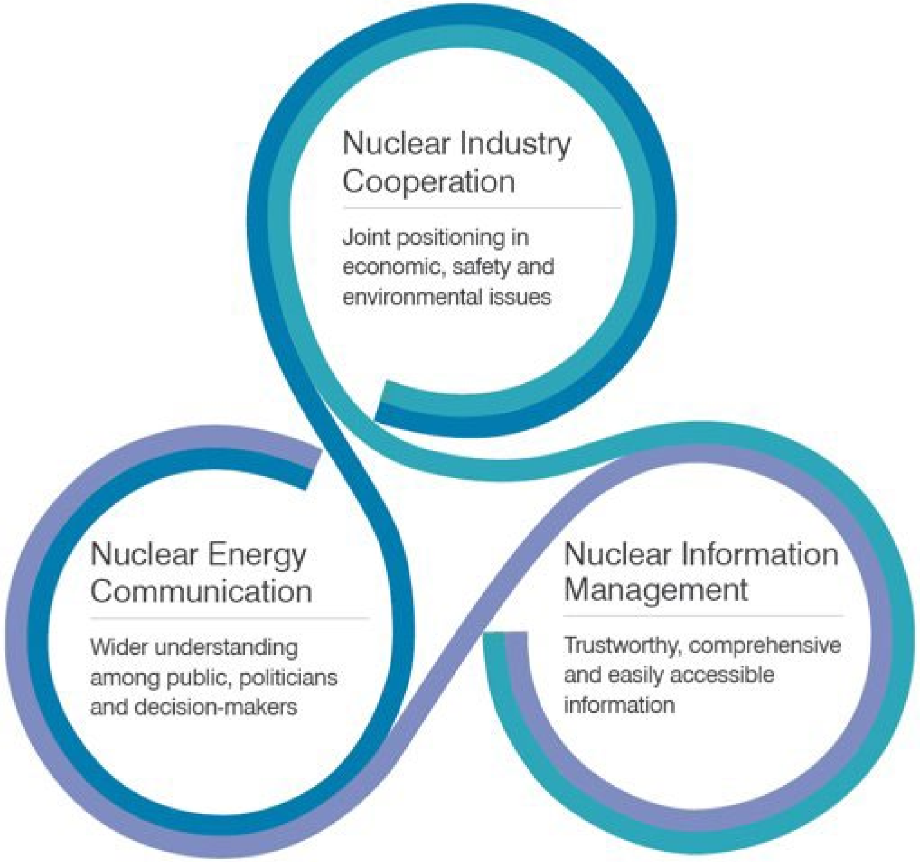
Overview of CORDEL Codes & Standards initiatives

Ronan Tanguy

Programme Lead – Safety & Licensing

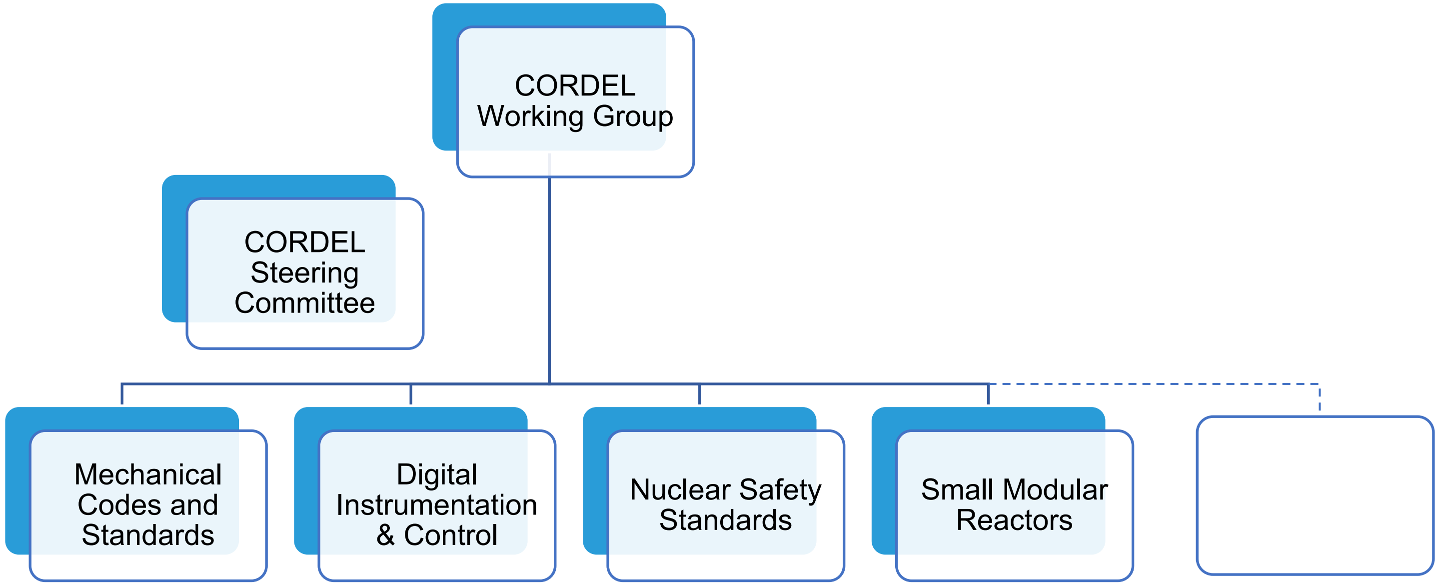
Advanced Reactor Codes and Standards Collaborative Workshop – November 2023

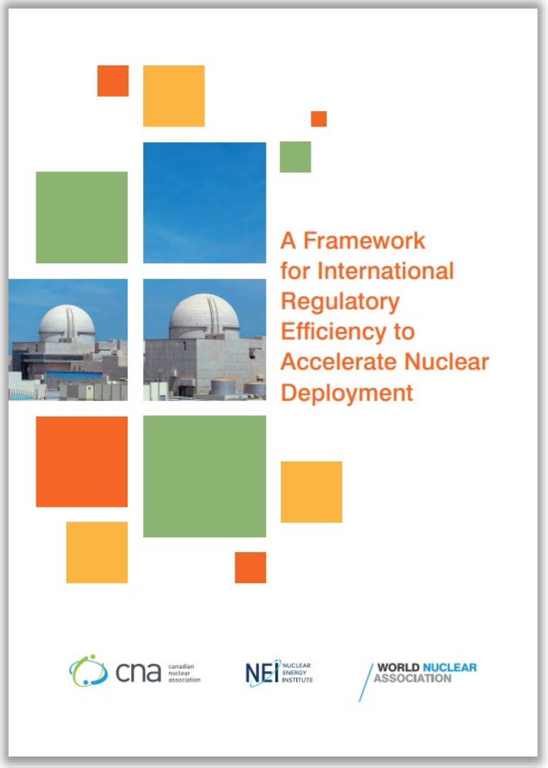
World Nuclear Association



CORDEL Working Group

- Mission to promote the standardization of nuclear reactor designs and harmonized approaches to licensing.





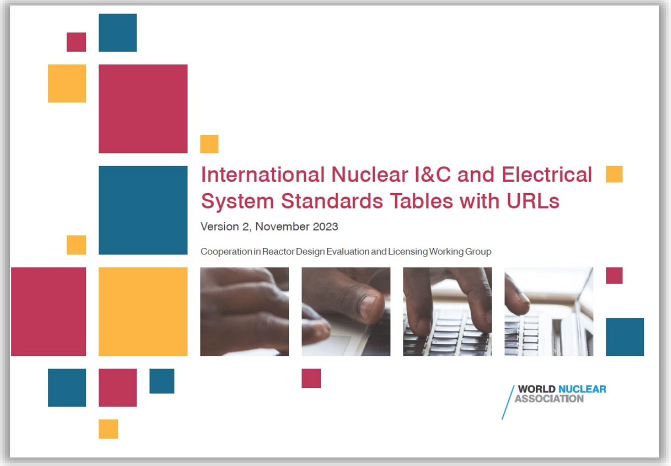
WORLD NUCLEAR ASSOCIATION

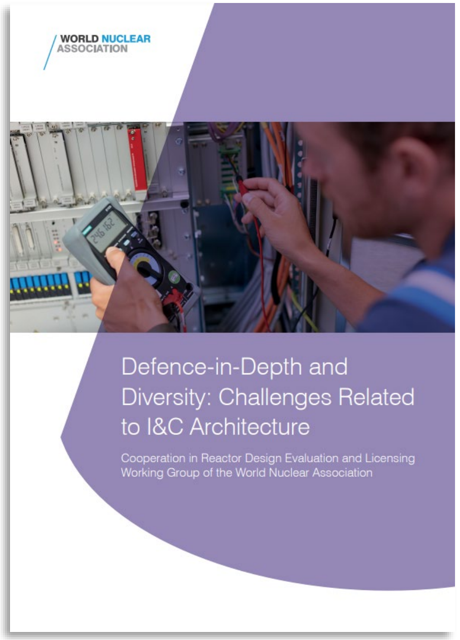
CORDEL Mechanical Codes & Standards Task Force

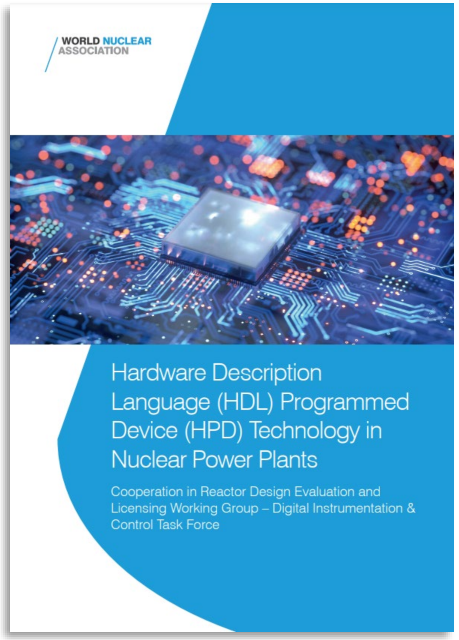
several series of reports since its inception:

- Comparisons of technical requirements within major nuclear mechanical codes & standards (ASME, RCC-M, KEPIC, JSME, etc.)
- Recommendations for harmonization and/or reconciliation of industrial practices
- Position papers on approaches to code development for the adoption of new technologies into the nuclear sector

CORDEL Digital Instrumentation & Controls Task Force







Engagement with key C&S Stakeholders

- Providing inputs to Industry Track Topic 2 – Common approaches on codes and standards for SMR
- Provide technical secretariat and contributions to the work of the group of nuclear mechanical SDOs that meet on a quarterly basis
- MCSTF Chair participating in workshop examining standardization of codes in a European context
- MCSTF and DICTF members participate in SDO committees (ASME, AFCEN, IEC, IEEE etc.) feeding report findings into code development activities
- Observe regulatory discussions and provide industry viewpoint

WORLD NUCLEAR ASSOCIATION

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Helping the global nuclear industry deliver 24/7 clean energy for all

ronan.tanguy@world-nuclear.org

www.world-nuclear.org
info@world-nuclear.org

ATTACHMENT 4

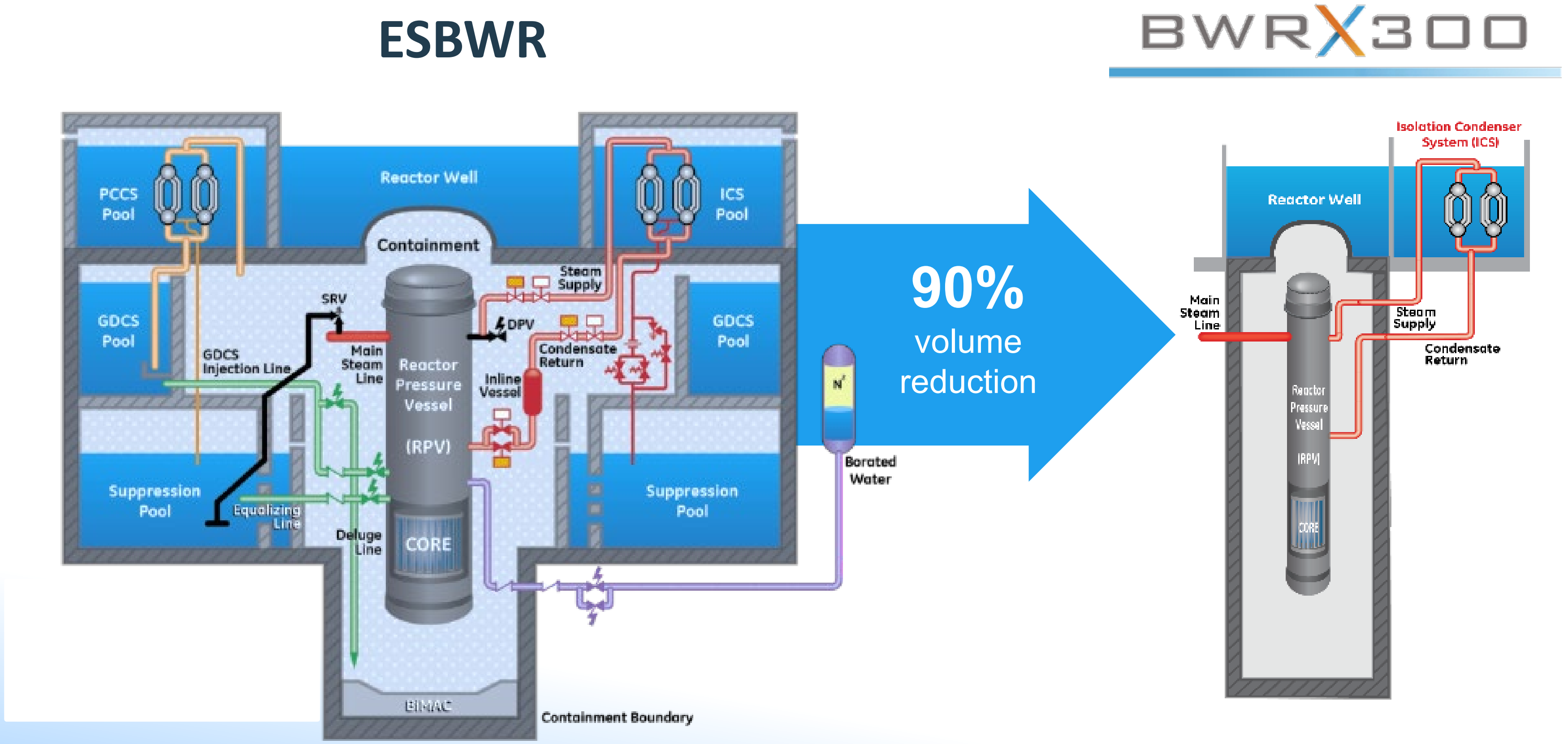
Code Requirements Discussion for the GE Hitachi Advanced Reactor Designs

Dennis Henneke
Consulting Engineer, GE Hitachi Advanced Reactor Design
November 30, 2023

Advanced Reactor Codes and Standards Collaborative

BWRX-300 - Background

The BWRX-300 is a small modular reactor, that is the 10th generation BWR which leverages the US Licensed ESBWR design – but using the PSA to simplify and optimize the design, in a design-to-cost approach.



Systems/components eliminated:

- Suppression Pool
- GDCS Pool
- Safety Relieve Valves & Spargers
- Depressurization Valves
- BiMac (core catcher)

Systems/components simplified:

- Passive Containment Cooling (PCCS)
- Containment
- Boron injection
- Security (built into design)
- Turbine
- Generator (air cooled)

Ontario Power Generation Selects GEH's BWRX-300

ONTARIO POWER GENERATION

IAEA

TORONTO | DECEMBER 2, 2021

GE Hitachi Nuclear Energy selected by Ontario Power Generation as technology partner for Darlington new nuclear project.

- Deployment could be complete as early as 2028
- **OPG submitted license-to-construct in Oct 2022 to Canadian regulator**
- Substantial economic opportunity for Ontario and Canada

Natrium Project

1)Natrium Reactor Overview:

- Natrium is a 300 Mwe sodium-cooled fast reactor, that uses a molten salt storage system to provide higher power outputs during high demand periods.

2)SSC Classification using Licensing Modernization Project (LMP):

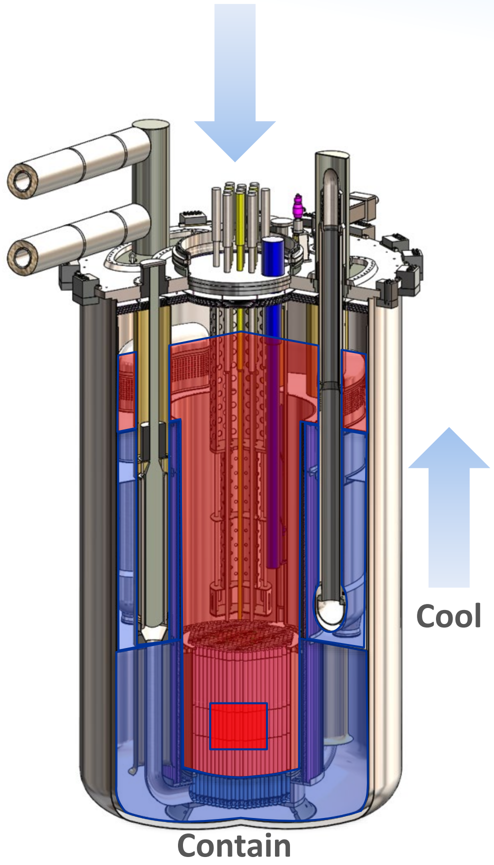
- Identify Safety Functions
- Assign Safety Functions to Systems in Plant Level Classification
- Decompose Systems to perform System Level SSC Classification

3)GEH is supporting TerraPower in the design and licensing of the Natrium plant, with plans to construct near Kemmerer, Wyoming.

Natrium Safety Features

IAEA

- Pool-type Metal Fuel SFR with Molten Salt Energy Island
  - Metallic fuel and sodium have high compatibility
  - No sodium-water reaction in steam generator
  - Large thermal inertia enables simplified response to abnormal events
- Simplified Response to Abnormal Events
  - Reliable reactor shutdown
  - Transition to coolant natural circulation
  - Indefinite passive emergency decay heat removal
  - Low pressure functional containment
  - No reliance on Energy Island for safety functions
- No Safety-Related Operator Actions or AC power
- Technology Based on U.S. SFR Experience
  - EBR-I, EBR-II, FFTF, TREAT
  - SFR inherent safety characteristics demonstrated through testing in EBR-II and FFTF



Control

- Motor-driven control rod runback
- Gravity-driven control rod scram
- Inherently stable with increased power or temperature

Cool

- In-vessel primary sodium heat transport (limited penetrations)
- Intermediate air cooling natural draft flow
- Reactor air cooling (RAC) natural draft flow – always on

Contain

- Low primary and secondary pressure
- Sodium affinity for radionuclides
- Multiple radionuclides retention boundaries

Factors affecting code requirements

- Electricity to large grids;
- Steam for district heating;
- Electricity to small/micro-grids, and
- Electricity and steam for industrial applications such as hydrogen production, oil and gas processing, and chemical processing

- For example, Issuance of ANS 20.2 (*Nuclear Safety Design Criteria and Functional Performance Requirements for Liquid-Fuel Molten Salt Reactor Nuclear Power Plants* - new standard), with purely deterministic requirements is not preferred.

Standard Plant Parameters-SSC designed to Industrial Codes and Standards

IAEA

- Safety related concrete is a huge cost for nuclear projects. SMR with designs that lower the amount of safety related concrete needed (reduce nuclear island footprint), reduce cost and make operations and maintenance easier.
- Focus on design-to-cost emphasizes minimizing plant volume, concrete & steel, while leveraging legacy design and licensing basis.
- SMR must be designed for significant reductions in operating staff, maintenance cost, and security requirements.
- System Architecture Requirements and Design provide requirements that influence the plant layout with respect to:
  - Fire barrier separation
  - Environmental and electromagnetic conditions
  - Space considerations for batteries, Uninterruptible Power Supplies, Unit Auxiliary Transformer, and the use of both 50 Hz and 60Hz equipment
- Plant Level Building Architectural and Life Safety Design Requirements provides requirements that will influence the building layout

BWRX-300 Code and Regulatory Requirements

IAEA

- Submitted PSAR to CNSC lists many of the plant-level design codes initially utilized for the BWRX-300 design – See NEDO-33950 Table B1.11-2.
- However, noted issues in applying standards to different countries. A few examples:
  - ASME Section III Div. 1 (pressure vessel) versus RCC-M applied in the UK and the EN code in the EU. Although different requirements, they should result in an equivalent level of quality.
  - Differences in Fire and Building codes such as NFPA 804, 101 and codes such as Canadian CSA N293S1, NBCC, etc.
    - Differences in Life Safety egress travel distance requirements, sprinkled maximum travel distances, etc.
    - CSA N293 S1 requires as a minimum, the fire protection water pumping system design shall be capable of providing 120% of the total required flow rate at the design pressure, assuming failure of the largest pump.
      - NFPA 804 requires fire pumps shall be provided to ensure that 100 percent of the flow rate capacity will be available assuming failure of the largest pump.
- **Overall, recommend continued support for IAEA and WNA Standard Harmonization Activities. However, try to minimize overlap and burden on advanced reactor developers.**

Additional BWRX-300 and Natrium Codes and Standards Requirements

IAEA

- GEH identified a few areas in the survey where there are gaps:
  - For example, sodium fire standard needs to be updated and re-issued (ANS 54.8)
- Not identified in the survey:
  - Need for standard to address decay heat for Non-LWR plants, such as sodium-cooled fast reactors. ANS 5.1 is only for LWRs, and a fast reactor version would be strongly desirable to minimize effort and regulatory risk in developing our own formulation/uncertainties.
  - For the PRA/PSA, will need the following issued prior to operation:
    - Advanced LWR (ALWR) PRA Standard.
    - Low-Power/Shutdown (LPSD) Standard (currently in trial use).
    - Updated version of the Non-LWR Standard RA-S-1.4 (incorporates LPSD, Level 2 and Level 3 standard updates).

ATTACHMENT 5
Permission to release full presentation pending.

a TerraPower & GE-Hitachi technology

EPRI Advanced Reactors Codes and Standards Workshop

Steven Unikewicz
ASME Fellow
Natrium Design Authority

SUBJECT TO DOE COOPERATIVE AGREEMENT NO. DE-NE0009054

ATTACHMENT 6

X-Energy ARCSC Insights

Jon Facemire, *Licensing Manager*

November 30, 2023

Intro to X-Energy use of C&S

- High Temperature Gas Reactor (HTGR), building on Next Generation Nuclear Power Plant (NGNP), Pebble Bed Modular Reactor (PBMR) and other international experience.
- Following Licensing Modernization Project (LMP) Methodology and guidance in NEI 18-04 as endorsed by RG 1.233, NEI 21-07 as draft endorsed in DG-1404 and the ARCAP guidance
- NEI 21-07 states that for CP Content: "The description should include any consensus codes and standards used or expected to be used in the design of SR SSCs."
- We have been active in Code Weeks trying to inform language about graphite in particular.

Intro to X-Energy use of C&S (cont.)

NRC response to public comments on DG-1404 included:

– "Regarding the discussion of providing a listing of consensus codes and standards in summary form, the NRC staff notes that this guidance is consistent with the guidance found in the ARCAP roadmap ISG Appendix A for preapplication activities that a prospective applicant should identify any consensus codes and standards or code cases that have not been endorsed or previously accepted by the staff."

Key Codes for the Xe-100 Include:

- ASME Section III Division 5 (2023 Edition)
- IEEE 603-2018
- ASCE 43-05 (considering 43-19)
- ACI 349-2013
- ASME Section XI Division 2 (2023 Edition)
- OM-2 (in draft, but we are planning based on draft)

Key Insights

- Codes could do more to lean into the language of LMP
  - NEI 18-04 and other classification regimes (50.69) allow the same components to perform functions of different safety significance. For example, our primary relief valves are SR for opening and NSRST for reclosing. Code should allow gradation in QA requirements for different functions of the same component.
  - Industry alignment on key philosophies for mapping of LBE categories to Code Service Levels / Stress Analysis could ease regulatory approval.
    - Suggest alignment that we want to keep BDBEs out of code space.
  - Code language could benefit from update to LMP terminology (avoid “important to safety” and its regulatory baggage, lean into risk-significant)
    - Important to safety in SRC definitions for Graphite in ASME Section III Division 5, we believe contributed to NRC only providing guidance for SR graphite in RG 1.87 R2.
  - Think risk-informed and performance-based. Probability of Failure or other code thresholds could link to PRA consequences not be red lines of design acceptability.
- High Quality Data sufficient to meet code requirements is an issue for Graphite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ATTACHMENT 7

Terrestrial Energy

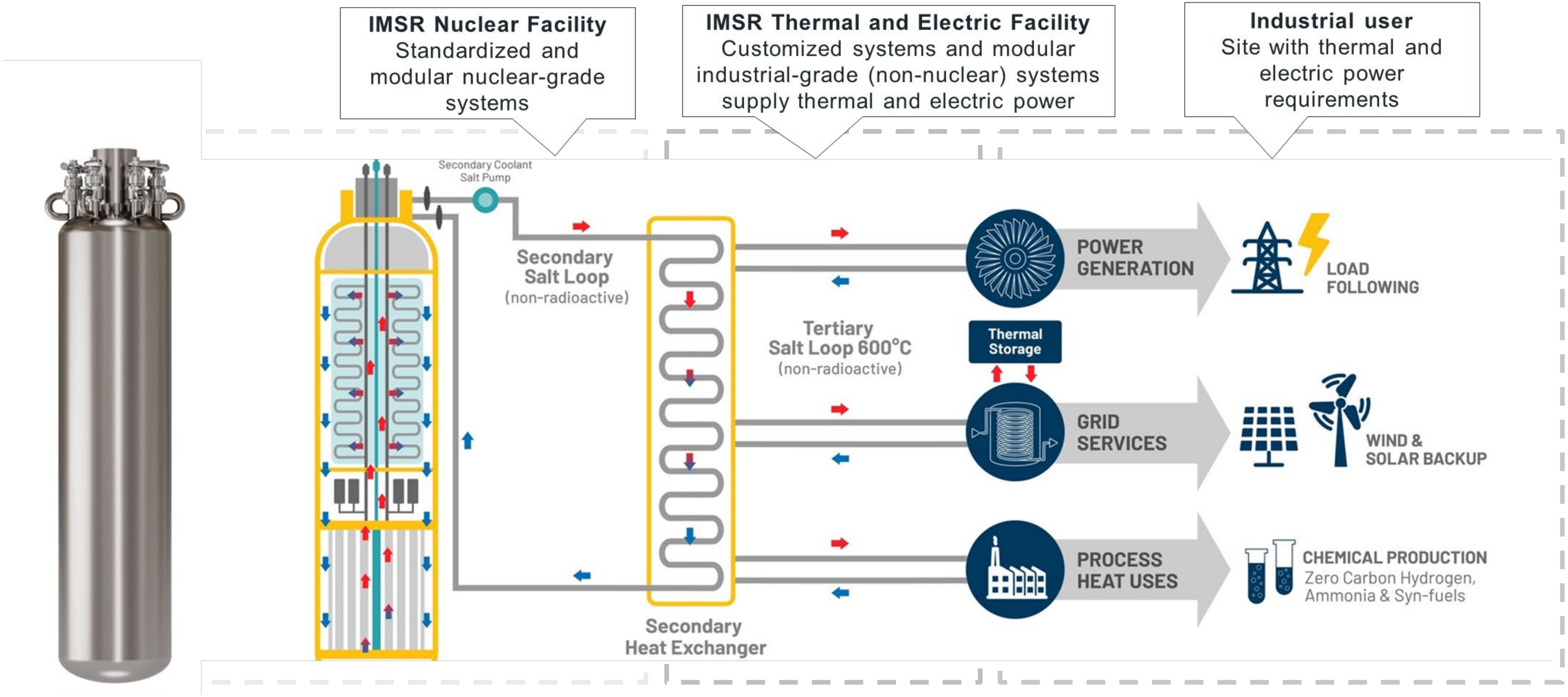
Advanced Reactor Codes and Standards Collaborative Workshop

William (Bill) Smith – SVP Operations & Engineering

November 30, 2023

TERRESTRIAL
ENERGY

How an Integral Molten Salt Reactor (IMSR) Plant works

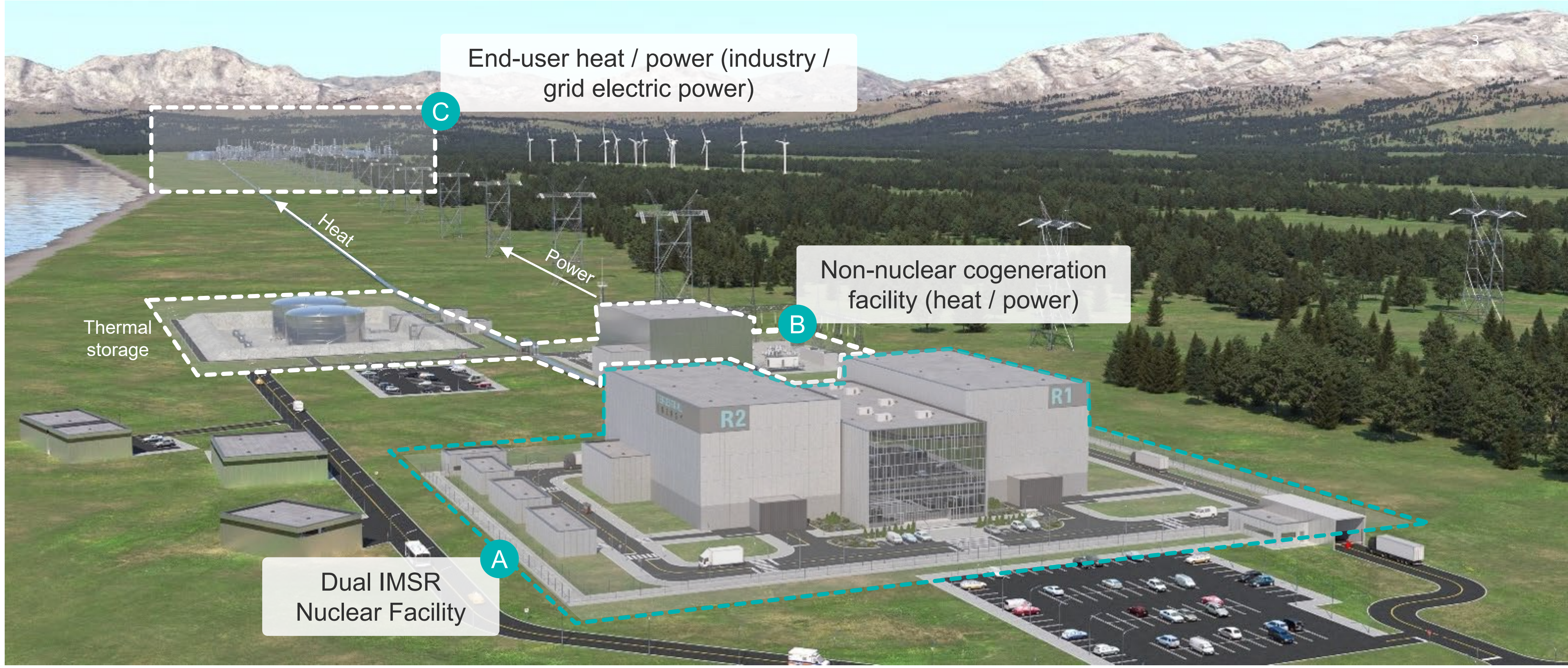


IMSR Thermal and Electric Facility is customized to heat duties that are site and application specific

Plant design delivers the flexibility to supply the heat and power needed

Separation of nuclear systems from thermal and electrical systems gives the flexibility that is essential to serve industries' many cogeneration needs

This separation of nuclear systems enables a standardized reactor design for regulatory efficiency while meeting the site- and use-specific needs of the industrial user with a customized Thermal and Electric Facility

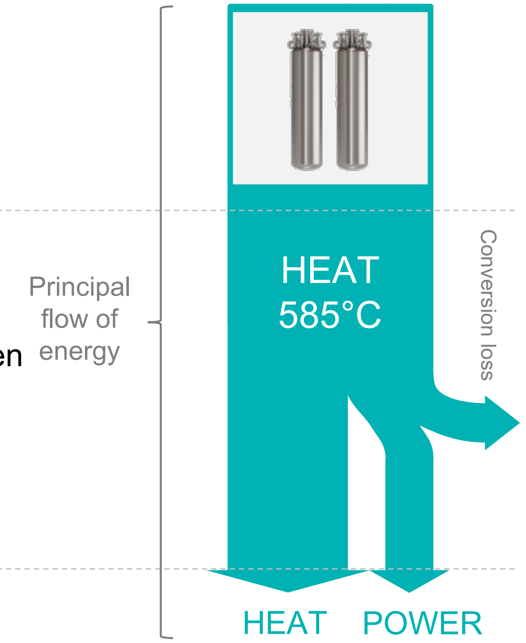


A Standardized dual IMSR Nuclear Facility

- Subject to nuclear regulation
- Standardized, simplifying design and saving costs
- 884 MW (gross) thermal energy production for 585°C supply

B Customized non-nuclear Thermal and Electrical facility

- Converts 884 MW (gross) thermal energy from two IMSRs to 585°C 822 MW (net) thermal or 390 MW (net) electric power for commercial supply – or any heat/electric power mix in between
- Can be commissioned and operating prior to Nuclear Facility (initially natural gas and electric grid powered)
- Can include molten-salt thermal energy storage and buffering to enhance an already strong load-following performance for commercial advantage



C Industrial cogeneration off-takers

- Chemical and petrochemical plant
- Hydrogen / ammonia / fertiliser plant
- Other industrials requiring clean heat & power

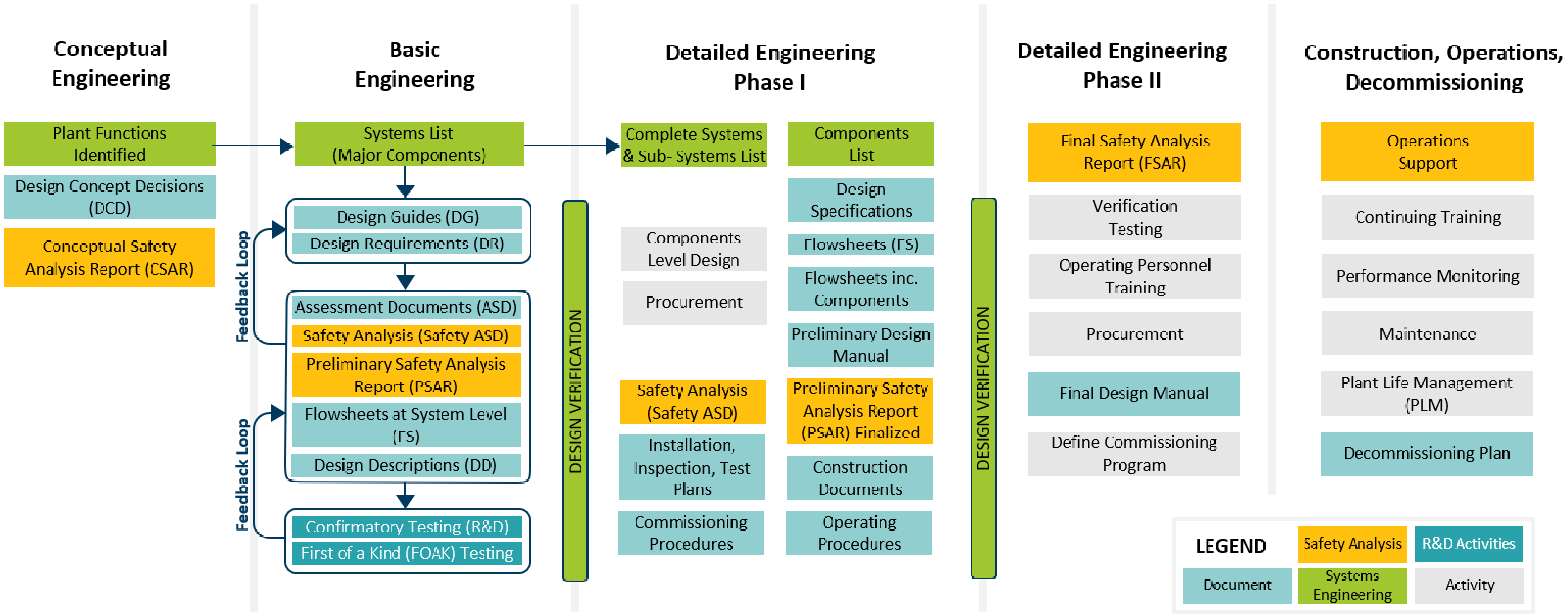
Municipal off-takers

- Electric grid
- Desalination

822 MWt (thermal) <<< 585°C >>> 390 MWe (electrical)

Note: Example is for a dual reactor core IMSR Plant. Scaling up is possible.

IMSR Life-cycle Design Process



Detailed Review of all Applicable Codes and Standards has been completed!

Regulatory reviews in process in the US and Canada

Terrestrial Energy leads the market in successfully completing VDR Phase 2 in 2023

The VDR concludes that **"no fundamental barriers to licensing" IMSR for commercial use** were identified

National regulators cover both vendor reviews and owner/operator licensing

Applicant: Technology Developer	Applicant: Owner/Operator
• CNSC – Vendor Design Review (VDR) • USNRC – Design Certification and/or Standard Design • ONR (UK) – Generic Design Assessment	• Construction Permit • Construction License • Operating License • License Amendments

CNSC VDR	USNRC engaged	License for plant commercial operation
✓ ***No fundamental barriers to licensing***	***Pre-application activities underway***	***Upcoming***

In April 2023, Canadian Nuclear Safety Commission (CNSC) concluded that "no fundamental barriers to licensing" the IMSR Plant for commercial operation were identified in the VDR

- Complies with Canadian nuclear safety requirements for a nuclear power plant
- Does not rely on unproven engineering practices (including inadequately supported analysis, R&D, or both)
- Limited requests for technical clarification and follow-up in future reviews

Scope of VDR

- High-level review covering IMSR life-cycle while design is evolving to provide timely feedback during design process
- Scope defined by "19 Focus Areas", which correspond to the "Safety and Control Areas" of a future license application
- Review and audit of Terrestrial Energy's engineering processes, design and analysis procedures and methodologies

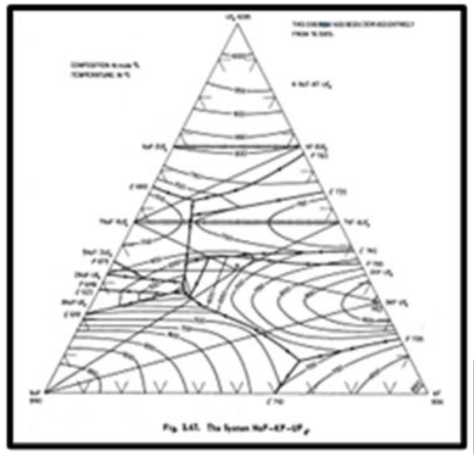
Significance of the completion of the Vendor Design Review

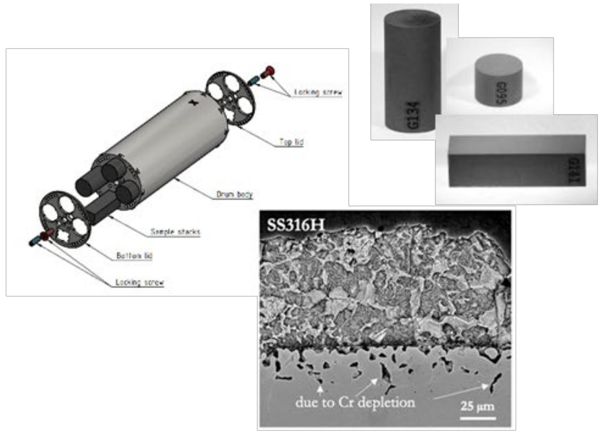
- Provides critical first step in licensing IMSR Plant for commercial use
- Terrestrial Energy ready to enter into agreements to proceed to site licensing and construction of IMSR Plant on Canadian soil

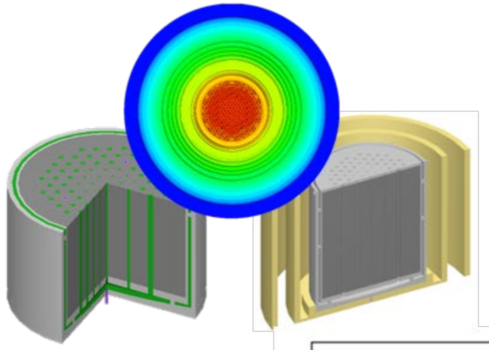
Integration and Coordination

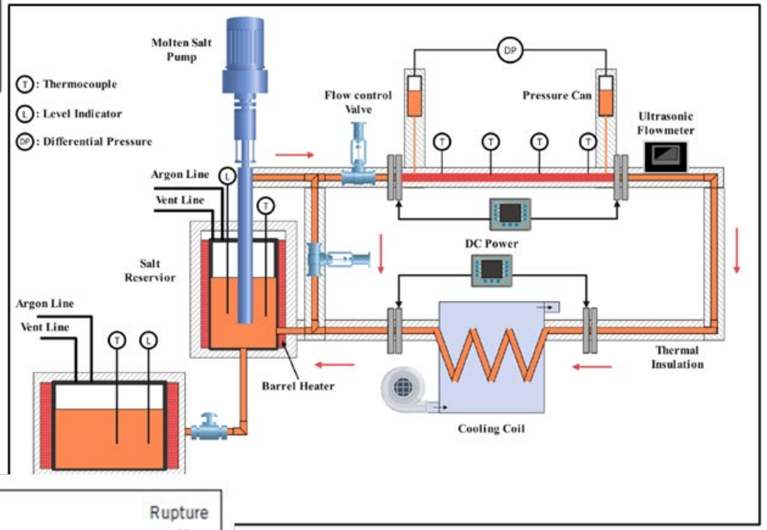
Themes

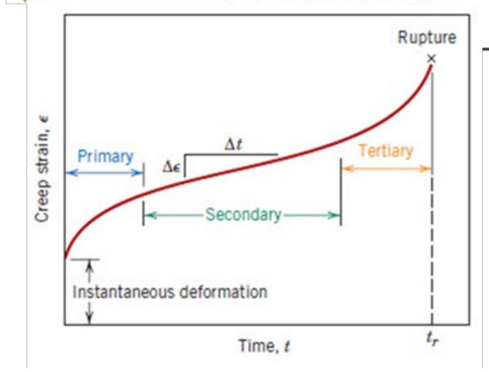
- Novel approaches and compliance to regulatory requirements and interaction with codes and standards
- Integrative workflows between Engineering, R&D and Safety Analysis and relationship to codes and standard
- Emergent details from PIE. related phenomena and deterministic and probabilistic safety analysis
- Collaborative efforts to “improve” codes and standards relevant to advanced reactors is a positive attribute of the Canadian environment











$$S_{PYS} = \sqrt{\frac{3}{4}}S_0$$

Collaborative Efforts with Standards bodies and Testing agencies is a must

TERRESTRIAL ENERGY

Making transformative nuclear energy a commercial reality

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www.terrestrialenergy.com

ATTACHMENT 8

www.holtec.com
www.smrllc.com

HOLTEC INTERNATIONAL

Confidential Information

SMR, LLC, A Holtec International Company
Krishna P. Singh Technology Campus
One Holtec Boulevard
Camden, NJ 08104, USA
[Not Export Controlled]

Standards Used During Holtec SMR Design

- ASCE Standards – Yes – No Gaps Identified
  - ASCE 42 – Seismic Design Criteria for SSCs
  - ASCE 4 – Seismic Analysis of Safety Related Nuclear Structures

Confidential Information

Standards Used During Holtec SMR Design

- ASME Standards – No Gaps Identified
  - ASME BPVC.III.NB – Rules for Construction of Nuclear Facility Components – Class 1 Components
  - ASME BPVC.III.NCD - Rules for Construction of Nuclear Facility Components – Class 2 & 3 Components
  - ASME BPVC.III.NCA – Rules for Construction of Nuclear Facility Components – General Requirements for Div 1 and Div 2
  - ASME.BPVC.III.NC - Rules for Construction of Nuclear Facility Components – Class 2 Components

Standards Used During Holtec SMR Design

- ASME Standards (Continued)
  - AMSE.BPVC.III.ND - Rules for Construction of Nuclear Facility Components – Class 3 Components
  - ASME BPVC.III.2 - Rules for Construction of Nuclear Facility Components - Code for Concrete Containments
  - ASME BPVC.III. NG - Rules for Construction of Nuclear Facility Components - Core Support Structures
  - ASME BPVC.XIII – Rules for Overpressure Protection

Standards Used During Holtec SMR Design

- IEEE Standards – No Gaps Identified
  - IEEE/NPEC 1819 - Standard for Risk-Informed Categorization and Treatment of Electrical Equipment in Nuclear Facilities
  - IEEE/NPEC 308 - IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations
  - IEEE/NPEC 317 - EEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations
  - IEEE/NPEC 741 - IEEE Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations
  - IEEE/NPEC 1023 - IEEE Guide for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations

Standards Used During Holtec SMR Design

- IEEE Standards (Continued)
  - IEEE/NPEC 1289 - Guide for the Application of Human Factors Engineering in the Design of Computer-Based Monitoring and Control Displays for Nuclear Power Generating Stations
  - IEEE/NPEC 2411 - Human Factors Engineering Guide for the Validation of System Designs and Integrated Systems Operations at Nuclear Facilities
  - IEEE/NPEC 384 - IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits
  - IEEE/NPEC 497 - Standard for Accident Monitoring Instrumentation for Nuclear Power Generating Stations
  - IEEE/NPEC 603 - IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations

Standards Used During Holtec SMR Design

- IEEE Standards (Continued)
  - IEEE/NPEC 1891 - Standard Criteria for Application Intellegent Digital Devices to Nuclear Power Generating Stations
  - IEEE/NPEC 61226 - Standard for categorization and classification of I&C and electrical systems in nuclear power generating stations
  - IEEE/NPEC 63113 - Nuclear Facilities - Instrumentation Important To Safety - Spent Fuel Pool Instrumentation
  - IEEE/NPEC 63160 - Nuclear Power Plants - Instrumentation, Control and Electrical Power Systems Important to Safety - Common Cause Failure Systems Analysis and Diversity;

Standards Used for Safety Systems and Risk Analysis Topical Area

- ANS Standards – No Gaps Identified
  - ANS-2.8 - Probabilistic Evaluation of External Flood Hazards for Nuclear Facilities
  - ANS-2.15 - Criteria for Modeling and Calculating Atmospheric Dispersion of Routine Radiological Releases from Nuclear Facilities
  - ANS-2.26 - Categorization of Nuclear Facility Structures, Systems, and Components For Seismic Design

Standards Used for Safety Systems and Risk Analysis Topical Area

- ANS/ASME Standards – Gaps Identified
  - ASME/ANS RA-S-1.1, Standard for Level 1/Large Early Release Frequency Probabilistic Assessment for NPP Applications
  - ASME/ANS RA-S-1.2, Severe Accident Progression and Radiological Release (Level 2) PRA Methodology to Support Nuclear Installation Applications
  - ASME/ANS RA-S-1.6 (ANS-58.22), Low Power and Shutdown PRA Methodology;

Standards Used for Safety Systems and Risk Analysis Topical Area

SMR HOLTEC INTERNATIONAL

- ANS/ASME Standards – Gaps Identified
  - Need Updated 2024 Level 1 PSA Standard to be issued endorsed by the NRC
  - Need Updated Level 2 PSA Standard to be issued and endorsed by the NRC
  - Need LPSD PSA Standard to be issued and endorsed by the NRC
  - Need the ALWR PSA Standard to be issued and endorsed by the NRC

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