G4SR-4 Pre-Conference Workshops – Monday, Oct 3, 2022

In alignment with the latest Small Modular Reactor development trends in Canada, the CNS Generation IV and Small Reactor Technology (G4SRT) Division's primary objectives are to fulfil CNS objectives as a learned society by providing a medium to share information with others practising fields such as:

- The development and implementation of the latest Generation IV nuclear design concepts, including Small Modular Reactors (SMR) development
- The analytical framework for analysis and assessment of transition scenarios (roadmap) to sustainable nuclear-energy systems employing Generation IV and small reactor designs
- The use of advanced materials, safety analysis methodologies, simulation tools etc. in the solution to design problems for these advanced reactor design concepts.

To meet these learning objectives, the following G4SR-4 Pre-Conference Workshops will be held in-person on Monday Oct 3, 2022, at the Delta Hotels Toronto Airport & Conference Centre.

Please visit the G4SR-4 website (www.g4sr.org) to register at Attendee Registration (xcdsystem.com)

Space capacity is limited, please register early to avoid disappointment.

(1) Advanced Manufacturing Workshop – Full-Day Workshop

(a) Organizers:

1. Christine Burow, Program Director, Canadian Advanced Manufacturing in Nuclear Alliance (CAMiNA)
2. Prof Lyndon Edwards, National Director, Australian Generation IV Research, Australian Nuclear Science and Technology Organization (ANSTO), and GIF Advanced Manufacturing and Materials Engineering Task Force (AMME-TF)
3. Invited Speakers - details to follow

(b) Workshop Focus:

This is a joint workshop from Generation IV International Forum (GIF) Forum with Industry 2022 and G4SR-4 . The workshop is being organized by:

- GIF Advanced Manufacturing and Materials Engineering Task Force (AMME-TF); and
- The Canadian Advanced Manufacturing in Nuclear Alliance (CAMiNA).

The workshop is designed to develop and disseminate knowledge of the steps required to successfully introduce advanced manufacturing to the supply chain of advanced nuclear reactors. As such it will be of interest to :

1. Gen IV reactor developers looking to use AM methodologies to reduce the time and cost of advanced reactor development and manufacture.
2. Supply chain companies seeking competitive advantage in AM innovations and knowledge in factory manufacturing.
3. Personnel involved in Nuclear Regulation and Nuclear Standards looking to gain knowledge on AM and the innovation it can bring to Advanced Reactor deployment.
4. Researchers looking for information on AM research roadmap, innovation discoveries and enabling infrastructure such as a modern AM research institute.

In order to address the objectives of the above-mentioned target audiences, the Workshop will consist of two parts:

- Part (a) Plenary Presentations by speakers with a focus on how the adoption of advanced manufacturing technologies can reduce the cost and time to deployment of advanced reactors and the challenges still be met regarding its widespread adoption for advanced high temperature reactors
- Part (b) will be break-out into two separate tracks:
    - Track (1) Advanced Manufacturing Demonstrations at McMaster Manufacturing Research Institute (MMRI), designed for those audience with broader interest on AM, and keen to see the demonstrations of AM innovations at work, while engaging further discussion with MMRI experts during demonstrations on the various topics presented at the Plenary session.
    - Track (2) is a participatory interactive workshop where participants will work collectively with a focus on the qualification of advanced processes and manufactured components which has been identified as a key barrier to advanced technology adoption. This workshop is the part of a series undertaken by the GIF Advanced Manufacturing and Materials Engineering Task Force deigned to identify the key steps required for the successful implementation of advanced manufacturing.

(2) **Nuclear Material Challenges for SMRs and Advanced Reactors – Full- Day Workshop**

(a) Organizers:

1. Dr. Colin D. Judge, Division Director, Characterization and Advanced Post-Irradiation Examination, Materials and Fuels Complex, Idaho National Laboratory (INL)
2. Dr. Mohammadreza Baghbanan, P. Eng., Project Manager, Ontario Power Generation | CNS Division Chair for Materials, Chemistry and Fitness-for-service.
3. Invited Speakers - details to follow.

(b) Workshop Focus:

The need to develop materials capable of performing in the severe operating environments expected in Generation IV reactors represents a significant challenge in materials science. There are a range of Gen-IV small modular reactor designs currently under the Canadian Nuclear Safety Commission's (CNSC) SMR Vendor Design Review process: molten salt reactor, high temperature gas-cooled reactor, molten-lead-cooled reactor, sodium cooled reactor. Each of the Gen IV SMR design has its own unique material demands. However, to achieve improved economic performance, most designs call for significantly higher operating temperatures than the current generation of LWRs to obtain higher thermal efficiency. In some cases, the desired operating temperatures rule out the use of the structural alloys employed today, due to high temperature, high neutron flux and high corrosion operating environment. This workshop brings out some of the best material experts from the US and Canada to discuss the approaches to materials development and qualification for advanced reactor technologies.

US Approach:

The U.S. approach to materials development and qualification for advanced reactor technologies involves a coordinated effort between the U.S. Nuclear Regulatory Commission, industry, DOE National Laboratories, and academia. High-throughput tools are being developed to enable rapid and innovative materials design and testing to support accelerated materials qualifications. Adopting physics-based modeling and data-analytics to materials design and analysis will improve the predictive tools to understand both as-fabricated behaviors, and advanced reactor conditions.

Talks in this workshop will outline the NRC development plan for Gen IV, material design and qualification efforts underway jointly between industry and national laboratories, and academic studies striving to understand material response to operating in these new environmental extremes.

Canadian Approach:

The Canadian approach follows the Roadmap for SMR that outlines a collaborative approach to bring together industry, utilities, various levels of government and other

stakeholders by leveraging expertise in areas such as materials engineering and design, offered by many research and development partners. This approach involves evaluating the characteristics and suitability of different SMR technologies and their alignment with Canadians' requirements and priorities.

Given OPG's recent announcement to construct Canada's first commercial, grid-scale Small Modular Reactor (SMR) in Darlington, talks in this Workshop will outline Utility's perspective on SMR Supplier/Manufacturer and Licensee Interface, leading to the discussion of nuclear material and chemistry research at the Canadian Nuclear Laboratories (CNL), followed by research activities undertaken at the Canadian universities under NSERC-UNENE Industrial Research in Nuclear Materials and NSERC-Canada Research Chairs in Mechanics and Materials, and Nuclear Fuels and Materials.

(3) **Integrated Safety Assessment Methodology (ISAM) Workshop – Full- Day Workshop**

(a) Organizers:

1. Dr. T. (Nithy) Nitheanandan, Director, Reactor Behaviour Division, Canadian Nuclear Safety Commission (CNSC).
2. Member of the Risk and Safety Working Group (RSWG) of the Generation IV Forum (GIF).
3. Invited Speakers/facilitators - details to follow.

(b) Workshop Focus:

This is a joint workshop from GIF Forum with Industry organized by the Generation IV International Forum (GIF) and G4SR-4.

The Generation IV (GIF) Risk and Safety Working Group (RSWG) developed an Integrated Safety Assessment Methodology (ISAM) to support the concept that "safety" is "built in" the Gen IV reactor design processes, rather than added on. ISAM accomplishes this by assimilating safety requirements as reactor systems are conceptualized and designed. The methodology is useful for the Gen IV technology development cycle, including the Small Modular Reactor (SMR) and Advanced Reactor (AR) concept and design development.

The full-day workshop will introduce the ISAM concepts: (a) Qualitative Safety Features Review - QSR methodology (b) Phenomena Identification Ranking Table - PIRT methodology (c) Objective Provision Tree - OPT methodology (d) Deterministic and Phenomenological Analysis (DPA) (e) Probabilistic Safety Analysis - PSA methodology. This will be followed by some hands-on work, such as group discussion and exercise activities applicable to SMR and AR early design cycles and analysis.

(4) Basic-Principle Simulator for Passive Boiling Water Reactor – Full-Day Workshop

(a) Organizers:

1. Wilson Lam, CNS G4SR Technology Division Chair, and G4SR-4 Conference Deputy Chair.
2. Douglas McDonald, BWRX-300 Product Manager, GE Hitachi Nuclear
3. Invited Speakers - details to follow.

(b) Workshop Focus:

GE Hitachi Nuclear Energy (GEH) has been selected by Ontario Power Generation (OPG) as the technology partner for the Darlington New Nuclear Project. GEH will work with OPG to deploy a BWRX-300 small modular reactor (SMR) at the Darlington site that could be complete as early as 2028. The BWRX-300 is a 300 MWe water-cooled, natural-circulation SMR with passive safety systems. It leverages the design and licensing basis of GEH's ESBWR boiling water reactor, which has been certified by the US Nuclear Regulatory Commission. It is currently undergoing a Canadian Nuclear Safety Commission pre-licensing Vendor Design Review, or VDR.

This is a workshop jointly organized by the CNS Generation IV and Small Reactor Technology (G4SRT) Division and GE Hitachi (GEH), with a focus on BWRX-300 design

The workshop Agenda:

Time	Agenda	Speakers	Duration
9:00	Opening remarks	Wilson & Doug	4 min
9:05	Evolution of BWRs – Conventional BWR, ABWR, ESBWR and BWRX300	Doug	25 min
	Basic Principle of Passive BWR Design Features and Simulator Demonstration: Part (A)- (J) • Theory & Simulator Demo • BWRX-300 Difference	 Wilson Doug	
9:30	Part (A) Direct cycle; Core Design; Fuel Assembly; Core Flux Shape properties; BWR Reactor Vessel	same	30 min
10:00 - 10:30	Coffee Break		30 min
10:30	Part (B) Main Steam System	same	20 min

10:50	Part (C) Turbine and Steam Bypass System	same	15 min
11:05	Part (D) Balance of Plant and Feedwater	same	15 min
11:20	Part (E) Containment	same	30 min
11:50 – 13:00	Lunch Break		70 min
13:00	Part (F) Rod Control System	same	15 min
13:15	Part (G) Pressure & Turbine Control System	same	15 min
13:30	Part (H) Water Level Control System	same	10 min
13:40	Part (I) Power/Flow Map	same	20 min
14:00	Part (J) Protection Systems	same	20 min
14:20 – 14:40	BWRX-300 Design focusing on the top-level features: (1) 10th generation BWR technology (2) Compliance with the international high safety standards (3) Designed to be cost competitive (4) Up to 60% capital cost reduction per MW (5) Evolved from the licensed ESBWR	Doug and GEH experts	20 min
14:45 – 15:15	Coffee Break		15 min
15:15 – 15:35	BWRX-300 Design focusing on the top-level features: (6) Designed to mitigate LOCAs with a simple, dry containment without relying on active safety systems (7) Reduced on-site staff and security (8) Design-to-cost approach (9) Proven components, fuel, and supply chain (10) Constructability integrated into design.	Doug and GEH Experts	20 min
15:35 – 16:35	Passive BWR Simulator Exercises : using the IAEA Passive BWR Simulator (which emulates the ESBWR) to demonstrate the features of Passive BWR features:	Wilson	60 min

	Power Reduction/Increase; Reactor Trip; Startup and Shutdown; Malfunction Transient Events that include AOOs and DBAs.		
16:35 – 17:00	Q & A	Doug, GEH Experts, Wilson	25 min
17:00	Workshop ends		

(5) Non-Electric Applications of Nuclear Heat - Full Day Workshop

(a) Organizers:

1. Shannon Bragg-Sitton, Director for Integrated Energy and Storage Systems, Idaho National Laboratory, USA, and Chair, GIF Non-Electric Applications of Nuclear Heat Task Force

2. Ali Siddiqui, Director, Advanced Reactors Program Development, Canadian Nuclear Laboratories, Canada.

3. Steve Napier, Nuclear Innovation and Research Office, United Kingdom

4. Gilles Rodriguez, Commissariat à l'énergie atomique et aux énergies alternatives (CEA), France

5.Invited Speakers - details to follow

(b) Workshop Focus:

- Nuclear energy has the potential to play a major role in global efforts toward economy- wide decarbonization, with advanced technologies providing deployment flexibility (with systems providing MW to GW of energy) and product flexibility.
- Decarbonisation of the electricity sector alone is insufficient to meet the challenging CO2 emission reduction targets that have been set by private industry, organizations, and nation states around the world.
- Direct use of nuclear-generated heat and/or process intermediates that may be produced using nuclear heat and electricity (e.g., hydrogen) to meet energy demand from the industrial and transportation sectors offer significant potential for further emission reduction—but designing systems that efficiently and reliably meet these energy demands requires a holistic, multi-disciplinary approach and significant communication among energy generators and energy users.

Please join us on October 3 for this full-day workshop to learn about the potential for advanced nuclear energy systems to support non-grid energy demands.

- Organized by the Generation IV International Forum interim Task Force on Non-Electric Applications of Nuclear Heat (NEaNH-iTF), this workshop will establish connections between the research community and industry, engaging both nuclear technology developers and energy end users.
- Via panel presentations and moderated discussions, we will review multiple scenarios in which nuclear energy systems could be used to support heat and electricity demands outside the power sector—while continuing to provide reliable, resilient electricity to meet grid demand.
- Panel sessions will provide a platform for nuclear technology developers to share the performance capabilities, system economics, and deployment timelines for their systems, and they will also provide opportunity to hear from members of the energy use community, ranging from data centers and water processing to chemical processes, steel manufacturing, and fertilizer production, among others.
- Stakeholders in the energy-use community are encouraged to share details of their energy needs and requirements, but to also raise any concerns they may hold regarding integration of nuclear energy to drive these processes.
- The research community will also have opportunity to share computational tools and facilities that could support multi-lateral and public-private partnerships for systems analysis and demonstration to accelerate the path to commercial deployment of novel zero-emission energy systems.
- Anticipated attendees include Gen IV reactor developers, energy system modelers, industrial energy users, regulators, researchers, and other stakeholders.
- Following the organized panel sessions, the workshop will include dedicated time for participants to brainstorm on energy system design and establish potential collaborations for future demonstration and deployment. Stay tuned for more details.

(6) NEST/SMART SMR Fellows Workshop - PRIVATE Full Day Workshop

The **OECD NEA NEST SMR Project** and the **SMART Program at McMaster University** are organizing the **NEST/SMART SMR Fellows Workshop on October 3, 2022**.

It is a **PRIVATE Workshop only for NEST and SMART members**.

The goal is to conduct an exercise, culminating with an in-person workshop, for student teams to understand the multi-disciplinary challenges in deploying advanced nuclear energy systems. Student teams will prepare and present a press release describing their deployment scenario, including the technical, economic, regulatory, and social challenges and approaches to overcome these challenges. Each team will be provided a mentor team and access to an expert's network. The deployment scenarios will be to deploy an SMR on a university campus in an urban environment. Student teams will be asked to

present from a different perspective, for instance: a policy NGO, an environmental NGO, a local governmental agency staff, a Federal governmental staff, a university leader, a technology company spokesperson, or a regulator.

G4SR-4 Organizing Committee

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