**UNENE: Response to CNL RFEOI on SMR's**

**July 28 2017**

## A) Executive Summary

**Request for Expressions of Interest** – CNL's SMR Strategy
**Lead Organization Responding**: University Network of Excellence in Nuclear Engineering (UNENE)
**Any other participating organizations**: UNENE is a not-for profit partnership of nuclear industry organizations and 12 Canadian universities with nuclear programs, to advance education and university R&D in nuclear science, technology and engineering.

**Stakeholder group:**

**Service or product provider:** UNENE can provide R&D, educational and review and advisory services, and can support CNL in outreach to governments and other stakeholders.
**Potential host community:** In the longer-term, UNENE universities may be appropriate locations for purpose built vSMR's, following the tradition of research reactors located at several UNENE universities.

**Summary of Interest**:

UNENE sees that the Canadian network of nuclear-associated universities is a valuable resource and a natural partner that can help support this CNL initiative. UNENE specialist teams can deliver on specific R&D topics that help complete the case for given SMR technologies, at university scale – a natural complement to the facilities and capabilities at CNL.

UNENE also provides a strong network of experts, independent from the vendor community, that can provide advice, independent review and support with stakeholders including governments, to this new initiative - an important factor in building support from stakeholders.

In the longer term, UNENE universities will provide a training ground for experts and leaders for the development and deployment of emerging technologies arising from this initiative.

**Contact Information:**
Please contact Jerry Hopwood, President, UNENE; Email: jerry.hopwood1@gmail.com; Phone: 647-972-1581
Or: Lori Cole, Office Administrator, UNENE, c/o:Tel: (905) 525-9140 ext. 20168; Email: UNENE@mcmaster.ca

UNENE Mailing Address: c/o Department of Engineering Physics, Bldg. JHE A315, McMaster University, Hamilton, Ontario, CANADA L8S 4L7:

## B) Main Body of Submission

### *General Information for Deployment of SMR Technology in Canada (Stakeholders or Other Interested Parties)*

1. *RFEOI Question: What are your energy needs?*
    - *Describe the attributes of the ideal solution to meet those energy needs.*
    - *Have you considered nuclear energy as a solution?*
    - *What is needed for you to consider nuclear energy as a solution?*

- UNENE, as an academic partnership organization, does not represent energy users as such; however, UNENE member universities do have significant energy needs, so these could become a fruitful topic for discussion looking ahead from the CNL SMR Initiative.
- UNENE universities have in some cases energy needs that may match a vSMR, particularly if Combined Heat and Power capabilities are included. (It should be noted that in the 1990's, a previous vSMR initiative by AECL (SLOWPOKE SES-10) considered a Canadian university as the first host site).
- Universities as energy users, would be interested in clean, GHG-free solutions in the future; if there is an demonstrated, economical, licensable path forward, then a vSMR option may be of interest in the longer-term future.
- Our UNENE nuclear experts will take a strong interest, and can advocate within the academic community overall, for a nuclear energy solution. What will be needed is a strong and resilient case to bring to the university community at large – a compelling clean energy case plus the ability to finance, obtain public support, license. Each of these would likely need an in-depth multi-year campaign to demonstrate.

2. *What do you see as your role in the process to bring an SMR to deployment?*
    - *Please provide details on your organization's readiness to work with CNL. This could include, but is not limited to: financial resources, technical capabilities, geographic constraints, particular areas of strength, size of workforce (in Canada/ out of Canada).*

UNENE and its member universities have a strong interest in advancing nuclear energy technologies to benefit Canada. This arises directly through our mission to carry out nuclear R&D that benefits Canada (as viewed by government through NSERC), and advanced education that advances the nuclear industry capability. Consistent with its mission, UNENE is interested in both creating next-generation advancements in knowledge, and in addition, in developing the next generation of experts and specialists to be capable in emerging fields of nuclear technology.

The CNL SMR initiative is an excellent opportunity for UNENE members to take part in a broad-based effort to bring next-generation nuclear technologies, with their attendant advantages, to fruition, at a stage in the life-cycle when R&D activities, including activities where UNENE can make a unique contribution, are crucial.

UNENE as an organization has established centres of research capability at member universities supporting the Canadian nuclear community in areas such as:

- Nuclear Safety Analysis and Thermalhydraulics
- Advanced Nuclear Materials
- Advances in Nuclear Fuels
- Corrosion Control and materials Performance in nuclear systems
- Health Physics and Environmental Safety
- Risk Based Life-Cycle Management
- Control, Instrumentation and Electrical Systems
- Radiation-Induced Corrosion
- High Temperature Aqueous Chemistry

These areas of research are supported by a powerful collection of experimental facilities at member universities, which can be harnessed to generate information and insights to support the SMR initiative. Examples include:

- 2 operating research reactors at McMaster and RMC respectively, with associated experimental capability, along with the expertise in small reactor operations, licensing and management.
- Wide-ranging material investigation facilities, including a large electron microscopy suite, a recently-commissioned particle accelerator, and
- Corrosion labs, thermalhydraulic simulation rigs and a full-scope I&C reactor mock-up.
-

This means that for CNL's initiative, UNENE can provide a wide-range of investigations into technology areas that support the SMR initiative, both using its existing concentrated expertise in specific topics, and in using its broad-based capability to address emerging topics and specialities. In addition, UNENE as an organization can provide important cooperative elements to this initiative:

- ability to prepare financial support through industrial members, leveraged through matching NSERC contributions;
- specialized technical capabilities from Industrial Research Chair and Cooperative R&D teams, grouped around a number of technology-independent topic areas that are relevant to SMR technologies;
- Ability to reach out to stakeholder communities both locally, provincially and nation-wide including a voice with governments
- Credible opinion-leaders in IRC Chairs and other expert faculty members.

UNENE employs experienced professors and instructors from several key universities in Canada that maintain a large number of national and international contacts that can support the SMR program, and can provide advisory, reviewer and steering support in SMR design, safety analysis and licensing tasks.

3. *From your perspective, what is needed to successfully deploy SMR technologies within Canada?*

- *The response should consider the following questions:*
  - *What do end users need to have confidence to adopt these technologies?*
  - *What do other industry partners and communities need?*

Launching a ground-breaking technology in the nuclear area is a challenging task requiring a very wide-ranging and determined effort. However, at UNENE we consider that, in view of the crucial importance to national energy security and environmental goals, pursuing advanced nuclear development is an absolute essential for Canada. The CNL SMR initiative is a vital element towards this objective; so identifying and addressing all the success factors at this initial stage is extremely important. Looking at some key attributes needed to enable confidence by end-users, the confidence eventually is expressed in a business case for investment in a SMR project. The business case needs to show the investor (whether a for-profit business, a government, or some other institution) that the money invested will yield an appropriate return, with uncertainties and risks identified, and a solid management plan prepared to address them. From the viewpoint of innovations in technology, this means that items such as the following examples, need to have been addressed, with all the required R&D, engineering, regulatory interface and project development preliminaries completed:

- Outputs (electricity and/or other) that match community/industrial needs; a defined role for the reactor unit that supplies known and understood energy needs;
- Sufficient and widely accepted research results on the use of new materials and components
- Licensibility; a well-developed safety case that has had sufficient review by the regulator to proceed, and is supported by a broad base of technical information; a decommissioning and waste management plan that has clear understanding of the scope of commitment required;
- Social acceptance (host community and wider acceptance); an established outreach program to communicate with, and listen to, the interests of the local community and other stakeholders;
- Operating reliability; sufficient information regarding component and material reliability and ageing effects, to enable an operating and maintenance plan consistent with operating targets
- Confidence in capital cost and delivery schedule; vendor, project manager and supply chain have worked together to prepare a credible project plan including commissioning and operations responsibilities;

  - *What is the biggest obstacle to deployment of prototypes or demonstration SMR technologies?*
  - *What is the biggest obstacle to deployment of these technologies on a commercial basis within Canada?*

Beyond the work required to prepare the business case, per above, gaps in readiness may include some of the following factors, depending on the technology readiness of the option under consideration:

- Lack of really detailed technology base; as the level of innovation from today's established reactor technologies increases, the number of knowledge gaps increases. Both regulators and

the final owner/operator will need to be assured that no significant knowledge gaps will be left as the project progresses;

- Lack of a proven demo unit; in recent years, owner/operators have been very cautious about embracing new technologies without a proven demonstration unit. "Provenness", absent such a unit, needs to be demonstrated by reference to bodies of relevant R&D and licensing review, and operating experience with existing technologies for specific topics;
- Lack of reliable technologies to reduce costs: For smaller reactor units, it will be essential to be able to operate with a much smaller staff complement. This in turn will require proven ability of passive systems, automated technologies, on-line and remote monitoring capabilities, to play a much greater role than for current technologies
- Lack of public knowledge, debate and understanding; public confidence in nuclear projects is not easily won, and will take time in advance of project kick-off, even for a demo project within a CNL location
- Lack of thorough decommissioning/waste plans; frequently, R&D and design development for a new technology focusses on the build and operating stages. But firm decommissioning and waste management plans will be essential to obtaining regulatory approval and community support.

*4. What role do you see R&D and/or technology development playing in addressing the obstacles?*

- R&D and technology development will need to build up a thorough knowledge base of the science and technology; fundamental research if and where required, to establish certainty in the technology; "filling the gaps" where a body of knowledge has been built up, but does not cover all potential regulatory questions.
- Examples of topics that may need to be investigated, general to new technologies, include:
    - Safety and I&C aspects of remote, or limited-staff operation
    - Developing accident and waste behaviour models to appropriate levels comparable to models for current technologies
    - Appropriateness of new materials used
    - Proven reliability of new materials and components
    - Ageing effects of new materials and coolants
    - Probabilistic safety assessments for technologies with reliance on passive systems
    - etc.
- A credible case needs to be built for the safety and reliability of new technologies, accessible to be understood by public/opinion-leaders/stakeholders. It will be important for technology development to include a built-in activity communicate the technology(s) to stakeholders, both institutionally (governments, agencies) and the wider community, to establish a robust social contract permitting projects to go ahead.

5. *What additional applications (e.g. district heating, hydrogen production, energy storage) do you consider as being most advantageous?*

- In the short term, as complementary applications to electricity production, the most prominent options could be district heating for residential communities, including small or isolated communities, e.g., northern communities, and industrial heat, e.g. for applications in oil-sands facilities. These applications would be relatively straightforward to implement, and have previous examples in other countries. Important technology issues would be the design of separation between nuclear systems and the group of non-nuclear ("balance of plant") energy delivery systems; and the control and instrumentation required for multiple users.
- In the medium-term, to follow through on GHG reduction commitments, hydrogen may become an important energy medium, e.g. in goods transportation; – demonstrating the use of SMR's as hydrogen production units may be an important step in national energy development. This may encourage technologies that can deliver high temperatures to facilitate Hydrogen generation.
- For export business: demonstrating the use of SMR's for desalination in parallel with electricity production may have powerful applications in a number of countries where fresh water is becoming scarce.

6. *Would you / your organization like additional information – in general terms – regarding SMR technology? If so, please suggest ways you feel we could best communicate with you or your organization / constituents, and any specific areas of interest or methods of communication. Registration to receive email updates for the RFEOI is available at www.cnl.ca/SMR.*

Yes: UNENE views that it can work in close cooperation with CNL to support this initiative. As the initiative develops, UNENE will wish to stay in touch, and to identify areas for cooperative activities. For example, UNENE would be pleased to join any stakeholder groups and to participate in regular updates, e.g. a short monthly videoconference. It would be useful to define SPOC's from both organizations to help with communications.

7. *Please provide any additional input you feel could help inform CNL's SMR strategy.*

**Statement of UNENE proposed role:**

UNENE sees that the Canadian network of nuclear-associated universities is a valuable resource and a natural partner that can help support this CNL initiative. UNENE specialist teams can deliver on specific R&D topics that help complete the case for given SMR technologies, at university scale – a natural complement to the facilities and capabilities at CNL.

UNENE also provides a strong network of experts, independent from the vendor community, that can provide advice, independent review and support with stakeholders including governments, to this new initiative. Given the importance of building support, both for the initial demonstration initiative at CNL,

and for the broader applications that may come in future, UNENE as a supporting partner can provide strong benefits to the initiative.

In the longer term, UNENE universities will provide a training ground for experts and leaders for the development and deployment of emerging technologies arising from this initiative. Looking farther ahead, there may be an opportunity for a UNENE university to be an early host for a vSMR application, if the match of technology and energy need emerges.

UNENE employs experienced professors and instructors from key universities in Canada that maintain a large number of national and international contacts. This provides a background network that can support the SMR program, and can provide advisory, reviewer and steering support in SMR design, safety analysis and licensing tasks.

Given these aspects, UNENE would propose to engage with CNL in this initiative, using regular interfaces as defined by CNL as the initiative proceeds. Examples would be membership in the initiative steering or oversight committees, and in technical advisory committees addressing specific R&D tasks. UNENE members can also take a role in providing independent technical reviewers for key documents and proposals, as needed.

*C) Technology Specific Information (SMR Technology Developers) – Not Applicable*