The Emissions-Free Energy (EFE) Working Group

Roger Humphries
AMEC NSS, Toronto, Ontario, Canada
Roger.Humphries@amec.com

Abstract

There has been a growing international interest in smaller, simpler reactors for generating electricity and process heat. They incorporate modern technological advances in reactor design, reactor safety, modular construction, proliferation resistance, and risk reduction. The interest in these reactors has been driven by many factors, including the need to reduce greenhouse gas emissions and provide reliable power in 'off-grid' or 'edge-of-grid' locations.

Licensing these new small reactors, particularly in Canada's resource rich remote northern regions, will raises issues in a wide variety of technical, institutional, socio-economic and regulatory policy areas. The first small reactor vendor to file a license application or to engage the CNSC in its pre-licensing vendor design review process is going to have to deal with these issues. However these issues affect the entire small reactor industry and it is essential that the industry as a whole address them. Accordingly, a small reactor industry-wide Working Group has been established to identify and prioritize the issues that need to be addressed and work with the CNSC and other interested stakeholders to agree on a resolution acceptable to all parties.

The objective of the small reactor industry is to introduce an economical, emissions-free source of electrical and thermal energy. It is the opinion of the WG that our emphasis ought to be on the product rather than the technology, hence the name Emissions-Free Energy Working Group. The EFE WG has initiated contact with the CNSC and has started its review of CNSC draft regulatory and guidance documents.

1. Introduction

In recent years there has been a rapidly growing international interest in smaller, simpler reactors for generating electricity and process heat. These reactors incorporate modern technological advances in reactor design, reactor safety, proliferation resistance, and modular construction. They feature reduced fission product inventories and hence reduced risk.

The interest in small reactors is driven by many factors, including the need to: reduce capital costs; reduce greenhouse gas emissions; provide reliable power in 'off-grid' or 'edge-of-grid' locations; replace retiring fossil plants that do not meet today's environmental standards; provide thermal energy for district heating; and, provide steam for process heat in various industrial processes and natural resource industries. These driving factors have led to a growing interest in Canada as a potentially significant market for small reactors.

Canada is a nation rich in natural resources and there is enormous potential for economic growth in its remote northern regions (particularly in the natural resources sector). However responsible extraction of these resources, particularly in the mining and petroleum industries, remains highly

energy intensive. When such activities involve the use of fossil generation in remote locations to supply heat and power there are a number of issues that can become significant:

- Delivery and storage of fuel (with sufficient reserves to cover supply interruptions) becomes a financial and environmental challenge to projects. Power generation costs can be very high and the potential for fuel spills can risk the public acceptance or economic viability of a project.
- High power costs limit spin-off economic growth around the projects (e.g. small manufacturing, small businesses).
- Projects have to find ways to mitigate emissions in environments where they cannot be tolerated in the face of climate change discussions.

The new smaller reactor designs currently being developed have the potential to:

- Provide a reliable emissions-free source of energy in these regions.
- Reduce the environmental footprint of northern projects.
- Drive economic growth and improve northern standards of living by lowering costs of power and supplying services such as fresh water and district heating.
- Allow fossil fuels to be used in more economically advantageous ways in other regions.

2. Small Reactors

2.1 Size Matters

Small reactors are not new, nor is their use in remote locations. Nuclear power had its beginnings in the United States with the highly successful naval nuclear power program, launched in 1955 with the USS Nautilus, the world's first nuclear powered submarine. The world's first nuclear plant to be hooked to an electrical grid was the US Army's SM-1, a 2 MWe training facility located in Fort Belvoir, Virginia. The world's first portable plant built in a remote location was the PM-2A at Camp Century, Greenland. An operating crew of one officer and 18 enlisted specialists built the plant in 77 days. The plant was completed in 1961 and delivered 2 MWe of electricity plus 1x10E7 Btu/hour of steam heat.

Figure 1 Camp Century, Greenland

In Canada the Nuclear Power Demonstration (NPD) plant served as a prototype, training facility, and test bed for the CANDU reactors. It went online in 1962, delivering 20 MWe to the grid.

These early reactors were the forerunners of today's civilian commercial nuclear power plants (NPPs). The global growth in nuclear power, the need to supply power to large grids and the 'economies of scale' have led to the development of increasingly larger NPPs, many of which are now in the 1,000 MWe and greater size range. However in spite of the general success of these large reactors in many situations, their large size and high capital cost make them

unsuitable in many locations and for many applications. In a paper on deliberately small reactors[1] Oak Ridge National Laboratory reports that 93% of all power generating units in the world have capacities less than 500 MWe, suggesting that the global market for SMRs is potentially quite large.

2.2 Small Reactors in Canada

There are a wide variety of potential applications and a large number of potential sites in the resource rich regions of Canada. Because of this a number of small reactor/SMR vendors have declared their interest in the Canadian market. These vendors come from different countries, both domestic and international, and have different reactor designs in various stages of development that are intended for different applications. However regardless of their country of origin and their licensing status in their home country, to be built and operated in Canada they will need to be licensed by the Canadian Nuclear Safety Commission (CNSC).

The Canadian nuclear regulatory framework is sufficiently flexible to allow for the licensing of reactors ranging from large NPPs to small research reactors. Nevertheless the licensing of these new smaller reactors, particularly in remote regions, will raise issues in a wide variety of technical, institutional, socio-economic and regulatory policy areas that will need to be resolved. While the CNSC is working to update its regulatory framework to include these new small reactors, it is the responsibility of the nuclear industry to:

- Identify the issues that need to be resolved.
- Develop industry-wide approaches to the resolution of these issues.
- Work with the CNSC and other interested stakeholders to agree on a resolution acceptable to all parties.

3. Licensing Small Reactors in Canada

3.1 Definition

The CNSC considers a small reactor facility to be one containing a reactor with a power level of less than approximately 200 MWt (about 75 MWe) that is used for research, isotope production, steam generation, electricity production or other applications. The CNSC does not use the acronym SMR in their regulatory documents. They consider it to be a marketing term, however, and do use it in some of their published literature and conference papers.

3.2 The Canadian Regulatory Framework

The Canadian nuclear regulatory framework came into effect in May 2001 with the passage of the *Nuclear Safety Control Act*[2] (NSCA) and the creation of the Canadian Nuclear Safety Commission. It consists of: 1) **Enabling Legislation**, including the NSCA and other laws passed by Parliament that govern the regulation of Canada's nuclear industry; 2) **Requirements**, as expressed in licenses and license conditions; and 3) **Guidance**, as expressed in guidance documents, staff review procedures and CNSC information (INFO) documents.

The primary piece of **Enabling Legislation** is the NSCA. It sets out the authority and obligations of the CNSC. These include its authority to regulate the Canadian nuclear industry and its authority to develop and issue regulations.

Requirements are mandatory. Licensees or applicants must meet these requirements to obtain or retain a license or certificate to use nuclear materials or operate a nuclear facility. The Requirements element of the regulatory framework includes: 1) regulations that set out statutory requirements; 2) licenses, certificates, license conditions and orders with which a licensee must comply; and 3) regulatory documents that provide greater detail than regulations regarding what licensees and applicants must achieve in order to meet the CNSC's regulatory requirements

Guidance documents provide direction to licensees and applicants on meeting requirements.

This hierarchy is frequently illustrated as a regulatory pyramid, as shown in Figure 2 below.

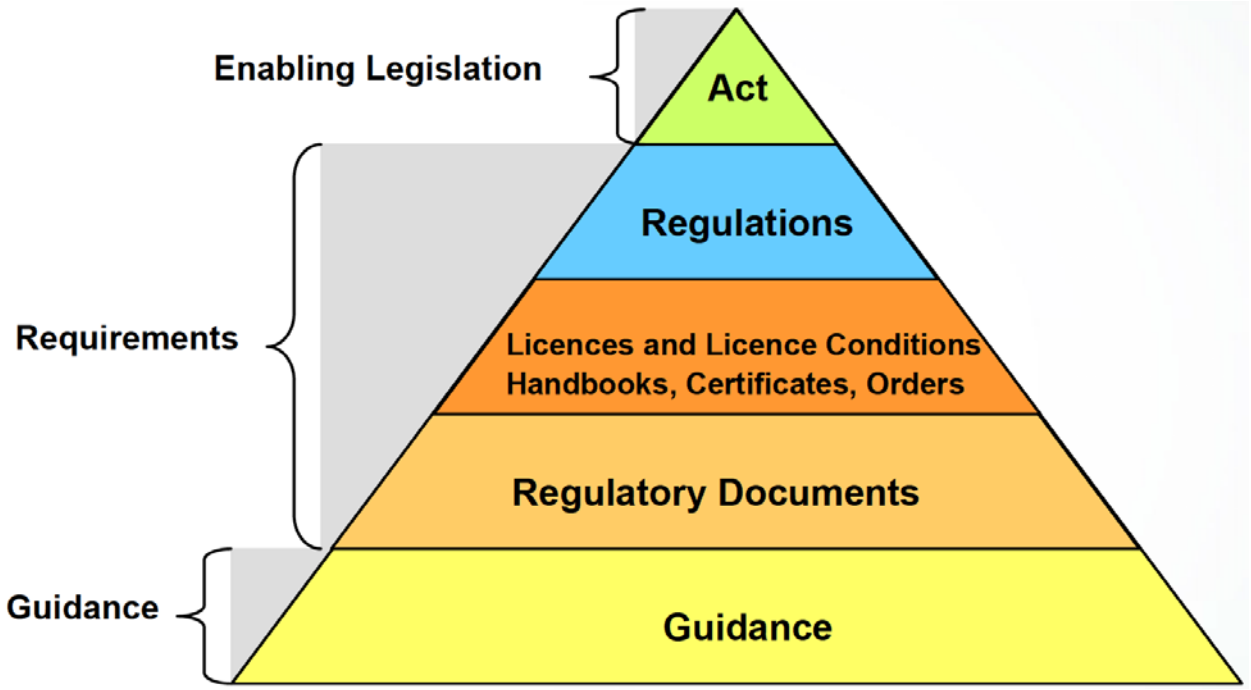

Figure 2: Elements of the Regulatory Framework

The CNSC is making a number of significant changes to their regulatory framework, through the vehicle of updated or new documents, to ensure that the licensing process explicitly includes small reactors, that it is technology neutral, and that it is independent of reactor size. In particular, some of the key features are:

- A risk-informed, or 'graded', approach that recognizes that the stringency of the design measures and analyses applied as a part of the safety case is commensurate with the level of risk posed by the reactor facility.
- The driver for the safety case is risk, not size (power level).
- Additional flexibility is possible for small reactor facilities.

3.3 Licensing Issues for Small Reactors

Licensing these new small reactors, particularly in Canada's resource rich remote northern regions, will raises issues in a wide variety of technical, institutional, socio-economic, licensing and regulatory policy areas. While many of the issues that arise will apply to small reactors of any size, those associated with very small reactors operating in remote locations are expected to be of most concern and/or most difficult to address. Those for the larger small reactors are likely to be similar to those for NPPs in general. Among the issues that will need to be addressed, in no particular order of importance, are:

- Transportation of factory manufactured reactors with fuel loaded from factory to site.
- Refuelling and maintenance in remote locations or shipping reactors loaded with spent fuel back to the manufacturing facility.
- Security requirements for facilities with the reactor buried deep underground.
- Public engagement.
- Location of facilities on Aboriginal lands.
- Emergency preparedness in remote locations.
- Minimum staff complement.
- Remote monitoring and/or operation.
- Exclusion zones for low-risk facilities.
- Owner/operator/vendor relationship.
- Insurance and liability requirements for small reactors.
- Decommissioning guarantees for small reactors.
- And many, many more…

3.4 The Need for an Industry-Wide Working Group

There have been informal discussions about the need for an industry-wide Working Group (WG) for the past three or so years. It has been recognized that the first small reactor proponent to either file a license application or to engage the CNSC in its pre-licensing Vendor Design Review[3] process is going to have to deal with these issues. However many of the issues to be addressed will affect the entire small reactor industry, and it is neither fair nor appropriate that a single proponent bear the burden of this process alone.

It is essential that the small reactor industry, working cooperatively and in conjunction with other interested stakeholders, address these issues as a unified body. Doing so will help distribute the resolution of many first-of-a-kind licensing costs amongst suppliers. It will also help ensure that a common, consistent set of requirements is applied to all small reactor facilities, including the manufacturing plants.

4. The Emissions-Free Energy Working Group

4.1 Objective

The overall objective of the Working Group is to act on behalf of the small reactor industry to identify and develop common approaches to resolving safety, licensing, regulatory framework, and/or other issues that are of particular concern for, and very likely unique to, small reactors in Canada.

4.2 Why the 'Emissions-Free Energy' Working Group?

In early discussions regarding the need for an industry wide small reactor Working Group it was referred to at various times as a Small Reactor WG, a Small Modular Reactor (SMR) WG, or a Very Small Modular Reactor (VSMR) WG depending entirely on the context of the discussion. There was a corresponding lack of clarity about who should participate in and actively contribute to the efforts of such a group. This lack of clarity was, if anything, compounded by the fact that ongoing developments in the Canadian regulatory framework for these smaller, simpler reactors considered them not to be SMRs or VSMRs but simply small reactors.

It was also recognized that a major factor likely to be encountered would be the frequently expressed concern, often to the point of fear, whenever the subject of nuclear power is raised. Whatever the reasons, this concern and/or fear is part of the reality that these new small reactor projects must face. This extends beyond the public's fear for their safety and environmental contamination, and includes the fear by some industries that introducing this "new" technology will have adverse technical, economic or licensing impacts on their projects.

In view of the above factors and the fact that one of the important driving forces for new, small reactors is the need to reduce greenhouse gas emissions, it was decided by the Working Group that our emphasis ought to be on the product rather than the technology. And the product we are striving to introduce and on which we wish to engage with the CNSC and other stakeholders is an economical, emissions-free source of electrical and thermal energy. We have, accordingly, established the group as an Emissions-Free Energy (EFE) Working Group.

4.3 The Working Group Agreement

The vehicle for establishing the Working Group was a Working Group Agreement (WGA)[4]. The WGA was, in essence, a 'we the undersigned' statement in which several people expressed their personal commitment to serve on the WG and actively participate in its work.

Once the WGA had been signed by its initial eleven members the launch of the EFE Working Group was communicated to and acknowledged by the CNSC on February 4, 2014.

The EFE WG has been established as an inclusive group, encouraging active participation by those who have an interest in small reactors and whose activities may influence, or be influenced by, the activities of the EFE WG. The WG membership currently includes small reactor vendors and other interested stakeholders from Canada, the US and Sweden.

4.4 Governance

Membership of the Working Group (i.e., persons interested in active participation) is drawn from private industry, government and academic organizations that have an interest in bringing small reactors into Canada. The composition of the working group may vary over time based on the specific issues being examined. Experts may be invited to participate on an on-going basis on the working group or contribute on an ad hoc basis.

The WG members work by consensus to the extent practicable. It is understood that the members represent the broader interest of the industry and not the respective organizations from which they came.

Organizations having representatives on the Working Group fund the cost of their participation. There is a need for additional contributions to the WG to fund the activities of a Secretariat. One of the early, and still on-going, activities of the Working Group is to establish a budget, a funding mechanism, and scope of work.

The Working Group holds meetings according to a schedule and agenda as mutually agreed upon by the members. Conference calls and emails are the most common form of communication.

5. Activities of the Working Group

The EFE Working Group is still in its early days and the activities it intends to take on are still evolving. The WG has made it's intentions known to CNSC and will seek to engage with CNSC staff in the near future.

One of its early activities was to work with Innovation Saskatchewan to organize a meeting amongst a group of experts from industry along with federal and provincial stakeholders to discuss emerging SMR regulatory and policy issues, particularly as they apply to very small reactors in remote locations.

The group is also working to provide comments on behalf of the small reactor industry to the CNSC on draft Regulatory Documents or Guidance Documents where they might adversely impact small reactor licensing.

As discussions with the CNSC move forward the Working Group will also engage with other bodies such as the Canadian Nuclear association, the Canadian Nuclear Society, the American Nuclear Society, and various standards organizations such as the CSA, ASME, IEEE and others.

6. Concluding Remarks

The need for an industry-wide body to represent the small reactor industry in discussions with the CNSC and other interested stakeholders regarding licensing and regulatory issues unique to small reactors has been recognized for the past few years. In order for SMRs to become a reality in the north or edge-of-grid applications, the establishment of such a working group is vital The Emissions-Free-Energy Working Group was formed in February 2014 to meet that need. The WG has begun its work and is looking forward to playing an important role in helping to establish a viable small reactor industry in Canada.

7. References

[1] Ingersoll, Daniel, *Deliberately Small Reactors and the Second Nuclear Era*, paper by Oak Ridge National Laboratory, ORNL Summer Interns, 2 June 2010.

[2] *Nuclear Safety and Control Act*, (S.C. 1997, c. 9)

[3] *Pre-licensing Review of a Vendor's Reactor Design*, GD-385, CNSC, June 2012.

[4] *Emissions-Free Energy Working Group Agreement*, Initial Release, Revision R0, 4 Feb 2014.