International Framework for Nuclear Energy Cooperation (IFNEC): Activities Related to the Deployment of Small Modular Reactors

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INPRO Dialogue Forum on Opportunities and Challenges in Small Modular Reactors
July 3, 2019, Ulsan, Republic of Korea
“The International Framework for Nuclear Energy Cooperation provides a forum for cooperation among participating states to explore mutually beneficial approaches to ensure the use of nuclear energy for peaceful purposes proceeds in a manner that is efficient and meets the highest standards of safety, security and non-proliferation. Participating states would not give up any rights and voluntarily engage to share the effort and gain the benefits of economical, peaceful nuclear energy.”

Adopted June 16, 2010 in Accra, Ghana
Infrastructure Development Working Group

Focuses on seven key areas:

- Human Resource Development
- Radioactive Waste Management
- Safety
- Security
- Small Modular Reactors
- Emergency Preparedness and Response
- Stakeholder Involvement

Cooperation with the IAEA an Important Tool
SMRs – A Frequent Agenda Topic

- May 20, 2009 – Manchester, UK
- December 9, 2009 – Vienna, Austria
- May 26, 2010 – Vienna Austria
- December 6, 2010 – Rome, Italy
- April 20, 2011 – Paris, France
- July 18, 2012 – College Station, Texas
- April 15, 2013 – Vienna, Austria
- May 8, 2014 – Bucharest, Romania
- June 15, 2015 – Paris, France
- June 26, 2017 – Paris, France
- May 29, 2018 – Paris, France
The Xe-100 Reactor

Technology

● The Xe-100 is a 200MWth/76MWe helium-cooled power plant that features a 15.5% LEU fuel cycle

● Small size and modular construction result in relatively low cost – single reactor plant of <$1B, expandable to 8 reactors on plant site (~600 Mwe)

● All components sized to maintain road transportability to reach remote locations and maximize siting flexibility

Status

● Began Conceptual Design in March 2017

● Conclude Conceptual Design within 24 months (by early 2019)
Transportable Nuclear Reactors: Technology Options

Features
- Integral SMR pool mount
- Load via Railway
- SMR Truck Transport

Siting
- Barge mounted
- On-land
- Underwater

Refueling
- On-site refueling
- Factory refueling
SMART Construction Plan – A Joint Effort

SMART Development
- SMART Standard Design
- Technology Validation Licensing
- Safety Enhancement for Post Fukushima Action Plan

Korea & KSA
Pre-Project Engineering
- FOAK Engineering Design
- K.A.CARE HCB
- PSAR

KSA
FOAK Plant Construction
- 2 FOAK Plants Construction
- Licensing (CP, OL)

1997 ~ 2015
3 Yr
5~6 Yr
An independent ongoing study of economics of SMRs (by Argonne National Laboratory and University of Chicago) presented preliminary findings to IDWG meeting attendees.

- Construction learning can bring down overnight cost.
- Predictable and streamlined regulatory and construction schedules that includes strong stakeholder involvement and support can reduce the cost of capital, which in turn can reduce levelized cost.
- Building multiple units at a site will bring down average cost per unit.
  - In some cases SMRs can be competitive with large plants
  - In some cases SMRs can be competitive with natural gas
- Transferring significant capital costs from the site to the factory can be one of the principal factors to reduce contingency costs.
- Standardized, certified designs can reduce duration risk, which is also a key factor reducing the cost of capital.

“Economies of Small and Modular” can be competitive with “Economies of Scale”.

Waste management issues are of interest.
SMR Waste Management

Small PWRs - If no change in fuel then:

- Fuel waste per GW€ similar to PWR’s but:
  - Fuel may not achieve high burnups (inability to shuffle in small cores)
  - Fuel throughput could be higher therefore greater volume of spent fuel

- Slightly larger % of structural waste (pressure vessel is larger fraction of total surface to volume ratio)

- Assume fuel is pond stored for ~20yrs, followed by dry store or reprocessing

- Key issues remain for plant decommissioning Co-60 from vessel/pipes/ internals, C-14, Ni and Fe isotopes.

Product of the UK National Nuclear Laboratory
Reviewed the IAEA’s “Milestones in the Development of a National Infrastructure for Nuclear Power” document

- No identified differences in how a country would need to develop its national infrastructure for LW SMR deployment versus a large reactor (i.e., no steps that could be skipped)

IAEA should be able to effectively safeguard LW SMRs, they may just be more resource intensive on a per MW basis (or even a per site basis)

Several technical features provide advantages against subnational threats

Overall, features indicate only small safeguards and physical protection differences relative to deployment of conventional LWRs

There are uncertainties to this assessment, as LW SMR designs are still evolving
SMR Regulators Forum

- Forum established in 2015 to look at regulation of SMRs
  - Capture good practices and methods
  - Interact with key stakeholders
  - Propose changes, if necessary to requirements and regulatory practices
- Two year pilot project – extended following positive results
- Seven countries initially involved
  - Canada, China, Finland, France, Korea, Russia, US (added UK and Saudi Arabia later)
- Several areas considered, e.g. EPZ to site boundary
- Currently has three working groups: Licensing Issues; Design and Safety Analysis; and Manufacturing, Commissioning and Operation
- Not highlighting specific technologies: LWR & HTGR

The need to review IAEA Safety Standards to ensure proper applicability to SMR was highlighted at the IFNEC SMR Workshop.
Challenges in Regulating SMRs
Paris May, 2018

- Common Issues in Safety, Licensing and Regulatory Frameworks for SMR Deployment - Stewart Magruder, IAEA
- Readiness for Regulating Small Modular Reactors - Hugh Robertson, Director General, Canadian Nuclear Safety Commission
- Regulating the Argentine CAREM Reactor - Nestor Masriera, ARN, Argentina
- Licensing for SMART in Korea - Seunghun Yoo, KINS
- Licensing of Floating Power Unit “Academician Lomonosov” - Alexey Ferapontov, Russian Federation
- Preparing for Regulating Advanced Nuclear Technologies (ANTS) - Elspeth McGregor, ONR, UK
- Design Certification of the NuScale Small Modular Reactor - Anna Bradford, USNRC
Licensing Challenges for SMRs

NuScale requested exemptions from the following regulations:

1. 10 CFR 50.46a and 10 CFR 50.34(f)(2)(vi) Reactor Coolant System Venting
2. 10 CFR 50.44 Combustible Gas Control
3. 10 CFR 50.62(c)(1) Reduction of Risk from Anticipated Transients Without Scram
4. 10 CFR 50, Appendix A, Electric Power Systems GDCs
5. 10 CFR 50, Appendix A, GDC 33 Reactor Coolant Makeup
6. 10 CFR 50.54(m), Control Room Staffing
7. 10 CFR 52, App. A, GDC 52 Containment Leakage Rate Testing
8. 10 CFR 50, Appendix A, GDC 40 Testing of Containment Heat Removal System
9. 10 CFR 50, Appendix A, GDC 55, 56, and 57 Containment Isolation
10. 10 CFR 50, Appendix K, Emergency Core Cooling System Evaluation Model
11. 10 CFR 50.34(f)(2)(xx) Power Supplies for Pressurizer Relief Valves, Block Valves, and Level Indicators
12. 10 CFR 50.34(f)(2)(xiii), Pressurizer Heater Power Supplies
14. 10 CFR 50.46, Fuel Rod Cladding Material
15. 10 CFR 50, Appendix A, Criterion 27, Combined Reactivity Control Systems Capability
The purpose of the Workshop was to have key stakeholders from the technical, industrial, financial, regulatory, and energy planning authority communities collectively develop optional SMR deployment plans and approaches based on what they believe would have the best chance for success.

Attendance included 120 expert representatives from 35 countries, 90 companies and nuclear-related entities, as well as the IAEA and World Nuclear Association.
At CEM8 (June 2017) Energy Secretary Rick Perry proposed a nuclear initiative under the Clean Energy Ministerial (CEM).

Less than one year later, at CEM9 (May 2018) the initiative was launched by 9 countries and key organizations, led by the United States, Canada, and Japan.

AT CEM 10 (May 2019) in Vancouver, -- for the first time ever -- nuclear was an integrated topic, alongside other clean energy sources such as wind, solar, geothermal, hydro, as well as energy efficiency.

“Nuclear energy’s vitally important but under-recognized contributions to clean air are made even greater by constant innovation. The NICE Future initiative highlights these contributions by reimagining nuclear’s advanced uses and applications. Nuclear provides a cleaner, safer, more reliable and more resilient energy supply for our world.”

Secretary of Energy Rick Perry, May 24, 2018

“We don't see a sustainable energy future in the absence of nuclear.”

IEA Executive Director Fatih Birol, May 24, 2018
The initiative focuses its work into action areas that include research and outreach to help countries understand how nuclear can enable their clean energy systems and reimagine the roles of nuclear.

**Activities**

- Initiate a cross-sectoral dialogue
- Develop resources for policy makers
- Build partnerships and engage in outreach

Integrated nuclear-renewables

Desalination for drinking water

Process heat

Flexible electricity grids

Hydrogen production and energy storage

Advanced smart designs (SMRs/Gen IV)

Nuclear waste reduction

*CEM10 officials discuss the book* Breakthroughs

*NICE Future-Millenial Nuclear Caucus event in Tokyo reaches out to young leaders*
IFNEC Global Ministerial Conference

Bringing the World SMRs and Advanced Nuclear

For more information on IFNEC, please visit www.ifnecc.org.
Thank You for Your Attention

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