Filling the Neutron Gap at CNL after Shutdown of the NRU Reactor

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Chalk River Laboratories is the single largest science and technology laboratory in Canada.

9,100 acres with 200 acres of lab complex
17 nuclear facilities, 70 major buildings
3,100 employees (500 PhDs & Masters)
1,600 engineering, scientific & technical staff

Advanced nuclear fuels and materials research
Radiobiology, radioecology and dosimetry
Hydrogen and hydrogen isotopes management
Nuclear safety, security and risk management
Nuclear and systems engineering
Nuclear chemistry applications
The NRU reactor enabled 60 years of scientific innovation.
500M+ patient treatments
CANDU reactor
Neutron spectroscopy
so now what?
Context shaping our strategy

• Canada is committed to achieving its climate goals
• Nuclear power is 18% of Canada’s energy mix
• Nuclear science and technology (S&T) drives a $6B domestic industry and 60,000 jobs
• $25B is being invested to refurbish CANDU reactors
• Canada has established federal nuclear S&T priorities for CNL for 10 years
• Canada is investing $1.2B over 10 years in CNL to sustain the capabilities needed in its national nuclear laboratory

CNL’s long-term strategy* features small modular reactors, supporting existing reactor fleets and much more

*http://www.cnl.ca/site/media/Parent/Long_Term_Strategy_2017April18.pdf
Canada’s Nuclear S&T Priorities

Supporting the development of biological applications and understanding the implications of radiation on living things

Enhancing national and global security by supporting non-proliferation and counter-terrorism

Nuclear preparedness and emergency response

Supporting safe, secure and responsible use and development of nuclear technologies

Supporting environmental stewardship and radioactive waste management

Science & Technology  
Federal

ENERGY  
HEALTH  
SAFETY & SECURITY  
ENVIRONMENT
Experimental program design

Irradiation test device development

Irradiation oversight at third-party facility

Radioactive material transportation

Post-irradiation examination and analysis

CNL remains a one-stop-shop for nuclear R&D.
Review ongoing and projected irradiations → Identify key parameters → Consolidate into work streams

Gather reactor options → Identify reactor characteristics

Match work streams to reactor options

Identify broadly applicable reactors → Investigate and down select for long-term partnerships

Identify reactors for limited use → Establish irradiation arrangements on a case-by-case basis
Projecting irradiation demand

• Support the development of various reactor designs through fuels and materials irradiations, including specific small modular reactor fuels for qualification, and next generation fuel development

• Underpin studies and experiments related to the aging, safety and life-extension of CANDU and light-water reactors

• Support the training and skills development of Canada’s future nuclear workforce

• Preserve and advance strategically important CNL facilities and expertise

• Leverage existing irradiated material inventory and nuclear data while addressing knowledge gaps related to the development of fuels of interest to Canada and commercial fuel vendors
Advancing SMR Technology Readiness

**TRL 1-3**
Fundamental principle and proof-of-concept testing

**TRL 4-6**
Component or subsystem validation in lab or simulated environment

**TRL 7-9**
Prototype or operational deployment

- Water-cooled
- High-temperature gas
- Sodium-cooled fast
- Lead-cooled fast
- Gas-cooled fast
- Molten salt
- Fusion

http://www.cnl.ca/site/media/Parent/CNL_SmModularReactor_Report.pdf
Defining key parameters for ongoing and future experimental programs

Suggested/actual reactor used
Required Power
Required Max Thermal Flux
Required Max Fast Flux

Irradiation arrangement and test conditions
  - loop, in-core position/channel, reflector position, rabbit, beam port
gas-cooled, flows, pressure/temp, instrumented,…

Required largest thermal flux test volume and thermal flux
Required largest fast flux test volume and fast flux

Time frame (dates), duration and number of tests

Irradiation demand trend, drivers, etc.

Irradiation needs are varied.
<table>
<thead>
<tr>
<th>Work Stream</th>
<th>Thermal Neutron Flux Required (n/cm²/s)</th>
<th>Fast Neutron Flux Required (n/cm²/s)</th>
<th>Irradiation Environment Conditions Required</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FUEL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CANDU Reactor</td>
<td>1.5 to 3.0E+14</td>
<td>&gt;1.0E+14</td>
<td>Pressurized Heavy Water Reactor preferred (CANDU or Advanced CANDU Reactor)</td>
</tr>
<tr>
<td>Light Water Reactor</td>
<td>&gt;1.0E+14</td>
<td>&gt;1.0E+14</td>
<td>Light Water Reactor preferred</td>
</tr>
<tr>
<td>Research Reactor</td>
<td>&gt;1.0E+14</td>
<td>&gt;1.0E+14</td>
<td>Pool Reactor</td>
</tr>
<tr>
<td>Advanced Reactor (fast or thermal)</td>
<td>&gt;2.0E+14 (up to 7E+15)</td>
<td>&gt;2.0E+14</td>
<td>Design-specific advanced reactor conditions</td>
</tr>
<tr>
<td>Advanced Reactor (SCWR)</td>
<td>To be determined</td>
<td>&gt;2.6E+13</td>
<td>Reactor-specific design conditions</td>
</tr>
<tr>
<td><strong>MATERIAL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Neutron Damage</td>
<td>&gt;1.5E+14</td>
<td>&gt;1.0E+14</td>
<td>Reactor-specific design conditions</td>
</tr>
<tr>
<td>Corrosion Loops</td>
<td>0.4 to 1.5E+14</td>
<td>~5.0E+13</td>
<td>Reactor-specific design conditions</td>
</tr>
</tbody>
</table>
Identifying preliminary list of technical characteristics of existing research reactors

### Evaluation Criteria

- **Technical requirements**
- **Strategic partners and cooperation**
- **Cost, transportation, logistics**
- **Reactor accessibility and long-term availability**
- **CNL’s ability to perform key activities to sustain technical competencies**
Exploring several options to address technical requirements

- Utilizing multiple research reactors
- Setting up long-term agreements for reserved space with one or more reactors
- Leveraging the IAEA International Centre based on Research Reactors (ICERR) scheme
- Securing space in an operating power reactor
- Acquiring time on a new test reactor
- Participating in the development of a new test reactor

There is no one-size-fits-all solution.
Providing solutions to challenges in energy, health, safety, security and the environment
What amazing things is the world turning to Chalk River for?


For starters.

Thank you

Merci

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