Canada and the Americas: Status and Market Outlook

USNIC Special Summit
June 6, 2017

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Our services include:

• Nuclear Business Development Advisory services

• Nuclear Energy Outlooks, Forecasts and Publications

• Market and Competitive Research and Analysis

• Market Intelligence Services
Our Recent Publications

Supply Chain Opportunities in the Canadian Nuclear Refurbishment Market
October 2016

Small Modular Reactor Market Outlook Report
Executive Version and Summary Update
June 2016

Supply Chain Opportunities in the UK Civil Nuclear Decommissioning Market

2015 United Kingdom Nuclear Energy Market Outlook
Presentation Overview

Current country statuses and outlooks:

– Canada
– Mexico
– Argentina
– Brazil
**Current Nuclear Energy Baseline in Canada**

**Bruce (Bruce Power LP)**
- 8 operating reactors rated at 6,268 MWe
- Produces 30% of Ontario’s electricity
- The largest operating nuclear plant in the world

**Point Lepreau (NB Power)**
- One reactor (638 MWe)
- Produces 30% of NB’s electricity

**Pickering (OPG)**
- 6 operating reactors rated at 3,094 MWe
- 2 permanently shutdown reactors

**Darlington (OPG)**
- 4 operating reactors rated at 3,524 MWe

Nuclear provides ~60% of Ontario’s electricity!!
Status of Nuclear in Canada

- Refurbishment (CANDU life-extension) of the 4 Units at Darlington Nuclear Generating Station

- Refurbishment of 6 Units at Bruce Power Generating Station plus other activities

- Pickering A & B will be extended until 2022-24, then decommissioned
Massive Investments for Refurbishment

Value of Refurbishments in Canada

$12.8 billion
Value of Darlington Refurbishment, Units 1-4.

$13 billion
Value of Major Component Replacement and Aging Management Program to refurbish Units 3-8 at Bruce Power
What is a CANDU® Refurbishment?

- CANDU® reactors are designed to have major components replaced during their lifespan
  - removal and replacement of pressure tubes, calandria tubes, feeder tubes, and other primary in-core systems

- Primary reason for this is use of zircalloy alloy components in a CANDU®
  - Robust under immense heat and pressure
  - Experience life-shortening metallurgical changes during operation (e.g., growth, sagging, and brittleness)
The CANDU® Power Reactor

- Large heat sinks
- Modular design
- On-power re-fueling
- Heavy water moderator
- Heavy water primary coolant
- Calandria tube
- Fuel bundle
- Pressure tube
Refurbishment – Darlington NGS

- Owned & Operated by Ontario Power Generation
  - OPG also is General Contractor and Project Manager for refurbishment project
  - OPG is a Crown Corporation owned by the Government of the Province of Ontario

- The four 934 MWs reactors will undergo a refurbishment between 2016 and 2025
Breakdown of Schedule for Darlington Refurbishment

90% of work has already been allocated to Ontario-based companies for Unit 1
Refurbishment – Bruce NGS

- Owned & Operated by Bruce Power LP

- 6 Units will undergo Major Component Replacement (MCR) from 2020-2033: C$8 billion

- Other life-extension activities from 2017-53 will total: C$7.3 billion

- Work is being awarded

- RFIs and RFPs available at www.brucepower.com
Work Packages for Bruce Refurbishment

• **Major Component Replacement (MCR):**
  – Replacement of Fuel Channels (Detube/Retube)
  – Replacement of Feeder Pipes
  – Replacement of Steam Generators
  – Bulkheads Installation and Removal
  – Enabling, Associated and Other Work
  – One-Time Costs

• **Asset Management (AM):**
  – Buildings and Structures
  – Fuel Route
  – Heat Exchangers
  – Pumps and valves
Potential Pinch Point for Supply Chain
Key Success Factors for Winning Business in Canada

• While there is focus on localization, several procurements will need to be sourced from outside of Canada.

• Some of the keys to success in this market include:
  – Developing and maintaining relationships with existing Canadian nuclear suppliers;
  – Setting out clear costs and timelines;
  – Delivering on quality; and
  – Helping to ensure that the overall project requirements are met.
Forecast for Nuclear in Canada

• Ontario’s Long Term Energy Plan (LTEP) states Government will continue to rely on nuclear as the backbone of the Province’s energy needs
  – 42% by 2025 (Bruce and Darlington)

• New nuclear builds are on hold

• SMRs and Advanced Reactors are being examined in Saskatchewan (~2027), Ontario, Alberta and potentially Northern Canada
MEXICO
Status of Nuclear in Mexico

• Mexico has two nuclear reactors generating almost 4% of its electricity
• The Federal Electricity Commission (CFE) is responsible for nuclear generation

Operating Mexican power reactors

<table>
<thead>
<tr>
<th>Reactors</th>
<th>Model</th>
<th>Net MWe</th>
<th>First power</th>
<th>Operating to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laguna Verde 1</td>
<td>BWR</td>
<td>800 approx</td>
<td>1989</td>
<td>2029</td>
</tr>
<tr>
<td>Laguna Verde 2</td>
<td>BWR</td>
<td>800 approx</td>
<td>1994</td>
<td>2034</td>
</tr>
<tr>
<td>Total (2)</td>
<td></td>
<td>1600 MWe</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Future of Nuclear in Mexico

- High-level government support for an expansion of nuclear power

- CFE’s most aggressive scenario for new power generation included up to ten new nuclear plants
  - Tentative schedule of commercial operation between 2026-2028
  - Low gas prices have recently overshadowed this

- Long term, SMRs may be considered for desalination of seawater for agricultural use
ARGENTINA & BRAZIL
Current Status of Nuclear in Argentina

- 3 PHWRs provide 4.4% of total generation

<table>
<thead>
<tr>
<th>Reactor</th>
<th>Location</th>
<th>Model</th>
<th>Net MWe</th>
<th>First power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atucha 1/Peron</td>
<td>100 km NW of Buenos Aires</td>
<td>PHWR (Siemens)</td>
<td>335</td>
<td>1974</td>
</tr>
<tr>
<td>Atucha 2/Kirchner</td>
<td>PHWR (Siemens)</td>
<td>692</td>
<td>June 2014</td>
<td></td>
</tr>
<tr>
<td>Embalse</td>
<td>Córdoba</td>
<td>PHWR (CANDU-6)</td>
<td>600</td>
<td>1983</td>
</tr>
<tr>
<td>Total (3)</td>
<td></td>
<td></td>
<td>1627 MWe</td>
<td></td>
</tr>
</tbody>
</table>

- Embalse reactor currently undergoing refurbishment to extend life another 30 years

- Carem-25 – Construction of SMR now underway at Atucha site
New Nuclear in Argentina

- **Atucha 3 (750 MW-rated, PHWR CANDU 6®)**
  - Contracts signed in May 2017, US$6 billion estimated cost
  - Construction start: 2018
  - Nucleoeléctrica Argentina SA (NASA): owner & architect-engineer as well as builder and operator, 70% local content
  - CNNC: technical support, equipment & instrumentation, financing
  - SNC-Lavalin / Candu Energy: subcontractor to CNNC

- **Atucha 4 (1,100 MW, Hualong One)**
  - Final agreement signed by China and Argentina in May 2017, including 85% Chinese financing
  - US$7 billion estimated cost
  - Between 50% and 70% of components and 100% of the civil works for the reactors will be sourced in Argentina
Current Status of Nuclear in Brazil

- Two nuclear reactors generate 3% of its electricity
- Reliance on hydropower (88%) leaves Brazil vulnerable to supply shortages during low rainfall years

Operating Brazilian power reactors

<table>
<thead>
<tr>
<th>Reactor</th>
<th>Model</th>
<th>Net capacity</th>
<th>First power</th>
<th>Commercial operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angra 1</td>
<td>PWR</td>
<td>626 MWe</td>
<td>1982</td>
<td>1/1985</td>
</tr>
<tr>
<td>Angra 2</td>
<td>PWR</td>
<td>1270 MWe</td>
<td>2000</td>
<td>12/2000</td>
</tr>
<tr>
<td>Total (2)</td>
<td></td>
<td>1896 MWe</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
New Nuclear in Brazil

• Angra 3 (1,405 MWe PWR)
  – Completion contract has been annulled – plant is half completed
  – Government announced plans to sell Angra 3 by 2018. Russian and Chinese investors are interested. Eletronuclear will be the operator.

• Two or more additional reactors being considered
  – AP1000 (Westinghouse)
  – Atmea-1 (Areva-Mitsubishi)
  – VVER (Russia)

• Financing is a challenge
CONCLUSIONS

• New international project and financing models are being implemented, led by Chinese financing.

• Major opportunities exist in Canada, particularly in the supply of equipment and services to the refurbishment projects.

• Potential for SMR deployment post-2027.
Let’s Get Started!

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