Strategic Insights Inc.

- 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 - Coming Soon!
Presentation Overview

Current status and outlooks:

- Canada
- Mexico
- Argentina
- Brazil
O CANADA, OUR HOME AND CLICHÉ LAND
A geographical guide to Canadian stereotypes
Current Baseline Nuclear Energy in Canada

**Bruce (Bruce Power LP)**
- 8 operating reactors rated at 6268 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 3094 MWe
- 2 permanently shutdown reactors

**Darlington (OPG)**
- 4 operating reactors rated at 3524 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 begins in October 2016
  - C$12.8 billion
  - 2016-2025

- Refurbishment of 6 Units at Bruce Power Generating Station plus other activities
  - C$13 billion
  - 2020-2033 (refurbishment), 2016-2053 (other activities)

- Pickering A & B will be extended until 2022-24
What is a 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, brittleness)
The CANDU® Power Reactor

- Large heat sinks
- On-power re-fueling
- Modular design
- Calandria tube
- Fuel bundle
- Pressure tube

Heavy water moderator

Heavy water primary coolant
Refurbishment - Darlington

- 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

- Four 934 MW reactors will undergo a refurbishment between 2016 and 2025
Work Packages for Darlington Refurbishment

1. Retube and Feeder Replacement (“RFR”)
   – Removal and replacement of pressure tubes, calandria tubes and feeders in each reactor

2. Turbine Generators
   – Inspections and repairs of four turbine generator sets

3. Fuel Handling
   – Defueling reactor and refurb of fuel handling equipment

4. Facility and Infrastructure Projects

5. Balance of Plant
   – E.g. Piping and valve work

6. Steam Generators
   – Mechanical cleaning, water lancing, inspection and maintenance work of the generators
Breakdown of Schedule for Darlington Refurbishment

- Retube and Feeder Replacement: 60%
- Turbine Generators: 12%
- Steam Generators: 4%
- Balance of Plant: 4%
- Prerequisite Projects: 10%
- Fuel Handling: 10%

90% of work has already been allocated to Ontario-based companies
Refurbishment - Bruce

• 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 2016-53 will cost C$5 billion, of which the short-term investments between 2016-2020 will total: C$2.3 billion

• Planning and initial RFQs for equipment has begun
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
Bruce Refurbishment Timetable
Forecast for Nuclear in Canada

• Ontario’s Long Term Energy Plan 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
- Federal Electricity Commission (CFE) is responsible for nuclear generation

<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

• 2015 - Development Program of the National Electric System included plans for three additional nuclear power 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
SOUTH AMERICA
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></td>
<td>PHWR (Siemens)</td>
<td>692</td>
<td>June 2014</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 (800 MW PHWR Candu 6)
  – Contracts signed in November 2015, US$6 billion
  – Nucleoeléctrica Argentina SA (NASA): owner & architect-engineer as well as builder and operator
  – CNNC: technical support, equipment & instrumentation, financing
  – CANDU: subcontractor to CNNC

• Atucha 4 (1,100 MW, ACP1000)
  – Framework agreement signed by China and Argentina in November 2015, includes lifetime supply of enriched uranium and fuel assemblies
  – US$7 billion, 50-70% locally sourced
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 MW PWR)
  – Completion contract awarded to Areva, US$7.59 billion
  – Expected 2018 operational date

• Additional reactors being considered
  – AP1000 (Westinghouse)
  – Atmea-1 (Areva-Mitsubishi)
  – VVER (Russia)
  – APR1400 (Korea)
  – CAREM (Argentina)

• Financing is a challenge
Conclusions

• New international project and financing models are being developed
  – Sign of the future!

• 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!

Strategic Insights Inc.
310 Front Street West
Suite 802
Toronto, Ontario
M5V 3B5
CANADA

+1 (416) 430-0468

Strategic Insights USA Inc.
1250 Connecticut Avenue N. W.
Suite 200
Washington, D.C.
20036
UNITED STATES

+1 (202) 827-7368

+1 888 405-9998
info@strategicinsights.ca

https://strategicinsights.ca/