

Canada and the Americas: Status and Market Outlook

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- Our services include:
 - Nuclear Business Development Advisory services
 - Nuclear Energy Outlooks, Forecasts and Publications
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 - Market Intelligence Services



Our Recent Publications

STRATEGIC } INSIGHTS

**Small Modular Reactor
Market Outlook Report**

Executive Version and Summary
June 2016

**Supply Chain Opportunities
in the Canadian Nuclear
Refurbishment Market
- Coming Soon!**

**2015 UNITED KINGDOM NUCLEAR
ENERGY MARKET OUTLOOK**

**SUPPLY CHAIN OPPORTUNITIES
IN THE
UK CIVIL NUCLEAR DECOMMISSIONING MARKET**




STRATEGIC } INSIGHTS

**2015 SMALL MODULAR REACTOR
MARKET OUTLOOK**





Presentation Overview

Current status and outlooks:

- Canada
- Mexico
- Argentina
- Brazil

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

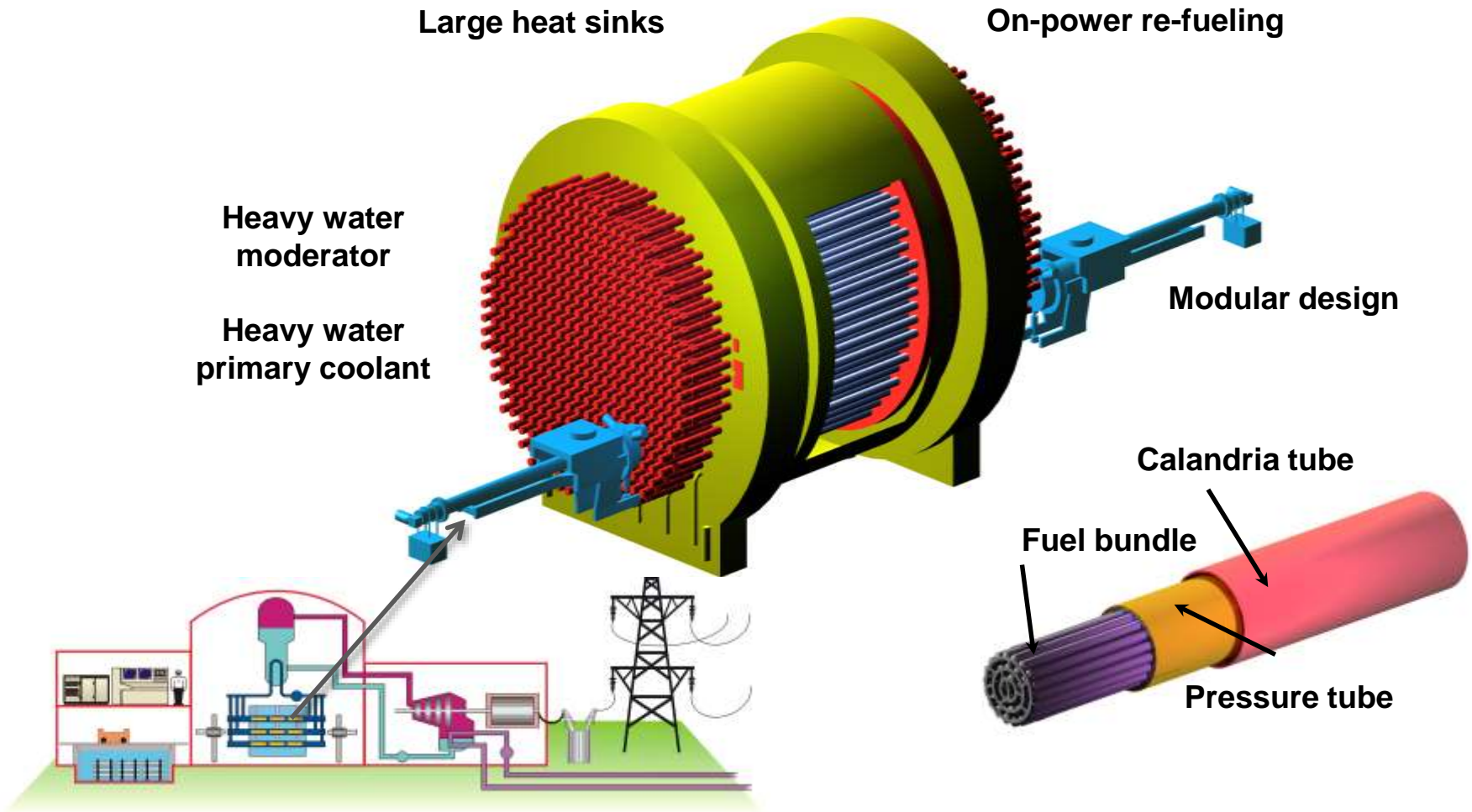
- Refurbishment (CANDU life-extension) of the 4 Units at Darlington Nuclear Generating Station begins in October 2016
 - C\$12.8 billion
 - 2016-2025
- Refurbishment of 6 Units at Bruce Power Generating Station plus other activities
 - C\$13 billion
 - 2020-2033 (refurbishment), 2016-2053 (other activities)
- 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



Refurbishment - Darlington

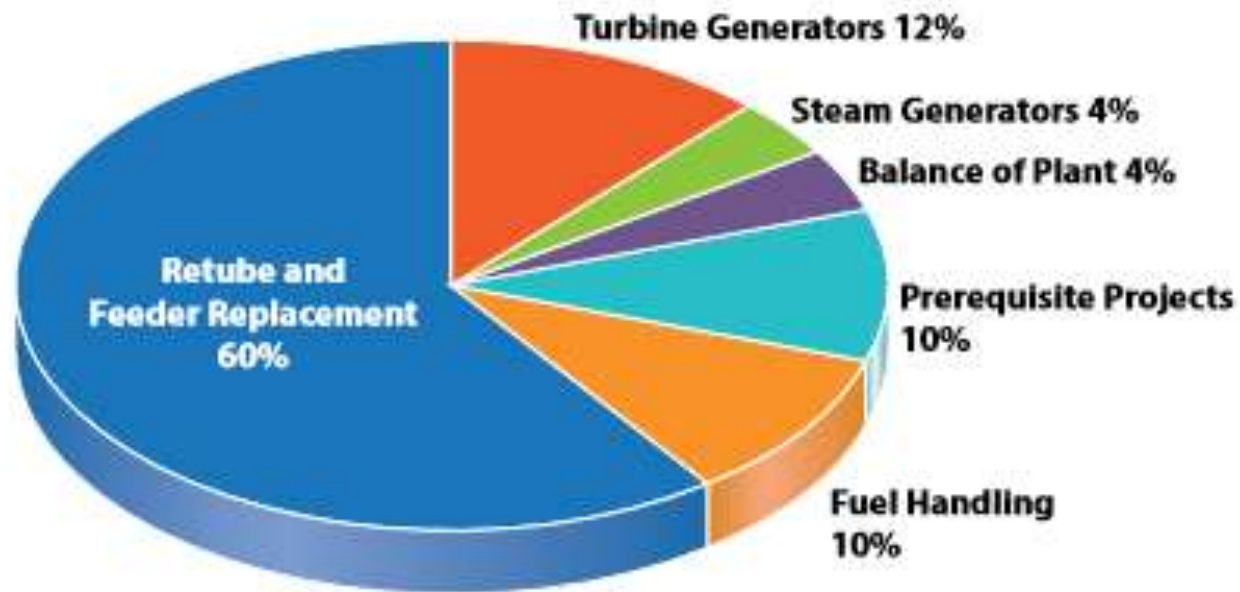
- Owned & Operated by Ontario Power Generation
 - OPG also is General Contractor and Project Manager for refurbishment project
 - OPG is a Crown Corporation owned by the Government of the Province of Ontario
- Four 934 MW reactors will undergo a refurbishment between 2016 and 2025



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



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

Refurbishment - Bruce

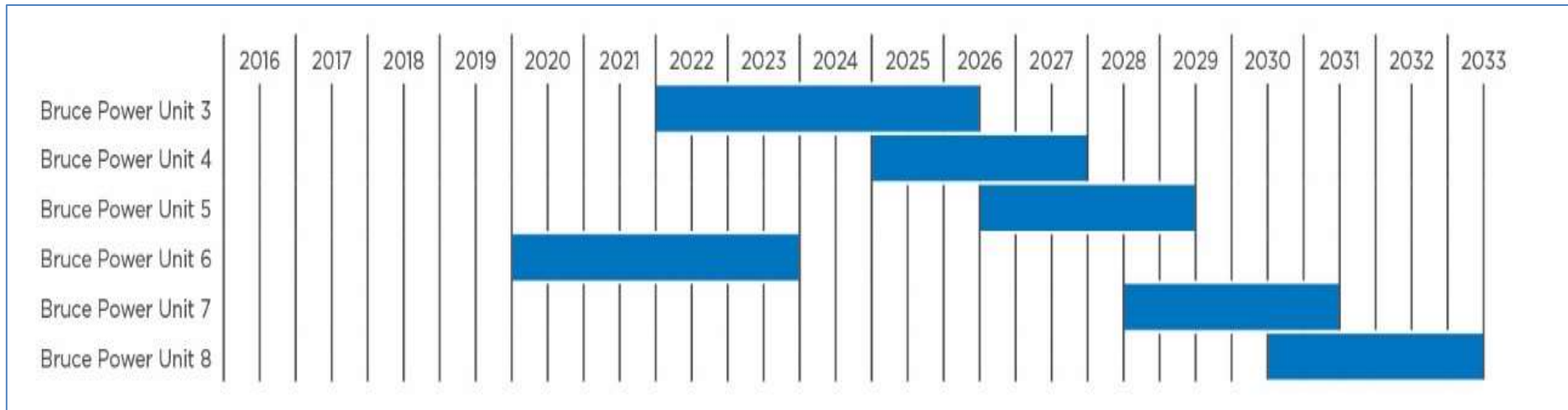
- Owned & Operated by Bruce Power LP
- 6 Units will undergo Major Component Replacement (MCR) from 2020-2033: C\$8 billion
- Other life-extension activities from 2016-53 will cost C\$5 billion, of which the short-term investments between 2016-2020 will total: C\$2.3 billion
- Planning and initial RFQs 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

Operating Mexican power reactors

Reactors	Model	Net MWe	First power	Operating to
Laguna Verde 1	BWR	800 approx	1989	2029
Laguna Verde 2	BWR	800 approx	1994	2034
Total (2)		1600 MWe		



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

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

- 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

Reactor	Model	Net capacity	First power	Commercial operation
Angra 1	PWR	626 MWe	1982	1/1985
Angra 2	PWR	1270 MWe	2000	12/2000
Total (2)		1896 MWe		

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/>