Énergie NB Power

Life Extension of the Point Lepreau GS – Powering the Future

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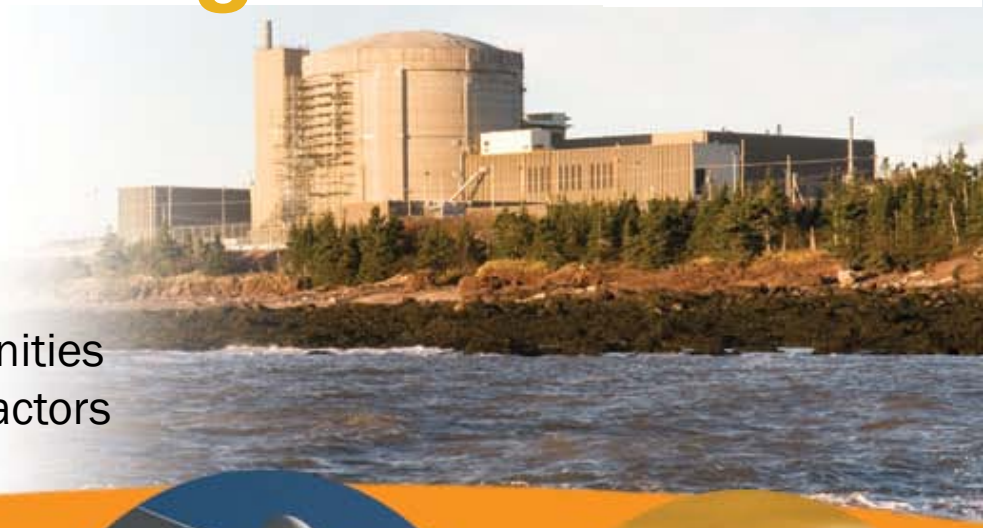
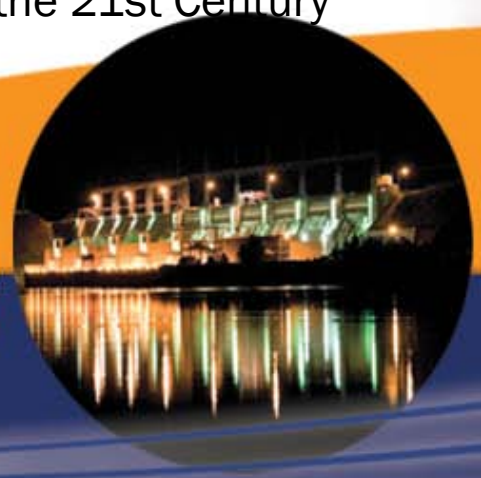
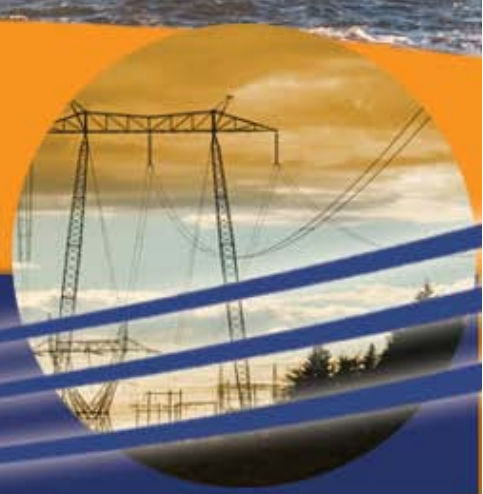
New Brunswick - Canada



October 27 – 30, 2009

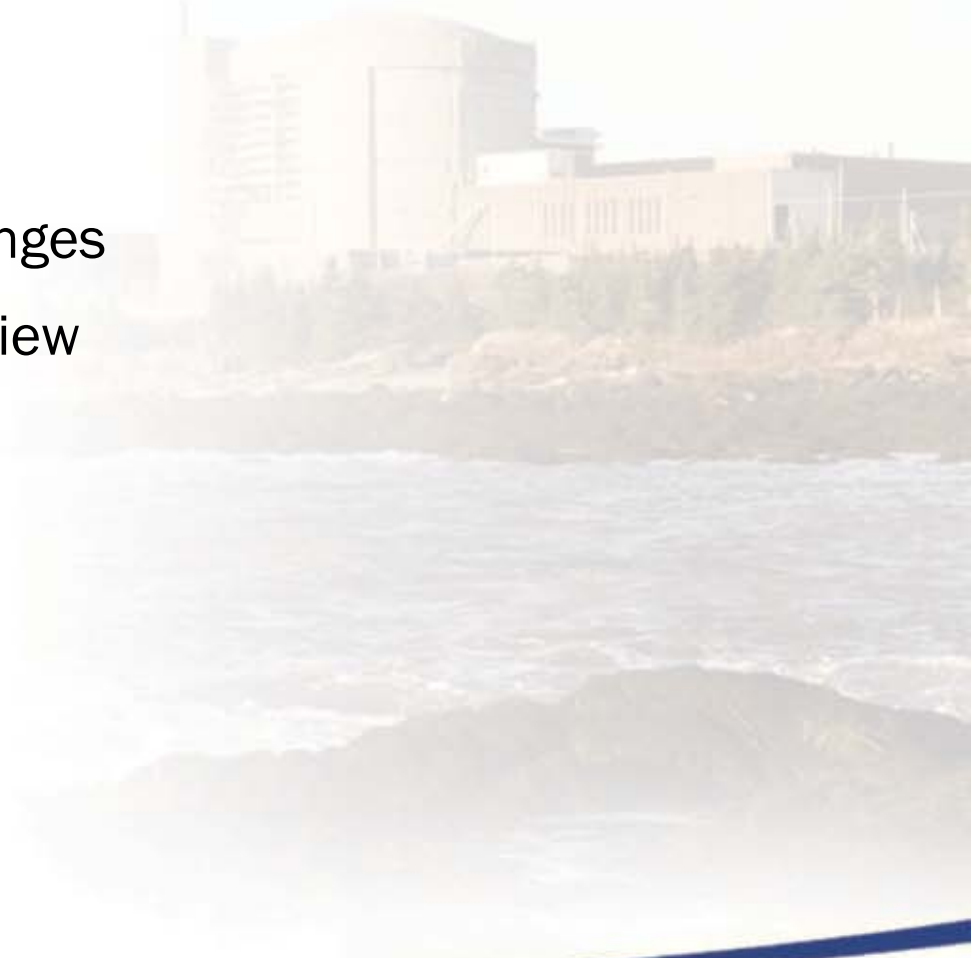
International Conference on Opportunities and Challenges for Water Cooled Reactors in the 21st Century





Outline

- Company profile
- Station design
- Early performance
- Operational challenges
- Refurbishment review
- Summary



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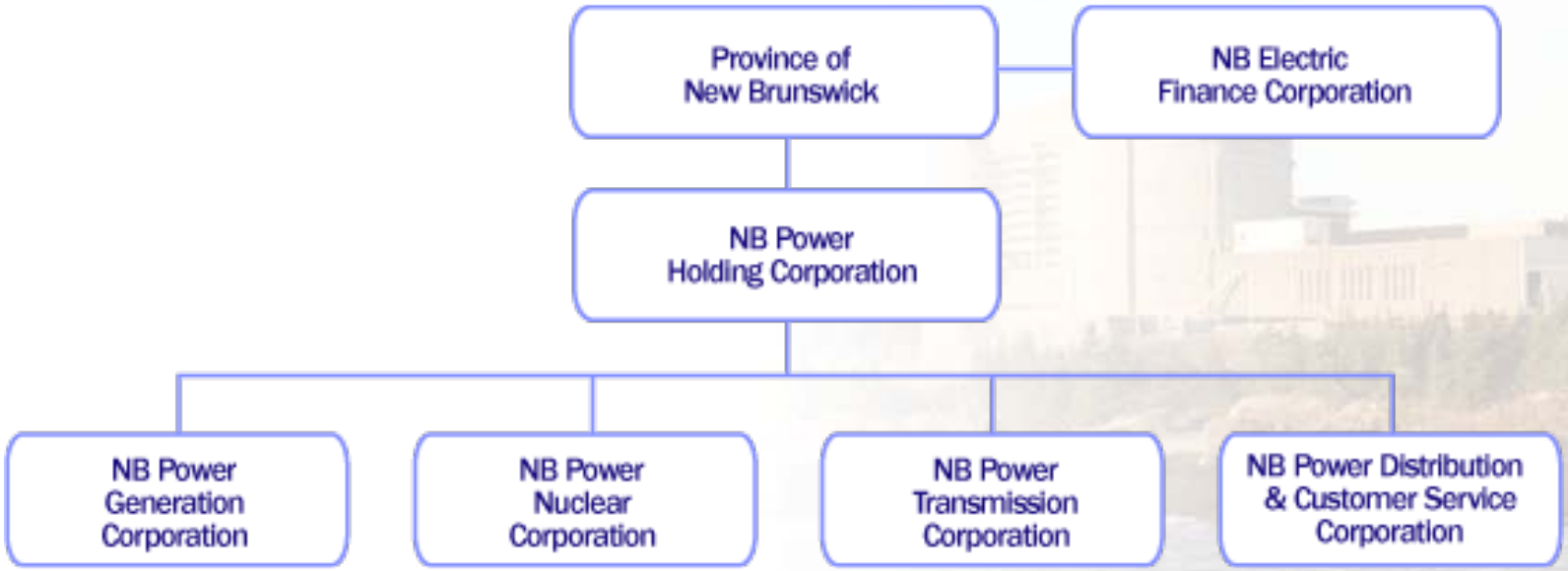
NB Power Group



- 86-year-old government-owned utility
- Holding company and four operating companies

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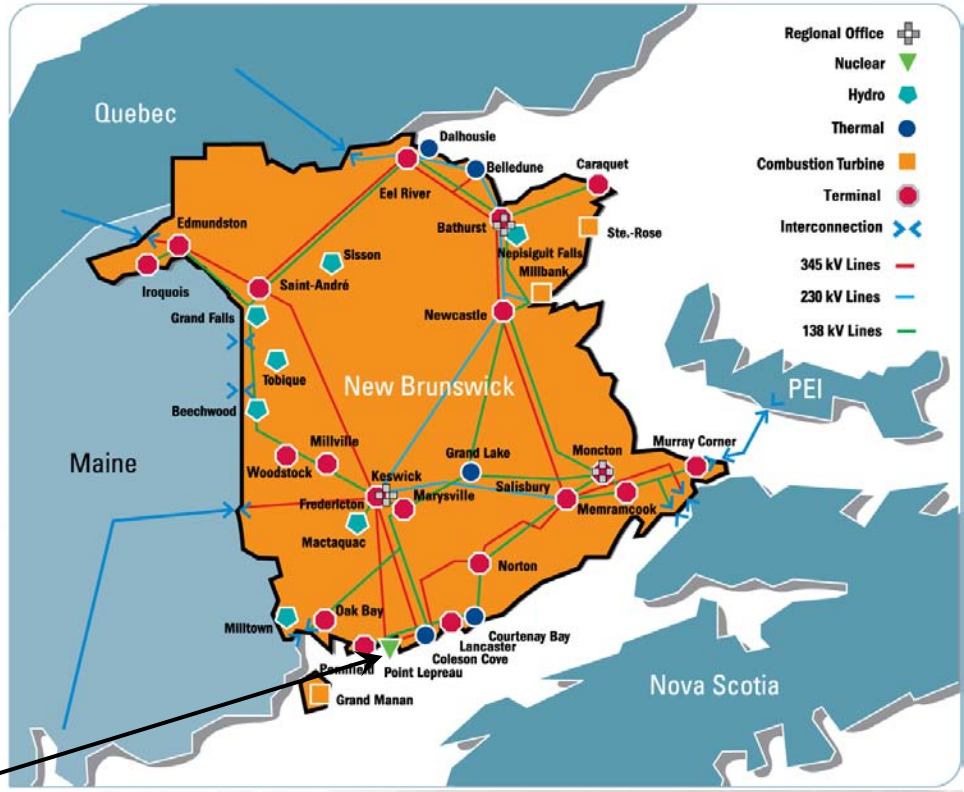
NB Power Overview

- Nuclear, Oil, Coal, Gas, Petcoke, Hydro, Diesel, Wind
- 20,284 kilometres of distribution line
- North America's most diverse networks of generating stations with installed net capacity of 3,959 MW
- Interconnects with Quebec, Maine, Nova Scotia and Prince Edward Island
  - export capacity 2,416 MW
  - Import capacity 2,209 MW



Point Lepreau G.S.

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Point Lepreau Generating Station

- ~750 employees
- First criticality: July 1982
- Commissioned in 1983 - 100% full power in March 1983
- Supplies approximately 25% -30% of in-province load
- Eliminates the need for 162 million barrels of oil
- Averted emissions of about 87 million tonnes of CO_2 during its first lifetime
- Produced 114 million MWh of power
- Lifetime capacity factor of 82%

635 MW net CANDU 6 reactor

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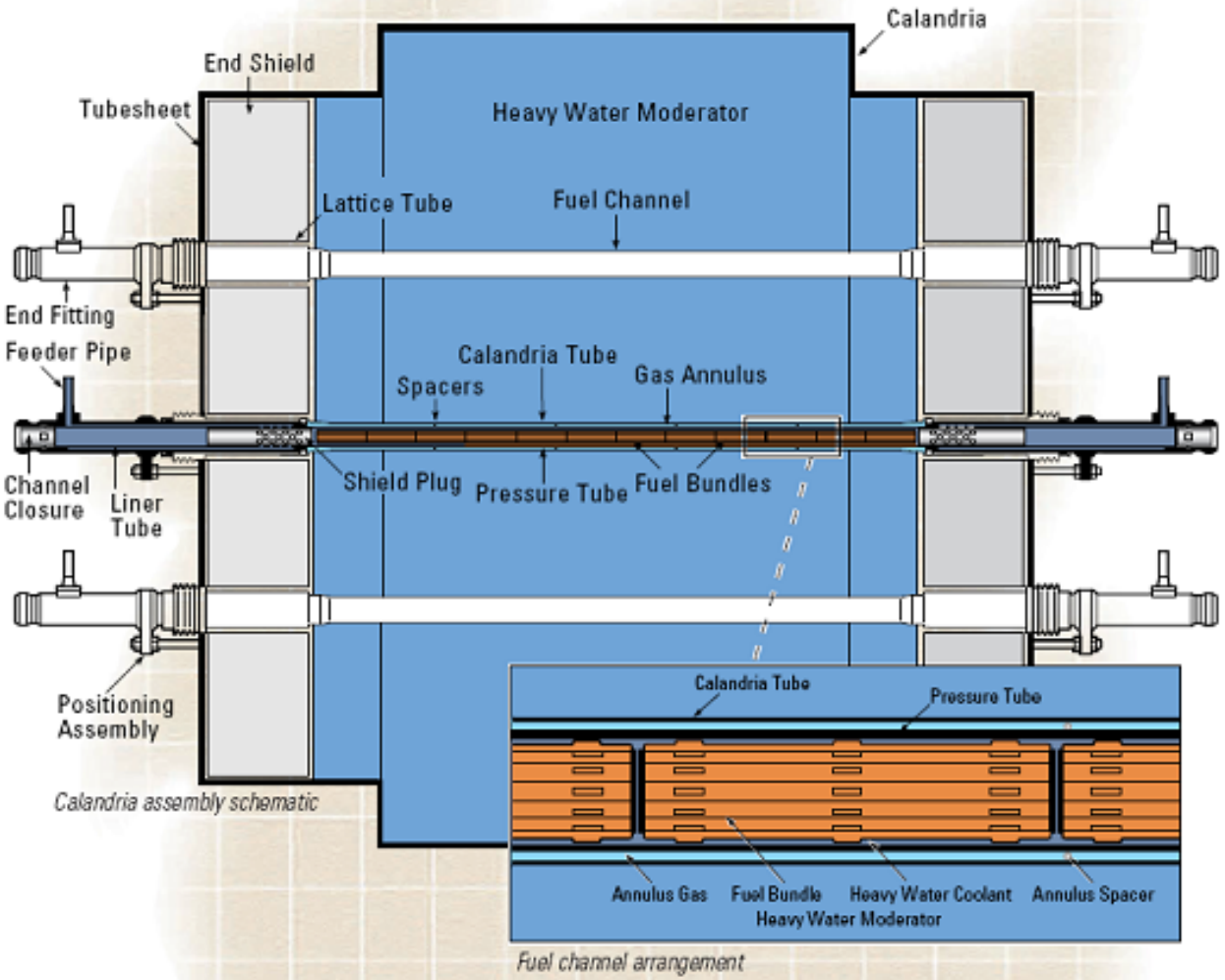
NB Power – Safety our Top Priority

- NB Power became the first full service utility in Canada to reach 12 consecutive months without a lost time accident
- Point Lepreau Generating Station
  - Point Lepreau G.S. staff achieved more than 4.8 million person-hours without a lost-time accident
  - AECL staff and contractors achieved more than 3.5 million person-hours without a lost-time accident
  - Integrated joint health and safety committee with all on-site contractors and NB Power
  - Continue to maintain some of the highest standards for health, safety and training throughout refurbishment and beyond

Reactor Assembly



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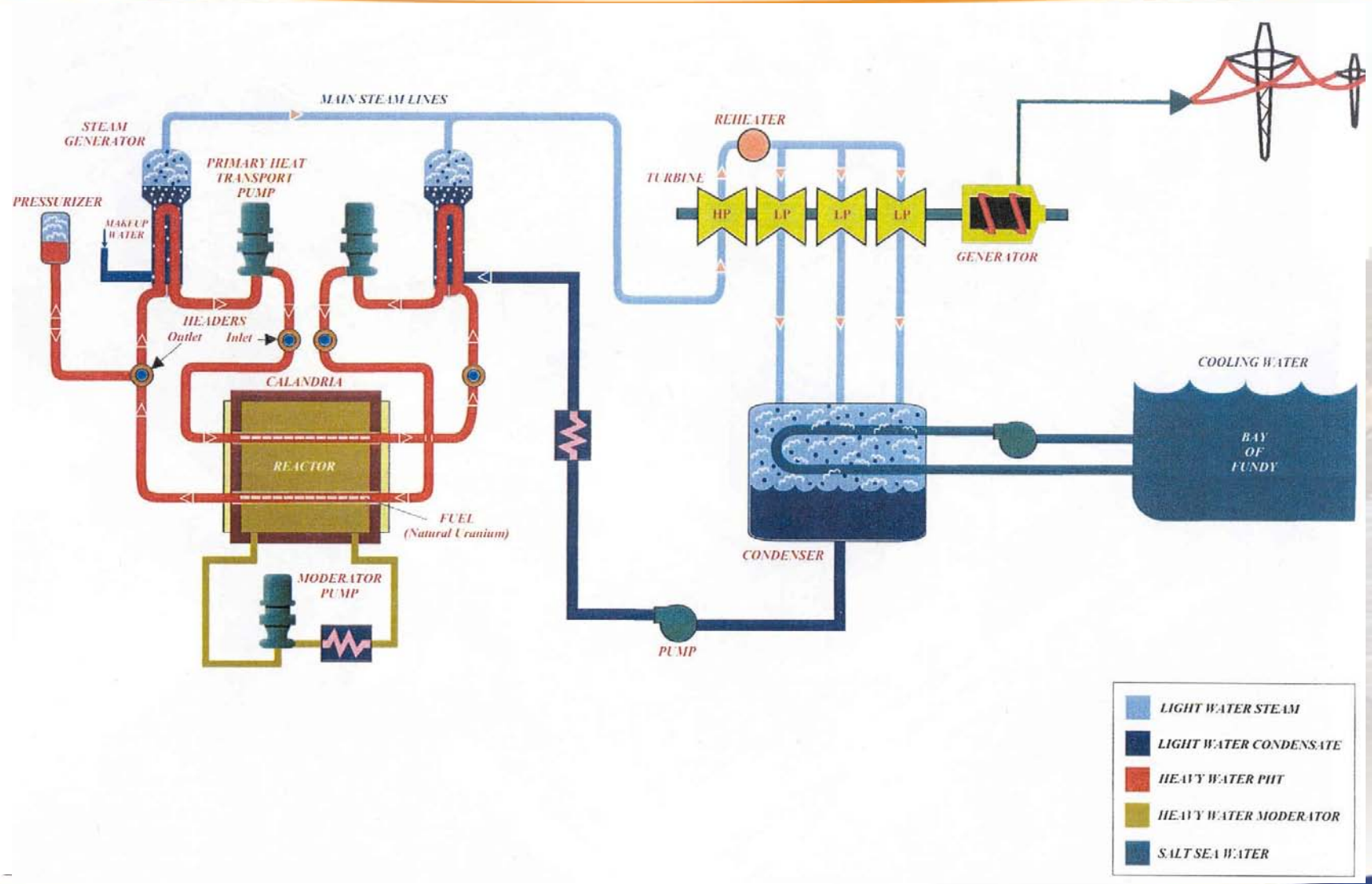
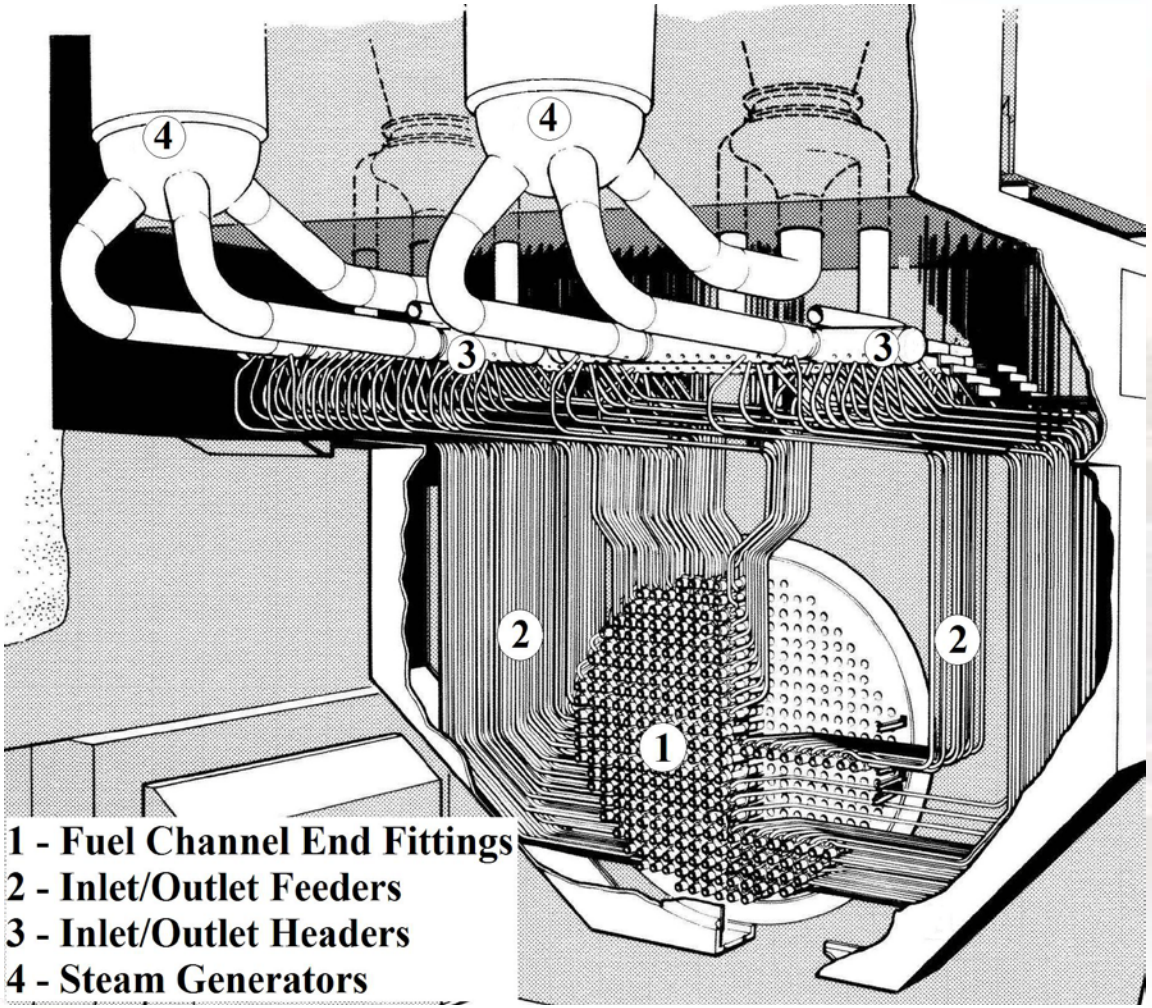
Basic schematic



Heat transport system



Inlets

- 265 Celsius
- 11 Mpa
- 1.5 - 2.5” NPS

Outlets

- 310 Celsius
- 10 MPa
- 2 - 2.5” NPS

Early operation – to 1994

- Annual outages < 30 days
- Average capacity factor = 93.4%
- Very low operating costs
- Established inspection programs
  - fuel channels
  - steam generators
  - turbine/generator

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Onset of ageing issues – mid-'90s

- Fuel channels
- Feeders
- Safety system trip logic
- Station control computers
- Uninterruptable power supply
- Turbine supervisory

Consequence: average capacity factor over the last half of the station's life = 72%

Nuclear safety culture remained strong

Safety margins were maintained

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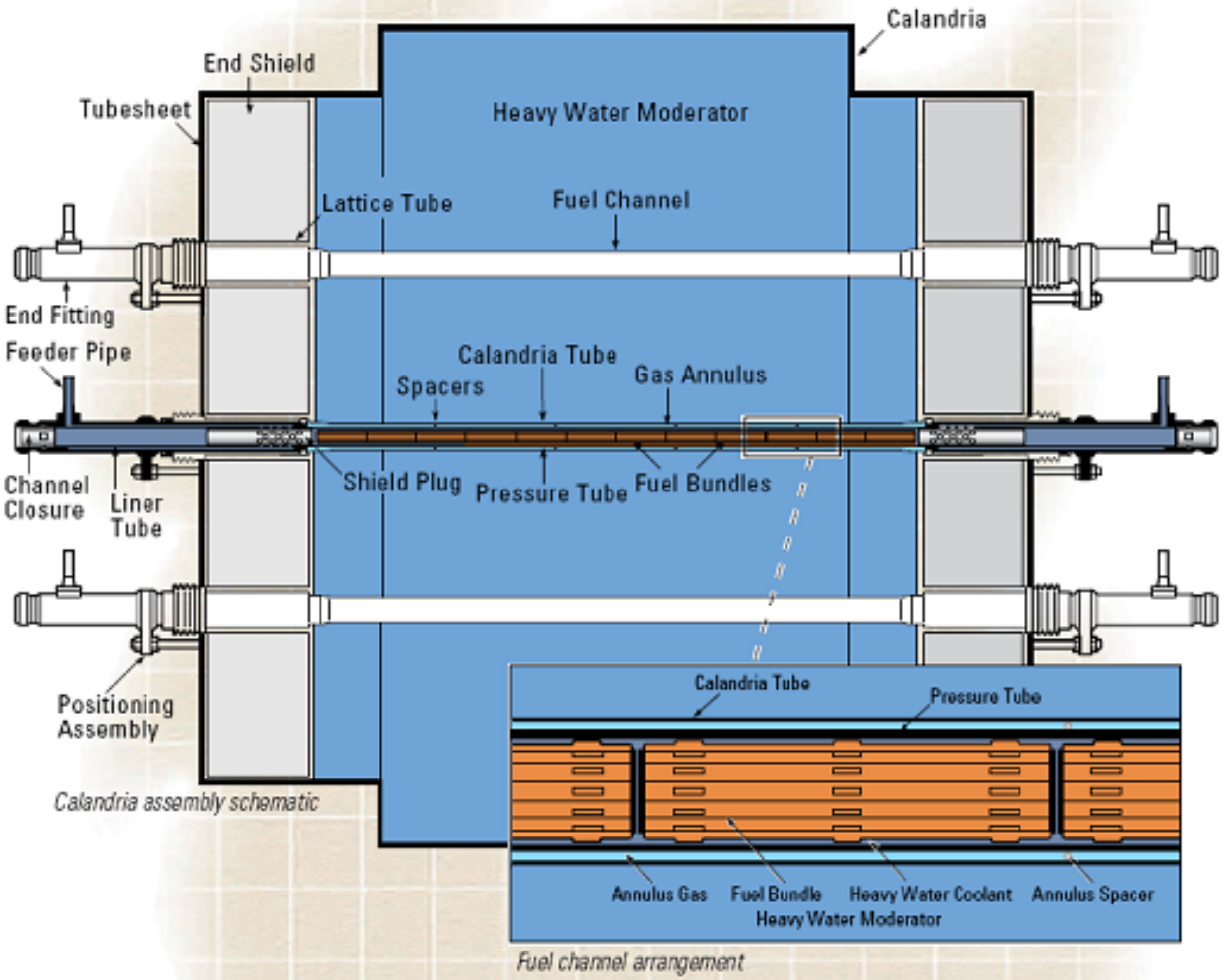
Fuel Channel Assembly



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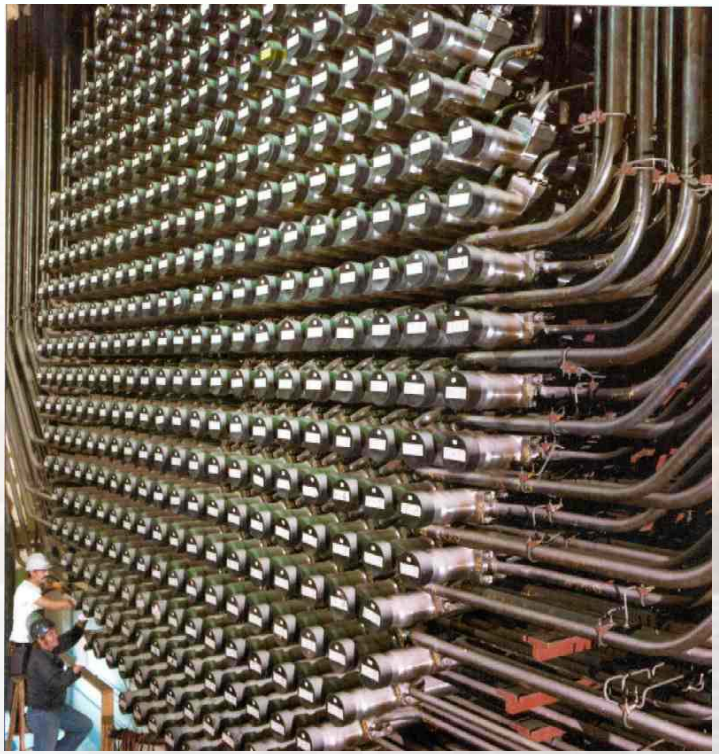
Fuel channels

- Spacer movement
  - Loose fitting spacers may move from design locations
  - Would not operate with contact between cool calandria tube and hot pressure tube – hydride solubility
  - One six-month outage (1995) and subsequent outage extensions

- Pressure tube (PT) diametral creep
  - Redistribution of coolant flow in bundle sub-channels with time
  - Reduction in margin to sheath dryout
  - Reactor derated 1998, ~1% per year (12% cumulative by 2008)

Feeders

- Cracking (outlets)
  - Unplanned outages in 1997 and 2001 because of leaks at bends
  - Large annual inspection campaign initiated
  - Cracks discovered on the ID on bend intrados
  - Cracks discovered on the OD on bend extrados
  - Cracks grew from undetectable to 75% through wall in one year
  - Crack location unpredictable
  - Stress corrosion cracking and low temperature creep cracking
  - Eighteen bends replaced because of cracking
    - two through wall
    - ten partial through wall
    - six falsely identified



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Feeders (continued)

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Feeders (continued)

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Feeders (continued)

- Thinning (outlets)
  - Excessive thinning at bends on outlet feeders in 1995
  - Large annual inspection campaign initiated
  - Predictable rate and location
  - Flow Accelerated Corrosion
  - Affected bends in six feeders replaced in 2005

Life extension process

- 1997/1998
  - Concluded refurbishment of the station was an economical option to other sources of energy
- 1999 - 2002
  - Condition assessments of the systems
- 2005
  - Refurbishment decision
- 2008 March
  - Refurbishment outage started

Refurbishment Outage Scope Drivers

- Safety
  - improved trip coverage
  - improved Core Damage Frequency
  - improved Large Release Frequency
  - codes and standards compliance
  - miscellaneous regulatory issues

} Level 2 PSA

- Economics (necessary and sufficient)
  - near end of life
  - reliability improvement
  - obsolescence
  - alternate operating cycle post-refurbishment

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Scope Determination

- Safety improvements
  - SDS1 and SDS2 trip coverage
  - Add containment filter vent
  - Add emergency source of water to calandria vault
  - Enhance moderator sub-cooling capability
  - Install Hydrogen recombiners
  - Install 3rd Standby Diesel Generator
  - Install 4th Recirculating Cooling Water pump
  - Upgrade fire protection throughout the power block
  - Install ventilation system for MCR

Scope Determination (continued)

- Age management/improve equipment condition
  - Replace fuel channels
  - Replace feeders

  } Retube
  - Calandria internal inspection
  - Rewind generator
  - Replace Shutdown System trip computers
  - Replace UPS
  - Replace vanadium flux detectors
  - Clean primary side of boilers
  - Inspect primary and secondary side of boilers
- Turbine uprate

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Phases of Refurbishment

- Stage 1 - Defuelling and draining
  - Completed on schedule in 2 months
- Stage 2 - Executing the outage work
  - In progress
- Stage 3 - Commissioning and return to service
  - Commissioning started where possible

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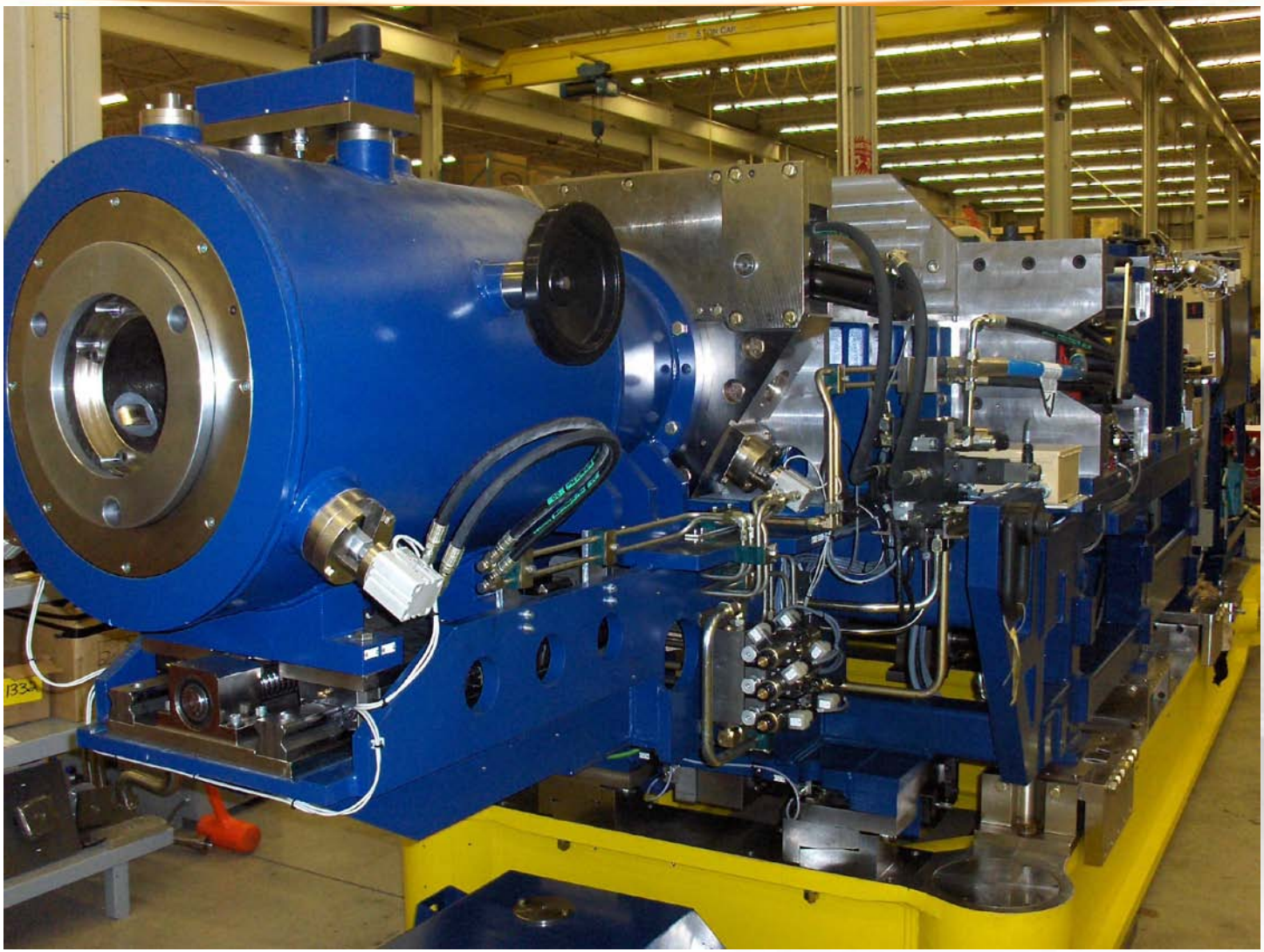
Specialized Tooling



Pressure Tube Volume Reduction

Checker board shear press

Processed tube segments

Complex Job - Pressure Tube Removal

Refurbishment Outage Scope - status

- Safety improvements
  - SDS1 and SDS2 trip coverage
  - Add containment filter vent
  - Add emergency source of water to calandria vault
  - Enhance moderator sub-cooling capability
  - Install Hydrogen recombiners
  - Install 3rd Standby Diesel Generator
  - Install 4th RCW pump
  - Upgrade fire protection throughout the power block
  - Install ventilation system for MCR

Status (continued)

- Age management/improve equipment condition
  - Replace fuel channels
  - Replace feeders

  } Retube

  - Calandria internal inspection
  - Rewind generator
  - Replace Shutdown System trip computers
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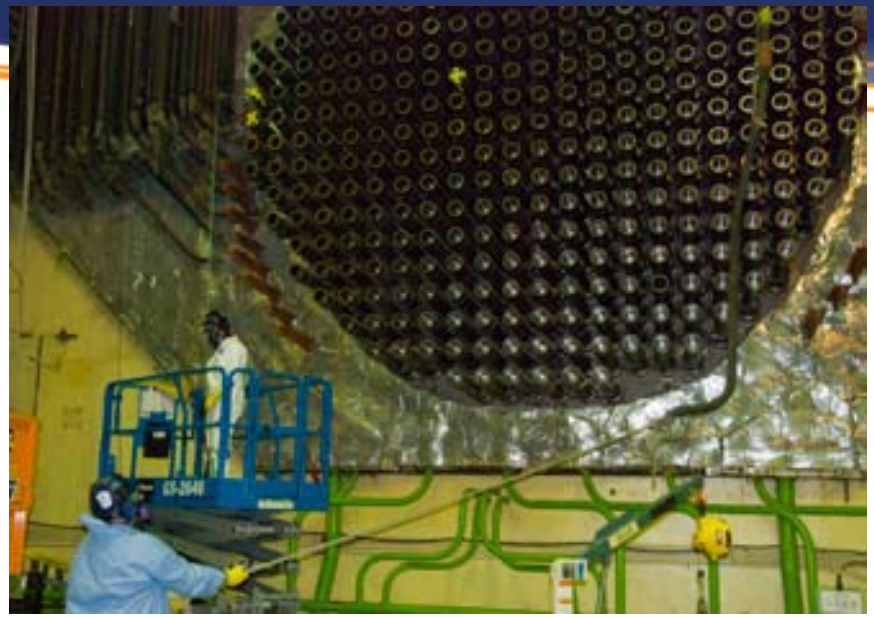
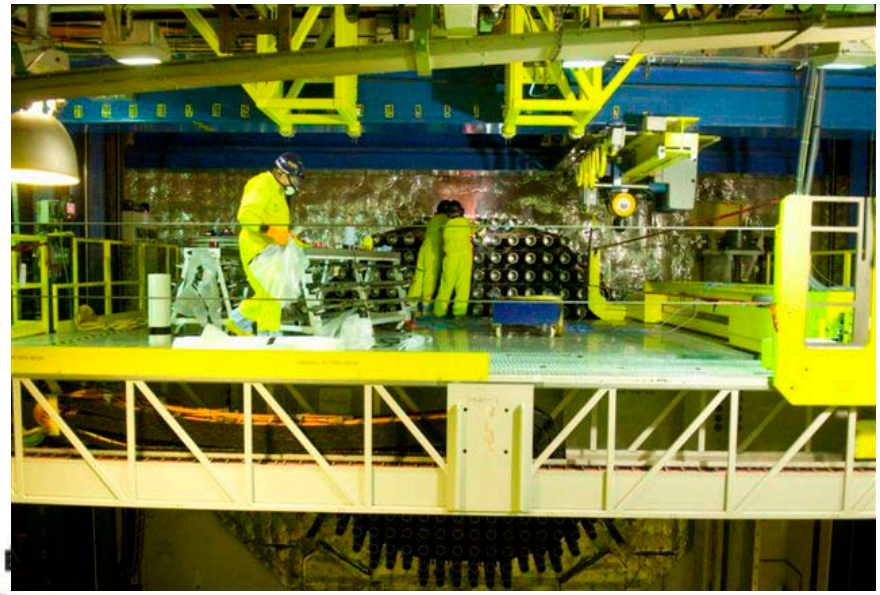
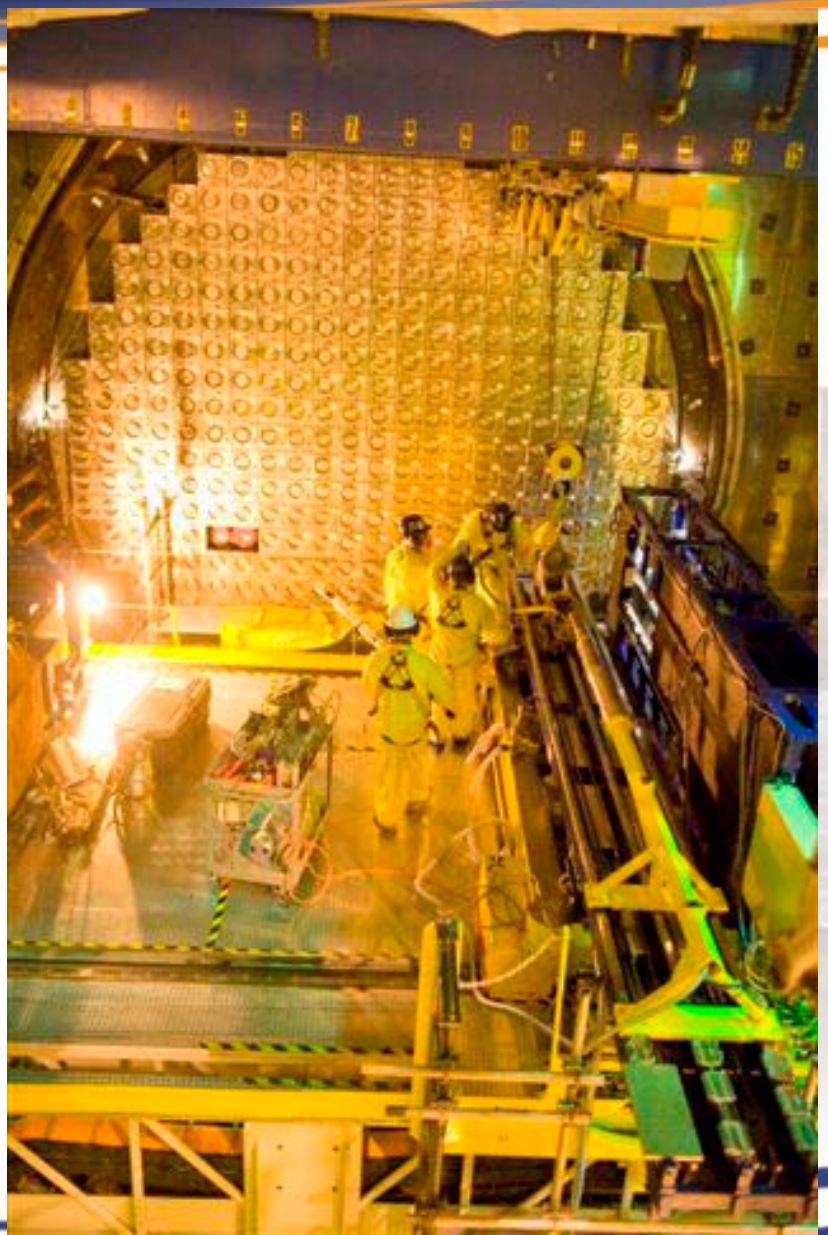
Retube status





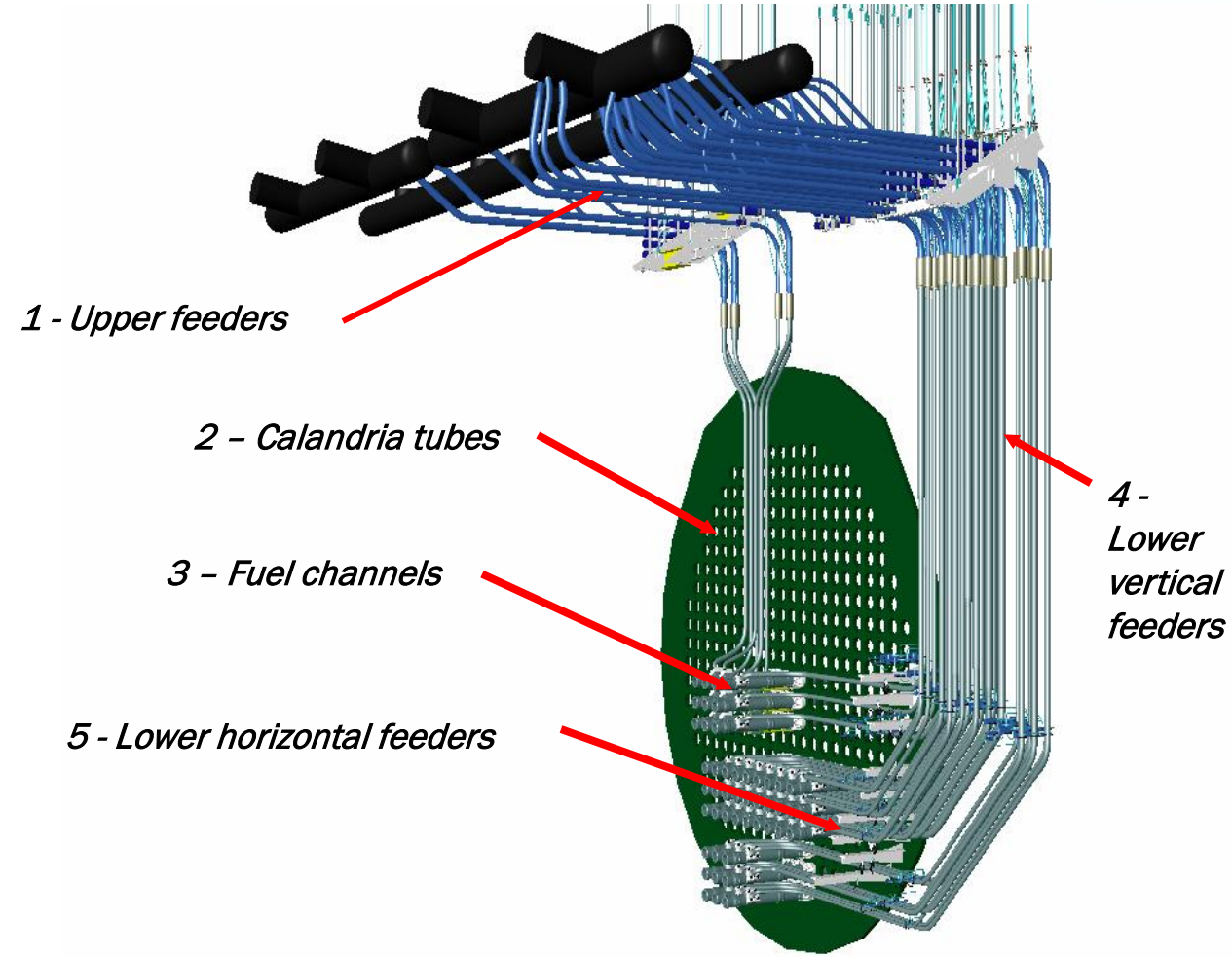
- Disassembly complete
  - End fittings removed
  - Pressure tubes removed
  - Calandria tubes removed
  - Feeders removed
- Inspections in progress
- Installation of upper feeders begun

Calandria Vessel Inspections



Replacement of 780 Feeders

Retube next steps



- Upper Feeder Installation in parallel
- Complete inspections
- Calandria Tube installation
- Install Pressure Tubes
- Install End-Fittings
- Install vertical and lower feeders

Main Generator and Turbine Rotors

- One of three turbine rotors safely delivered to the station and installed
- Two other turbines recovered, delivered and installed
- Alignment of turbines in-progress

- Main generator rotor rewound and reinstalled
- Main generator stator rewound and reinstalled

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Emergent Work

- Replace emergency water line
  - ~1000 m buried pipe
- Condenser tube degradation
  - temporary fix - epoxy sealed inserts
  - full replacement in 2012
- Raw service water pipe in concrete degraded

Partnership – Key Stakeholders

- NB Power continues to implement communication plan activities
- Strong sense of partnership with our communities, main contractors and trade unions
- Periodic refurbishment updates to the Canadian Nuclear Safety Commission (Regulator)

Summary

- Safety and quality continue to be our top priorities
- CANDU 6 is a robust design
- Condition Assessment process was effective
- Comprehensive Age management programs are necessary
- Lessons learned will prove valuable to others considering similar CANDU refurbishments
- Daily progress continues

The Point Lepreau GS will restart successfully and will operate safely and reliably for the next 25 to 30 years.

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Powering the Future....