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International Symposium on PREparation for DECommissioning

Compilation and analysis of national and international OPEX for Safe Enclosure prior to decommissioning

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Purpose of the Presentation

Comparing Canadian SwS experience with the larger pool of experience from the international community to:

- classifying the main issues or themes,
- examining means to mitigate these, and
- formulate general measures of “good practice”.

The CANDU Reactor Fleet in Canada
Operator, Location, units /size (MWe)

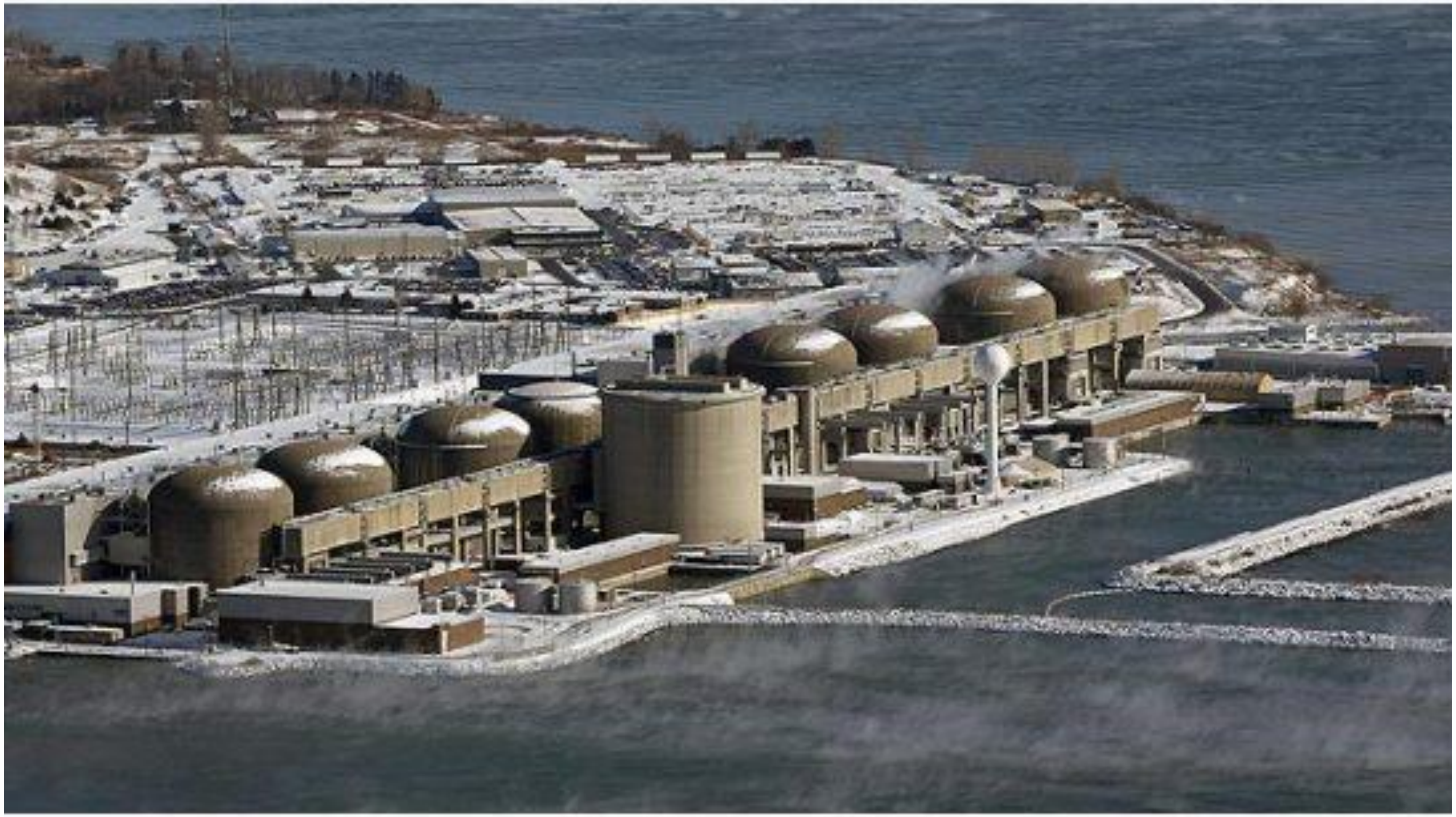
Operational Plants:

- OPG Pickering, 8x540 (2 Permanently SD)
- OPG Darlington 4x880
- Bruce Power 4x750 , 4x~800 (uprated)
- New Brunswick Power 1x600

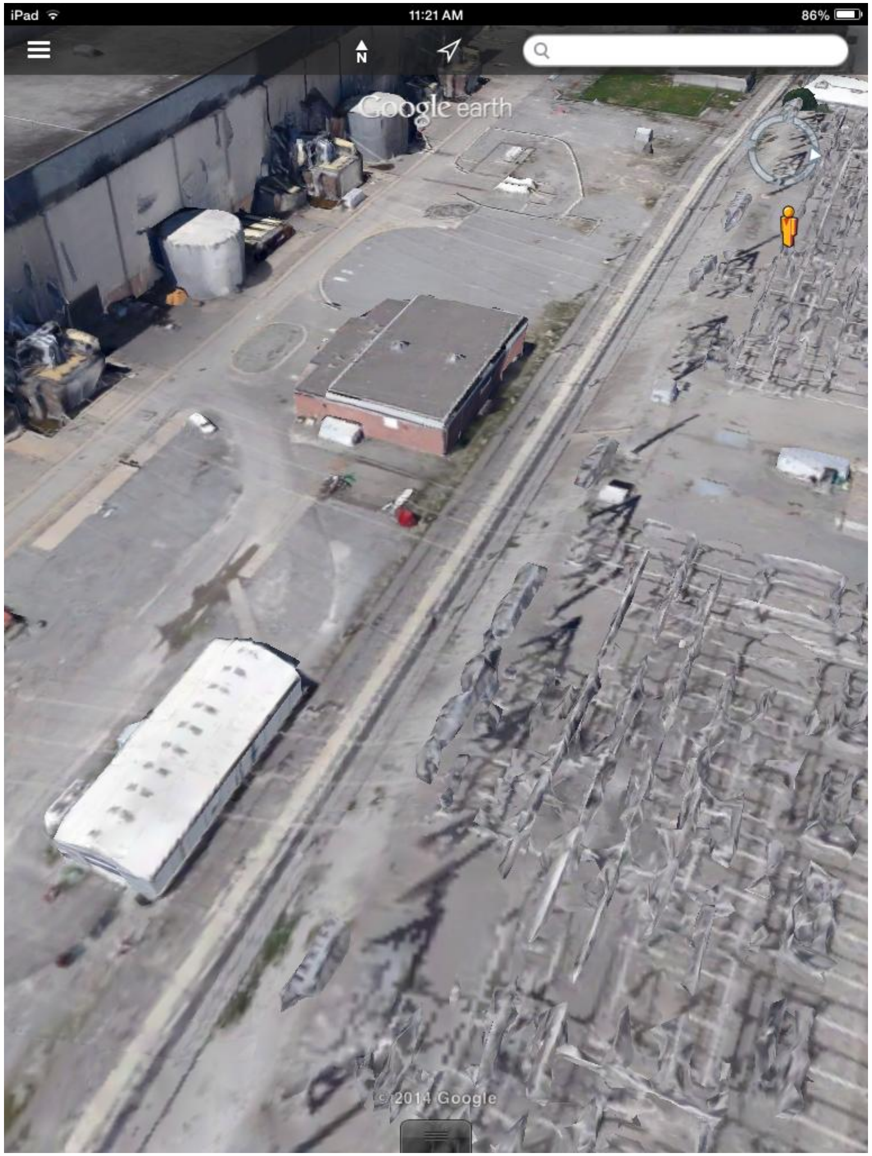
Prototypes & Shut Down Units

- OPG NPD Rolphton 20, Douglas Point 220 (SD-PHWRs)
- Hydro Quebec G1 275 (SD BHWR), G2 675 (SD-PHWR)

Pickering Nuclear Generating Station

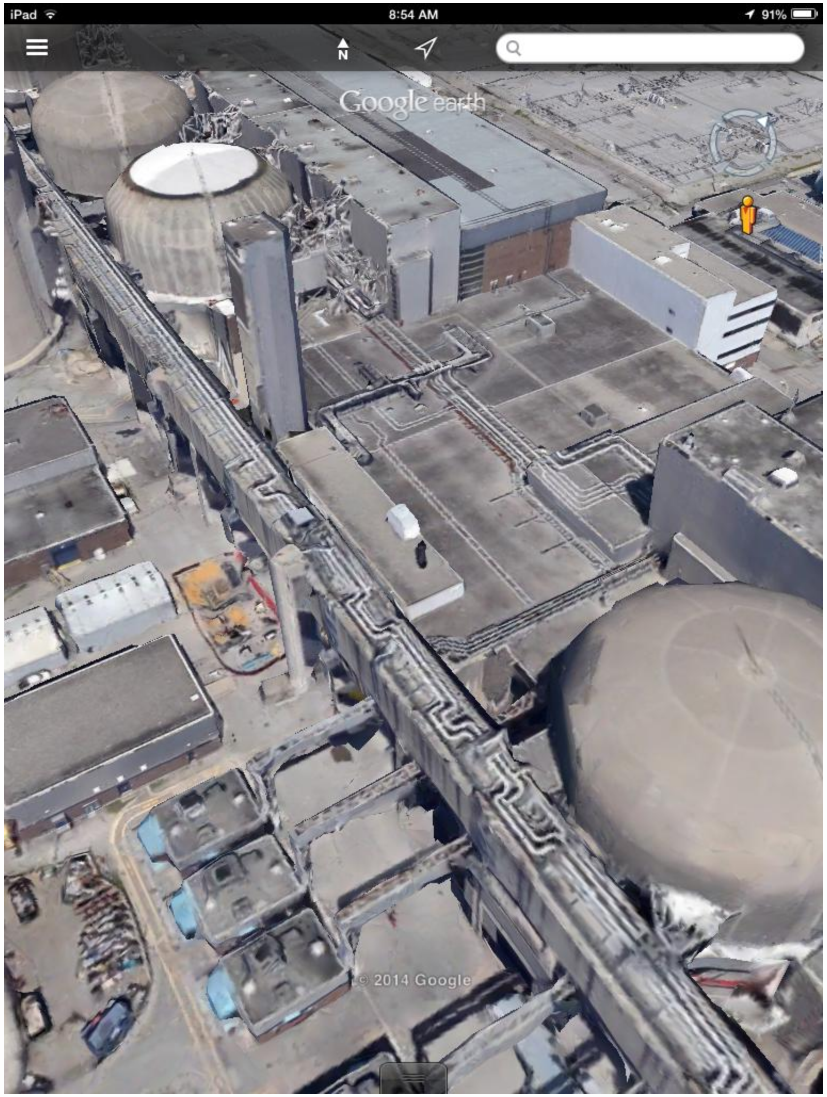


Pickering Switchyard and Outbuildings



Relatively Modern Admin and Cafeteria

Pickering – Reactor Domes and Pressure Relief Duct



Options for Decommissioning and their Application to Canadian CANDU Reactors.

IAEA Guidance and various national standards generally consider three strategies for decommissioning:

a) Immediate (prompt) dismantlement

b) Deferred dismantlement

c) Entombment.

The most common approach historically, and the current preferred approach for CANDU reactors in Canada involves deferred dismantlement for NPPs.

Deferred Dismantlement - SwS

This approach has been preferred in order to allow:

a) *decay* of short-lived, high energy gamma radionuclides to minimize occupational dose,

b) the licensing and construction of *fuel and waste disposal*,

c) *funds to be accumulated* for decommissioning,

d) management, staff and other resources to *focus on their primary (operational) responsibilities,* or multi-unit sites where some units remain in operation or transition, and

e) *evolution of the technology* and practices for safe dismantlement.

Canadian Extended Safe Enclosure Expce -1

Several of the reactors listed in Table 3 have been shut down for extended periods. Their OPEX includes:

- incompletely drained process systems leading to leaks and contamination spread,
- problems with drainage collection, sump pumping,
- persistence of tritium in the reactor buildings indicating a need for vapour recovery drying,
- corrosion of components and structures,
- failure of foundation drains/drainage,

Canadian Extended Safe Enclosure Expce-2

- problems due to equipment being removed from service that was subsequently needed, and
- housekeeping irregularities affecting repeat access.
- Storage with Surveillance Plans had to be continuously upgraded to remain in compliance
- extensive effort had to be devoted to configuration management and documentation of Safe Storage
- resin storage tanks (below grade) have been a source of concern for Env. Release of radioactivity

OPEX: Issue list Extended safe enclosure (1)

1. Frost rupture of incompletely drained pipe
2. Hazards from falling objects or structural materials
3. Mould Growth
4. Structural failure of misc. infrastructure elements
5. Freeze thaw (temperature cycling) structural and envelope damage
6. Failure of (live) electrical system
7. Water accumulation through ingress via failed building envelope, condensation, pipe burst, etc.
8. Human Intrusion, unauthorized equipment removal or storage
9. Animal Intrusion

OPEX: Issue list Extended safe enclosure (2)

10. Erosion, Subsidence
11. Airborne radioactive contamination and spread of surface radioactive contamination,
12. Airborne contamination and spread of non-radioactive surface contamination or other degradation of air-quality.
13. Corrosion of structural elements or fixtures
14. Failure of equipment to support SwS
15. Degradation of isolation safety tags
16. Unintended blockage (and/or isolation) of venting of areas and equipment
17. Inadequate “Housekeeping”, & general degradation
18. Groundwater contamination

Good Engineering Practice in Safe Enclosure (1)

These are based on requirements from current:

- applicable guidelines and proven practice,
- codes and standards,
- issues identified from the Canadian and International OPEX analysis

Good Engineering Practice in Safe Enclosure (2)

Those practices should:

- allow for establishment of the facility condition at the beginning of the safe enclosure, and
- address the intended facility condition during the period of the safe enclosure.
- aim to maintain the systems, structures and components in a stable and safe state by defining a set of specific criteria (actions) and related inspections to meet uniform, acceptable conditions for extended safe enclosure.

Good Engineering Practice in Safe Enclosure (3)

A typical list of such practices should include:

- identification of systems remaining operational,
- isolation of buildings,
- reconfiguration of systems (electrical, communication, fire protection, ventilation, heating, etc.),

Good Engineering Practice in Safe Enclosure (4)

- isolation and draining/venting/flushing and removal of systems (water, air, gas, solids,), isolation, conditioning and removal of equipment and machines (turbine, generator, large storage tanks, etc.),
- identification of all areas with radioactive contamination
- removal of unwanted/unneeded materials (radioactive, nuclear/radiological, hazardous and all miscellaneous materials), liquids and equipment on floors and other surfaces.

Suggested Measures

- Suggested Measures to Mitigate Safe Enclosure Issues for Canadian CANDUs

- The activities required to prepare the Canadian CANDU Reactor Buildings for safe enclosure would include :

SUGGESTED MEASURES (1)

- fuel and heavy water removal from the reactor and isolation of equipment not required during safe enclosure.
- chemical decontamination of primary cooling channels may be carried out.
- building ventilation may be configured (or resizing) to provide breathable atmosphere during entry and for air distribution, control and monitored exhaust, heating and dehumidification to prevent condensation, mould growth or local freezing.

SUGGESTED MEASURES (2)

- drainage modifications may be needed to allow collection and removal of water due to in-leakage, condensation, etc.,
- annunciation for the drainage sumps, establishment of a central collection, sampling and transfer point for all the drainage collected,
- shutoff and isolation of all service water supplies.
- the main reactor building crane may be de-energized but maintained in a state that it can be readily returned to service if needed.

SUGGESTED MEASURES (3)

- early removal of asbestos would limit its spread throughout the plant.
- removal of liquid and solid PCB sources with the highest concentrations is foreseen.
- where auxiliaries are not kept in service, local auxiliary system and procedural support will be needed, e.g. lighting, heating, air supply or local ventilation, communication, air sampling and monitoring at Zone interfaces.

SUGGESTED MEASURES (4)

Good engineering practice to establish the conditions at the beginning of the safe enclosure would also include:

- complete removal of all stored resins, filters and hazardous materials,
- installation of barriers to control infestation, reduction of security footprint to include only that required for controlled substances,
- removal of all loose contamination,

SUGGESTED MEASURES (5)

- establishment of a monitoring program for any effluent streams,
- reconfiguration of the fire detection and suppression systems,
- removal of stores inventory for support systems and warehousing it offsite, establishment of laundry processing offsite, reconfiguration of communications, equipment salvage, and isolation or reconfiguration of all electrical systems and components

SUGGESTED MEASURES (6)

- reconfiguration of the shoreline to increase its long-term stability, and
- isolation of structures communicating with the lake should be considered.

Periodic Inspections for Buildings During Safe Enclosure

- Most buildings can be designated as “out of service” during safe enclosure,
- Some services may still be required in those designated as “partially in service”.
- For example: lighting, heating, ventilation, electrical power, drainage, emergency communication and service cranes may all be required during the safe enclosure, together with procedures to support their operation and maintenance.

Periodic Inspections (2)

The aim of periodic inspections is to maintain conditions that consider the physical characteristics and hazards of SSCs during safe enclosure, viz to:

- Eliminate risks to inspection personnel;
- Maintain reliable conditions for SSCs that remain partially in service; and
- Minimize the impacts of gradual degradation on eventual demolition and removal.

Periodic Inspections (3)

- Most of the inspections required during safe enclosure would be visual.
- Guidance for observations and data to be recorded should be included in walk-down personnel training.
- Photographic records should be kept for comparison during subsequent inspections.
- Standardized training for inspectors is required, and should include descriptions and example photographs of modes of degradation.

Periodic Inspections (4)

The large number and range of building purposes and types on the plant site suggests grouping them by similarity of function & features

- Group A – Reactor Buildings
- Group B – Turbine Halls, Service Building
- Group C – Deep Structures (e.g. deep basement and connection/proximity to water intake systems)
- Group D - Steel frame buildings with metal\brick\block cladding
- Group E – Tanks and Towers

Periodic inspections & "Walkthroughs"

- periodic inspections during the safe enclosure are needed to address the building structural, "envelope" integrity & general conditions.
- "structural integrity" => no safety hazard (e.g. from collapse, debris falling, degraded floors or barriers,
- internal inspections should involve all accessible areas and surfaces interior to the building such as roof, walls, floor, openings, concrete and metal components & joints.
- "Walkthroughs" are a simplified form of internal inspection, following a predetermined path, illuminated by fixed lighting, and kept free of hazards

Inspection Frequency

- Should include a baseline inspection; subsequent inspections would be established at a given frequency.
- The frequency of subsequent inspection should be based on the results of the initial inspection, and the period can be gradually increased
- Frequencies should be set and revised systematically and involve the owners, the inspection agency involved and oversight authority.
- The typical minimum frequency of the “walkthrough” would be one (1) per month.

An Example of a Checklist for Building Structure and Envelope Inspections

Inspection #	Material/Location	Some Typical Inspection Methods
1.	Concrete (External and Internal)	Visual, impact hammer, crack measurement, non destructive test (e.g. ultrasonic testing –UT), coring
2.	Brick (External) (see Note 2)	Visual
3.	Steel/Metal (External and Internal)	Visual, thickness measurement, torque wrench and or, finger tightness check
4.	Roof (External) (see Note 2)	Visual, physical check (i.e. walking the roof feeling for soft spots that indicate water accumulating between the roof deck and roof membrane)..
5.	Piping (Internal to Buildings)	TV camera – interior piping, non destructive test (e.g. UT)
6.	Joints – Caulking and Sealants (Internal &External)	Visual, thickness gauge (loss of coating thickness), knife and tape (method for adhesion of metallic coating), testing for blistering of paints, testing for rust on painted surfaces
7.	Insulation (Internal)	Visual
8.	Coatings (Internal, External	Visual, thickness gauge, knife and tape method for metallic coating, test method for blistering

Conclusions -I

- Extended safe enclosure poses significant challenges for maintaining structures in an acceptable condition
- CANDU sites with lake exposure and harsh climate pose a number of unique issues
- Compliance with existing codes and standards is required, but their is little specific guidance in them
- National and international OPEX is rich with relevant examples for design and implementation of Safe Enclosure

Conclusions -II

- Periodic inspections are required whose frequency and focus address the most vulnerable systems and structures.
- Inspection frequencies will vary from weekly rounds for areas subject to rapid change in condition to years where slow physical changes may be occurring.
- Initial frequencies can be reduced as safe enclosure conditions are confirmed to be stable over longer periods.