Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

CMD 21-H4.59A

File / dossier : 6.01.07
Date: 2021-05-26
Edocs: 6572106

Supplementary Information

Renseignements supplémentaires

Presentation from Darek Kulczyński

Présentation de Darek Kulczyński

In the Matter of the

À l'égard de

Darlington New Nuclear Project

Projet de nouvelle centrale nucléaire de Darlington

Application to renew the nuclear power reactor site preparation licence for the Darlington New Nuclear Project

Demande de renouvellement du permis de préparation de l'emplacement d'une centrale nucléaire pour le projet de nouvelle centrale nucléaire de Darlington

Commission Public Hearing

Audience publique de la Commission

June 10-11, 2021

10-11 juin 2021

Canada

Why Darlington B is essential for Canada and Ontario

1. Prime Minister Trudeau announced a target of **40-45% reductions in greenhouse gas emissions below 2005 levels by 2030.**
2. Canada is committed to **reaching net-zero emissions by 2050**
3. **By 2025** Pickering NGS A & B will have been permanently shut down **(approximately 3,000 MW(e) disconnected from the Ontario grid).**
4. **One or two Darlington units will be off line for overhaul.**
5. Nuclear capacity already removed (P2 & P3) and to be removed in 4 years' time from Pickering NGS A&B amounts to **4,124 MW(e)** net [4,328 MW(e) gross].

Pictures, graphs and drawings [courtesy of]: Public domain [Status report 68 - Enhanced CANDU 6 (EC6), CANDU Energy Inc.], OPG (2007 and 2012), Prof. Rich A. Muller [BEST] (2012).

Non-nuclear low CO_2 emission options:

>> Wind Turbines – **not good** (capacity factor < 25%, cumbersome connections, infrasound effects on humans etc.)

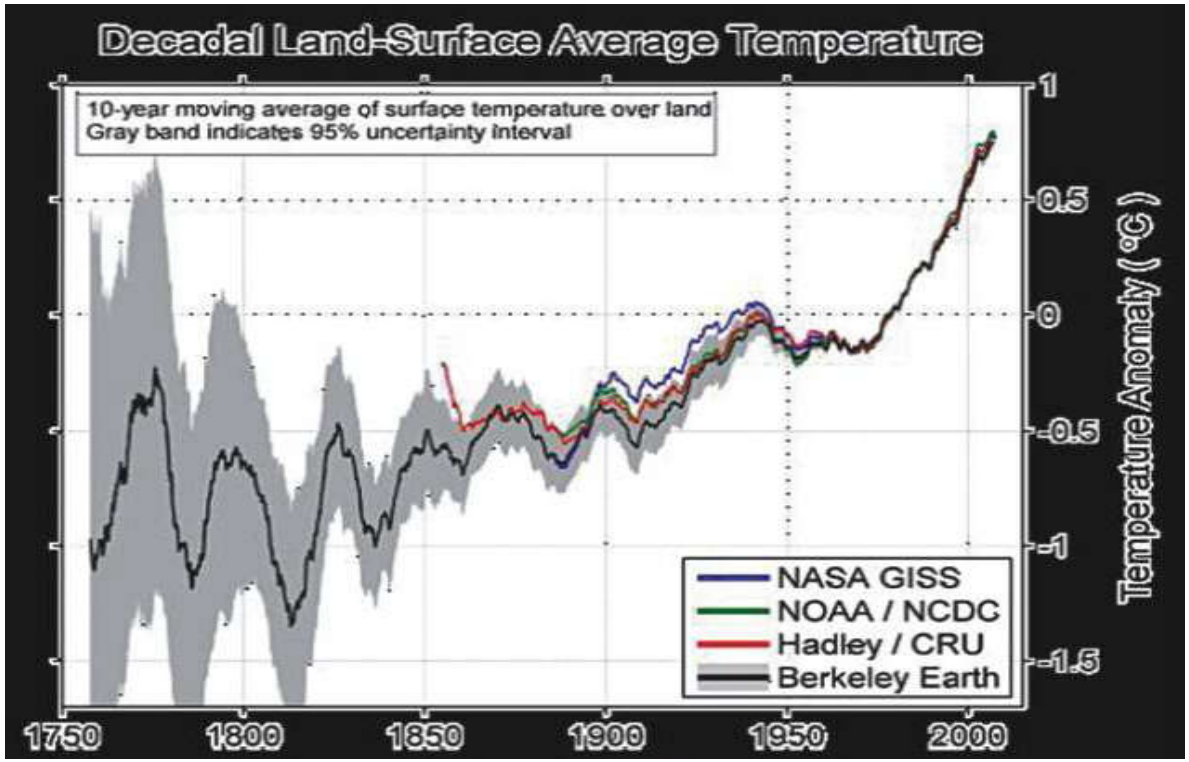
>> Solar Panels – **not good** (insufficient capacity factor, power rating etc.)

>> Hydraulic generation – **good but** most waterpower has already been harnessed in Ontario

>> Power Plants burning Natural Gas – **not good!**

Methane CH_4 is 30 times stronger Greenhouse Gas than CO_2.
(1900 0.7 ppm of CH_4 in Earth's atmosphere, in 1990 1.7 ppm).

Burning natural gas remains number one source of CO_2 in Canada



Currently Nuclear Power provides about 60% of Ontario energy needs which constitutes 33% of generating capacity (MW)

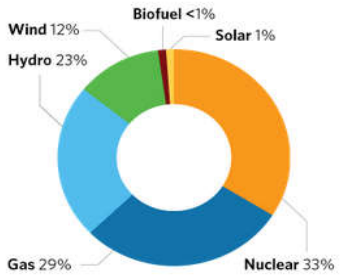
At least 3000 MW of nuclear power need to be added to Ontario grid shortly after 2025 just to maintain the emission status quo and ensure that Ontario's power demand is being met.

Energy Output (TWh) *Notes:* *- Represents IESO-metered generation that may be distribution connected.* *- Due to rounding, percentages may not add to 100.*	Nuclear	87.8 (60%)	90.4 (61%)
	Hydro	36.9 (25%)	36.4 (25%)
	Wind	11.8 (8%)	11.0 (7%)
	Gas/Oil	9.7 (7%)	9.5 (6%)
	Biofuel	0.4 (<1%)	0.4 (<1%)
	Solar	0.8 (<1%)	0.7 (<1%)
Imports (GWh)		5,178	6,613
Exports (GWh)		20,377	19,779
Demand	Total (TWh)	132.2	135.1
	Peak (MW)	24,446 on July 9	21,791 on July 29
Price (cents/kWh)	Hourly Ontario Energy Price (avg. weighted)	1.39	1.83
	Global Adjustment (Class B)	11.82	10.8
	Total Cost of Power (Class B)	13.21	12.63

Capacity

Grid-connected capacity in 2020 totalled 38,644 MW. This includes the addition of 54 MW of solar, and 985 MW of gas generation that reached commercial operation in 2020.

Figure 1: Grid-connected capacity as of December 2020.



Nuclear	13,009 MW or 33%
Gas/Oil	11,317 MW or 29%
Hydro	9,060 MW or 23%
Wind	4,786 MW or 12%
Biofuel	295 MW or <1%
Solar	478 MW or 1%

Note: Represents IESO-metered generation that may be distribution connected.

Demand Response Auction

Through the 2019 Demand Response Auction, 779.8 MW was secured for summer 2020 and 799.5 MW for winter 2020/2021. Demand Response Auction participants are consumers, or third-party organizations coordinating consumers, who are available to reduce electricity consumption when prices rise or as required to help ensure the reliability of Ontario's electricity system.

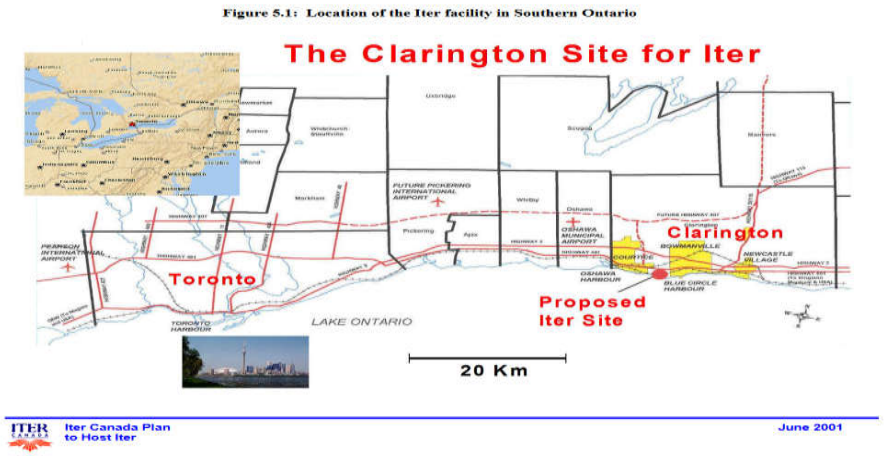
About the existing Darlington A [4 x 930 MW(e)]

Commisioning 1989-1990: Problems with BBC generator rotor cracks and Fuel Bundles cracks (PHT Pump 5 blade resonance) successfully resolved.
Operations: In 2016, DNGS-A obtained INPO-1 rating (safety, and other indicators of excellence). **WANO: DNGS - one of the safest and top performing nuclear stations** in the world **(for the third time in a row)**.

DNGS-A achieved great results re: capacity factor - continuous safe operation, e.g.
1) May 15, 2012 D4 worked for 633 days without a trip or shutdown
2) Feb 4th, 2021 Darlington Unit 1 was shutdown for maintenance after 1,106 days of continuous generation, setting the world nuclear operation record and world thermal plant generation record.

Plans for Darlington B

- Prior to 1990: DNGS-B was to be 4 x 930 MW e, similar to DNGS-A
- DNGS-B was canceled by Ontario NDP Government
- In 2001: plans to use Darlington B site for ITER (International Thermonuclear Experimental Reactor) - subsequently awarded to Cadarache, France.
- In 2011 Public Hearings: The Society of Energy Professionals suggested that Enhanced CANDU 6, 740 MW be considered for the Darlington B site (Addendum to the SEP submission).
- In 2013 Ontario Liberal Government suspended competitive bidding for Darlington B
- In 2020 it was announced that a Small Modular Reactor might be built at Darlington B site



Closing the nuclear generation gap…
PLAIN ARITHMETIC

OPG has applied to build up to 4 new nuclear units at their Darlington NGS site.

There are two designs that could be considered:

- AP-1000, an American Pressurized Water Reactor (PWR) by Westinghouse with a projected **net power rating of 1,117 megawatt electric (MWe).**
  - **4 x 1,117 = 4, 468 that is: Pickering A & B (originally installed) + 8 % or Pickering A & B (2 + 4 units that remain in operation) + 44%.**

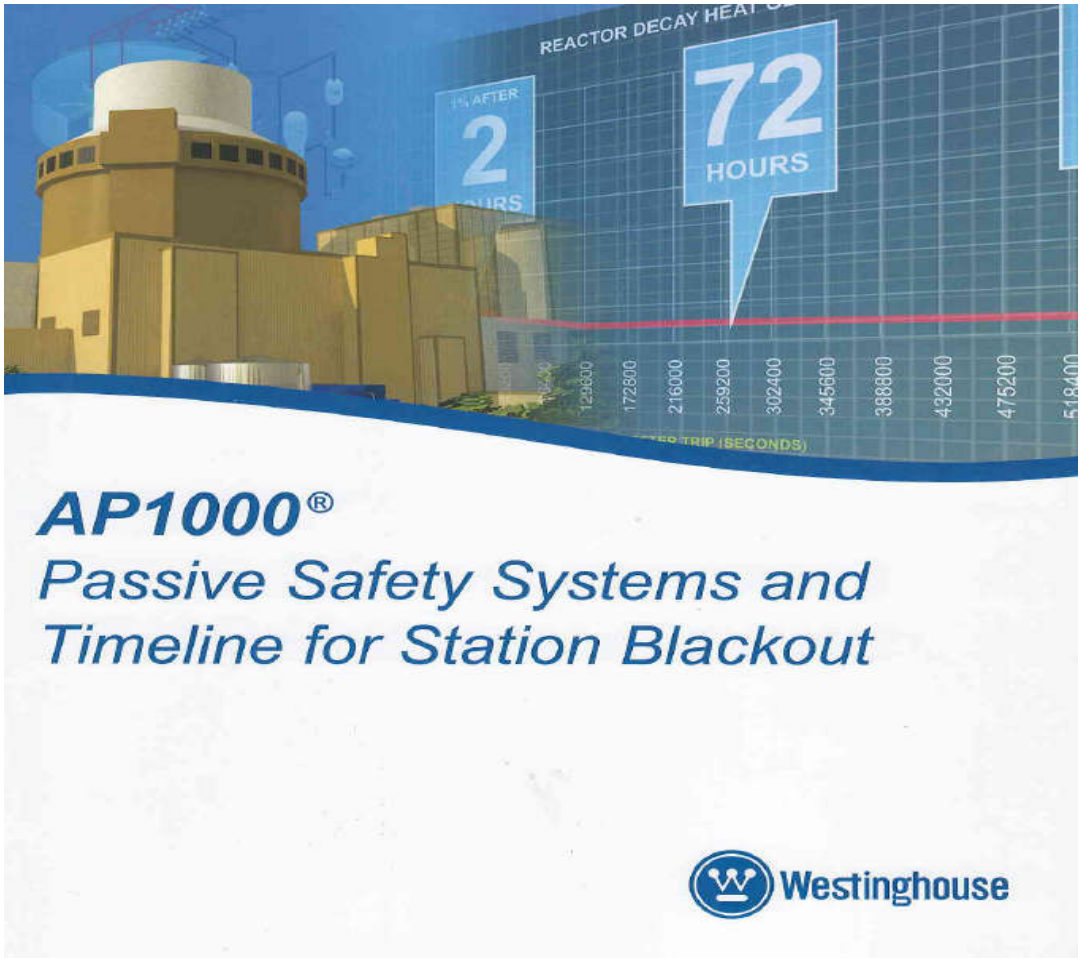
- EC 6 (Enhanced CANDU 6) – Pressurized Heavy Water Cooled and Moderated Reactor (PHWR)- by CANDU Energy (previously AECL) with the projected **net power rating of 700 megawatt electric (MWe)** approx.

  - 4 x 700 = 2,800 that is: **68% of Pickering A & B (originally installed) or 90% of Pickering A & B (2 + 4 units that remain in operation)**.

  - Building more than 4 EC 6 units (4 at Darlington and additional 2 at, say, OPG's Weseleyville site), would replace fully the power available from Pickering A and Pickering B (all 8 reactors).

AP 1000 is a **1,117 megawatt electric (MWe)** and seems safe but…
>> There is **limited Canadian expertise in PWR's**,
>> **Westinghouse has had problems** with delivering on time, especially since announcing bankruptcy

Still, probably the best PWR on the market; could proceed with caution

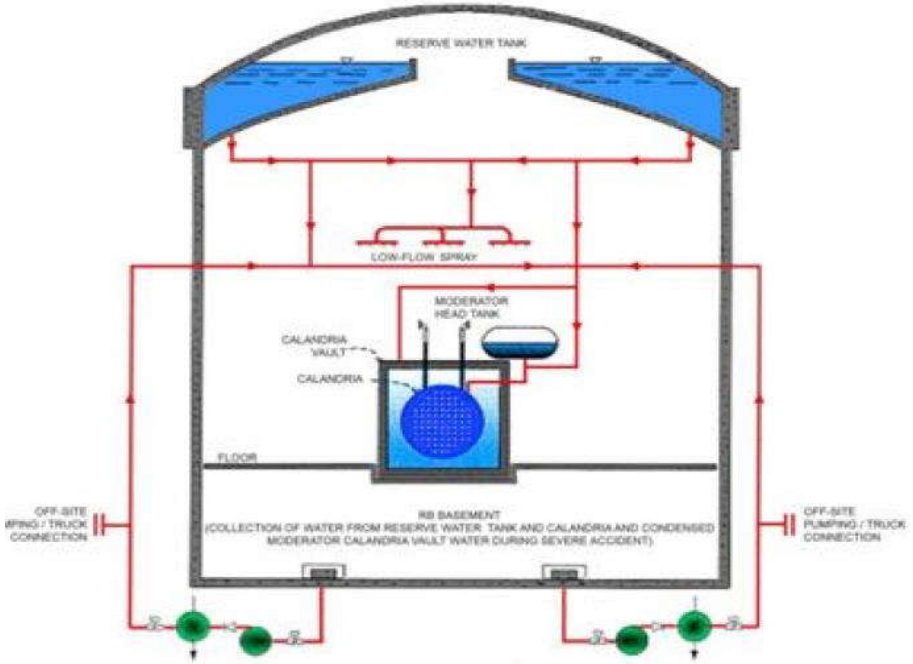


ENHANCED CANDU 6 [740 MW(e) gross output]

EC6™ is a PHWR reactor - designed in a twin unit arrangement, based on the successful and safe CANDU 6 model; employs modularization and pre-fabrication.

Ample PHWR expertise and CANDU infrastructure exists in Canada (D2 refurbishment was a success).

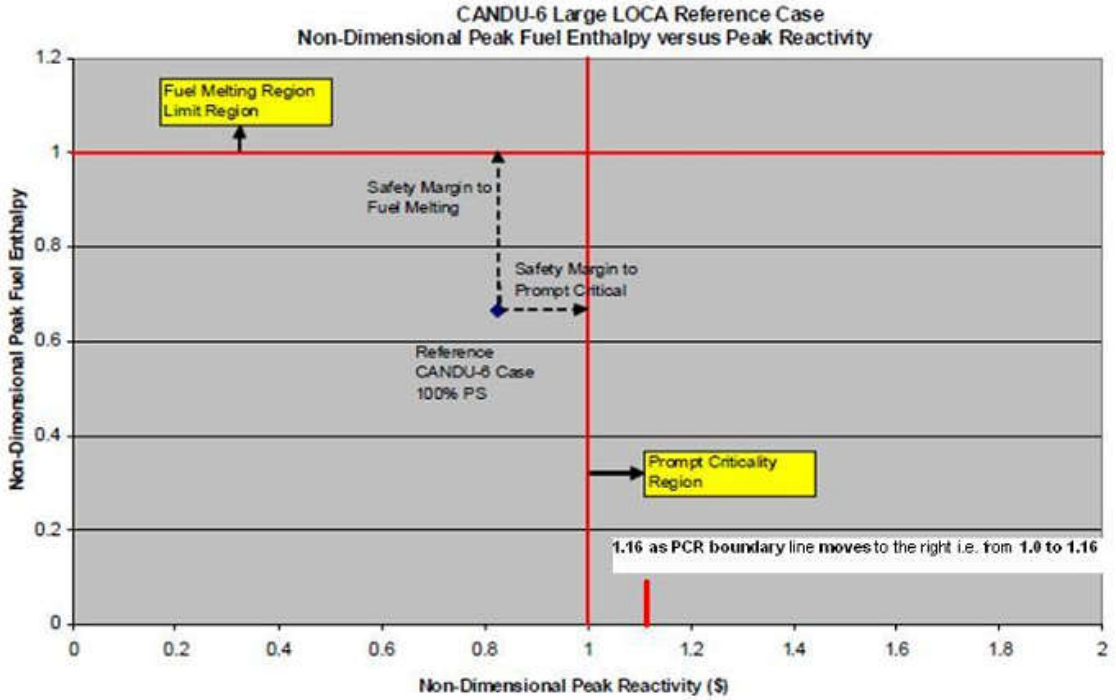
EC6 is equipped with advanced safety features, many passive, similar to those implemented in AP1000.



Severe Accident Recovery System (SARS)

Safety margins of EC6 predecessor CANDU 6 model are very good.

[1]. D.A. Meneley and A.P. Muzumdar, "Power Reactor Safety Comparison -- a Limited Review", Proceedings of CNS 30th Annual Conference, Calgary, AB, 2009 May 31-June 3.
[2] University Network of Excellence in Nuclear Engineering (UNENE) Fuel Engineering Course by Dr. Paul Chan
[3] A.J. Muzumdar and D.A. Meneley, "Large LOCA Margins in CANDU Reactors -- an Overview of the COG Report", Proceedings of CNS 30th Annual Conference,Calgary, AB, 2009 May 31-June 3.



In the figure above, **large LOCA data for a CANDU-6 reactor** corresponds to the largest break upstream of a core pass (i.e., **100% Pump Suction break**). **The margin to Prompt Criticality** is even **greater** when adjusted for CANDU's longer neutron lifetime with respect to PWR reactors.The vertical **PCR boundary** line **moves** to the right i.e. from **1.0 to 1.16** on the **abscissa**. This is a non-dimensional reactivity limit for shutdown rods to be effective.

What about Small Modular Reactors? [<= 300 MW (e)]

- Too small for Ontario's nuclear power needs
- Great idea for remote areas (e.g. Arctic).
- Good for Alberta for ecological Tar Sand Oil extraction
- Federal Government, not OPG or the Ontario Government to develop and promote SMR's
- Should build the first SMR at Chalk River, not at Darlington B site
- .
- **FINAL NOTES ON DARLINGTON B:**
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- **It takes at least 6 years to build and commission a nuclear unit** (were it be AP1000 or EC6).
- **The end of Pickering is approaching. There is no time to waste…**

Ref: NuScale Power. Technology Overview | NuScale Power [Internet]. [cited 2020 Sep 3]. Available from: https:// www.nuscalepower.com/technology/technology-overview