



**Atlantic Pacific
Spaceline Enterprise
Incorporated**

To:

Mr. David Morton, Commissioner/Panel Chair

Mr. Dennis Cote, Commissioner

Ms. Karen Keilty, Commissioner

Mr. Richard Mason, Commissioner

c/o

Commission Secretary

British Columbia Utilities Commission (BCUC)

Sixth Floor, 900 Howe Street, Box 250

Vancouver, B.C., V6Z – 2N3

E-mail Address:

commission.secretary@bcuc.com

Date: 2017.08.30th (Wednesday)

Hello Mr. Morton and Panel Commissioners,

**Subject: Financial Assessment Report
For
Site C Dam Inquiry**

Attached to this cover letter is our above submission for the aforementioned Inquiry.

We are complying with the ‘Terms of Reference’ cited in the B.C. Lieutenant Governor in Council’s directive issued under Order-in-Council (OIC) No. 244, dated Wednesday, 2017 August 2nd that asks five questions. This submission is a business analysis with relevant data that fits in to the ‘Scope of Inquiry’ by determining how the costs associated with the Site C Dam development will affect both the ratepayers and the taxpayers of B.C.

In our opinion; however, the ultimate question to be addressed here is: “What is the ‘end game’ between ‘public ownership’ or ‘private ownership’ of energy sources in B.C.?”

If the Commission requires any further information or wishes to discuss any of the assumptions, data, or findings provided in this report, the author is available to do so in writing or in person. Finally, thank you for your time and attention.

Respectfully submitted and signed,

Yours truly,

Keith William Steeves

Pres. & CEO

A.P.S.E. Inc.

E&OE

1 of 1.

**Financial Assessment Report
For
Site C Dam Inquiry
By
Keith William Steeves**

Recommendations

- 1.) Scrap the “No Nuclear Power” policy mandated in both the **British Columbia 2007 Energy Plan**, (P. 6) and Sub – section 2(o) under Part I – British Columbia’s Energy Objectives in the B.C. **Clean Energy Act** [SBC 2010] Chapter 22.
- 2.) Ditch (i.e., either the **Continue, Suspend** or **Terminate** scenario) the Site C Dam project and ‘**Substitute**’ the Septimus Nuclear Power Plant (NPP) proposal at the Site C Dam site instead. This energy generating portfolio project is both valid and justifiable. The aforementioned ‘*ban*’ against nuclear power is **not**.
- 3.) Redirect the Site C Dam Transmission Lines to the BC-Alberta Border, and sell the NPP generated electricity to the Alberta oil and gas industry at (bulk) market rates, with no subsidies.

Introduction

First, for this submission, we are pleased to provide commentary on Questions 3 (b) (ii), 3 (b) (iii), and the first half of 3 (b) (iv). We leave the other questions to be addressed to other more capable and qualified parties.

Please note that we stress here the first half of 3 (b) (iv) which reads:

*Given the energy objectives set out in the **Clean Energy Act**, what, if any, **other portfolio of commercially feasible generating projects ...***

could provide similar benefits (including firming; shaping; storage; grid reliability; and maintenance or reduction of 2016/17 greenhouse gas emission levels) to ratepayers at similar or lower unit energy cost as the Site C project?

[**Bold** Type added]

If either or both the BCUC and The Lieutenant Governor in Council objects to the this submission proposal that is presented herein, then they also *must object* to the recommendations made by Mr. Guy Immega on BCUC submission F48-1. As Mr. Immega states himself in his own submission under heading:

**Notes on Purchase of Power from Independent Power Producers (IPPs), dated:
August 29, 2017**

“2. The Clean Energy Act of 2010 prohibits BC Hydro from developing small hydro sites. This policy should be reviewed.”

Second, as we are pressed for time in making this submission, we will endeavour to hit only the important points. We, therefore, can only make a rough draft at this time for to the BCUC.

Problem

As a number of the BCUC submissions have stressed, both the B.C. provincial government and the BC Hydro ratepayers cannot afford the capital investment expense of the Site C Dam, especially if it incurs large cost over runs. Many submissions hold that there is no market for the energy created by the Site C dam because there is no demand. Others say that is not true. Also, many people do not seem to trust B.C. Hydro's self – serving electricity demand projections to justify building Site C. Others say there are valid reasons why the BC Hydro projections do not appear to justify past experience.

So, under both the 'Terms of Reference' and the 'Scope' of the Inquiry, how are B.C. residents to judge the financial merits of Site C? This is especially true and difficult when the general public does not have the financial data to make a decision of this magnitude, nor is even capable of making the financial decision of this nature.

Solution

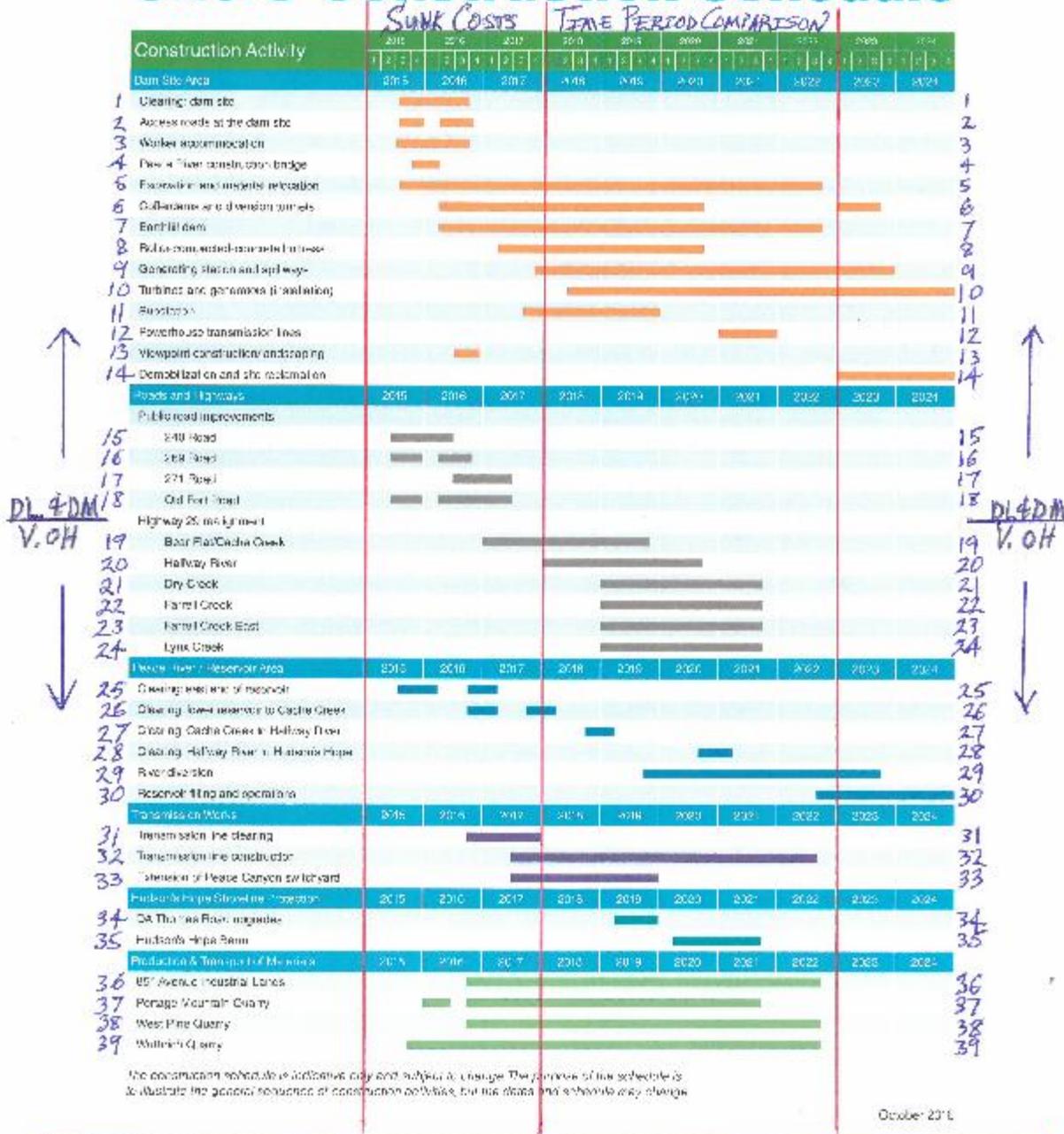
To solve this problem, we answer this question by turning to conventional "*Decision – Making*" analysis used in the field of Management Accounting. This type of methodology is called a "**Make of Buy**" Decision (i.e., also called a "**Sourcing Out**" decision.) This methodology has been around for at least a century or more and it employs a type of accounting called **Variable Costing**. In using Variable Costing for any type of business venture or business project, etc., a business manager wants to determine: "What is the cheapest way of doing a certain type of activity?" In essence, the activity could be anything. For the business manager, he/she asks: "Is it cheaper to '*make*' a good or service in house or is it cheaper to '*buy/contract out*' the need requirement to an outside party. To determine the best solution, the business manager divides the total cost of the desired good or service required between two types of costs; namely, "**Fixed**" costs and "**Variable**" costs. The difference in definition between the two cost types has to do with the level of production. Fixed Costs stay fixed no matter what the level of production in making it, while the Variable costs change according to the level of production.

Since we have been unable to get any costing data out of BC Hydro for this analysis, we had to rely on what was available. From the BC Hydro own web site, we used their "**Site C Construction Schedule**". We believe there is just enough financial information to determine a "Make or Buy" decision regarding Site C.

Relevant Costing Analysis of Construction Costs



Site C Construction Schedule



Note of Explanation

The above BC Hydro “**Site C Construction Schedule**” shows thirty – nine (39) Line Items that are grouped into six categories; namely:

- | | |
|--|----------------------------|
| 1.) Dam Site Area | (Line Items 1 through 14) |
| 2.) Roads and Highways | |
| A.) Public Road improvements | (Line Items 15 through 18) |
| B.) Highway 29 realignment | (Line Items 19 through 24) |
| 3.) Peace River / Reservoir Area | (Line Items 25 through 30) |
| 4.) Transmission Works | (Line Items 31 through 33) |
| 5.) Hudson’s Hope Shoreline Protection | (Line Item 34 and 35) |
| 6.) Production & Transportation of Materials | (Line Items 36 through 39) |

This Construction Schedule cover a ten (10) year time period from January 1st, 2015 through to December 31st, 2024 and each year is broken into quarters. On this schedule we have drawn three (3) vertical red lines; namely:

- 1.) First line at the beginning of January 1st, 2015 as the start of Site C construction.
- 2.) Second line at the beginning of January 1, 2018 which is to demark “**Future Costs**” going forward from “**Past Costs**”.
- 3.) Third line at the beginning of January 1st, 2023 as an arbitrary ending point for business comparison, analysis and evaluation.

Now, for this submission, and in accounting, we are defining the time period in the first three years of Site C construction schedule as having incurred “**Sunk Costs**”. In this time period, the scheduled work activity on Site C has been done and has been paid for. Whether BC Hydro is actually “on budget” and “on time” is another matter and has to be determined. For our discussion here, we assume it has been! We cannot do anything about these expenditures. You cannot get them back – unless you go to court! Hence, the term “Sunk Costs”. In terms of a “*Make or Buy*” decision, what is important about “Sunk Costs” is that they do not matter in make decisions about “**Future Costs**”.

Going on, what we want to look at in this analysis are the “*Future Costs*” in the five (5) year period we call the “**Time Period Comparison**” between January 1st, 2018 and December 31st, 2022. Here, we are attempting to answer the questions to 3 b) (ii), 3 (b) (iii), and 3 (b) (iv). With regards to 3 (b) (iv), we are including another “portfolio” category for comparison. We call it the “**Substitute NPP**” option as against the other three categories; namely, *continue*, *suspend*, and *terminate*, specified under the “*Terms of Reference*” in the order.

NPP refers to **Nuclear Power Plant**. In this submission, “Sunk Costs” are ignored in the “Make or Buy” decision; however, in a “**Substitute NPP**” option many of these expenses would have to had to been incurred, but for “Future Costs” they are not. (Thank you very much BC Hydro!) This means a NPP option becomes even more competitive as compared to continuing with Site C.

Financial Assessment of Options

Line Item	Sunk Costs	Continue	Suspend	Terminate	Substitute NPP
	S = Sunk	Yes = Costs Incurred	No = Costs NOT Incurred	+ = Additional Costs Incurred	
1	S	-----	-----	-----	-----
2	S	-----	-----	-----	-----
3	S	-----	-----	-----	-----
4	S	-----	-----	-----	-----
5		YES	YES +	No +	No +
6		YES	YES +	No +	No +
7		YES	YES +	No +	No +
8		YES	YES +	No +	No +
9		YES	YES +	No +	Yes & No +
10		YES	YES +	No +	YES
11		YES	YES +	No +	YES
12		YES	YES +	No +	YES
13	S	-----	-----	-----	-----
14		YES	YES	YES	YES
15	S	-----	-----	-----	-----
16	S	-----	-----	-----	-----
17	S	-----	-----	-----	-----
18	S	-----	-----	-----	-----
19		YES	YES +	No	No
20		YES	YES +	No	No
21		YES	YES +	No	No
22		YES	YES +	No	No
23		YES	YES +	No	No
24		YES	YES +	No	No
25	S	-----	-----	-----	-----
26	S	-----	-----	-----	-----
27		YES	YES +	No	No
28		YES	YES +	No	No
29		YES	YES +	No	No
30		YES	YES +	No	No
31	S	-----	-----	-----	Yes or S
32		YES	YES	No	Yes
33		YES	YES	No	Yes
34		YES	YES +	No	No
35		YES	YES +	No	No
36		YES	YES +	No	No
37		YES	YES +	No	No
38		YES	YES +	No	No
39		YES	YES +	No	No
		O.C.	O.C. & L.R	O.C. & L.R.	

O.C. = Opportunity Costs L.R. = Lost Revenue

Potential Alternatives Comparison

Analysis: (Items to be considered):

- 1.) Line Item examination
- 2.) Opportunity Cost considerations
- 3.) Revenue Loss Effect on Suspend and Terminate
- 4.) Externalities of Cost/Benefits Effect, but are out of scope.

The decision between four portfolios comes down to this question:

**Are the Line Items (36 – 39) plus (5 – 8) plus (19 – 24) either
Greater than, Equal to, or Less than**

**The cost incurred for the Substitute NPP components for the Nuclear Reactor Core,
Nuclear System, and the Nuclear Housing, but not the generator and powerhouse building
structure?**

If they are greater, NPP is better than continuing with Site C, and
If they are equal or less than Site C, then the externalities should be looked at.

For comparison with Clean Energy British Columbia (CEABC) concerns regarding Site C, the following list is given.. (Topics cited from Mr. David Austen, Clark Wilson LLP, BCUC Inquiry Respecting Site C File F18-2, August 25, 2017)

2. Model Heading: Electricity Production

- | | |
|-------------------------------------|-----------------------|
| A. Sub-heading: Dependable Capacity | See explanation below |
| B. Sub-Heading: Energy | See explanation below |

3. Model Heading: Capital Cost

- | | |
|--|--------------------------------|
| A. Sub-Heading: Dam | Does <u>Not</u> apply to a NPP |
| B. Sub-Heading: Diversion Tunnels | Does <u>Not</u> apply to a NPP |
| C. Sub-Heading: Cofferdam | Does <u>Not</u> apply to a NPP |
| D. Sub-Headings: Spillway, Intake and Penstock | Does <u>Not</u> apply to a NPP |
| E. Sub-Heading: Transmission | See explanation below |
| F. Sub-Heading: First Nations Settlement Costs | See explanation below |

- | | |
|---|-----------------------|
| 4. Heading: Operating and Maintenance Costs | See explanation below |
| 5. Heading: Financing | See explanation below |
| 6. Heading: Revenue | See explanation below |
| 7. Heading: Unit Energy Cost Calculation (Plant Gate Price) | See explanation below |

Explanation of differences between CEABC concerns and an NPP for the above Headings:

2(A): NPP offers firm dispatchable energy and within limits can be ramped up. A NPP also does not have river restrictions or restrictions on fisheries. Unlike the Site C dam, a NPP is not restricted by geography, topography, or seasonality. By comparison, a NPP can be built with extra generating capacity that can be activated later, or further NPP power production units (i.e.,

reactors) can be built and added on to the system, whereas the Site C dam generating capacity cannot be increased - unless extra reservoir energy storage capacity is used. Also, a NPP does not have to run in tandem with the upstream hydro units or their level of activity.

2(B): A NPP will not affect river flow rates. Like a run-of-the-river generating system, any water taken out of the river would be discharged back into the river. The Halfway and Moberly river discharges will have no affect on a NPP. It is expected that the average annual (firm) energy production of 5,100 GWh from a NPP will satisfy the same BC Hydro need requirements as would be expected from the Site C dam.

3(E): The same interpretation applies as in the CEABC, but with a NPP more flexibility is gained by servicing either the B.C. north – east gas industry or the Alberta oil and gas industry if a different transmission line route were chosen to meet market demand.

3(F): As a NPP would have a smaller ecological footprint on the local environment, the corresponding First Nations Settlement Costs would be lower for both the B.C. ratepayers and taxpayers. Also as a result of less environmental impact, any future court costs damage awards incurred by a NPP would require lower contingency amounts.

4: Annual amounts for school, municipal and property taxes would be expected to be in the same range as the Site C dam. On the negative side for a NPP, refurbishing and replacement costs would have to take place and may well be higher than the Site C dam. Also, there would have to be cost charges for both insurance and decommissioning of the NPP. These costs would most likely depend upon the level of nuclear power usage in the world. A greater usage would mostly likely bring on lower rates and lower costs through greater efficiencies and lower probability failure rates. We suspect the main financial drawback in employing a NPP will be in higher operating costs due to larger number of onsite high skilled unionized operating staff.

5: It is assumed here that the financing structure for a NPP would be similar to the Site C dam project. It probably would depend upon how the financial markets perceive the level of risk associated with the NPP. If newer generations of NPP can perform better than earlier models, then the perceived level of risk would probably come down; hence, financing costs would be lower. One way around this problem is thought to be through ‘group purchases’ by buying in bulk by a consortium of national governments for the same type of standard NPP model.

6: Revenue forecasts will depend on who is doing the forecasting and what that party’s perception revenue generation over the amortization period.

7: Annual cash flow forecasts will require greater access to information before this question can be fully answered. Again, it is assumed and would be expected that annual cash flow forecasts would be similar to the Site C dam project.

Evidence in support of a NPP

The following series of maps below show the location for a potential Septimus Nuclear Power Plant (NPP) at the Site C Dam site. These maps are not only to physically show it is possible to install a NPP at this location but to also show that the previous “Sunk Costs” associated with Site C has been put to good use by contributing to the initial development of the NPP and in meeting

the requirements for obtaining a “Licence to Prepare Site” (LTPS) from the Canadian Nuclear Safety Commission.

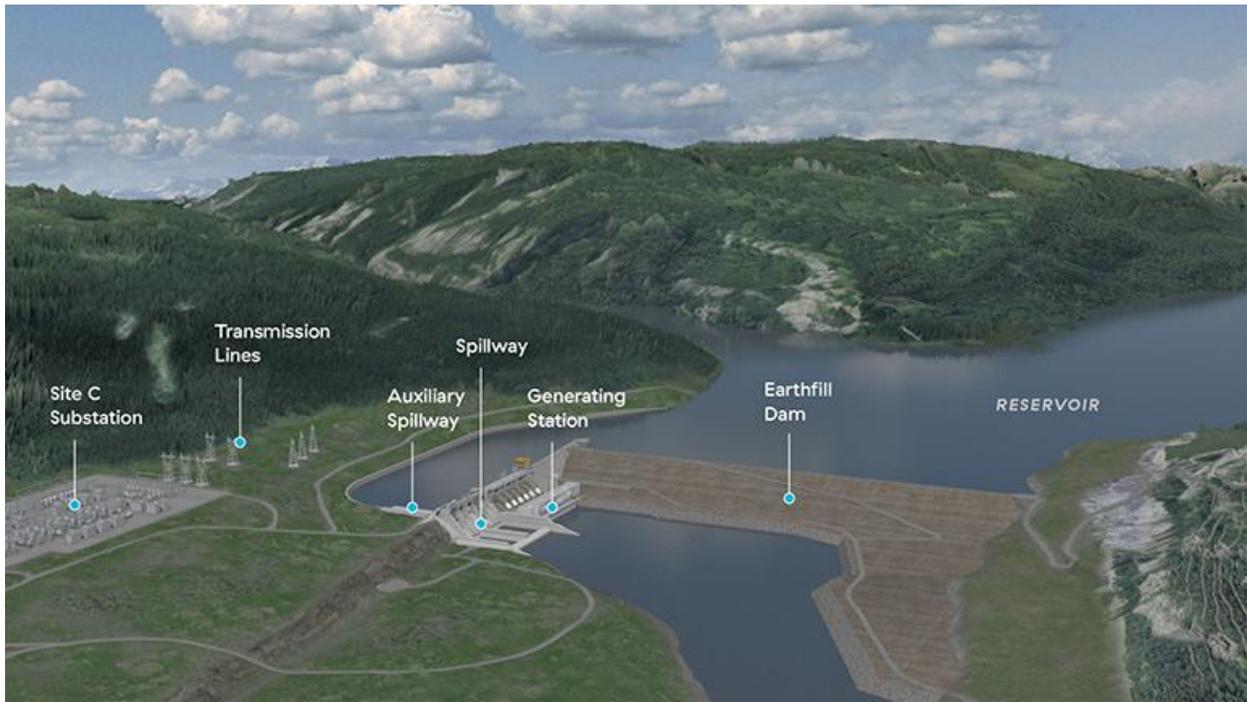
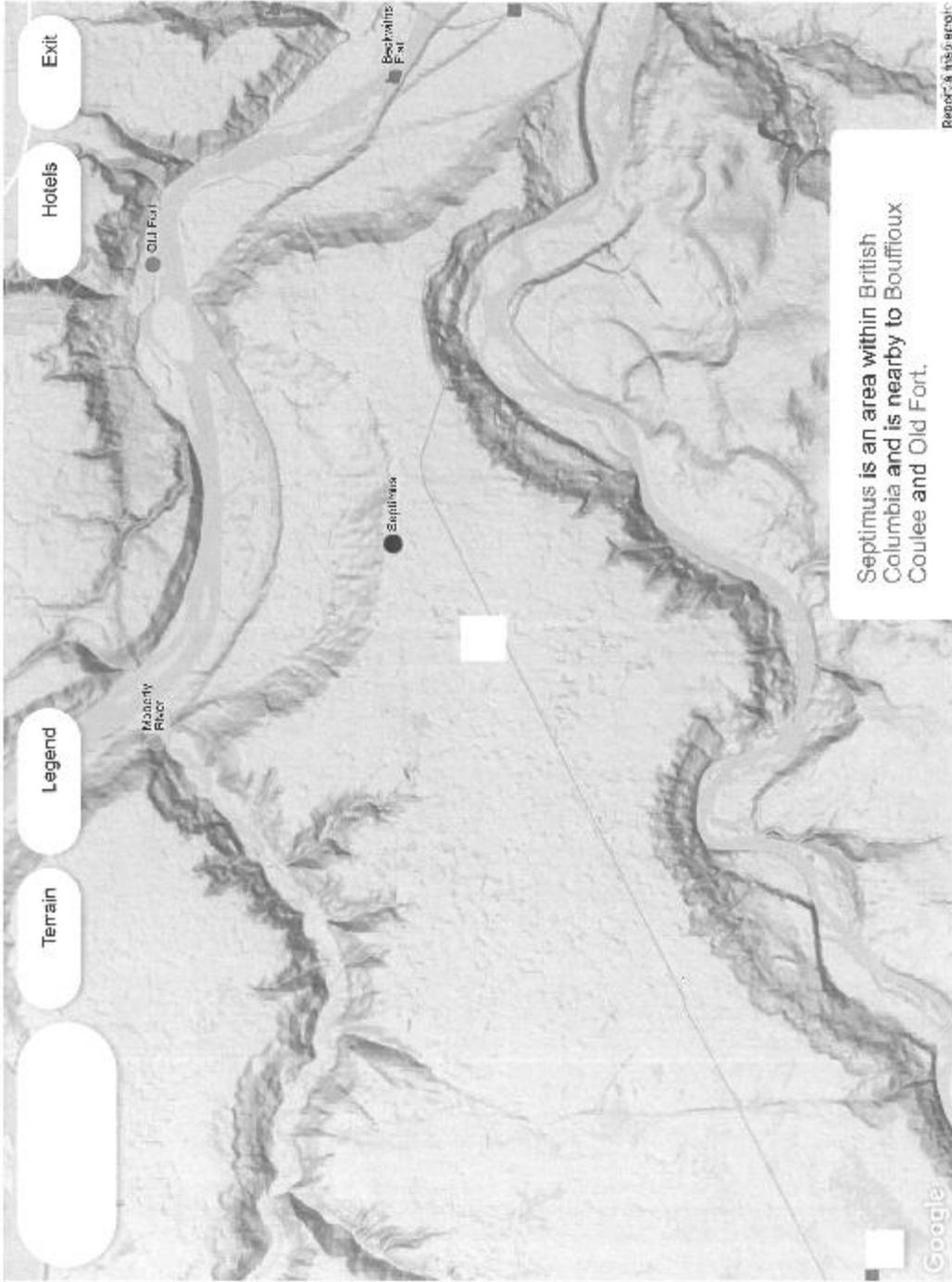


Diagram below shows the topography south of the Site C location. The “White Tower” is located near the black dot marked “Septimus”. The area around the white square in the middle is the region for the proposed NPP site at the planned Site C Substation site.

<https://maps.cartia.com/24634300/Map>

Septimus Map - British Columbia - Mapcarta



Report # 4180-01010

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Below are current pictures from the Site C dam site. Note the “white” tower “aggregate” crushing plant on south side of Peace River as a reference point.



This area on the right side of the above “white” tower (left side of picture) is to be the Site C Substation location. In this BCUC submission argument, this same area is thought to be the most suitable site for a nuclear power plant (NPP) because:

- 1.) This area would be 60 meters above the river flood plain,**
- 2.) The area has been cleared of forest growth,**
- 3.) The area is flat and the soil has been compacted.**
- 4.) The above rock material ‘might’ be suitable for power plant construction and is already available ready for use on site.**
- 5.) River crossing bridge to this site has been built and connecting roads have been either upgraded or built.**
- 6.) Current excavation work for the powerhouse next to the river could be used as a cooling pond if required.**





Below is a photo of worker's housing dorms on the north side of the Peace River.



One Possible Potential Problem with the NPP

Location of the **North Peace Regional Airport (YXJ)** on the east side of Fort St. John.
(Managed and operated by Vantage Airport Group, Vancouver, B.C.)
Although this problem is out of “scope” for the Inquiry, this problem needs to be added.



The proposed Septimus Nuclear Plant site is located approximately 9 km south west from the above North Peace Regional Airport located on the east side of the City of Fort St. John.

Aircraft either taking off or landing in a south west direction at this aerodrome would come near to over flying the NPP site.

Furthermore, the Saturday, 2017 August 19th submission comments made by Mr. Neil G. Thompson (BCUC Inquiry Respecting Site C # F20 – 1) are also relevant to this problem. The proposed NPP is just inside the 6 miles Visibility Range standard set by the World Meteorological Organization for forecasting and aviation fuel management decisions. Therefore, observational visibility problems from low clouds, mists, and fogs may be encountered, and this would, to some degree, may cause disruptions, extra costs and risks. For example, one possible problem of this nature might be airframe icing.

These problems, while not insurmountable, may require establishing some additional regulations to the air traffic control. Some examples are placing navigational aids, such as lights, radar reflectors, and navigational approach signals, on the NPP infrastructure to warn approaching aircraft would be advised. Likewise, having the appropriate aircraft flight navigational manuals updated to show where the NPP is a potential flight hazard, and informing regional air carriers and local private sector flyers of the new obstacles near the flight path.

The following Diagram has been sourced from Internet web site:

Canadian Airport Map with 9km Drone Exclusion Zones:canada

<https://www.nrc-cnrc.gc.ca/eng/solutions/collaborative/civuas/uav_site_selection_tool.html>

UAV Site Selection Tool - National Research Council Canada

https://www.nrc-cnrc.gc.ca/eng/solutions/collaborative/civuas/uav_site_selection_tool.html

Government of Canada / Gouvernement du Canada

National Research Council Canada

Home > Programs and services > Research programs and collaboration opportunities > Civilian Unmanned Aircraft Systems program > UAV Site Selection Tool

UAV Site Selection Tool

Instructions: This interactive map is intended to help UAV operators select sites away from aerodromes and built-up areas. Further details available on the [help](#) page. Please note the [disclaimer](#).

Search for location

Map Controls

UAV Operations Centre
Enter the centre of the UAV operations zone. Decimal degrees only e.g. (33.223, -44.231)
56.2379, -120.2169

Or

Cursor's position on the map
Latitude and Longitude
56.3138, -121.1624

Select UAV Weight

- 1kg or less
- 1 kg to 25 kg
- Model Aircraft (Recreational Drone)

Related information

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Google

2 km

Map [Report a map error](#)

1 of 2

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Similarly, drone aircraft should be banned from flying near the NPP. As can be seen in the above Transport Canada map, the NPP site falls just outside the airport's no fly zone. Similar restrictions should be sought for the NPP.

Added advantages of NPP over the Site C Dam project would be:

- 1.) Reduced construction dust in the air as no Site C Dam would be built.
- 2.) No smoke produced burning wood debris as no wood debris would be generated as the dam reservoir would not be created.
- 3.) No extra moisture would be added to the local air mass as the dam reservoir would not be created.
- 4.) Any local air moisture generated from the NPP could be controlled at site.

Implementation of the Decision (or Plan of Action)

Listed below are the Canadian Nuclear Safety Commission (CNSC) Licencing Procedures for Class 1A NPP showing the time it takes and what work is required to be done for implementation. They state nine years to complete. This NPP requires everything done in 5!

May 2017

REGDOC-3.5.1, Licensing Process
for Class I Nuclear Facilities and Uranium Mines and Mills

Where the CNSC will need to carry out an environmental assessment in addition to its regulatory review, the timelines will accommodate the time needed to carry out the environmental assessment within the 24 month timeline.

The timelines do not include the time:

- that the CNSC waits for a response to a request for information that is required to complete the review
- to accommodate an applicant's request to extend the schedule for submitting required information
- to address matters outside the CNSC's control, such as the time for other jurisdictions to participate in and complete an environmental assessment

8.2 Expected regulatory review timelines for subsequent licensing stages

Regulatory review timelines provide more predictable timing of regulatory reviews of applications for licences for, while continuing to protect health, safety, security and the environment. The regulatory review process includes measures to allow Aboriginal groups, the public and interested parties to participate fully in the regulatory review of a licence application.

Timelines for the assessment of an application for a first licence for subsequent licensing stages are provided for illustrative purposes in the following sections. These timelines:

- assume that the CNSC will receive complete and comprehensive applications
- include the time needed for resolution of CNSC's comments on submissions
- assume the CNSC is solely responsible for completing the EA
- include the time required for the two-part licence hearing process, which is approximately four months and the Commission decision-making process which is up to 90 days

8.2.1 Class I nuclear facilities: Timelines for regulatory reviews of applications

Timelines for Class IA nuclear facilities:

Licensing stage	Timeline (months)
Licence to prepare site	24
Licence to construct	32
Licence to construct and operate	40
Licence to operate	24
Licence to decommission	24

See Appendix B.1 for a chart depicting licensing timelines for Class IA nuclear facilities (i.e., nuclear power plants and research reactors), from the initial application to a licence to operate.

See Appendix C, Regulatory Process for the Transition of a Reactor Facility from Operation to Decommissioning End State, for additional guidance on the regulatory lifecycle of a reactor facility.

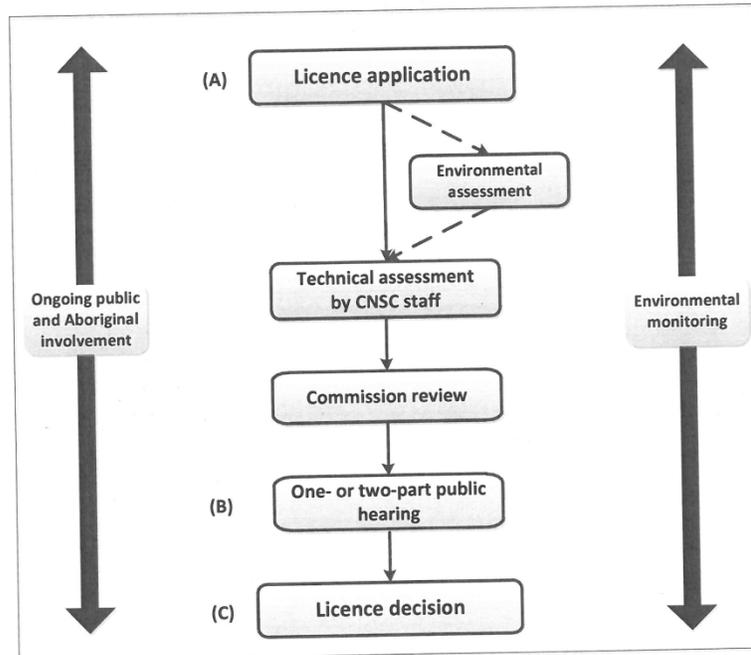
Appendix A: Process for Obtaining a Licence for Class I Nuclear Facilities and Uranium Mines and Mills

Upon receipt of an application, the CNSC has the authority under section 24(2) of the *Nuclear Safety and Control Act* to decide whether to issue a licence.

Licensing hearings usually take place through a one- or two-part process. Public hearings give the applicant, CNSC staff, the public and Aboriginal groups an opportunity to be heard before the Commission. Most decisions involving major nuclear facilities are made through the two-part public hearing process, during which two hearings typically take place 60 days apart.

Figure 1 depicts the process for obtaining a licence for Class I nuclear facilities and uranium mines and mills.

Figure 1. Licensing process for Class I nuclear facilities and uranium mines and mills



Notes:

Public and Aboriginal involvement and environmental monitoring are ongoing throughout the licensing process.

(A) The scope of the licence application determines the complexity of the review by CNSC staff and the Commission (see section 8 of this document for more information). If the environmental assessment

takes place at the same time as the regulatory review of the application, it will be presented to the Commission for decision at Part 1 of the hearing.

- (B) The applicant and CNSC staff present their submissions to the Commission at the public hearing, which is open to the public and broadcast on the CNSC's website. The public and Aboriginal groups are also encouraged to present their views on the application to the Commission.

Submissions that are filed with the CNSC for public hearings are called Commission Member Documents. For more details, see CNSC regulatory document G-379, *Guide for Applicants and Intervenors: Writing CNSC Commission Member Documents* [3].

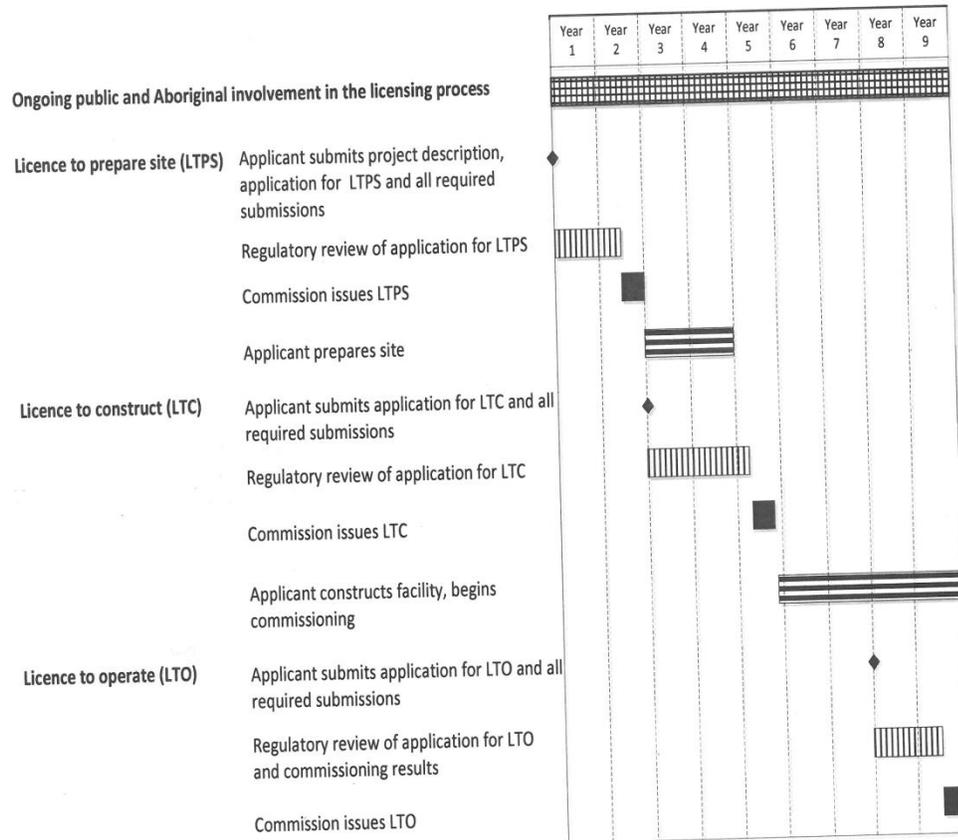
- (C) Following the hearing, the Commission deliberates and renders a decision. The CNSC issues the Commission's decision on the granting of the licence. The Commission's decision and its reasons for decision are usually published within six weeks of the conclusion of the hearing.

Appendix B: Licensing timelines for Class I Nuclear Facilities and Uranium Mines and Mills

B.1 Class IA nuclear facilities (reactor facilities)

Figure 2 depicts the licensing timeline from the initial application to a licence to operate for Class IA nuclear facilities.

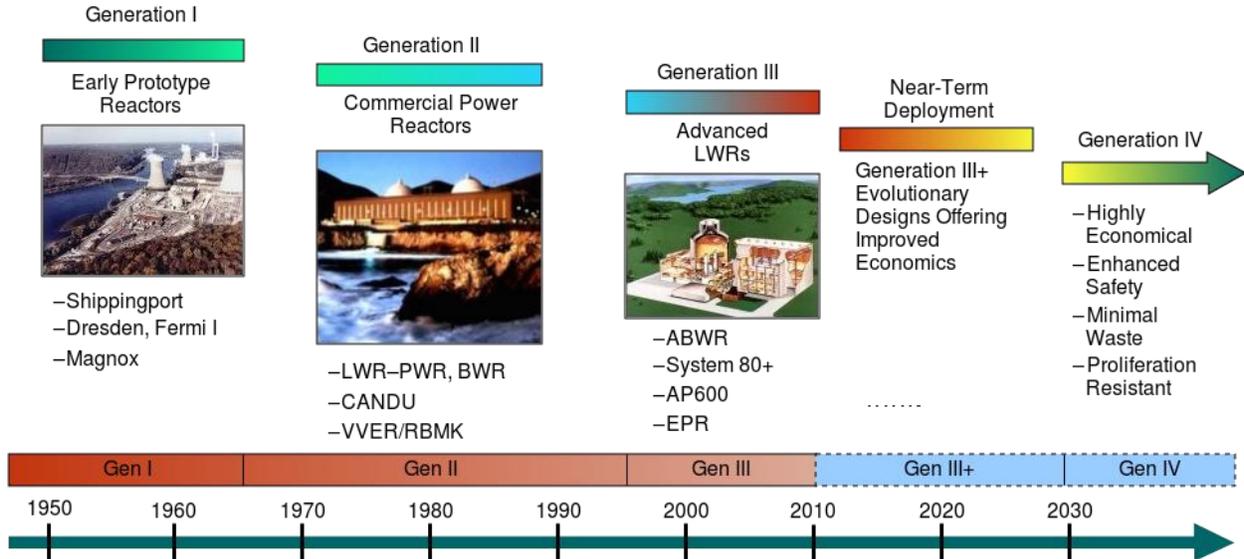
Figure 2. Licensing timeline for Class IA nuclear facilities



Nuclear Reactor Types for Assessment

Generation II, III, III+, and IV nuclear Reactor models

Generation IV: Nuclear Energy Systems Deployable no later than 2030 and offering significant advances in sustainability, safety and reliability, and economics



Decision Selection Factor:

Commercially available “Off-The-Shelf” (COTS) Rule Requirement

Three reactor designs were selected using the COTS Rule:

- 1.) Pebble Bed Reactor Design: Chinese HTR – PM 600 reactor plant
- 2.) Pressurized Water Reactor (PWR): Westinghouse Nuclear AP1000 reactor plant
- 3.) Boiling Water Reactor (BWR): GE Hitachi ABWR or ESBWR reactor plant

Chinese HTR – PM 600 reactor plant



HTR-PM (Tsinghua University, China)

Introduction

In March 1992, the China Central Government approved the construction of the 10 MW pebble bed high temperature gas cooled test reactor (HTR-10). In January 2003, the reactor reached full power (10 MW) operation. Tsinghua University's Institute of Nuclear and New Energy Technology (INET) has completed many experiments to verify crucial inherent safety features of modular HTRs, including:

- Loss of off-site power without any countermeasures;
- Main helium blower shutdown without any countermeasures;
- Withdrawal of control rod without any countermeasures;
- Helium blower trip without closing outlet cut-off valve.

The second step of HTGR application in China began in 2001 when the HTR-PM project was launched



*Reactor Configuration of HTR-PM
(Courtesy of Tsinghua University, with permission)*

Development Milestones

1995	Start construction of HTR-10
2000	HTR-10 first criticality
2001	Launch of commercial HTR-PM project
2003	HTR-10 full power operation
2004	HTR-PM standard design was started jointly by INET and Chinergy Co.
2006	Project approved as national key technology project
2006	Huaneng Shandong Shidaowan Nuclear Power Co., Ltd, the owner of the HTR-PM, was established by the China Huaneng Group, the Nuclear Industry Construction Group and Tsinghua University
2008	HTR-PM Basic design completed
2009	Assessment of HTR-PM PSAR completed
2012	Helium Test loop construction completed
2012	HTR-PM First Pour of Concrete
2013	Fuel plant construction completed with installation of equipment on-going
2017	First operation expected

Target Applications

The HTR-PM is a commercial demonstration unit for electricity production. The twin reactor units driving a single turbine configuration was specifically selected to demonstrate its feasibility.

Following HTR-PM, commercial deployment of HTR-PM based on batch construction is foreseeing, and units with more modules and bigger power size are under investigation. Standardized reactor modules with 2, 6 or 9 reactors with a single turbine (200, 600 or 1000MW) are envisaged.

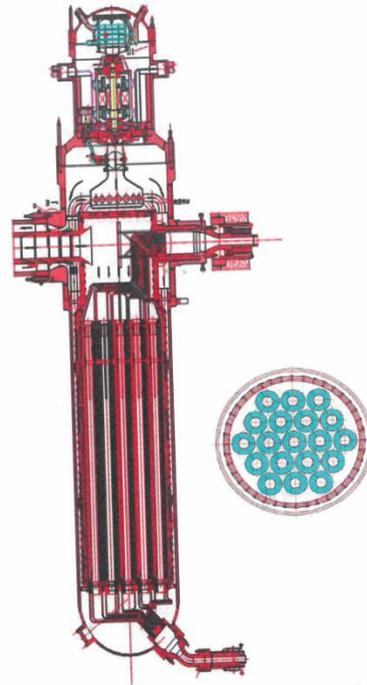
Development and research on process heat applications, hydrogen production and gas turbines are continuing for future application.

MAJOR TECHNICAL PARAMETERS:	
Parameter	Value
Technology Developer:	Tsinghua University
Country of Origin:	China
Reactor Type:	Modular Pebble bed High Temperature Gas Cooled Reactor
Electrical Capacity (MW(e)):	210
Thermal Capacity (MW(th)):	2x250
Expected Capacity Factor (%):	85
Design Life (years):	40
Plant Footprint (m ²):	~60,000 (site)
Coolant/Moderator:	Helium / Graphite
Primary Circulation:	Forced circulation
System Pressure (MPa):	7
Main Reactivity Control Mechanism:	Negative temperature coefficient; control rod insertion
RPV Height (m):	25
RPV Diameter (m):	5.7 (inner)
Coolant Temperature, Core Outlet (°C):	750
Coolant Temperature, Core Inlet (°C):	250
Integral Design:	No
Power Conversion Process:	Indirect Rankine Cycle
High-Temp Process Heat:	Yes, possible with different configuration
Low-Temp Process Heat:	Yes, possible with different configuration
Cogeneration Capability:	Electricity only; possible with different configuration
Design Configured for Process Heat Applications:	No
Passive Safety Features:	Yes, large negative temperature coefficients, large heat capacity
Active Safety Features:	Yes, control rod insertion with SCRAM; Turbine trip
Fuel Type/Assembly Array:	Pebble bed with coated particle fuel
Fuel Pebble Diameter (cm):	6
Number of Fuel Spheres:	420,000
Fuel Enrichment (%):	8.5
Fuel Burnup (GWd/ton):	90 (average discharge)
Fuel Cycle (months):	N/A; Online / on-power refuelling Fuel remain in the reactor for ~35 months
Number of Safety Trains:	N/A
Emergency Safety Systems:	Control rod insertion; Circulator trip; isolation of secondary circuit; drain of steam generator in the case of steam generator tube break
Residual Heat Removal Systems:	Passive
Refuelling Outage (days):	N/A since online
Distinguishing Features:	Passive post-shutdown decay heat removal
Modules per Plant:	Two reactors with their own steam-generator feeding one turbine-generator set
Estimated Construction Schedule (months):	59 months for 1 st unit under construction
Seismic Design (g):	0.2
Predicted Large Release Frequency:	Core damage frequency not applicable to HTGRs No off-site shelter or evacuation plan needed
Design Status:	Under construction

Specific Design Features

The primary circuit consists of the reactor pressure vessel, the steam generator (SG) pressure vessel and the hot gas duct vessel connecting the two in a side-by-side arrangement. The core is a ceramic cylindrical shell housing the pebble bed, which acts as a reflector, heat insulator and neutron shield. The control rod system and the small absorber sphere system are two independent control systems of reactivity. These two independent systems fulfil the requirements of diversity and redundancy, and are both located in the reflector region. On average fuel spheres are circulated 15 times through the reactor to ensure a low power peaking factor and to limit the peak fuel temperatures during loss of coolant events. The design allows load follow (100%-50%-100%) but the two reactor units can further also be operated independently.

The main helium blower, designed as a vertical structure, is installed on the top of the steam generator inside the steam generator pressure vessel. The super-heated SG is a vertical, counter-flow, once-through generator with a helium-water interface. There are multiple units consisting of helical heat transfer tubes.

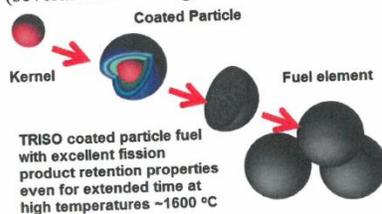


Once-through helical steam generator

Safety Features

The HTR-PM incorporates the inherent safety principles of the modular HTGR. The lower power density, good coated particle fuel performance and a balanced system design ensures that the fundamental safety functions are maintained. A large negative temperature coefficient, large temperature margin, low excess reactivity (on-line refuelling) and control rods ensures safe operation and limits accident temperatures. The decay heat is passively removed from the core under any designed accident conditions by natural mechanisms, such as heat conduction or heat radiation, and keeps the maximum fuel temperature below 1620°C, so as to contain nearly all of the fission products inside the SiC layer of the TRISO coated fuel particles. This eliminates the possibility of core melt and large releases of radioactivity into the environment.

Consequently there is no need for emergency core cooling system(s) in the design, and the decay heat is removed by natural mechanisms. The reactor cavity cooling system operates using cooling panels connected to an air cooler, but the fuel temperature will not exceed the limit if this system is not operating. The margins during normal operation and accident conditions are large (several hundred degrees in temperature).

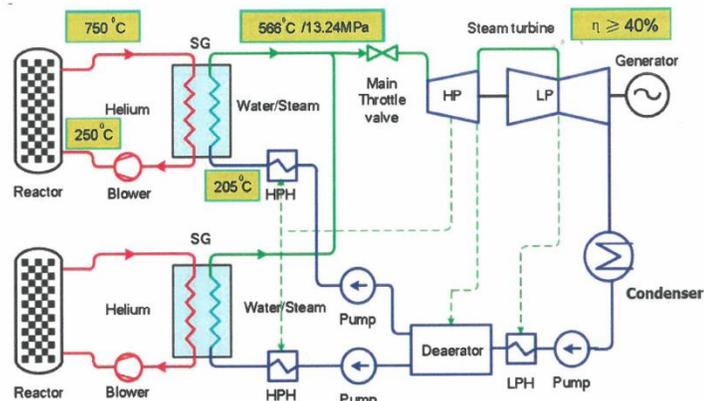


Fuel Characteristics

The HTR-PM utilizes the triple coated isotropic (TRISO) ceramic coated particle fuel element, which contains fuel kernels of 200–600 μm UO₂, UC₂ and UCO, but can also contain thorium or plutonium. The various layers of the TRISO fuel element include a porous carbon buffer layer and two dense pyrolytic carbon layers separated by a silicon carbide layer.

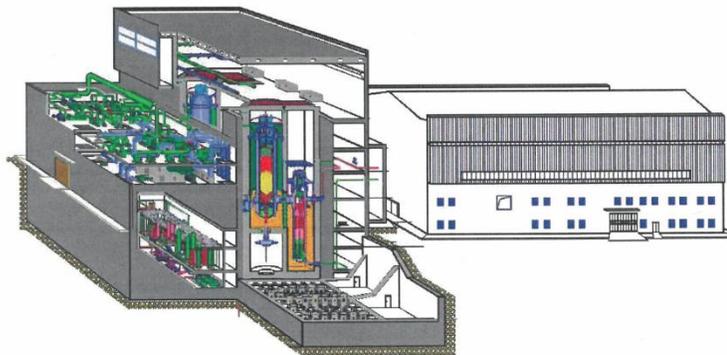
Description of the power conversion system

The Rankine power conversion with two reactor units and a single turbine-generator set is shown below. Each reactor unit has its own SG. During normal operation, driven by the primary helium circulator, the helium coolant passes the steam generator, and to heat up the 205°C feed water into 566°C superheated steam in the secondary loop. Then the superheated steam comes into the turbine to generate electricity. In the normal shutdown conditions, the reactor coolant system can also remove the core decay heat to the heat sink through the steam generator and the startup/shutdown circuit.



HTR-PM twin unit power conversion components and flow diagram (Source: Tsinghua University)

The nuclear island contain the two reactor units, and the building provide protection from external events. Other equipment for functions such as the fuel handling (loading, burnup measurement, unloading), the primary pressure release system, the secondary circuit isolation system, steam generator emergency draining system, and the sub-pressure ventilation system are also located in the reactor building. The conventional island thermodynamic system consists of the condenser, main water feed water system, regenerative extraction steam system, heater drain deflation system, auxiliary steam system, plant recycled water and the open cycle cooling water systems, closed cycle cooling water systems, vacuum systems, etc.

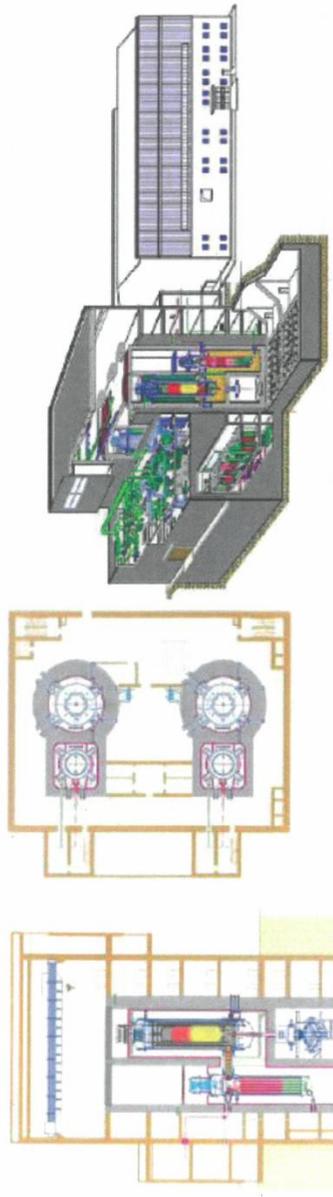


HTR-PM nuclear island and conventional island layout (Source: Tsinghua University)

Licensing and Certification Status

The preliminary safety analysis report (PSAR) was accepted by the licensing authorities during 2008-2009. First concrete was poured in December 2012 and construction is progressing as planned. The FSAR (Final SAR) assessment is expected in 2016 with operation towards the end of 2017.

HTR-PM: multi-module reactor steam turbine plant to properly address safety, cost and technology feasibility



Connect to one steam turbine, 200MWe

two module in one reactor plant

Each reactor module 100 MWe

Demo. plant

Multi-module in one reactor plant

Each reactor module 100 MWe

Comm. plant

Connect to one steam turbine, 200, 300, 600 MWe



Current status and technical description of Chinese 2nd 250MW_{th} HTR-PM demonstration plant
Zhang Peng, Zengqi Wu, Baohong Wang, Youxian Gu, Yuxiang Sun, He Li*, Nubi Deng



Westinghouse Nuclear AP1000 reactor plant



About: Westinghouse AP1000® Reactor

The AP1000 reactor is the most advanced nuclear power plant design in the global market. It is a next-generation Pressurised Water Reactor (PWR) that builds on the proven success of the standard Westinghouse PWR design.

The plant features innovative passive safety systems that use natural forces – such as gravity, convection and natural circulation – to automatically shut down the reactor and maintain a safe condition in the highly unlikely event of an accident.

It is built using modular construction techniques, allowing tasks that were traditionally performed in sequence to be completed in parallel – an approach that is designed to save time and money while enhancing quality.

The AP1000 plant also is economical in its operation – with less concrete and steel and fewer components and systems, there is less to install, inspect and maintain. In addition, it promotes ease of operation with the most advanced instrumentation and control (I&C) systems in the industry.

The plant has attained an unsurpassed safety pedigree as a result of reviews by safety regulators in Europe, Asia and the Americas.

Each AP1000 reactor has an output of around 1150MW. When fully operational, the three AP1000 units at Moorside will have a gross capacity of up to 3.8GW, providing around seven percent of the UK's projected electricity requirements – enough electricity to power approximately 6 million homes.

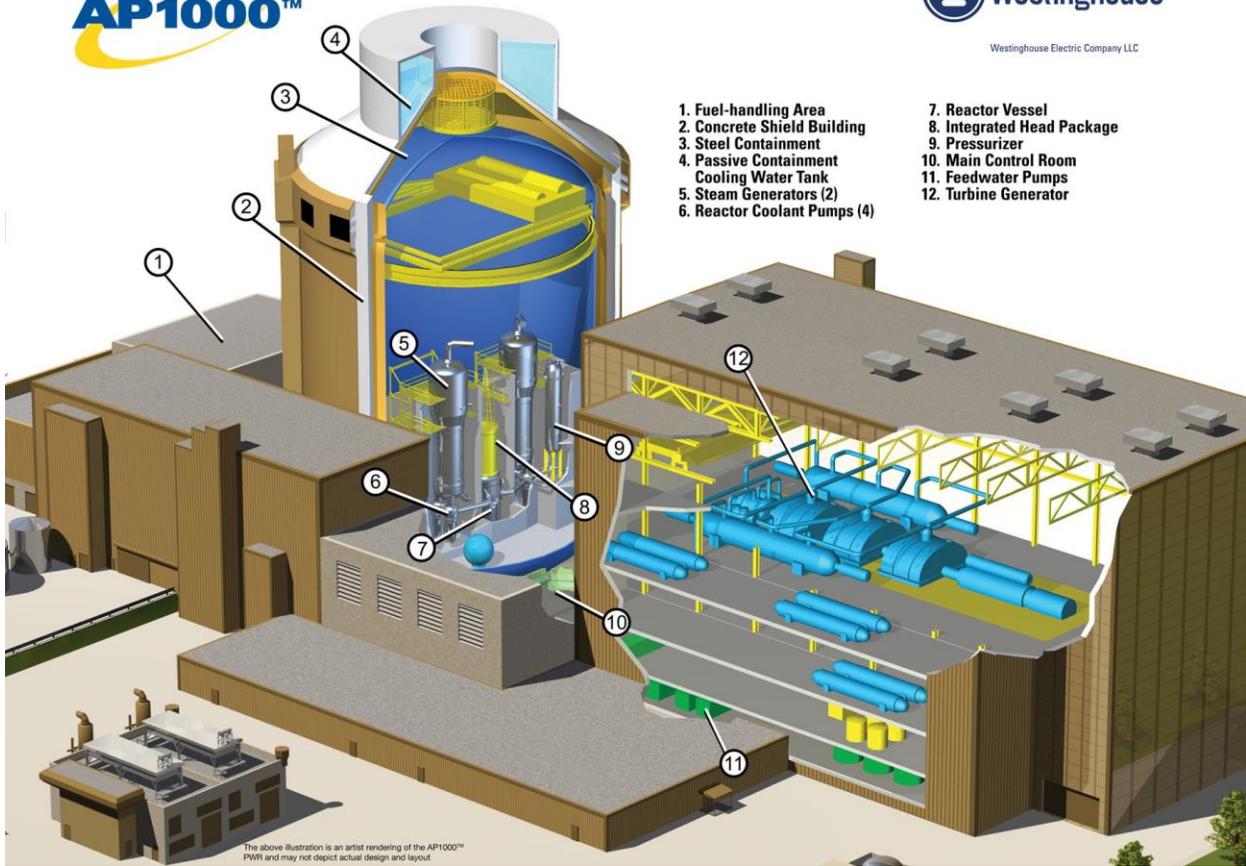
AP1000 plant key features

- The safest, most advanced nuclear power plant available in the worldwide marketplace
- Based on standard Westinghouse PWR technology that has achieved more than 3,000 reactor years of highly successful operation
- An 1150 MW design that is ideal for providing baseload generating capacity
- Modular in design, promoting ready standardisation and high construction quality
- Economical to operate - less concrete and steel, and fewer components and systems, mean that there is less to install, inspect and maintain

AP1000™

Westinghouse

Westinghouse Electric Company LLC



For more information visit <http://westinghousenuclear.com/New-Plants/AP1000-PWR>

GE Hitachi ABWR or ESBWR reactor plant

GE Hitachi Nuclear Energy

Advanced Boiling Water Reactor (ABWR)

fact sheet

Technology, Schedule, and Cost Confidence

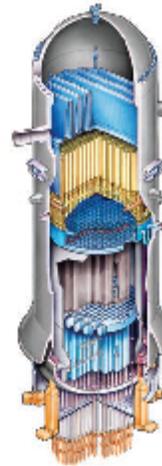
The Advanced Boiling Water Reactor (ABWR) is the foundation of GEH's nuclear reactor portfolio. The Gen III design is available today to meet power generation needs ranging from 1350 to 1460 MW net. It delivers proven advanced technology and competitive economics.

ABWR already has an impressive track record. It is the world's first and only Generation III nuclear plant design in operation today, providing the benefit of a combined 20 reactor-years of operational experience. GEH's first ABWR began commercial operation at Kashiwazaki-Kariwa in Japan, in 1996. Three additional ABWRs are operating in Japan with two more under construction in Japan, and two in Taiwan. The ABWR is licensed in the U.S., Japan and Taiwan.

The ABWR is a direct cycle Light Water Reactor that reflects 50 years of continued evolution from GEH's initial BWR concept—combining the best features from our worldwide BWR fleet. Our well-established, global supply chain is already qualified and prepared today to support deployment of new nuclear power plants.

Benefits and Features of the ABWR

- Lowest-in-Class core damage frequency at power (1.6×10^{-7} /year)
- Standardized design capable of further uprates
- 60-year Design life
- Modularized design to optimize construction schedule
- Demonstrated capital and O&M cost structure in Japan
- Significantly lower in staffing and maintenance costs per kWh than the current U.S. installed base of Gen I and II nuclear reactors



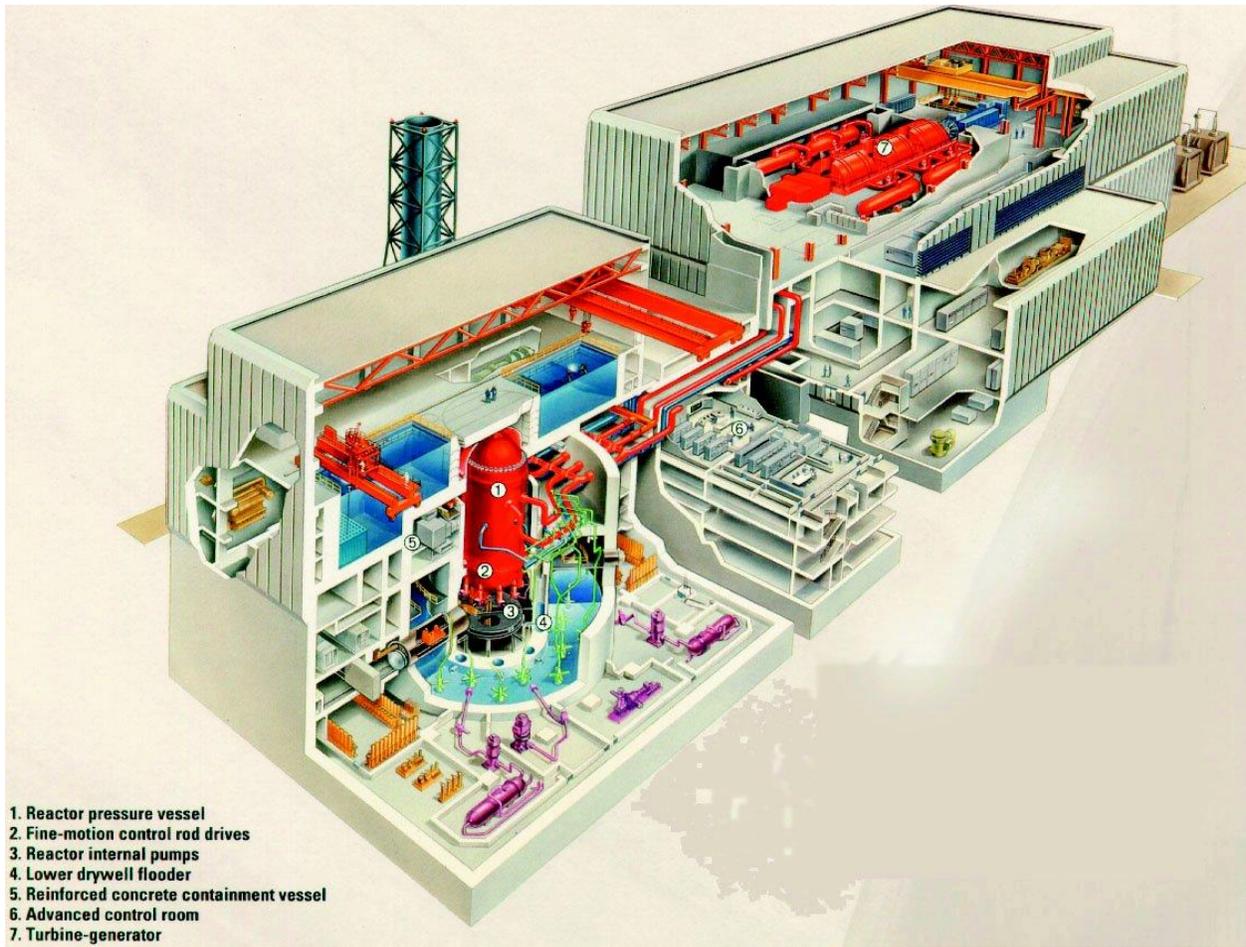
Simpler yet Safer Design with Advanced Technology

- **Reactor internal pumps** – eliminates external recirculation systems
- **Integrated containment and reactor building** – improved seismic response, compact, and easier to construct
- **Compact reactor building** – less construction material and shorter construction times
- **Optimized modularization** – module designs refined and proven in real installations
- **Sophisticated control systems** – fully digital, providing reliable and accurate plant monitoring, control, and diagnostics
- **High integrity fuel, improved water chemistry, and radiation source elimination** – reduced radwaste and occupational exposure



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a product of
ecomagination

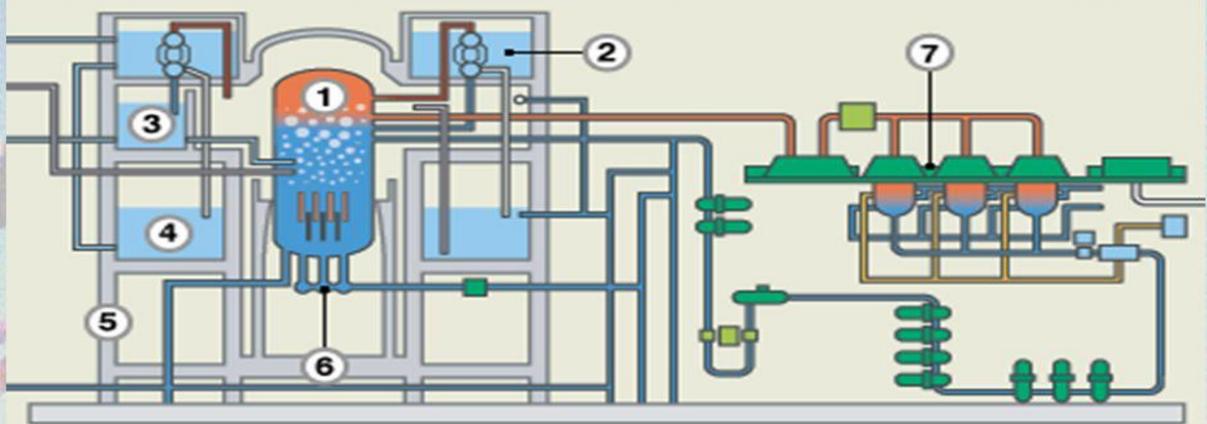


1. Reactor pressure vessel
2. Fine-motion control rod drives
3. Reactor internal pumps
4. Lower drywell flooder
5. Reinforced concrete containment vessel
6. Advanced control room
7. Turbine-generator

ESBWR: Economically Simple BWR

• A derivative of Boiling Water Reactor for which it is claimed has several safety features but which inherently has two disadvantages of basic design

- Vertical control rods which must be driven upwards
- Steam in turbines can become radioactive



Analysis

Advantages

- 1.) Chinese HTR – PM 600 reactor: 1.) COTS, 2.) Modular, and 3.) Going in to production
- 2.) Westinghouse Nuclear AP1000 reactor: 1.) COTS, 2.) Proven manufacturer with experience
- 3.) GE Hitachi ABWR or ESBWR reactor 1.) COTS, 2.) Simpler design, 3.) Establish companies

verses

Disadvantages of each reactor design

- 1.) Chinese HTR – PM 600 reactor: 1.) Pebble Bed Pallets brake down, 2.) No Containment Housing, 3.) Based on older Generation II+ technology
- 2.) Westinghouse Nuclear AP1000 reactor: 1.) Recent bad manufacturing track record in U.S.
- 3.) GE Hitachi ABWR or ESBWR reactor: 1.) Possibility of radioactive leaks in the system, 2.) Few systems in operation worldwide,

Conclusion

This report selects the Westinghouse Nuclear AP100 reactor plant. The reasons for this choice are:

- 1.) The decision provides a financial lifeline to Westinghouse Nuclear which is currently in Chapter 11 in the United States. (Due to this situation, B.C. could get a ‘good negotiated deal’ on its purchase price.)
- 2.) This decision would help contribute towards developing the ‘Transnational Infrastructure Program’ with the United States, which has been advocated by the Trump administration. The Transnational Infrastructure Program was set up to help TransCanada Corporation in its quest to build the Keystone XL pipeline.
- 3.) By supporting the ‘Transnational Infrastructure Program, this would put us in ‘good light’ so to speak with the Trump Administration.
- 4.) As a consequence, this deal could be used to serve as the ‘Icing-on-the-cake’ in the trade negotiation process with the United States to assist in reaching an agreement to settle the Softwood Lumber Dispute.
- 5.) The deal would also serve to advance “Plan B”, NWMO Option # 5, and the H5R Project.

References

Have to leave out references due to time limit.