BRITISH COLUMBIA UTILITIES COMMISSION

IN THE MATTER OF THE UTILITIES COMMISSION ACT
S.B.C. 1996, CHAPTER 473
and
An Inquiry into British Columbia's Electricity Transmission Infrastructure and Capacity Needs for the Next 30 Years

A Contribution to the Scope of the Inquiry
on the Need and Benefit of an HVDC Power Highway
Linking Northern and Southern British Columbia

by

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BC HVDC INITIATIVE

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1. Introduction

The purpose of this contribution to the long-term infrastructure plan for electricity transmission, (the BCUC Transmission Inquiry), is to point out the importance and the advantages of an HVDC (High Voltage Direct Current) bulk power link between the North and South regions of BC for the incorporation of renewable energy projects in Northern and Central BC. This is in line with the Government's policy, expressed in the Terms of Reference, to fully consider the potential long-term regional development of generation resources and the long-term transmission needs to access these resources.

This submission adheres to the “Staff Discussion on Scope of the Inquiry”, Section 5, Transmission Inquiry, Exhibit A-12 on all In Scope points with the exception of “specific routes or technological specifications of transmission projects”. We do not favour a specific route other than the power is to be delivered from point ‘A’ to a yet to be determined point ‘B’ approximately 800 km apart. It has been proven conclusively for transmission of bulk power over the distance in consideration that HVDC is the effective technology. The reduced environmental impacts and benefits of transmission for renewable energy sources are presented in this submission.

BC is blessed with an abundance of energy resources and it is thus paradoxical that it is a net importer of electric energy, a situation the Government is trying to redress by 2016. One of the main constraints on the development of additional generation is the long lead time required to obtain additional right-of-way. While a big transmission project can be designed and build in less than three years, the process of selecting a line route and obtaining the right-of-way (ROW) can be considerably longer. The Transmission Inquiry is a timely effort to make the process of selecting generating and transmission options more transparent, and by discussion with private and public stakeholders, hopefully shorten the times required to put selected options in service in order to meet the goal of electric energy self-sufficiency for the Province by 2016 as a first step, and export power thereafter.

During the first workshop organized by BCUC on 17 April 2009 it became clear that the process of selection was to be performed with the help of an optimization algorithm (the tool). This is a process which seeks out the optimal (least cost) development of generating plants and transmission lines over a period of time subject to a number of technical and political constraints. For example the maximum amount of power that can be transmitted through a transmission corridor (from a risk point of view) is a technical constraint. The omission of nuclear plants in the generation mix is a political constraint. It is part of our endeavour not only to have the HVDC bulk power highway between Northern and Southern BC included in the mix of transmission options to be considered for future grid expansion, but also to show that this option is superior, both technically and economically, to the alternating current (AC) options.

2. Present Situation

Power from two hydroelectric generating plants, (Gordon M. Schrum and Peace Canyon), situated on the Peace River in Northern BC is transmitted through three series-compensated 500 kV AC transmission lines to the Prince George area, (Williston station), and then further South to the Vancouver area. The 500 kV transmission lines are generally located in one power corridor from G.M. Shrum to Kelly Lake substation. The combined maximum power of the two Peace River generating plants is 3,400 MW. An additional generating plant on the Peace River, downstream from the Peace Canyon plant, (Site C), could provide an additional 900 MW. It is questionable, and BCTC will correct this if necessary, whether this additional energy could be evacuated without building additional transmission. Even if it was possible the 500 kV corridor would now become a bottle neck for any new renewable generation in Northern BC. There are significant small hydro, biomass, and wind energy resources in Northern BC and allowing these to be developed, in accordance with Government policy, will require additional transmission capability in the very near future if we are to achieve energy self-sufficiency by 2016.

Since the present process of route selection and ROW acquisition is cumbersome, it is highly desirable when selecting a new bulk power line corridor to acquire sufficient ROW to accommodate future expansion for the next ten or twenty years. The one, two or three bulk power lines that will be installed in this corridor could then be staged to accommodate growth secure in the knowledge that the line can be designed and built in less than three years. This removes significant uncertainty from BCTC planners' task, and will prevent delays in transmission infrastructure development that could potentially force BC to import more electrical energy.

The existing 500 kV corridor can transmit 3,000 MW to 4,000 MW. If we want to double this amount of power by adding new transmission lines a new corridor is warranted since the loss of 7000 to 8000 MW concentrated in one corridor due to a wind swept fire, or other disasters, would be catastrophic.

In order to meet the 2016 deadline it is thus critical to initiate the process of route selection and ROW acquisition for the new corridor as soon as possible since the duration of this task is highly uncertain. However, as will be shown below, route selection is very much dependant on the transmission technology which will be adopted – that is, alternating current (HVAC) or direct current (HVDC).

3. WREZ Adoption

We consider the adoption of the WREZ (Western Renewable Energy Zone) model to be an important and integral part of the Transmission Inquiry process. Establishing renewable energy zones provides stability and predictability for generation project development. For the purpose of this submission we have focused on one wind generation region in the province as identified in "Assessment of the Energy Potential and Estimated Costs of Wind Energy in British Columbia", Garrard Hassan Canada Inc., 2008 02 22, Issue E, for BC Hydro.

As stated in the Assessment, the Peace region has potential for over 18,000 MW of wind power generation with levelized costs in the average range of $100 to $110 per MWh. And, we anticipate this region will be designated one of the WREZ regions. It was conservatively estimated that 20%, or 3,600 MW would be commercially viable in the near future; however, we do not make any claims to actual viability as these figures are used for high level planning. Facilitating this amount of power transmission would require a new bulk transmission system from the Peace region to the southern load centres, which, in part, forms the basis for this submission.

4. The HVDC Option

For long distance bulk power transmission HVDC is more economical than HVAC. The reason is that the lower cost of the HVDC transmission line, for length exceeding about 600 km, will more than compensate the higher cost of the two terminal convertor stations when compared to HVAC line and station cost. HVDC power lines are, for that reason, long lines with no possibility of connecting to or tapping off the DC line between its terminal stations. IPP's cannot connect to the DC line except through regional lines ultimately feeding into terminal stations. This is in marked contrast with the 500 kV AC lines where IPP's can connect at any point along the line provided sufficient transmission capacity exists on these lines. Although this appears to be a disadvantage for the DC line it is actually a significant advantage as the DC bulk power line can be built in isolated areas.

We suggest that the Transmission Inquiry consider the option of building an HVDC bulk power highway, in its own separate corridor, between a location in the vicinity of the Peace River and a location near the US border, over a distance of approximately 800 km. In a first stage a +/-500 kV, 2000 MW bipole could be build on a right-of-way large enough to accommodate a second, (or even third), eventual bipole. If the option proves attractive both voltage and power capacity of the HVDC link would need to be optimized by further study.

Besides lower cost, the main advantage of the HVDC option will be that after completion of the first bipole this scheme will allow unloading of the near capacity 500 kV AC power corridor which will remove the constraints for IPP's to feed into the existing 500 kV grid.

HVDC is a proven mature technology which has been around for some time. Major existing systems are:

Table 1: Existing Large HVDC Systems

Name	Location	Voltage	Power	Length
Nelson River	Manitoba	Bipole 1: 450kV Bipole 2: 500kV	3,850 MW combined	895 km 937 km
Pacific Intertie	USA	+/- 500 kV	2,000 MW	935 km
Inga-Shaba	Dem Rep. Congo	+/- 500 kV	560 MW	1,700 km
Gezhouba-Shanghai	China	+/- 500 kV	1,200 MW	1,046 km
James Bay- Sandy Pond (Mass.)	Canada-USA	+/- 450 kV	2,000 MW	1,480 km
Three Gorges-Guangdong	China	+/- 500 kV	3,000 MW	940 km
Three Gorges-Shanghai	China	+/- 500 kV	3,000 MW	1,060 km
Itaipu	Brazil	+/- 600 kV	2 x 3,150 MW	2 x 800 km
Yunnan-Guangdong (*)	China	+/- 800 kV	5,000 MW	1,400 km

(*) completion date: 2010

For long distance transmission HVDC is more economical than HVAC. But besides the cost advantage there are some other major benefits:

4.1. Technical Advantages of the Proposed HVDC Bulk Power Highway

1. The existence of the DC power corridor will unload the 500 kV AC power corridor which will then allow further loading of the 500 kV AC lines with renewable energy projects (small hydro, biomass, wind) in their vicinity.
2. The DC line can be controlled to distribute power between the DC and AC power corridors. This transmission grid management will facilitate the incorporation of alternative energy sources from geographically distant locations.
3. The DC line will facilitate the stabilization of the AC grid.

4. Location of the Northern DC terminal in the Peace River area is advantageous as the reactive power needed to supply the converter terminal is readily available.
5. This location is also ideal to receive additional power from potential wind farms situated in the Peace River area and to provide a second tie to Alberta or northward to Alaska.
6. Proximity of the wind farms to the hydro stations will allow the reservoirs on the Peace River to act as energy buffers for the wind farms. These buffers could allow wind energy to be considered more as firm energy rather than temporary energy.
7. The Southern terminal will be ready to perform a similar function as the Northern terminal with eventual possibility of exporting power to the US either trough AC or through DC in a multi-terminal mode similar to the Bay James- Sandy Pond, Mass. link.
8. The voltage and capacity of a DC bipole will need to be defined by further study, but a 2000 MW at +/-500 kV is reasonable.
9. One such bipole, roughly the equivalent of two 500 kV series compensated AC lines, would add more than 50% to the existing North-South power transfer capacity.
10. The DC line can be designed so that loss of one pole would still allow 90% (1800 MW) of power to flow on the remaining pole.
11. The preferred location of this new corridor would be directly South of the Peace Canyon/Site C sites, staying East of the existing 500 kV corridor, and by-passing the Vancouver metro area on its East side to a location near the US border.
12. There would be no need for transposition towers.
13. The lighter weight of the DC tower (less than half the weight of a 500 kV AC tower) provides more options for installation. The possibility of installing these lighter structures by helicopter may shorten the overall line length by considering line segments that would normally be judged inaccessible.

4.2. Environmental Advantages of HVDC

1. Smaller footprint. The right-of-way width required by two bipoles (4000 MW) would be much smaller (about half) than that required by the present 500 kV AC corridor (3 lines, 3000 MW)
2. Electromagnetic induction caused by the alternating field is absent; consequently there is no risk of micro currents being induced in the human body. This would be an important factor in mitigating concern of adjacent residents.
3. The DC line is more aesthetic than the AC line. The structures are lighter (less than half the weight) and the line uses fewer conductors.

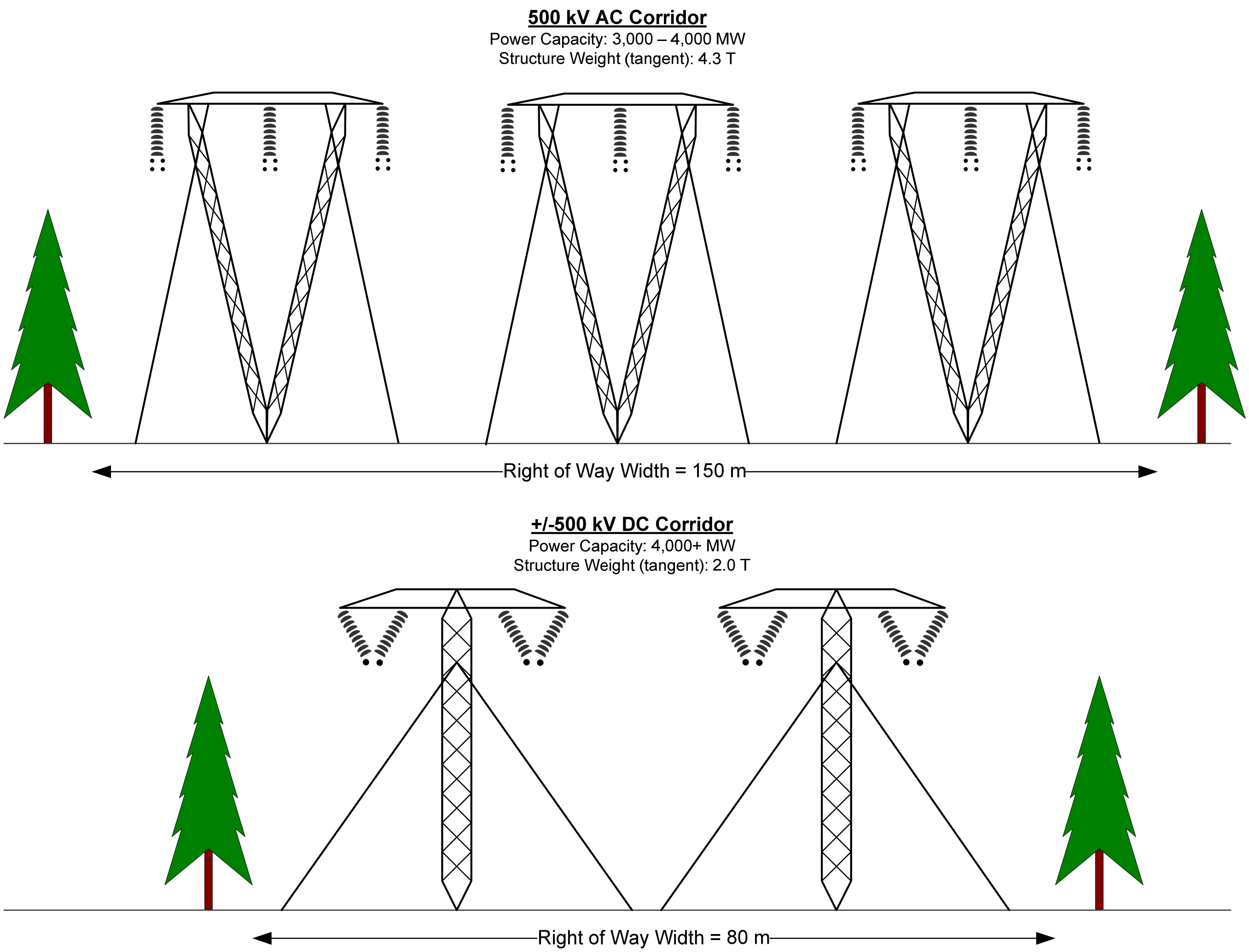

Figure 1: Transmission Corridor Widths

4.3. Cost Advantage of HVDC

Capital costs shown here are estimates of actual costs obtained with a design and cost estimating tool called TROP, and from existing constructed lines. Costs can vary depending on the state of the economy. Over the last year cost of steel varied by as much as 30%-40%.

Comparison is made between one HVDC bipole (2000 MW) and two 500 kV AC lines (combined 2000 MW).

Table 2: HVAC and HVDC Cost Comparison

Transmission Option	Capital Cost ($ Million)
500 kV HVAC	
2 x 800 x 1 $M/km	1,600
Stations	100
Total	**1,700**
+/- 500 kV HVDC	
Lines (guyed mast)	
800 km x 0.8 $M/km	640
Converter Stations	500
AC Stations	30
Total	**1,170**

Considering the rough nature of these costs, it can be seen that the cost of the HVDC option would be approximately 2/3 the cost of the AC option. If the Brazilian Itaipu system is used as a model (two +/-600 kV bipoles), the HVDC system could transmit twice the power (6,300 MW) of the existing HVAC system on a narrower right of way.

5. Summary

1. The existing 500 kV North-South corridor is close to its maximum capacity.
2. In order to tap large potential renewable energy resources in the North a second separate corridor needs to be created.
3. It is shown that HVDC bipoles should be installed in this new corridor as they are more cost effective, and environmentally and socially more acceptable than their AC counterparts.

4. This new power highway will reduce power transfer along the existing corridor thus allowing new renewable generation to be injected in the existing corridor.
5. HVDC will improve transmission grid management enabling creation of an open marketplace where alternative energy sources from geographically distant locations can easily be sold to customers wherever they are located.
6. The lighter weight of the DC structures will allow consideration of corridor routes which would normally not be considered when using heavier AC structures.
7. If the above conclusions are accepted by the Transmission Inquiry, it is recommended that BCTC immediately start with the process of corridor selection taking into account the many technical and social constraints. Acquisition of the right-of-way is a long process, but careful examination and selection of the areas to be transversed taking into account existing construction options may help reduce this burden.
8. In parallel to the previous task studies should be initiated to choose the optimal DC voltage and power capacity of the bipoles to be built in the new power corridor. Corridor capacity could take into account potential future connections to Alberta and Alaska as well.
9. Once HVDC and the new bulk power corridor have been selected it will facilitate the planners' task to select generation options and connect them to either the existing AC corridor or directly to the HVDC terminal stations.

Respectfully submitted,

______________________________	9 May 2009
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6. Biodata

Guy J. Van Uytven, P. Eng., M. Eng., MBA

Guy Van Uytven has 40 years experience in electrical power systems with an emphasis on high voltage transmission planning studies and design (ac and dc). He is the author of the TROP computer assisted design program, one of the first programs developed to help design and estimate costs of HV transmission lines (ac and dc). He has line construction experience (5 years) and has been an Owner's Representative managing line and station contractors.
He has worked with the Acres, Monenco and Teshmont consulting companies and is now an independent consultant.

Some relevant studies in the context of the Transmission Inquiry are:

- Project Manager for an advisory project with the Ministry of Electric Power, China. The project involved the planning of electric power generation and transmission over a 25 year planning horizon for South China (5 provinces).
- Project Director for a study evaluating the benefits of an interconnection between two electrical grids in East China.
- Design of the +/- 400 kV HVDC Gull Island transmission line connecting the Lower Churchill to St. John (NL)
- Design of the +/- 600 kV (6,300 MW) Itaipu (Brazil) transmission line.

Relevant technical papers authored or co-authored are:

- "L'utilisation du courant continu pour les interconnexions à longue distance", (The use of direct current for long distance interconnections), CIGRE/UPDEA Symposium, 25-27 November 1985, Dakar, Sénégal.
- "Design of the Proposed +/- 400 kV DC Gull Island Transmission Line", IEEE PES Summer Meeting, 17-22 July 1977, Mexico City, Mexico.
- "Generation of Optimal Strategies for Electric Power System Expansion using a Branch-and-Bound Algorithm", Canadian Operational Research Society, 16-19 May, 1977, Montreal.
- "Computer-aided EHV Transmission Line Design Optimization", Congresso Panamericano de Ingenieria Mecanica, Electrica y Ramas Afines, V Reunion, 12-18 August 1973, Bogota, Columbia.

L. Scott Taylor, P. Eng.

Graduate of Lakehead University, 1989, B. EE., he is a Professional Electrical Engineer with extensive background in high voltage utility and heavy industrial systems, telecommunications and broadband networks. His areas of expertise include Protection and Control: protective relaying SONET, ATM and Ethernet communications including routing and switching.

Notable achievements:

- Designed and installed the first SONET fibre optic communication and protection system in Canada.

- Designed and led the project team for the first municipally owned fibre optic broadband network in Canada/N. America.
- Responsible for the transmission and substation engineering for a private utility in Ontario.
- Designed and installed the broadband ATM network for the Puerto Rico Ministry of Education.
- Lead electrical engineer on various IPP projects in BC utilizing 138 kV and 230 kV transmission interconnections.