HOW A TRANSCANADA ELECTRIC SUPERHIGHWAY

WILL PROFITABLY ACHIEVE RENEWABLE ENERGY OBJECTIVES

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Introduction

A TransCanada electric transmission system is presented as an essential way forward to reduce thermal electric generation and increase renewable energy integration. To meet this national objective, the TransCanada electric grid must be economic. It is not possible today to economically justify the cost of the grid just on differential electricity prices. As each interconnected province retires thermal generators and as its load grows, reserve margins (total capacity greater than peak load) can be reduced while maintaining the same degree of reliability. The TransCanada grid would thus delay the need for new replacement generation. Some of the saving can be allocated to help pay for it.

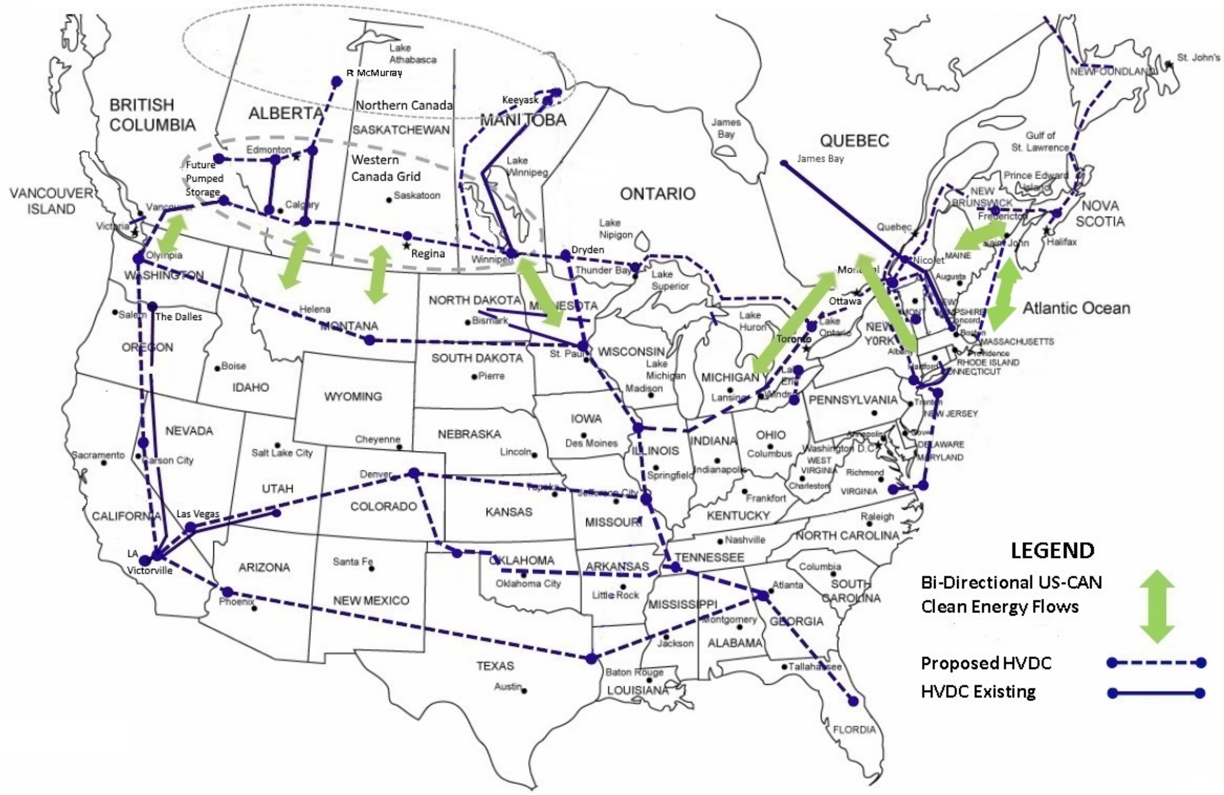

Figure 1: Conceptual TransCanada Electric Superhighway integrated with one option for a US macrogrid (The US portion of the macrogrid developed from an option proposed by the Midcontinent Independent System Operator, Inc. of Carmel, Indiana[1])

[1] https://www.cne.cl/wp-content/uploads/2017/04/Dale-Osborn.pdf

Greater benefits can be achieved for the TransCanada grid if it is integrated with a potential overlaying electric grid in the USA or "macrogrid" as they designate it. Increased and profitable penetration of wind energy with increased inter-provincial electric transmission for was shown by the 2016 Pan-Canadian Wind Integration Study (PCWIS), co-funded by Natural Resources Canada (NRCan) and the Canadian Wind Energy Association (CanWEA).

How the TransCanada Grid can be Profitable

Benefits are:

1. With wide-area transmission, wind and solar variable generation are assured an outlet into a larger market. The clean energy economy will grow as developers are attracted access to a wide area market the TransCanada Grid will offer.

2. In the west, hydroelectricity in Manitoba and BC and new pumped storage facilities[2] would be utilized as bulk energy storage, providing balancing capability and capacity to back up new variable renewable energy generators.

3. Provinces have announced plans to retire aging thermal generators. Not replacing all retired generators with new ones to maintain the required level of reliability of their electric services is possible if provinces help each other during peak periods. A TransCanada Grid would enable the sharing of reduced reserve margins (total capacity above peak load). In 2016, Alberta operated with 35% margin[3], excluding wind, solar and interconnections. Some of the savings on avoided replacement generation to reduce reserve margins can be invested in the TransCanada Grid.

4. The adverse impacts of sudden regional weather changes on solar and wind energy generation are smoothed out in a power system spanning several regions.

5. Reserve margin sharing is aided by regional diversity, both daily (east-west) and seasonal (north-south). This occurs naturally by the staggering of regional peak loading periods due to time and climatic differences.

[2] http://www.bclocalnews.com/news/386659781.html
[3] AESO 2016 Annual Market Statistics, February 2017, Figure 15, p.15.

6. A larger more integrated wide area electric energy market would be established for all interconnected regional utilities. So what is this market possibility? It is not a capacity market. It is an Energy Imbalance Market (EIM). This is the most significant market now being developed in the western US where variable generation continues to develop. The advantage of this market is that the western US regions are trading across regional and state borders much more than they ever did before. This goes against today's Alberta's and western Canada's Balkanized attitude.

The Canadian electric east-west superhighway will be profitable if developed wisely and in stages. The four western Canada provinces is one stage. Being profitable will attract investors and it would be investor owned such as oil and gas pipelines are. If the TransCanada pipeline company desired to upgrade the Energy East Pipeline to cross Manitoba, Ontario, Quebec and New Brunswick, then there is no reason why an investor owned transmission line could not traverse the western provinces[4]. However, this upgrade from natural gas to oil is now cancelled by TransCanada.

The grid has no energy flowing on it for reserve margin sharing except to assist a province from time-to-time when unable to meet its peak load. The grid may only carry load perhaps 5% of the time in a year for this purpose. Under such circumstances the empty grid can then be used for other profitable markets in electric energy. This includes more effective use of variable wind and solar energy by enabling a province to better balance of intermittency as well as allowing increased installation variable energy generators in every province. Any electric utility, investor owned or crown corporation may not choose to market energy regularly on the grid, but they can still take advantage of significant reserve margin generation benefit over time to achieve overall lower electricity costs for their customers. As stated above, An Energy Imbalance Market would pool in electricity generation within a region (say western Canada) and dispatch resources. This could moderate the variability of renewable generation resources and electricity demand on a least--cost basis.

The Alberta Electric System Operator is managing the "Regional Electricity Cooperation and Strategic Infrastructure Initiative" (RECSI)[5] for completion this year. This is a good start but more is needed to achieve full benefit of a profitable western grid.

[4] Examples of possible investor owned electric interconnections: http://www.cleanlineenergy.com/projects
[5] https://www.aeso.ca/market/market-updates/regional-electricity-cooperation-and-strategic-infrastructure-initiative-recsi/

In 1970, I participated in a study to electrically interconnect Britain with France justified on reduced reserve generation in both countries. Initially Britain rejected it but France was partially inclined. In time, a substantial interconnection was built. Being a profitable venture, they are contemplating increasing the grid connections between them. So, it will happen with a TransCanada Electric Superhighway

Socially Acceptable Transmission

While the benefits over costs of the TransCanada grid can be determined, one of the main challenges today with overhead high voltage transmission implementation is achieving social and environmental acceptance. Public opposition to additional power transmission lines is apparently much more related to appearance and lack of real say in location than other factors. European and US experience has shown low profile aesthetic designs can improve the prospect of lessened visual impact and thereby increase public acceptance[6].

Their reduced land requirements also increase the likelihood that the compact line can share transportation corridors and lessen environmental impact with a narrower right-of-way

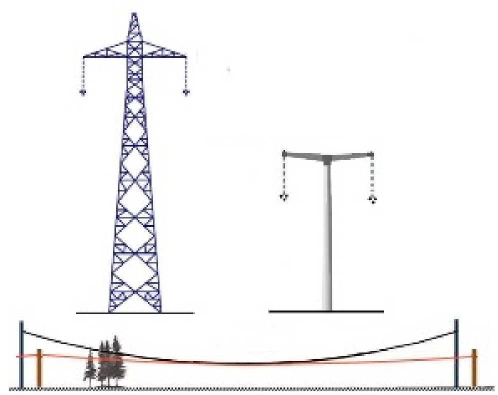

Figure 2: Comparison of 4000 MW HVDC transmission towers. Span length between low profile towers can increase without increased height using low sag conductors

The Challenge to the Provinces

There are many challenges to moving forward on a TransCanada Electric Superhighway. The greatest challenge is achieving provincial co-operation.

Challenge No. 1: Some of the biggest differences exist within the western provinces. To succeed, the west (and all provinces) must find a way to work together and cooperate.

[6] http://www.powerpylons.com/ See also: M. Salimi, L. Barthold, D. Woodford, A. Gole, "*Prospects for Compaction of HVDC Transmission Lines*", 2016 CIGRE-IEC Colloquium, May 9-11, Montreal, QC

Challenge No. 2: This second challenge is for the provincial utilities to allow reduction of their internal reserve margins to perhaps near zero by depending on electric capacity from other provinces. As older plant is retired, it need not be replaced if reliable reserve margin capacity can be obtained from the TransCanada Electric Superhighway. It is the cost saving in not replacing retired generators with new generators that is one of the largest economic benefits for the TransCanada Electric Superhighway. An Energy Imbalance Market would pool electricity generation across the western provinces including renewable generation.

Challenge No. 3: Environmental and social opposition to construction of high voltage DC transmission lines will arise. When the TransCanada Electric Superhighway project is to move into the construction stage, objection to the HVDC overhead transmission line needs to be approached consensually. The transmission towers or pylons must be aesthetic in appearance and low profile across areas of concern.

A Vital Role for the Federal Government

The western portion of a future TransCanada Electric Superhighway will require an independent system operator (ISO). Its role would be to operate and manage the markets transacted between regional electric networks province to province. The Alberta Electric System Operator (AESO) operates and manages the electricity markets in Alberta and does so as an independent operator under the jurisdiction of the Alberta provincial government.

A Western Canada Independent System Operator (WCISO) would operate and manage the markets transacted between western regional electric networks province to province and possibly for market transactions with the USA on behalf of the provinces.

Looking further into the future, a western Canada portion of the TransCanada Electric Superhighway could be expanded like as shown in Figure 3 with a medium voltage direct current MVDC interconnection between Nunavut to the Northwest Territories. The MVDC interconnection between the territories would only be developed if the microgrids along with the utilities of Yellowknife and Hay River would economically benefit from increased local variable generation with existing and new hydroelectricity and reduction in diesel and thermal generation.

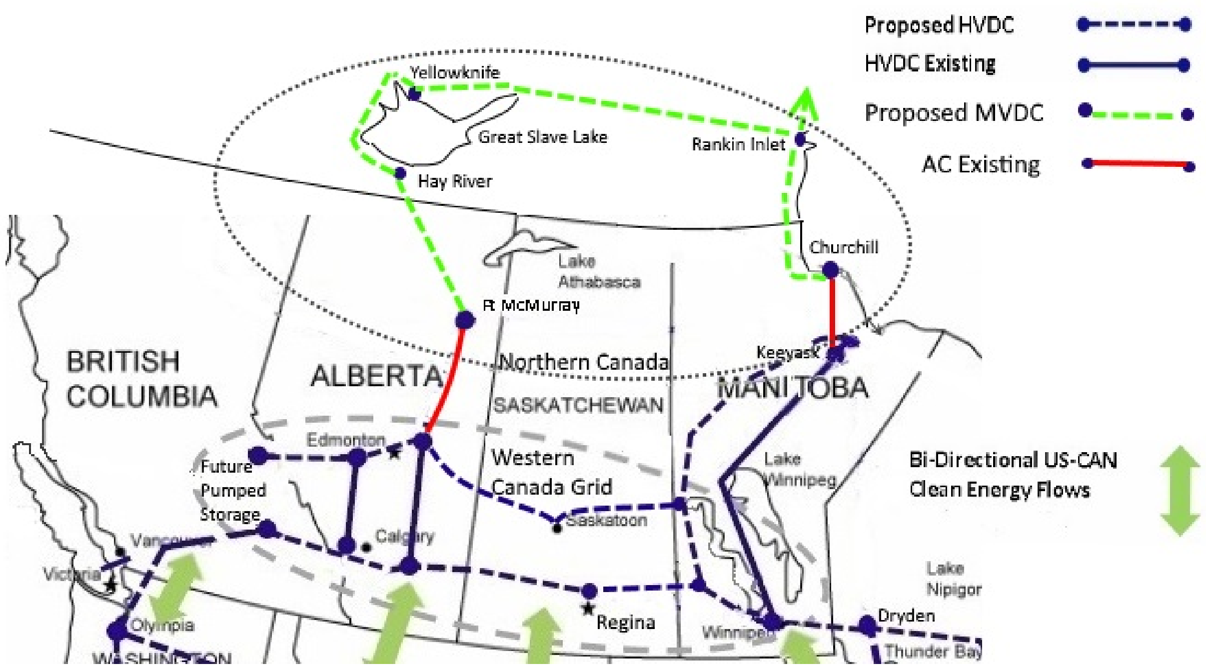

Figure 3: A conceptual future northern expansion of the Western Canada portion of the TransCanada Electric Superhighway for increased reliability and power transfer

The Next Step Forward

With profitability guaranteed, an investor owned TransCanada Electric Superhighway is needed and essential. To pave its way, the electric utilities in the western provinces can begin to jointly plan their generation retirements and expansions so that over time, their firm reserve margins are reduced to minimum levels, perhaps less than 10%. Their reliability of supply will be maintained through the western electric superhighway if they choose to connect to it Coordinated planning of generation requirements may be separate to the WCISO.

An investor owned western electric grid will provide capacity to balance expanded wind and solar generation enabling their much greater development and penetration. It will also provide capacity for meeting individual utility peak load conditions to maintain their reliability of supply.

The TransCanada Electric Superhighway when connected to the US will serve as a wide area market for regional electric utilities through the WCISO. The regional electric utilities and their grids in turn will provide markets for the future development of distributed energy resources or microgrids[7]. **Electric energy markets will be local (microgrids), regional (the provinces & territories of Figure 3) and then transcontinental using a macrogrid (Figure 1) with a WCISO managing the western Canada markets.**

[7] IEEE 1547, Standard for Interconnecting Distributed Energy Resources with Electric Power Systems