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On Strengthening North American Electrical Energy Security with a View on Net-Zero Emissions

The recent events that burdened Texas and several other states with calamitous power outages brought about by extreme cold, and last year's rolling outages in California brought about by wildfires and extreme heat conditions, are gradually convincing Americans that Climate change brought about by global warming is real and threatening. In testimony[1] this month before the US Senate, Frank Rusco, Director of Natural Resources and Environment, stated that climate change is expected to have far-reaching effects on the electricity grid that could cost billions and affect every aspect of the electricity grid, from generation, transmission, and distribution to end-user demand.

With the change in the US administration, addressing climate change has once again become a priority, just behind the COVID-19 crisis. Strengthening North American energy security was one of the items discussed by PM Trudeau and VP Harris on February 1st. It was also an issue raised in the February 23rd meeting between PM Trudeau and President Biden in the context of their global warming policy discussion.

A comprehensive report entitled "Accelerating decarbonization of the US energy system" commissioned by the U.S. National Academies of Sciences * Engineering * Medicine, was published recently by the National Academies Press. One of its main recommendations was to plan, permit and build critical infrastructure.

The recently held Canadian Academy of Engineering webinar on the findings of the Trottier Report highlighted challenges and strategies for completing large (hydro) infrastructure

[1] United States Government Accountability Office. Testimony Before the Committee on Environment and Public Works, U.S. Senate. ELECTRICITY GRID RESILIENCE: Climate Change Is Expected to Have Far-reaching Effects and DOE and FERC Should Take Actions. Statement of Frank Rusco, Director, Natural Resources and Environment on March 10, 2021.

projects. Building Trans Canada transmission lines was part of their identified infrastructure development plans.

The need for more systems interconnections was also identified, after a two-year study, in a recent webinar on "The Future of Electric Power in the US" held on February 25th by the US National Academies of Sciences*Engineering*Medicine. One of their recommendations was for Congress to establish a National Transmission Policy. Another was for the Federal Energy Regulatory Commission (FERC) to identify the major transmission line corridors which would be key to enable power shipment across much of the country.

Let us be very clear. No amount of interconnections would have saved Texas from the catastrophic outages they recently experienced. From analysis of their grid, it can be seen[2] that they lost half of their generating capacity (25,000 MW natural gas, 15,000 MW wind). Their generation reserve, necessary to maintain the delicate balance between demand and generation, dropped to below 1,750 MW. To prevent such a disaster from happening again, they must winterize their natural gas generating plants and all other electrical power sources. When that has been accomplished, they could use their spare natural gas capacity to provide adequate generation reserve.

The winterization of Texas' natural gas facilities, while urgent, needs to be viewed as a transitory step if the United States is to achieve net-zero emissions by 2050. As current gas generation capacity is phased out, interconnection with neighbouring utility pools will be essential. With that in mind, planning for this transition should commence immediately. Because of the large demand loads involved, HVDC or UHVDC transmission lines capable of managing large energy flows in both directions will be needed.

The use of HVDC lines or back-to-back convertor stations makes it also much easier to control power flow and prevent outages (blackouts) in one power pool from expanding to the neighbouring pool. An example of this is the big Northeast blackout of 2003 which spared Quebec because there was no synchronous link between Quebec and Ontario or New England.

In the absence of fossil fuel generating plants, with a forecast that generating capacity will have to triple by 2050[3], and to ensure a stable and sustainable electrical energy supply, utility pools across of North America should be linked. The advantages of doing so are clear. If the sun goes down in Florida, there will still be plenty of sunshine in Arizona and California. If wind fails in the Southwest there is still wind in Texas or in the Northern plains of Alberta, Saskatchewan, Manitoba. If energy demand peaks in a region of the U.S., there is hydro storage available in

[2] REVISED_ERCOT_Presentation (1).pdf - Google Drive

[3] Accelerating Decarbonizations in the U.S. - Report - National Academies 25932.pdf

Canada to help out. Peak electrical loads, which usually occur in the evening, differ from the East to the West which allows time shifting of generation supply.
Utility pools need sufficient generation reserve to deal with unforeseen events such as a major transmission outage, generator outage and/or a sudden rise in demand (as happened in Texas). That generation reserve can be supplied, within limits, from spare online generating capacity or from energy storage systems such as batteries, pumped storage, hydro reservoirs and potential blue or green hydrogen-driven generating plants.

Under normal conditions, utility pools should provide enough capacity to carry the expected load in that pool. They are designed to be able to deal with the problem of an interconnecting tie being lost for whatever reason. However, generating reserve required to deal with unexpected conditions could be shared between pools. A continent-wide interconnection, a **Supergrid**, would also be able to replace time-dependant expensive generation by less expensive reserve generation from a distant source. Generating reserve can be 20% of the generating capacity of a pool hence such sharing of reserves would yield significant savings. The establishment of such a North American Supergrid would facilitate the electric energy sector in achieving net zero emissions by the year 2050. The fuel savings alone would likely more than compensate for the costs of establishing this Supergrid. The elements of the Supergrid such as the HVDC or UHVDC transmission lines and convertor stations are proven technology with known costs and performances.

Canada can play an important role by providing hydro energy storage and can maintain its reservoir levels by importing inexpensive solar/wind energy from the South during periods of surplus power there. An MIT study[4] of the Quebec- New England interaction showed that such an interconnection would provide a win-win situation for all involved. This MIT model likely would be viable in the mid-continent with Manitoba and in the west with British Columbia.

Europe, with its big synchronous grid, is proceeding towards a European Supergrid with HVDC connections. This is called the Trans-European Network. Because of its high population density, they have decided that all HVDC links would be build underground. The 750 km long SuedLink links Northern and Southern Germany with two +/-550 kV cable circuits with a capacity of 4,000 MW. The climate in Northern Germany is favourable to wind farms, but in the South, it favours solar generation. Therefore, depending on weather conditions and electricity demand, SuedLink will transport wind power and Norway's hydroelectric energy from the north to the south, and solar power from the south to the north.

[4] MIT paper on 2-way trading.pdf

A European SuperGrid[5] would enable international energy trading, increased penetration of renewable energy, and improved security of supply. Because the North American Supergrid would be about twice the size of the European Supergrid the advantages of demand time shifting and variable availability of wind, solar and hydro storage would be even more evident.

As is happening in Europe, development of a North American Supergrid could take place piece by piece. In the context of talks about a Canadian Northern Energy Corridor, one option would be an interconnection between Prince Rupert, BC and NF&L with North-South links to the US at appropriate locations. Such a northern energy corridor would have several benefits:

1. It would allow the transfer of renewable energy in either direction across the country.
2. It would allow the transfer of stored hydro energy either way to supplement deficiencies in intermittent renewable energy or to provide generating reserve.
3. Pipelines could be installed to ship oil, gas, blue hydrogen[6] to either Atlantic or Pacific coasts.
4. Our Northern coast would have access to electric power which would foster development of mines, industries and associated communities.
5. HV power lines and pipelines would necessitate a construction road which could be converted to a year-round transportation link.
6. Russia is developing their access to the Arctic with roads, ports and additional icebreakers. China is also interested in the Arctic and using the Northwest Passage for shipping and a desire for Canadian resources. The energy corridor would facilitate the development of our Arctic shoreline and improve Canadian presence and sovereignty in the Arctic.

Operation and control of the North American Supergrid could be performed by a Cooperative of regional transmission operators (RTO's), who currently count Canadian power utilities among their members, or it could be by a new federal bi-lateral regulatory entity.

A bilateral Canada-U.S. Committee should be set up to look at a North American Supergrid. Study and planning for a Supergrid should start now if the Supergrid is to be initiated by 2030 and fully operational by 2050, with the ultimate goal of net zero emissions from North America by 2050.

It can be done, the technology is there, let us start.

Guy Van Uytven, P.Eng., FCSSE **April 2021**

[5] Supercharge Me: The Case for The European Energy Supergrid | GE News
[6] Canada to sign agreement with Germany on joint push to develop hydrogen market - The Globe and Mail