Q. Re: **Upgrade Transmission Line Corridor** *Bay d'Espoir to Western Avalon*, Pages 27-28 and 52-53.

Please provide Hydro's assessment of the relative costs and technical benefits, including reliability, of installing generators to provide synchronous condenser capabilities instead of installing simple synchronous condensers.

A. Hydro has approximately 40 years of operational experience with nominal 50 MW simple cycle combustion turbines equipped with clutches such that the electric generator, or alternator, can be used as a synchronous condenser for system voltage control when the unit is not required to produce real power (MW) in generate mode. Therefore, it would be natural for Hydro to assess the potential of equipping any proposed combustion turbine with a clutch for synchronous condenser operation, or conversely providing a combustion turbine engine (i.e., prime mover) and clutch on any proposed synchronous condenser for standby, or emergency, power generation.

At present, simple cycle combustion turbines are available with output ratings in the 50 – 60 MW (nominal) range in a single prime mover configuration to meet Hydro's capacity needs. As a result, an aero-derivative combustion turbine package can be sized with an output rating in the 100 – 120 MW (nominal) range with two prime movers (engines) turning a common electric generator (this is known as a double ender configuration)[1]. A typical electric generator for the 120 MW nominal combustion turbine is the Brush Electric 165.948 MVA generator as highlighted in Table 5.1 of the application. This generator has a synchronous condenser capability

[1] Both Hardwoods and Stephenville combustion turbines have two nominal 25 MW prime movers connected to a common nominal 50 MW electric generator.

of +127/-44 MVAR. In synchronous condenser mode the unit has an inertia constant of 1.01 kW.sec/kVA.

The analysis of the Labrador – Island HVdc Link has demonstrated a need to have a minimum of two 175 MVAR high inertia synchronous condensers in service at Soldiers Pond. Based strictly on reactive power rating, one would determine that there must be 2 x 175 MVAR or 350 MVAR of synchronous condenser capability. Assuming a nominal 120 MW combustion turbine with 127 MVAR synchronous condenser capability, a minimum of three combustion turbines would be required to meet the reactive power requirement.

In addition to the reactive power requirement, the analysis has demonstrated the need for additional inertia on the Island Interconnected System to support frequency response during temporary pole and bipole outages. The Soldiers Pond 175 MVAR synchronous condensers have an inertia constant of 7.84 kW.sec/kVA. With two 175 MVAR synchronous condensers in service at Soldiers Pond, the plant contributes 2744 MW.sec of inertia. With an inertia constant of 1.01 kW.sec/kVA, the 127 MVAR synchronous condenser associated with a nominal 120 MW combustion turbine provides 167.7 MW.sec of inertia. In order to provide the same amount of inertia as the 175 MVAR Soldiers Pond synchronous condensers there must be seventeen 127 MVAR synchronous condensers (2744/167.7 = 16.36).

The planning criteria also require that the system be stable with one synchronous condenser out of service. Therefore, there must be a minimum of eighteen 127 MVAR synchronous condensers installed to replace the three 175 MVAR high inertia synchronous condensers at Soldiers Pond.

Eighteen 127 MVAR synchronous condensers connected to eighteen nominal 120 MW combustion turbines represents 2160 MW of installed combustion turbine capacity. Page 35 of Hydro's Supply and Install 100 MW (Nominal) of Combustion Turbine Generation dated April 10, 2014 estimates the installed cost for a new 120 MW combustion turbine at $1,260/kW. Consequently, eighteen new 120 MW combustion turbines would cost on the order of $2.7 billion.

The high level analysis provided here demonstrates that in order to replace the proposed 175 MVAR high inertia synchronous condensers at Soldiers Pond with simple-cycle combustion turbines with synchronous condenser capability a minimum of eighteen 120 MW (nominal) units would be required providing a total installed plant capacity of 2160 MW (nominal) at an estimated capital cost of $2.7 billion. Clearly, the generator/synchronous condenser alternative is not an economically viable solution.