Q. Please provide the updated AC integrations studies for the 2011 HVDC configuration. This should include the AC system operational performance criteria, and any operational issues that need to be factored into the system design.

A. The AC integration studies for the 2011 HVdc configuration are underway with a scheduled completion date of November 2011 such that the HVdc system specification (including converter control requirements) will be completed for the project decision gate 3 in mid to late December 2011.

The objectives of integration study are:

- Develop an integrated model of the Newfoundland, Labrador and Maritime AC systems including the Labrador – Island and Maritime HVdc links;
- Identify all required upgrades to the Newfoundland and Labrador AC systems to meet the Newfoundland and Labrador Hydro System Planning Criteria. These upgrades may include additions to ensure sufficient system inertia, reactive power compensation and increased thermal capacity on the AC transmission systems to withstand specified contingencies;
- Identify the operating limits of the HVdc systems and specify high level control system requirements; and
- Identify requirements to modify existing protection and control schemes for the Newfoundland and Labrador AC systems. These modifications may include adjustment to the existing under frequency load shedding scheme, adjustment to protective relaying schemes and the addition of special protection schemes.

The steady state system criteria for the Newfoundland and Labrador AC systems are as follows:

- AC system bus voltages
  - 0.95 pu to 1.05 pu – all equipment in service
  - 0.90 pu to 1.10 pu – N-1 contingency
  - minimum permissible voltage at Come By Chance 230 kV bus is 0.922 pu under contingency
- Thermal loading on a transmission line or transformer should not exceed 100 % of:
  - Rate A – Summer season (30 ˚C ambient) – light load
  - Rate B – Spring/Fall season (15 ˚C ambient) – intermediate load
  - Rate C – Winter season (0 ˚C ambient) – peak load

  for all equipment in service and N-1 contingencies in steady state.

The transient system criteria for the Newfoundland and Labrador AC systems are as follows:

- Load shedding should not occur for the loss of the largest on line generator in the Newfoundland AC system;
- Load shedding should not occur for the temporary loss of a pole or bipole;
- System response should be stable and damped;
- Post fault recovery voltages on the AC system shall be as follows:
  - Transient under-voltages following fault clearing should not drop below 0.70 pu;
  - The duration of the voltage below 0.80 pu following fault clearing should not exceed 20 cycles;
- Post fault frequencies should not drop below 59 Hz and should not exceed 61.5 Hz; and

- Under frequency load shedding should be minimized

Operational philosophy of the Labrador – Island HVdc Link is as follows:

- Labrador – Island Link capacity is defined as 900 MW at Muskrat Falls
- Normal power flow will be from Muskrat Falls in Labrador to Soldiers Pond in Newfoundland;
- Reverse power flow is not required;
- The Labrador – Island Link will provide frequency control for the Newfoundland AC system.
- Reserve capacity for the Newfoundland AC system will be a combination of:
    - Operation of the Labrador – Island Link below rated 900 MW (i.e. generation reserve in Labrador); and
    - Operation of Newfoundland hydroelectric generation at economic operating points (i.e. spinning reserve being the difference between economic operating point and rated operating point)
- For sudden loss of a pole there shall be no under frequency load shedding on the Newfoundland AC system. From rated load in bipole mode, failure of one pole will move the Labrador – Island Link from bipolar mode operation to monopolar mode operation with earth return via shore pond electrodes. In monopolar mode the healthy pole is required to change its output from rated power (i.e. 450 MW) to twice rated power (i.e. 900 MW or 2 pu). The duration of the 2 pu operation in monopolar mode is set at 10 minutes to allow system operators in the Newfoundland and Labrador Hydro Energy Control Center time to start standby generation on the Newfoundland AC system and reduce loading on the Labrador – Island Link. To limit the amount of standby generation (i.e. fast start aero derivative combustion turbine) to be installed on the Newfoundland AC system, the continuous

monopolar rating of each pole has been set at one and one half times rated bipolar power (i.e. 675 MW or 1.5 pu);

- Labrador – Island Link monopolar mode 10 minute rating is defined as 900 MW at Muskrat Falls.
- Labrador – Island Link monopolar mode continuous rating using earth return is defined as 675 MW at Muskrat Falls.
- The sudden loss of the Labrador – Island Link bipole will result in the loss of in excess of 800 MW of generation to the Newfoundland AC system. A special protection scheme will be evaluated to address these conditions. (It should be noted that to address the sudden loss of generation under the Isolated Island scenario, an under-frequency load shedding scheme similar to the one currently in place will be required.)

The scope of the ongoing integration analysis includes:

- Load flow, short circuit and transient stability analysis using PSS/E version 32;
- Approximately 20 base case scenarios are to be assessed with Newfoundland AC system loads ranging from a minimum of 420 MW (summer night) to the future peak load case, the Newfoundland hydroelectric generation dispatch ranging from minimum through economic to maximum output, and the Labrador – Island Link loading ranging from 80 MW to 900 MW both bipole and monopole modes of operation;
- Contingencies include:
    - Temporary HVdc line faults near each converter;
    - Permanent pole failures on each link;
    - Temporary pole to pole faults on each link;
    - Temporary bipole failures on each link;

- Permanent bipole failures on each link;
- Permanent three phase faults in each of the Newfoundland and Labrador AC systems;
- Single phase 230 kV line faults with unsuccessful reclose on the Newfoundland AC system;
- Single phase 345 kV line faults with unsuccessful reclose on the Labrador AC system;
- Loss of generation in each of the Newfoundland and Labrador AC systems; and
- Loss of a synchronous condenser on the Newfoundland AC system.