Q. Please explain the proposed transfer scheme including the timeline for the transfer and the impact on power transmission for the cables in the Strait of Belle Isle in the following situations:

a) a fault in the spare cable;

b) a fault in the primary cable which is operating in conjunction with the spare cable; and

c) a fault in the primary cable which is operating by itself.

A. To ensure bipolar operation of the Labrador-Island Link is not interrupted for a single cable fault, a total of three HVdc submarine cables are being installed in the Strait of Belle Isle, one cable per pole plus a spare which will be energized by being connected in parallel to one pole cable under normal operation. The spare cable will be provided with high-speed switching devices to allow the following switching operations:

(a) Isolating the de-energized spare cable from the faulted pole;

(b) Discharging the disconnected, but charged, spare cable by connecting it to ground; and

(c) Connecting the already discharged spare cable onto an energized operating pole.

Given that the spare cable will normally operate in parallel with one of the pole cables, a fault in either the spare cable (question part (a)), or the pole cable paralleled with the spare (question part (b)), will be cleared by the same method.

The switching arrangement is shown in Figure 1.

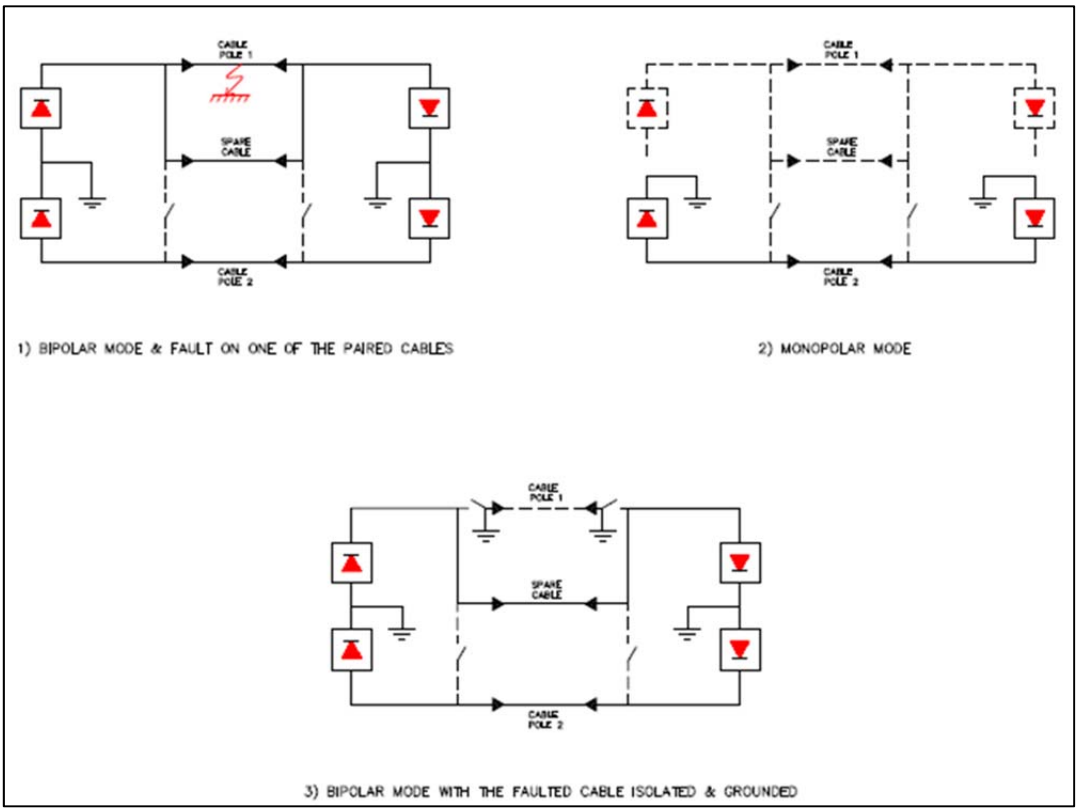

Figure 1: Fault Clearing on One of Paired Cables

In the event of a fault in one of the paralleled cables in Pole 1 as depicted in Figure 1, the LIL will automatically go into monopolar mode on Pole 2 with blocking of faulted Pole1. This operation will remove Pole 1 and both paralleled cables from the circuit. With the LIL in monopolar mode, the ten minute 100% overload capability of the HVdc system will be used to supply power on Pole 2 (the unfaulted pole). The switching sequence ensures isolation and discharging (grounding) of the faulted cable on Pole 1. With the faulted cable on Pole 1 isolated, Pole 1 is returned to service by de-blocking the converter, effectively returning the LIL to bipolar operation with a single cable on each pole. In this scenario there will be no customer interruptions as spinning reserve on the Island Interconnected System will

be used to make up the shortfall in supply[1]. Given that the single cable on Pole 2 has a five minute 100% overload capability in monopolar operation, the switching sequence will be completed and the system returned to bipole mode in less than five minutes.

For a fault on the single pole cable (question part c), the switching arrangement is shown in Figure 2. In the event of a fault on the single pole cable, Pole 2 as depicted in Figure 2, the LIL will automatically go into monopolar mode on Pole 1. This operation will remove Pole 2 and the faulted cable from service. With the LIL in monopolar mode, the ten minute 100% overload capability of the HVdc system will be used to supply power on Pole 1 (the unfaulted pole). From minute ten to minute 20, the load on the LIL in monopolar mode must be decreased to the maximum continuous overload rating of 50%.[2] This is accomplished by start-up of the stand by generation sources as required. With the LIL in monopolar mode, the switching sequence will isolate the faulted cable on Pole 2 and ground it.

At this point there are two cables connected to Pole 1. There are two options for the HVdc system at this point. The system can either remain in continuous monopolar operation or return to bipolar mode.

[1] Recall in response to PUB-NLH-217 that the Labrador – Island HVdc Link has a bipolar rating of 830 MW delivered at Soldiers Pond and a ten-minute monopolar earth return rating of 662 MW and a continuous monopolar earth return rating of 552 MW. For the most onerous loading case, a delivery of 830 MW at Soldiers Pond, there is 157 MW scheduled for the Emera Block and 673 MW for the Island. During a pole outage, the Emera Block is curtailed leaving the 662 MW ten minute capability for use on the Island. The 11 MW difference (673 – 662) is made up by the minimum 154 MW of spinning reserve carried on the Island when the LIL is operated at maximum import.

[2] Recall that the LIL monopolar rating of 100% for ten minutes decreases linearly to the continuous overload rating of 50% over ten minutes.

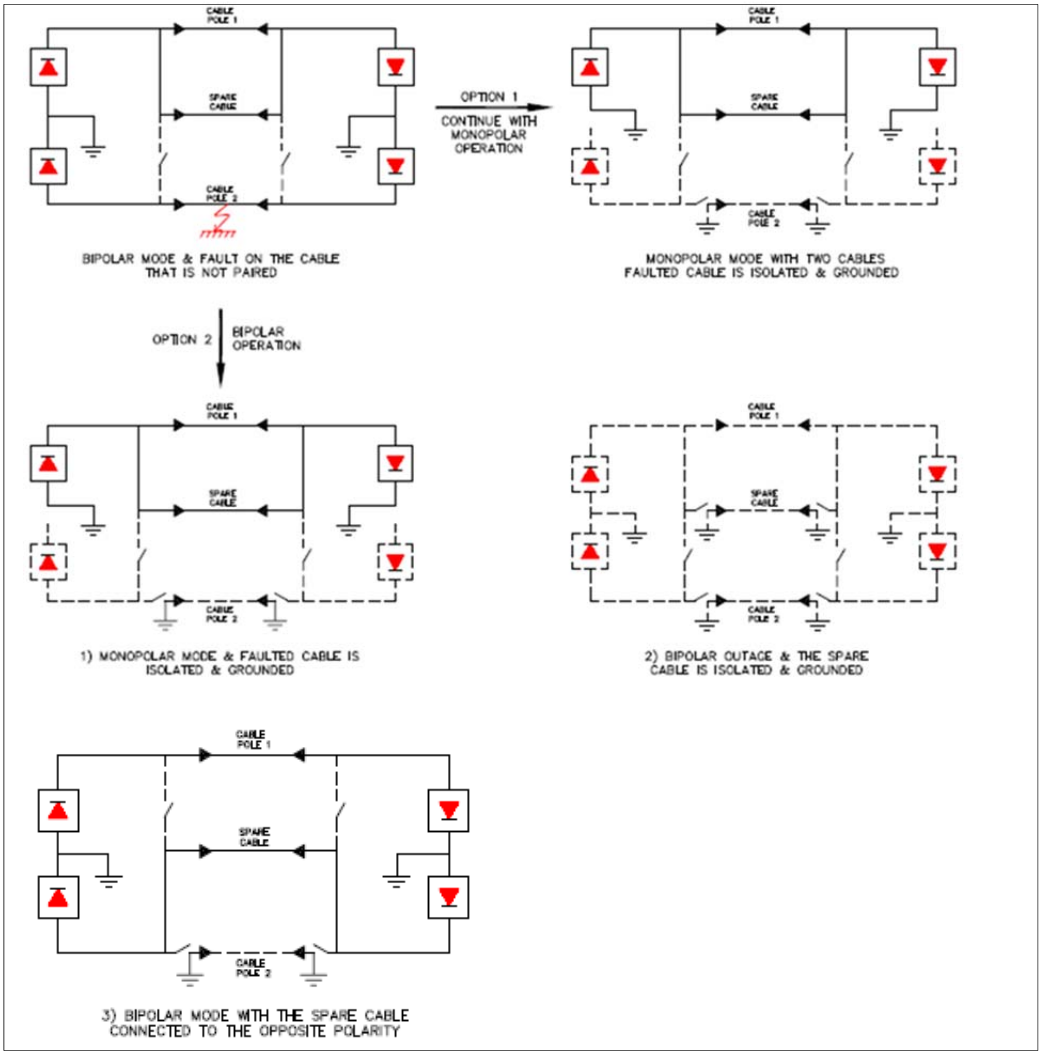

Figure 2: Fault Clearing on Single Cable Pole

In continued monopolar operation, Pole 1 will utilize the ten minute 100% overload capability of the HVdc system to supply power during which time standby generation on the Island is brought online. During the ten minute 100% overload period, each of the paralleled cables on Pole 1 carries 100% rated current and as a result are not overloaded. Following the ten minute overload period, the HVdc system will ramp over ten minutes to 50% overload on Pole 1. During the 50% overload condition on Pole 1 the parallel cables will be loaded to 75% of rated

current each. The response to PUB-NLH-217 outlines the capacity and generation for this situation.

To return to bipolar operation following the fault on the Pole 2 (single) cable and 50% continuous overload operation, specific operator given command(s) is required. The switching sequence requires a temporary block of Pole 1. During the temporary block of Pole 1 the high speed switches open to isolate the spare cable. With the spare cable isolated from Pole 1, Pole 1 is de-blocked permitting the HVdc system to deliver up to 100% overload for five minutes. With Pole 1 in monopolar mode and one cable in service, the spare cable is discharged through its ground switches. Once the spare cable is discharged, it is connected to Pole 2 and energized at opposite polarity with the de-blocking of Pole 2. With both Pole 1 and 2 energized the LIL returns to normal bipole mode operation with one cable per pole. Recall that the Island Interconnected System must be able to withstand the temporary bipole fault with no loss of load or system instability. The application of a specific operator command to transfer the spare cable from Pole 1 to Pole 2 in order to return to bipole mode is utilized to ensure that the Island Interconnected System has stabilized with sufficient high inertia synchronous condensers and reserves to withstand the temporary block of Pole 1. Once initiated, the switching sequence is completed in less than five minutes to prevent overload of the single cable in monopolar mode on Pole 1.

In the event that there is a fault on the converter or overhead conductor of Pole 1 (pole with parallel cables), the LIL will automatically go into monopolar mode on Pole 2 with blocking of faulted Pole1. This operation will remove Pole 1 and both paralleled cables from the circuit. With the LIL in monopolar mode, the five minute 100% overload capability of the HVdc system will be used to supply power on Pole 2 (the unfaulted pole) as there is one cable on Pole 2. At this point the spare cable is

isolated from Pole 1 and discharged through its ground switches. Once fully discharged, the spare cable is switched into the energized Pole 2 circuit using pre-insertion, or discharging, resistors to configure the monopolar operation on Pole 2 with paralleled cables.

With respect to the switching required to discharge the energized cable and insert the de-energized cable into an energized pole, standard ac circuit breakers with per-insertion or discharging resistors will be used. The selection of suitable pre-insertion resistors and breakers for the cable discharging and charging requires the coordination of the cable and converter manufacturers, and as such is a topic for final design. The analysis to date has indicated that the cable discharge and charging times will be on the order of ten to 40 milliseconds, with pre-insertion resistor in the 400 Ω size range with by-pass times on the order of two seconds. Consequently, the cable switching is expected to occur well within the five minutes overload capability of the submarine cables.