Q. Figure 8, on pg. 22 of the Report referred to in PUB-Nalcor-151, demonstrates that there is an angular stability issue with increased transfers which are not solved by the addition of a shunt capacitance at Come by Chance. The reason provided but not demonstrated was that the angular stability issue was a result of a voltage stability problem. In Exhibit CE-03(Public), one of the recommendations was that the effectiveness of power system stabilizers should be investigated, including the identification of potential new stabilizers to provide benefit to the overall stability of the system. This recommendation would suggest that angular stability problems exist in the absence of voltage instability. Please demonstrate that this instability is a direct result of voltage instability and not angular instability.

A. A transmission system is designed to deliver power within appropriate voltage operating ranges and also to recover from disturbances. In the specific case of the Bay d’Espoir to Western Avalon network, the Report discusses the effects of increasing power transfer from Bay d’Espoir to Western Avalon. The issues considered in this report are thermal limits, voltage stability, and angular stability.

As indicated on Page 17 of the Report, several alternatives were considered to increase the transfer capacity of the Bay d’Espoir to Western Avalon network. The Report demonstrates that the addition of shunt capacitors at Come By Chance helps the system to maintain acceptable voltage levels in contingency cases, such as those involving the loss of a unit at Holyrood. The capacitor bank addition therefore improves the voltage stability of the system.

The Report did not conclude "that the angular stability issue was a result of a voltage stability problem." These are two separate stability considerations, and as indicated in the Report, "While the addition of the capacitor banks on the Avalon Peninsula would increase the voltage stability of the system by providing significant reactive power support, the system must also be designed to have an adequate angular stability."

The angular stability of a power system refers to the ability of synchronous machines to remain in synchronism following a disturbance. This type of stability is therefore achieved by limiting the angular swings of generator rotors during system events to ensure that synchronism is not lost.

There are two subtypes of angular stability:

- small-signal angular stability, which refers to a power system's ability to maintain synchronism following a small disturbance. In such a case, the disturbance is small enough such that the system equations may be linearized for analysis. These linear equations are the basis for the design of controls for system elements such as exciters and power system stabilizers, and

- transient stability, which refers to the ability of a power system to maintain synchronism following a severe disturbance, such as a transmission line fault. During transient events, the linearization of system equations is not permissible, but rather the system must be designed and operated within stability margins to ensure recovery following the disturbance.

Power system stabilizers may be applied to address small-signal stability issues. As noted in Exhibit CE-03 (Public), analysis of the 735 kV network in Labrador indicated that oscillations in power flows were poorly damped. It was therefore recommended that this undesirable behavior could be corrected through an improved control system in the form of a correctly designed and tuned power system stabilizer.

Exhibit CE-03 (Public) also recommended that the requirement for power system stabilizers for the Newfoundland ac system be reviewed. This recommendation relates to a requirement to perform a detailed review of small-signal stability on the Island system with the HVdc interconnection. Such a review would involve the analysis of controls such as generator excitation systems and a requirement for the incorporation of power system stabilizers may be identified as part of this analysis. This level of analysis must be performed in concert with the detailed design of the HVdc control systems by the supplier of the Labrador Island Transmission Link.

The analysis described in the Report relates to transient stability issues. Specifically, it was noted that the system would be unable to recover from a severe system events such as a fault on TL202 or TL206 under specific conditions. During such a disturbance, system controls such as power system stabilizers would be ineffective.

As indicated in the report, if a system does not have adequate transient stability, system additions are required. For the Bay d'Espoir to Western Avalon corridor, acceptable transient stability would only be achieved through the addition of series compensation on TL202 and TL206 or through the addition of a new transmission line.

Increased power flow to the Avalon Peninsula can only be accomplished by addressing both voltage stability and transient stability issues. Voltage stability would be improved through the addition of capacitor banks, while transient stability would be improved by the addition of either a new transmission line or series compensation on TL202 and TL206.