Q. Please describe Newfoundland Power's transmission system planning policy, criterion and process. Include in the response the numbers and titles of personnel involved with the transmission planning process.

A. **Terminology**

Newfoundland Power does not use the terms "transmission" and "subtransmission" to differentiate portions of its transmission system. Newfoundland Power uses the terms "transmission system" or "transmission line" to refer to the parts of its electrical system that transmit electricity from the infeed points of the Newfoundland and Labrador Hydro ("Hydro") bulk electricity grid, or from its own generation sources, to Newfoundland Power's distribution substations.

Accordingly, the following is Newfoundland Power's single response to Requests for Information PUB-NP-155 and PUB-NP-156.

General

Newfoundland Power operates a transmission system that comprises 104 transmission lines with a combined total length of 2,062 kilometres, together with the associated line terminations and substation transformers. Newfoundland Power's transmission system operates primarily at voltages of 66 kV and 138 kV, with a very limited portion operating at 33 kV for legacy reasons.

The general objective of Newfoundland Power's transmission planning is to ensure that its transmission system operates in a safe, reliable and cost-effective manner. Proper planning ensures the transmission system is able to supply the aggregate electricity requirements of consumers at all times, taking into account expected future load growth and scheduled, and reasonably expected unscheduled, outages of system components.

The Company maintains models of the electricity system that enable it to analyze and evaluate its transmission system. These models are used in forward-looking planning studies and also for operational planning.[1]

Planning requires both engineering analysis of different electricity system configurations and economic analysis of alternatives. It also requires the application of engineering standards, judgement and experience.

In planning and monitoring the capability of its transmission system, Newfoundland Power applies criteria for both voltage and current (or capacity). The various

[1] Operational planning involves analysis of short-term or temporary system configurations.

components of the transmission system are monitored on an ongoing basis with reference to these criteria, and any issues identified are addressed as appropriate.

In addition to considering the capability of its transmission system relative to the applicable voltage and capacity criteria, Newfoundland Power also considers the extent to which service reliability concerns may require that redundant capacity be incorporated into its transmission system.

Planning Criteria

Voltage Criteria

The voltage criteria used by Newfoundland Power for system planning purposes are based on limits prescribed in the Canadian Standards Association ("CSA") standard *CSA CAN3-C235 – Preferred Voltage Levels for AC Systems, 0 to 50,000V*.[2] The CSA standard includes recommended voltage variation limits for circuits up to 1,000V at service entrances, and recommended voltage variation limits at point of sale and purchase for circuits between 1,000V and 50,000V. The voltage limits are defined for both normal and extreme operating conditions.

Newfoundland Power applies these voltage criteria to ensure that the quality of the electricity provided to the customer is within acceptable limits. Essentially, voltages on transmission lines are managed so as to ensure that the specified criteria are met on the downstream distribution lines.

Capacity Criteria

Capacity criteria for Newfoundland Power's transmission system ensure that current levels on the transmission system under specific operating conditions do not exceed the thermal loading limits of the various components of the system. The major components of Newfoundland Power's transmission system are the transmission lines and the substation transformers.

For transmission lines, the capacity criteria are determined through the analytical methods outlined in the standard *CSA C22.3 No.1 – Overhead Systems*.

Newfoundland Power's conductor capacity (ampacity) planning criteria are based on maximum allowable conductor temperatures expected under normal seasonal ambient temperature and wind conditions. For substation transformers, the capacity planning criterion is set at the nameplate rating of the transformer. These criteria are sufficiently

[2] Section 4.1 of the *Public Utilities Act* provides that voltages at the customer's terminals shall not exceed four per centum from declared constant voltages. In 1994, the Board approved the use of CSA No. CAN3-C235-83 for determining allowed voltage levels.

conservative to allow for the effects of equipment aging, and for such reasonably anticipated abnormal conditions as extreme peaks and cold-load pick-up.[3]

Reliability Considerations

Newfoundland Power's transmission system connects the Company's distribution substations to the delivery points where the system is connected to Hydro's 230 kV bulk power grid. Newfoundland Power's transmission lines are not part of the 230 kV bulk power grid.

The transmission lines on the 230 kV grid are critical to the overall security of the Island Interconnected System.[4] For that reason, the 230 kV grid is designed to ensure that the loss of any single transmission line will not result in a power interruption to customers. Newfoundland Power's transmission lines are not designed to meet the same reliability criteria.

Newfoundland Power's transmission system planning incorporates engineering judgments that seek to achieve a reasonable balance between cost of supply and reliability of service. This results in differing levels of redundancy for different transmission lines.[5]

Planning Process

General

Newfoundland Power's transmission system planning process involves the monitoring and forecasting of power flows and voltages on the transmission system to identify deficiencies. When deficiencies are identified engineering studies are carried out to develop appropriate solutions.

Newfoundland Power's transmission system planners use a model to simulate system performance under various conditions to ensure compliance with the defined voltage and capacity criteria.

The model incorporates the electrical characteristics of each major system component including transmission lines, power transformers, generators, and voltage regulating equipment.

[3] For detailed information on conductor capacity criteria, see the Response to Request for Information PUB-NP-146. For detailed information on substation transformer capacity criteria, see the response to Request for Information PUB-NP-145.

[4] The 230 kV grid consists of the high voltage transmission lines that tie all of Hydro's major generation sources on the island of Newfoundland to the major load centres. The 230 kV grid extends from Stephenville and Corner Brook on the west coast of the island to St. John's on the east coast.

[5] Where limited redundancy exists, the Company's fixed generation, mobile generation, and mobile substation equipment provides support during extended transmission outages and major transmission rebuilds and upgrades.

The model is used to evaluate system performance through load-flow analysis and short circuit analysis.

Load-flow Analysis

The load-flow analysis is completed for a specific point in time, which is typically the time of expected winter peak demand. The base case includes conditions as they are expected to exist at that time, including consideration of anticipated additions and retirements. Generation and loads are set at their expected levels at each bus. The model is run to determine (i) the flows in each line and transformer and (ii) the voltages at each bus. These values are examined to assure that no bus voltage is outside its acceptable operating range and that no line current flow exceeds the applicable criteria.

Short Circuit Analysis

Short circuit modeling is used to help design the system-protection equipment and to assure that circuit breakers are capable of withstanding and interrupting the largest possible fault, or short-circuit current.

Short circuit analysis determines how much fault current might flow at each node in the grid if a short circuit occurs. This information is important because excessive fault current can damage equipment and pose a safety hazard to workers.

Short circuit studies are done for three reasons: (i) to make sure any change to the system, for example adding a generator, reconfiguring lines, or changing a transformer, does not raise fault currents above the interrupting capability of the existing circuit breakers; (ii) to tell the designers of new substation equipment what size breakers are needed at that location; and (iii) to provide information for setting protective relays.

Other Inputs

In addition to the results of load-flow analysis and short circuit modeling, the load forecasts prepared in conjunction with the development of the Company's annual capital budgets are considered in relation to the capacity of existing substation transformers to meet forecast peak loads.

Newfoundland Power also completes periodic voltage regulation studies to ensure the transmission system continues to be capable of delivering voltages within the prescribed voltage criteria.

Voltages on the transmission system are monitored in real time by the Company's Supervisory Control and Data Acquisition ("SCADA") system. Transducers and digital protective relays transmit information about voltages at individual substation transmission and distribution busses to the SCADA system. Voltage values are continuously monitored and compared to the high and low voltage limits. In addition to

providing an alarm at the Control Centre where a violation of a voltage limit merits immediate attention, the voltage data is also archived for future analysis.

Planning Studies

In addition to ongoing monitoring, forecasting and system modeling, Newfoundland Power conducts transmission planning studies as required. Studies are carried out primarily to assess the impact of load growth, aging infrastructure and the addition of new generation sources to the electricity system.

Newfoundland Power's system load growth has averaged approximately 1.7% annually over the past 10 years. Load growth has not resulted in a requirement for any new transmission lines during that period.[6] Over the same period, however, load growth has resulted in several capacity additions to the Company's substations.[7]

Newfoundland Power completes an annual review of its aging transmission lines. The results of this review are considered as part of the Company's capital budgeting process, and regularly documented in capital budget filings. When necessary, a more detailed study will be carried out to determine the best approach to rebuilding a transmission line.[8]

In 2008, two wind generation farms were connected to Newfoundland Power's transmission system. The interconnection of these new generation sources necessitated a technical analysis of Newfoundland Power's transmission system. The results of load-flow analysis related to the interconnection of the Fermeuse wind farm were subsequently included in a review of the ground clearances on transmission line 24L, and resulted in upgrades to increase ground clearances in specific locations along the transmission line.[9]

Personnel

Overall responsibility for transmission system planning at Newfoundland Power rests with the Electrical Engineering section of the Company's Engineering Department. Ongoing planning activities are coordinated by the System Planning Engineer, supported by a Senior Electrical Engineer, two Engineering Technologists and engineering work-term students. Additional support is provided by the Supervisor, Distribution Engineering and Standards.

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6 The last addition to Newfoundland Power's transmission system related to load growth was the construction in 1993 of transmission line 70L between Oxen Pond and Stamp's Lane Substations in St. John's.

7 For example, the report *2014 Additions Due to Load Growth*, filed as part of the Company's 2014 Capital Budget Application, recommended the addition of transformer capacity at Hardwoods, Bay Roberts and Marble Mountain substations.

8 For example, the report *Bonavista Loop Transmission Planning*, filed as part of the Company's 2006 Capital Budget Application, considered the replacement of transmission lines on the Bonavista Peninsula.

9 The conductor ampacity analysis included a forecast of expected conductor currents from which a forecast of conductor operating temperatures was developed. Analysis of the effect of the forecast conductor operating temperatures revealed increased conductor sags which impinged on limits for allowable safe ground clearances.

In addition, the Manager, Revenue and Supply, who is a senior engineer with broad system planning experience, provides oversight and advice in relation to the Company's transmission system planning activities.