Planning Level Description of Load Shedding RAS Under 5L71 and 5L72 Double Contingency for Mica Unit 6 Transmission Integration

---

Introduction:

In recent BC Hydro's Long-Term Acquisition Plans (LTAP), four peaking generation units had been planned in Revelstoke and Mica generating plants, such as Revelstoke Unit 5&6 and Mica Unit 5&6.

Based on a comprehensive study, BC Hydro optimized the generation development sequence in Columbia basin: Revelstoke Unit 5 is under construction and is scheduled to enter service in 2010; Mica Unit 5; Mica Unit 6; and then Revelstoke Unit 6.

In order to accommodate the integration of an ultimate six units at Revelstoke or at Mica, a third 500 kV line was considered from each generating plant to alleviate the potential system impacts when losing entire Revelstoke generating station (3000 MW) or Mica generating station (2830 MW) under double contingencies. The system upgrade project is a new 500 kV Downie switching station (DOW) looped into 5L71 and 5L72, which includes two new 500 kV lines (DOW-MCA and DOW-REV).

Considering the cost and long project lead time of building new 500 kV lines, a system load shedding RAS is required to address these rare but severe double contingency events such as N-5L71/72 or N-5L75/77 after the addition of the 6th unit at either Mica generating station or Revelstoke generating station.

This document provides conceptual information on the application of load shedding RAS to improve the security of the transmission system without new 500 kV line to either MCA or REV, the expected performance of the RAS, and the related issues for Mica Unit 6 Integration.

Background:

<u>Load Shedding RAS Application in BCTC system</u>

Three load-shedding RAS to secure the system from the simultaneous loss of two 500 kV lines are currently applied in the existing system:

1) Load-shedding RAS on Vancouver Island is required when 5L30&5L32 or 5L29&5L31 or 5L42&5L45 are tripped out simultaneously, referring to SOO 7T-41

   After the 500kV supply from LM to VI is opened, a Direct Transfer Trip (DTT) will directly shed VI load. About 1400 MW of VI load will be shed in minutes under the worst operation scenario.

2) A load-shedding RAS scheme is applied for simultaneous outages of the Western BC-US inter-tie lines, 5L51 and 5L52, under import conditions into BC from US.

   The 5L51 and 5L52 contingency RAS will transfer trip the Eastern BC-US inter-tie 2L112 from Nelway to Boundary and result in a BC and Alberta islanded system from the Western Interconnected System. The load-shedding scheme is implemented through the under-frequency load-shedding scheme in BC or Alberta or both systems to control frequency in the island.

3) An UVLS RAS is applied for loss of any two Interior to Lower Mainland grid lines to mitigate voltage instability.

   This RAS improves system security for multiple system contingency events. It employs a PLC based logic that is triggered by under-voltage at 2 out of 3 critical buses on LM and VI and simultaneous change in reactive power output from the synchronous condensers at Burrard generation station and VIT substation.

BCTC Planning Criteria Related to Double Contingencies

According to WECC/NERC Planning Standards, planned/controlled loss of demand or curtailed firm transfer is allowed under system contingencies in Category C to secure the electric system.

Due to the low probability of double 500 kV line contingency, such as the loss of two parallel lines along the same transmission path, BCTC would apply load shedding RAS to secure the system under system contingencies in Category C, if the associated system upgrades cannot be justified.

Current BCTC's Operation Limitation on Double-Line Transmission Path:

Presently, the limit of power transfer on double 500 kV circuits in parallel is about 2500 MW, which is applied in BCTC transmission system to mitigate the potential system impacts caused by simultaneous double line outages.

According to The Rating of WECC Path 3, the continuous import capability from US to BCTC is 2000 MW. However, Path 3 has a demonstrated capability of temporary emergency import of about 2850 MW. A system incident event occurred around 10:48 AM on June 06 2002 when BC was importing about 1460 MW and 5L75/77 (Revelstoke generation) was lost. The instantaneous import from BPA system to BCTC system reached 2850 MW through inter-ties, and the system survived and was restored in one hour. The 2850 MW amount is the maximum recorded import level on the BPA to BCTC inter-tie in the past ten years.

Without the application of system load shedding RAS, the power transfer via 5L71 and 5L72 should be limited in 2500 MW. After suddenly losing 2500 MW of generation or power transfer in a double contingency event, the neighbor utilities provide about 2500 MW of temporary support via the inter-ties. Automatic Generation Control (AGC) will bring BCTC's operating reserve on-line over several minutes, which is at least 500 MW (5% of BCTC system peak load or single largest generating unit). The continuous level of power import from BPA system under this event should be less than 2000 MW, the WECC path rating.

Load Shedding RAS for Mica Unit 6 integration:

With the addition of Mica Unit 6, the transfer demand from Mica to the system will be about 2830 MW, which exceeds the BCTC's operation limit of power transfer on a two-line transmission path (2500 MW). Based on technical and economic comparisons, load shedding RAS, combined with series compensation on 5L71/72 and a 500kV shunt

capacitor bank at Nicola substation, is suggested to accommodate the integration of Mica Unit 6

The RAS design which covers the RAS logic, facility requirement, and project implementation in detail, usually occurs in transmission project definition/execution phase or in the operational system study phase. A high level concept description of applying load shedding RAS for Mica Unit 6 integration is therefore summarized at this planning stage.

Key Assumptions in Conceptual Analysis

- Mica peaking units are built to serve BCTC system peak load. Mica is dispatched with high output level in winter peak load period. Mica peaking units are assumed off-line during light load conditions.
- At pre-contingency condition, the power exchange via BCTC-BPA inter-tie is zero MW. With the electricity self-sufficiency policy in BC, the coincidence of running Mica heavy generation output and operating BPA-BCTC inter-tie with heavy import should be rare. This scenario is not addressed in this conceptual analysis.
- The momentary power transfer capability from BPA to BCTC system should be about 2850 MW, which was proved in a historical incident.
- The double contingency incident is expected to be restored (at least one line be restored) in one hour in average.

Load Shedding RAS Design Concepts

- The load shedding RAS is automatically armed when the generation output from Mica is greater than 2500 MW. This logic may be refined to include the import level at BPA-BCTC inter-tie. For example,

  $$\textit{Mica generation} + \textit{power import at BPA-BCTC inter-tie} \leq 2500\ MW$$

  based on detailed system studies in operational study stage.
- In the transient period right after losing double lines 5L71 and 5L72, the instantaneous support demand from neighbor utilities should be less than 2850 MW and fast responding load shedding scheme may not be necessary. More system operational study will be required to verify this in RAS design stage.
- The application of load shedding scheme is to restore the BPA-BCTC inter-tie within its path rating, 2000 MW. When considering that 500 MW of operating reserve in BCTC system is available (Minimum Operating Reliability Criteria - MORC), about 330 MW [2830 MW (MCA) less 2000 MW (Path 3) less 500 MW (operating reserve)] of system load is expected to be shed for the worst case scenario. If more operating reserve is available, fewer load is expected to be shed.
- This load shedding RAS for Mica Unit 6 is a system remedial action scheme: The loads that are shed could be anywhere in the system. At this stage, the

loads prepared for UVLS and UFLS schemes will be selected with higher priority. The location of these loads will be determined by BCH Customer Care and be optimized for easier RAS implementation in RAS design stage.

Expected Need to Arm Load Shedding RAS for Mica Unit 6

- According to BC Hydro's estimates, after Mica Unit 6 integration, the time duration that Mica generates greater than 2500 MW of power is
    1. less than 70 hours per year with operating reserve at Mica. The probability of arming this load shedding RAS is about 0.8 %; or the worst case
    2. less than 193 hours per year without operating reserve at Mica. The probability of arming this load shedding RAS is about 2.2 %.
- Based on the statistic data in Table 1, there are three events of simultaneous 5L71 and 5L72 outage, and the total outage duration is 2.8 hours. The probability of double contingency of 5L71/72 is about 0.0016%. The frequency of double contingency is 0.15 times per year.

    Table 1, Non-momentary double outages of 5L71&5L72 from 1987 to 2006

Starting Time	Restored Time	Line	Time Duration	Cause
1990-08-13 21:27:00	1990-08-13 22:05:00	5L71	38 minutes	LI - Lightning (Prime Cause)
1990-08-13 21:27:00	1990-08-13 22:09:00	5L72	42 minutes	
1993-07-20 16:46:00	1993-07-20 16:56:00	5L71	10 minutes	LI - Lightning (Prime Cause)
1993-07-20 16:46:00	1993-07-20 16:47:00	5L72	1 minute	
2005-07-29 17:01:01	2005-07-29 19:10:00	5L71	2 hours 9	LI - Lightning
2005-07-29 17:01:01	2005-07-29 19:10:00	5L72	2 hours 9	

- Considering zero interchange with BPA and 500 MW of operating reserve available in BCTC system, the calculated time duration with load shedding caused by 5L71/72 double contingency is
    1. 0.00112 hours per year with operating reserve at Mica; or
    2. 0.00309 hours per year without operating reserve at Mica.
- The most possible cause for the double line outages of 5L71 and 5L72 is lightning, which usually occurs in spring and summer. However, Mica peaking units are usually required to serve BCTC system peak load in winter time. Therefore, the expected time duration of activating load shedding scheme after 5L71/72 double contingency could be lower than the calculated hours per year.