Feasibility Study For

Alcan to BCTC Transfer Limit Increase

From 380 MW to 420 MW

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System Planning & Performance Assessment, BCTC

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Executive Summary

Alcan has requested BCTC to assess the feasibility and equipment requirement for increasing Alcan to BCTC transfer from 380 MW to 420 MW. Power flow and transient stability studies have been conducted to assess the feasibility of transfer limit increase.

The study results based on a 400 MW KIT load indicate that the following 1st contingencies will cause unacceptable dynamic performance and tripping of 2L103 by the out-of-step relay:

- 5L41 (KLY-CKY)
- 5L4 (GMS-PCN)

In addition, loss of a KIT potline load would result in power surge through 2L103 and its possible trip out. If not tripped, 2L103 and 2L99 will overload with a severity dependent on the ambient conditions.

Therefore, to accommodate the 420 MW transfer from Alcan new equipment is required for implementing the following:

- A new KMO generation shedding RAS to shed KMO units in response to the single contingencies of 5L41, 5L4, and any one of the KIT potlines.

Prior to the RAS completion, with the transfer increased to 420 MW, the above contingencies could cause 2L103 trip out, severe overload on 2L103 and 2L99, and consequently degraded system performance.

The feasibility study is based on all existing North Coast transmission equipment and protection in service. Detailed operation constraints, and special requirements such as minimum units online requirement and generation shedding RAS arming will be covered in a separate study at a later stage.

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1 Introduction

Alcan has requested BCTC to assess the feasibility of increasing its power transfer limit from 380MW to 420 MW.

1.1 Purpose of Study

This project is to conduct power flow and transient stability studies to assess the feasibility of transfer limit increase, and identify any reinforcement if required.

1.2 System One Line Diagram

Figure 1 shows the system one-line diagram of Alcan (BC) and BCTC North Coast area. Alcan (BC) System is connected to BCTC main system via a long radial connection; the KIT-MIN 287 kV line (2L103, 2.5 km), MIN-SKA 287 kV line (2L99, 59 km), then three serial 500 kV lines , SKA-TKW (5L63, 143 km) , TKW-GLN (5L62, 131 km) and GLN-WSN (5L61, 175 km), with a total transmission distance about 510 km. Outage of any one line would result in islanding conditions.

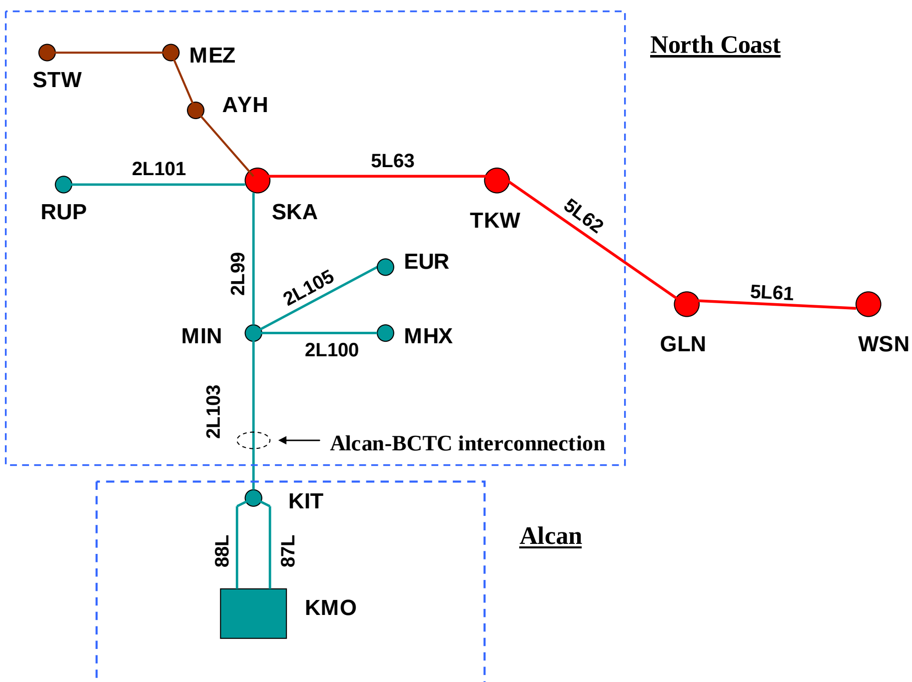

Figure 1 Alcan and BCTC North Coast System One Line Diagram.

2 System Conditions

Various factors have been taken into considerations in the assessment, including the following:

2.1 Existing North Coast System Protections

(1) Alcan-BCTC Tie (2L103) Tripping Scheme

Table 2.1 KIT-MIN (2L103) Tripping Scheme

Protections	settings
Under-frequency	57.5 Hz
Out-of-Step Relay	• Apparent impedance looking from MIN to KIT 0.18 --- 0.16 p.u • Apparent impedance looking from MIN to SKA 0.18 --- 0.16 p.u • Apparent impedance crossing |0.18 – 0.16| gap time 2 cycles • Supervision voltage 0.85 pu • Supervision voltage delay time 5 cycles
Under-voltage	KIT287 < 256 kV (0.89 pu) for 2.0 sec
Excess Power Flow to BCTC	Power relay with KIT-MIN > 500 MW for 1.5 seconds

(2) Alcan-KMO Over-frequency Generation Shedding Scheme (temporary)

When KIT-MIN power flow transfer is above 150 MW, KMO three units will be armed for over frequency generation shedding at 61 Hz, 61.3 Hz and 61.6 Hz respectively.

(3) Alcan Separation Scheme

The Alcan tie will trip open upon detecting any multi phase fault from MIN, KIT or detecting any permanent fault on the KMO-KIT line.

2.2 Transmission Line Thermal Ratings

2L99 and 2L103 may overload during summer when Alcan export is high. The actual limit would be restricted by summer ambient conditions as implied in Table 2.2 below.

Table 2.2 Transmission Line Thermal Ratings

Line Designation	Summer Rating @ 30 C		Winter Rating @ 10 C	
	kA	MVA at 287 kV	kA	MVA at 287 kV
2L103	632	314	1175	584
2L99	632	314	1175	584

3 Study Methodology

3.1 Study Assumptions

1. The study uses 2009 light summer and heavy summer loading with the following system conditions:

- All existing BCTC North Coast transmission equipment in service.
- KIT 287 kV bus pre-outage voltage is between 285 - 287 kV
- KMO Joint VAR Control in service.

2. Alcan to BCTC transfer limit is affected by the number of KMO generating units on line. This study is based on all 8 KMO units in service.

3. Alcan to BCTC transfer limit is also affected by the Minette area net load. Eurocan generation will reduce Minette area net load and increase flow on 2L99, thus increasing the stress between KMO and BCTC system. This study is based on a typical Minette area net load of 50 MW.

4. Alcan exporting to BCTC limit is also affected by Kitimat load. This study is based on Kitimat load of 400 MW.

3.2 Studies Conducted

North Coast system pre-outage and post-outage power flows and transient stability performance in response to disturbances have been studied using PSS/E based on system normal pre disturbance condition.

3.3 Contingencies

The study covers major facility outages in Alcan, North Coast, Peace system and some Interior to Lower Mainland lines.

3.4 Generation Shedding

The existing generation shedding schemes for GMS and KMO are applied as required.

4 Study Results

Table 4.1 summarizes study results for various contingencies.

4.1 Disturbances in North Coast System

(1) 2L101 contingency with fault at SKA. With the fault cleared within 6 cycles and KMO generation shedding of 330 MW, both power flow and dynamic studies indicate system performance is acceptable.

(2) 2L105 contingency with fault at MIN. There is an existing separation scheme to trip 2L103 by DTT.

(3) 2L105 single-phase fault at MIN. The fault is cleared within 6 cycles. The separation scheme will not respond to 1-ph fault and both power flow and dynamic studies indicate system performance is acceptable.

(4) 1L387 contingency with fault at SKA. The fault is cleared within 8 cycles. The dynamic study indicates system performance is acceptable.

4.2 Disturbances in Alcan System

(5) KIT potline 1 fault at 13 kV bus. With the fault cleared within 14 cycles the dynamic study indicates system voltage performance is acceptable. However due to large power surge through 2L103, the circuit may be tripped by the power surge protection. If not tripped, the post contingency power flow indicates transmission line 2L103/2L99 may be overloaded with a severity dependent on ambient conditions. Shedding one fully loaded KMO unit in response to the disturbance will mitigate the problem.

(6) KIT potline 1 fault at 287 kV bus (1-ph fault). With the fault cleared within 6 cycles the dynamic study indicates system voltage performance is acceptable. However due to large power surge through 2L103, the circuit may be tripped by the power surge protection. If not tripped, the post contingency power flow indicates transmission line 2L103/2L99 may be overloaded with a severity dependent on ambient conditions. Shedding one fully loaded KMO unit in response to the disturbance will mitigate the problem.

(7) KMO-KIT line 87L 1-ph fault at KMO. With the fault cleared within 6 cycles and successful auto-reclose after 86 cycles the dynamic study indicates acceptable system performance. For a single line to ground fault with unsuccessful auto-reclose, 2L103 will be tripped by slip relay. For a multiphase fault, 2L103 will be tripped by the Alcan separation scheme.

4.3 Disturbances in BCTC 500 kV System

(8) 5L4 contingency at GMS. With the fault cleared within 4 cycles and unsuccessful auto-reclose after 32 cycles, the dynamic study indicates the slip relay will be triggered to trip 2L103 when the KIT-MIN transfer flow is 420 MW. This is not expected to occur for KIT-MIN transfer of 380 MW. Shedding one fully loaded KMO unit in response to the disturbance will mitigate the problem.

(9) – (12) 5L1/2/3 or 5L11/12/13 single and double contingencies: With KMO generation shedding of 330 MW applied, the system dynamic performance is acceptable.

(13) 5L87 contingency at KLY. With the fault cleared within 4 cycles and unsuccessful auto-reclose after 50 cycles, the dynamic study indicates system performance is acceptable.

(14) 5L41 contingency at KLY. With the fault cleared within 4 cycles and unsuccessful auto-reclose after 29 cycles, the dynamic study indicates the slip relay will be triggered to trip 2L103 when the KIT-MIN transfer flow is 420 MW. This is not expected to occur for KIT-MIN transfer limit of 380 MW. Shedding one fully loaded KMO unit in response to the disturbance will mitigate the problem.

(15) 5L42 contingency at KLY. With the fault cleared within 4 cycles and unsuccessful auto-reclose after 28 cycles at CKY the dynamic study indicates system performance is acceptable.

(16) 5L40 contingency at CBN. With the fault cleared within 4 cycles and unsuccessful auto-reclose after 30 cycles at ING the dynamic study indicates system performance is acceptable.

(17) 5L45 contingency at CKY. With the fault cleared within 4 cycles and unsuccessful auto-reclose after 28 cycles at MDN the dynamic study indicates system performance is acceptable.

(18) 5L81 contingency at NIC. With the fault cleared within 4 cycles and unsuccessful auto-reclose after 60 cycles at ING the dynamic study indicates system performance is acceptable.

4.4 Disturbances Causing Islanding Situation

Contingencies on 5L61/62/63 or 2L99 will cause the Alcan system and part of the BCTC system to become islanded with overfrequency during high KIT-MIN transfer period. The most severe overfrequency happens with 2L99 contingency and a KIT-MIN pre-outage transfer of 420 MW. The potential problem has been assessed by applying generation shedding based on over frequency protection settings of KMO units. The results indicate the over-frequency can be limited to 61.6 Hz.

5 Conclusions

Power flow and transient stability studies have been used to assess the feasibility of increasing Alcan to BCTC maximum transfer limit from 380 MW to 420 MW, and also to identify the required transmission reinforcement for this increase.

The study results based on a 400 MW KIT load indicate that the following 1st contingencies will cause unacceptable dynamic performance and tripping of 2L103 by the out-of-step relay:

- 5L41 (KLY-CKY)
- 5L4 (GMS-PCN)

In addition, loss of a KIT potline load would result in power surge through 2L103 and its possible trip out. If not tripped, 2L103 and 2L99 will overload with a severity dependent on the ambient conditions.

Therefore, to accommodate the 420 MW transfer from Alcan new equipment is required for implementing the following:

- A new KMO generation shedding RAS to shed KMO units in response to the single contingencies of 5L41, 5L4, and any one of the KIT potlines.

Prior to the RAS completion, with the transfer increased to 420 MW the above contingencies could cause 2L103 trip out, severe overload on 2L103 and 2L99, and consequently degraded system performance.

The feasibility study is based on all existing North Coast transmission equipment and protection in service. Detailed operation constraints, and special requirements such as minimum units online requirement and generation shedding RAS arming will be covered in a separate operational study at a later stage.

Table 4.1 Summary of KMO export study results

(BCTC system normal with 2009 light summer loading case, 8 KMO generators and 4 KIT capacitor banks on line)

Case	Contingencies	KIT-MIN transfer 420 MW		KIT-MIN transfer 380 MW		Comments
		Slip relay trips 2L103 (Dynamic study)	Post-contingency overloading (Power flow study)	Slip relay trips 2L103 (Dynamic study)	Post-contingency overloading (Power flow study)	
1	2L101 @SKA 287 bus, fault cleared @ 6 cycles, KMO gen shed 330 MW @ 11 cycles.	No	No	No	No	Existing KMO gen shed RAS
2	2L105 @MIN 287 bus, fault cleared @ 6 cycles	Tripped by separation scheme	No	Tripped by separation scheme	No	
3	2L105 1-ph fault, @MIN 287 bus, fault cleared @ 6 cycles	No	No	No	No	
4	1L387 @SKA138 bus, fault cleared @ 8 cycles	No	No	No	No	
5	KIT potline 1 @13.2kV bus, fault cleared @ 14 cycles, potline 1 (90 MW) and shunt capacitor tripped.	No	2L103/2L99 overloading depends on ambient temperature	No	2L103/2L99 overloading depends on ambient temperature	With 420 MW transfer, shedding of one KMO unit (110 MW) @ 14 cycles to prevent overload on 2L103/2L99.
6	KIT potline 1 287kV/13.2kV transformer HV 1-ph fault, cleared @ 6 cycles, potline 1 (90 MW) and shunt capacitor tripped.	No	2L103/2L99 overloading depends on ambient temperature	No	2L103/2L99 overloading depends on ambient temperature	With 420 MW transfer, shedding of one KMO unit (110 MW) @ 14 cycles to prevent overload on 2L103/2L99.
7	KMO-KIT 87L 1-ph fault @KMO 287 bus, fault cleared @ 6 cycles, 1.43 second reclose successful	No	No	No	No	
7-1	KMO-KIT 87L fault @KMO 287 bus, fault cleared @ 6 cycles, 1.43 second reclose unsuccessful	Tripped by separation scheme.	No	Tripped by separation scheme.	No	
8	5L4 @GMS 500 bus, fault cleared @ 4 cycles, 0.53 second reclose unsuccessful	Yes (at borderline)	No	No	No	With 420 MW transfer, shedding of one KMO unit (110 MW) @ 14 cycles to prevent slip relay from being triggered.

9	5L1 @GMS 500 bus, fault cleared @ 4 cycles, KMO gen shed 440 MW @ 14 cycles, 0.55 second reclose unsuccessful	No	No	No	No	Existing KMO gen shed RAS
10	5L1&5L2 @GMS 500 bus, fault cleared @ 4 cycles, GMS gen shed 1140 MW @ 9 cycles, KMO gen shed 440 MW @ 14 cycles, 0.55 second reclose unsuccessful	No	No	No	No	Existing KMO gen shed RAS
11	5L11 @WSN 500 bus, fault cleared @ 4 cycles, KMO gen shed 440 MW @ 14 cycles, 0.55 second reclose unsuccessful	No	No	No	No	Existing KMO gen shed RAS
12	5L11&5L12 @ WSN 500 bus, fault cleared @ 4 cycles, GMS gen shed 840 MW @ 9 cycles, KMO gen shed 440 MW @ 14 cycles, 0.55 second reclose unsuccessful	No	No	No	No	Existing KMO gen shed RAS
13	5L87 @KLY 500 bus, fault cleared @ 4 cyclest, 0.83 second reclose @ NIC unsuccessful	No	No	No	No	
14	5L41 @KLY 500 bus, fault cleared @ 4 cycles, 0.48 second reclose @ KLY unsuccessful	Yes	No	No	No	With 420 MW transfer, shedding of one KMO unit (110 MW) @ 14 cycles to prevent slip relay from being trigged.
15	5L42 @KLY 500 bus, fault cleared @ 4 cycles, 0.47 second reclose @ CKY unsuccessful	No	No	No	No	
16	5L40 @ CBN 500 bus, fault cleared @ 4 cycles, 0.5 second reclose @ ING unsuccessful	No	No	No	No	
17	5L45 @ CKY 500 bus, fault cleared @ 4 cycles, 0.47 second reclose @ MDN unsuccessful	No	No	No	No	
18	5L81 @ NIC 500 bus, fault cleared @ 4 cycles, 1.0 second reclose @ ING unsuccessful	No	No	No	No	

Note 1:

The system performance in the table is based on 2009 LS loading case. The 2009 HS loading case has been checked for contingencies 7, 8, 13, 14, 15, 16, 17, and 18 of the table. The results indicate that transient power swings through 2L103 are less severe with 2009 HS loading case than those with the 2009 LS loading case.

Note 2:

KMO - KIT (L87/L88) continuous summer rating is 1463 A, at 30 C degree.

KIT - MIN (2L103) continuous summer rating is 632 A, at 30 C degree.
KIT - MIN (2L103) continuous summer rating is 1175 A, at 10 C degree.

Note 3: Small generators/IPPs in North Coast and Peace system:
EUR generation = 25 MW
BRL generation = 8 MW
FLS generation = 7 MW
MCM generation = 110 MW
DKW generation = 24 MW
BMW generation = 102 MW

Table 4.1-1 KMO export study results with 5 KIT capacitor banks in service
(BCTC system normal with 2009 light summer loading case, 8 KMO generators and 5 KIT capacitor banks on line)

Case	Contingencies	KIT-MIN transfer 420 MW		KIT-MIN transfer 380 MW		Comments
		Slip relay trips 2L103 (Dynamic study)	Post-contingency overloading (Power flow study)	Slip relay trips 2L103 (Dynamic study)	Post-contingency overloading (Power flow study)	
8-1	5L4 @GMS 500 bus, fault cleared @ 4 cycles, 0.53 second reclose unsuccessful	Yes (at borderline)	No	No	No	
14-1	5L41 @KLY 500 bus, fault cleared @ 4 cycles, 0.48 second reclose @ KLY unsuccessful	Yes	No	No	No	