BC hydro

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Facilities Study for

Alberta to US

Available Transfer Capability

Report No: NPP2002-05
June 3, 2002

System Planning & Grid Operations,
Transmission Line of Business

Engineering Services

Executive Summary

The following OASIS requests were submitted to BC Hydro Transmission Line of Business (TLoB) for Long Term Firm Point-to-Point transmission service under the Wholesale Transmission Service (WTS) tariff on the EAL × BPAT Path:

- *No. 293825 – TransCanada Power for 25 MW (Jan 2001 – Dec 2005)*
- *No. 299499 – Duke Energy for 100 MW (Jan 2001 – Dec 2005)*
- *No. 343349 – BC Hydro Power Supply for 250 MW (Apr 2001 – Mar 2006)*
- *No. 344670 – TransCanada Power for 50 MW (Jan 2002 – Dec 2006.)*

Further to the 28 February 2001 "System Impact Study for Increased Interior to Lower Mainland Transfer (without new transmission line)" report (http://gridops.bchydro.bc.ca/transmission_system/studies/ILM_SIS.pdf), this Facilities Study identifies Network Upgrades that would provide Available Transfer Capability (ATC) on the EAL × BPAT Path through the Interior to Lower Mainland transmission system.

This Facilities Study identifies the required modifications to TLoB's Transmission System, including a good faith estimate of the cost and scheduled completion date for such modifications to provide increments up to the total 425 MW of the transmission service requests.

The Study concluded that 425 MW of ATC is available on the EAL × BPAT Path. The following are Network Upgrades required to provide incremental ATC above existing commitments:

ATC	***Incremental Reinforcements***
0 MW	*No reinforcements*
> 0 MW ≤ 170 MW	• *Series capacitor bank on 5L82 upgraded for 3.3 kA operation* • *Series capacitor bank on 5L41 & 5L42 upgraded for 3 kA operation* • *Summer ratings of 5L42 upgraded to 3 kA* • *Summer rating of 2L1 to 0.98 kA* • *Replace 5L44 2.0 kA circuit breakers (5CB11 at Ingledow Station) with 3.0 kA circuit breakers* • *Addition of 1 × 250 MVAR and 1 × 250 MVAR mechanically switched shunt capacitors at Ingledow 500 kV Station and Meridian 500 kV Station*

ATC	***Incremental Reinforcements***
> 170 MW ≤220 MW	• *Series capacitor bank on 5L81 upgraded for 3.3 kA operation* • *Summer ratings of 5L44 upgraded to 3 kA* • *Summer ratings of 2L90 & 2L91 to 0.7 kA* • *Replace 5L40 2.0 kA circuit breakers (5CB7 & 5CB8 at Ingledow Station) with 3.0 kA circuit breakers* • *Addition of 1 × 250 MVAR mechanically switched shunt capacitor at Nicola 500 kV Station*
> 220 MW ≤290 MW	• *Series capacitor bank on 5L87 upgraded for 3 kA operation* • *Addition of 1 × 250 MVAR mechanically switched shunt capacitor at Meridian 500 kV Station*
> 290 MW ≤390 MW	• *Summer rating of 5L41 upgraded to 3 kA* • *Replace 5L82 3.0 kA circuit breakers (5CB12 & 5CB22 at Nicola Station, and 5CB7 & 5CB8 at Meridian Station) with 4.0 kA circuit breakers* • *Addition of –200 to +300 MVAR SVC at Ingledow 500 kV Station* • *Addition of 1 × 250 MVAR and 1 × 250 MVAR mechanically switched shunt capacitors at Ingledow 500 kV Station and Meridian 500 kV Station*
> 390 MW at least 425 MW	• *Replace 5L81 3.0 kA circuit breakers (5CB18 & 5CB28 at Nicola Station, and 5CB9 & 5CB10 at Ingledow Station) with 4.0 kA circuit breakers* • *Addition of 1 × 250 MVAR mechanically switched shunt capacitors at Ingledow 500 kV Station*

In addition, various Remedial Action Schemes are required for Undervoltage-Load-Shedding, Direct Load Shedding, Generation Shedding and Transfer Trip for multi-contingency events. Alberta generation shedding must also be available for various multi-contingency events.

As there are no interconnection requirements identified, there are no Direct Assignment Facilities included in this Facilities Study.

The earliest possible in-service date of Network Upgrades is considered to be 31 December 2004.

Appendix A contains the Network Upgrade facilities costs and schedules for providing the transmission service.

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1. Introduction

The 28 February 2002 "System Impact Study for Increased Interior to Lower Mainland Transfer (without new transmission line)" identified Network Upgrades that would provide approximately 1090 MW of additional ATC.

This Facilities Study identifies the required modifications to TLoB's Transmission System, including a good faith estimate of the cost and scheduled completion date for such modifications to provide increments up to the total 425 MW of transmission service requests.

2. Terms of Reference

The base conditions for the study are the BC Hydro native load requirements from 2004/05 to 2007/08 and prior firm export and transfer commitments. The Point-of-Receipt (POR) for the transmission service is the EAL × BCHA Path, and the Point-of-Delivery (POD) is BCHA × BPAT Path.

3. System Study Results

Studies were performed as per TLoB's Transmission System Planning Criteria and Study Methodology. These studies were conducted to:

- Determine the ATC of the EAL × BPAT Path.
- Assess the elements constraining the ATC.
- Determine Network Upgrades that would relieve the constraints.

3.1. N-1 Capability

The Interior to Lower Mainland transmission network has 0 MW available N-1 transfer capability and is thermally limited by the first contingency single outages of 5L81 or 5L82. Upgrading AMC II on 5L82 and AMC I on 5L81 will avoid overloads. Reactive support in the form of shunt capacitors and static var compensators was then determined to match the thermal transfer capabilities.

3.2. N-1 during Maintenance Capability

The Interior to Lower Mainland transmission network has 0 MW available N-1 transfer capability during maintenance and is thermally limited by the outages of 5L81 and 5L82, or of 5L81 and 5L41. Upgrading CRK on 5L42 and CHP on 5L41, and 5L44 will avoid overloads on the 500 kV system. At higher transfer levels, GUI on 5L87 will have to be upgraded for outages of 5L81 and 5L82. Corresponding circuit breaker replacements are also required.

Upgrades of 2L1, 2L90 & 2L91 will prevent overloads on the underlying voltage systems for a contingency with a 230 kV or 500 kV circuit out-of-service.

A Transfer Trip of 2L27 to protect 2L22 and 2L27 from thermal overload is required for a contingency with 5L81, 5L41 or 5L44 out-of-service.

In the South Interior, a Remedial Action Scheme is required for Alberta generation shedding for 2L293 contingency with 5L92 out-of-service.

3.3. N-2 and N-2 during Maintenance Capability

For equitable service, Alberta generation shedding is required for double outages of 5L51 & 5L52, 5L81 & 5L82, or 5L91 & 5L98. Remedial Action Schemes are also required for Selkirk area and Alberta generation shedding for a 5L76 & 5L79 double contingency with 5L98 out-of-service.

3.4. Available Transfer Capability

The following table provides the Contingencies and Incremental Reinforcements for the corresponding ATCs for both sequences:

ATC	Contingency	Incremental Reinforcements
0 MW		No reinforcements
> 0 MW ≤ 170 MW	• 5L81ko/5L82ol • 5L81mo/5L82ko/5L41ol 5L82mo/5L81ko/5L41ol • 5L81mo/5L82ko/5L42ol 5L82mo/5L81ko/5L42ol • 5L42mo/2L2ko/2L1ol • 5L41mo/5L81ko/5L44ol 5L81mo/5L41ko/5L44ol • 5L42ko or 5L82ko	• Series capacitor bank on 5L82 upgraded for 3 kA operation • Series capacitor bank on 5L41 upgraded for 3 kA operation • Series capacitor bank on 5L42 upgraded for 3 kA operation Summer rating of 5L42 upgraded to 3 kA • Summer rating of 2L1 to 0.98 kA • Replace 5L44 2.0 kA circuit breakers (5CB11 at Ingledow Station) with 3.0 kA circuit breakers • Addition of 1 × 250 MVAR and 1 × 250 MVAR mechanically switched shunt capacitors at Ingledow 500 kV Station and Meridian 500 kV Station
> 170 MW ≤ 220 MW	• 5L82ko/5L81ol • 5L41mo/5L81ko/5L44ol 5L81mo/5L41ko/5L44ol • 5L42mo/2L90ko/2L91ol 5L42mo/2L91ko/2L92ol • 5L81mo/5L82ko/5L40ol 5L82mo/5L81ko/5L40ol • 5L42ko or 5L82ko	• Series capacitor bank on 5L81 upgraded for 3 kA operation • Summer ratings 5L44 upgraded to 3 kA • Summer ratings of 2L90 & 2L91 upgraded to 0.7 kA • Replace 5L40 2.0 kA circuit breakers (5CB7, 5CB8 at Ingledow Station) with 3.0 kA circuit breakers • Addition of 1 × 250 MVAR mechanically switched shunt capacitor at Nicola 500 kV Station
> 220 MW ≤ 290 MW	• 5L81mo/5L82ko/5L87ol 5L82mo/5L81ko/5L87ol • 5L42ko or 5L82ko	• Series capacitor bank on 5L87 upgraded for 3 kA operation • Addition of 1 × 250 MVAR mechanically switched shunt capacitor at Meridian 500 kV Station

ATC	Contingency	Incremental Reinforcements
> 290 MW ≤ 390 MW	• 5L81ko/5L82ol • 5L81mo/5L82ko/5L41ol 5L82mo/5L81ko/5L41ol • 5L42ko or 5L82ko	• Series capacitor bank on 5L82 upgraded for 3.3 kA operation • Replace 5L82 3.0 kA circuit breakers (5CB12 & 5CB22 at Nicola Station, and 5CB7 & 5CB8 at Meridian Station) with 4.0 kA circuit breakers • Summer ratings of 5L41 upgraded to 3 kA • Addition of –200 to +300 MVAR SVC at Ingledow 500 kV Station Addition of 1 × 250 MVAR and 1 × 250 MVAR mechanically switched shunt capacitors at Ingledow 500 kV Station and Meridian 500 kV Station
> 390 MW at least 425 MW	• 5L82ko/5L81ol • 5L42ko or 5L82ko	• Series capacitor bank on 5L81 upgraded for 3.3 kA operation • Replace 5L81 3.0 kA circuit breakers (5CB 18 & 5CB28 at Nicola Station, and 5CB9 & 5CB10 at Ingledow Station) with 4.0 kA circuit breakers • Addition of 1 × 250 MVAR mechanically switched shunt capacitors at Ingledow 500 kV Station

Notes: For cost efficiency, Series capacitor banks on 5L81 and 5L82 will be upgraded for 3.3 kA operation when upgrade for 3 kA operation is required.
Various Remedial Action Schemes are required for Undervoltage-Load-Shedding, Direct Load Shedding, Generation Shedding (including Alberta generators) and Transfer Trip for multi-contingency events.

At 425 MW of transfer on the EAL × BPAT Path and during system peak load, the BC Hydro system will have approximately 90 MW of additional losses.

4. Network Upgrade and Direct Assignment Facilities

The required Network Upgrade facilities costs and schedules for providing transmission service are shown in Appendix A.

As there are no interconnection requirements identified, there are no Direct Assignment Facilities included in this Facilities Study.

5. Project and Transmission Service Risks

This Facilities Study contains some uncertainty in the plan, reinforcement, costs and in-service dates.

6. Conclusions

The Study concluded that 425 MW of ATC is available on the EAL × BPAT Path. The following are Network Upgrades required to provide the ATC:

- Series capacitor banks on 5L81 and 5L82 upgraded for 3.3 kA operation
- Series capacitor banks on 5L41, 5L42 and 5L87 upgraded for 3.0 kA operation
- Summer ratings of 5L41, 5L42 and 5L44 upgraded to 3.0 kA
- Summer ratings of 2L1, 2L90 and 2L91 upgraded up to 1 kA
- Addition of –200 to +300 MVAR SVC at Ingledow 500 kV Station
- Addition of 3 × 250 MVAR, 3 × 250 MVAR and 1 × 250 MVAR mechanically switched shunt capacitors at Ingledow 500 kV Station, Meridian 500 kV Station and Nicola 500 kV Station
- Replace 5L81 and 5L82 3.0 kA circuit breakers (5CB12, 5CB18, 5CB22 & 5CB28 at Nicola Station; 5CB9 & 5CB10 at Ingledow Station; and 5CB7 & 5CB8 at Meridian Station) with 4.0 kA circuit breakers
- Replace 5L40 and 5L44 2.0 kA circuit breakers (5CB7, 5CB8 & 5CB11 at Ingledow Station) with 3.0 kA circuit breakers salvaged from the item above
- Add/Upgrade/Modify various Remedial Action Schemes which are required for Undervoltage-Load-Shedding, Direct Load Shedding, Generation Shedding (including Alberta generators) and Transfer Trip for multi-contingency events.

As there are no interconnection requirements identified, there are no Direct Assignment Facilities included in this Facilities Study.

The earliest possible in-service date of Network Upgrades is considered to be 31 December 2004.

Appendix A contains the Network Upgrade facilities costs and schedules for providing the transmission service.

Appendix A.

Network Upgrade Facilities

A.1 Series Capacitor Stations

A.1.1 Chapmans Series Capacitor Station on 5L41

Upgrade Chapmans Series Capacitor Stations by reconnecting existing capacitors on one set of platforms and provide additional capacitors on separate platforms to increase the rating with no change to compensation level. The station characteristics are:

Compensation	57%
Series reactance	51.4 ohms
Nameplate current rating	2730 A
Continuous overload rating	3000 A (8 hrs in 12 hrs)
Reactive Rating	1147 MVAR (550 & 600 MVAR per segment)
Bank Configuration	MOV gapless (approx 100 MJ per platform)
Nom. operating voltage	500 kV
Max. continuous voltage	550 kV

Provide new protection and control for equipment on new platforms, and using existing protection and control on the existing platforms is acceptable. Provide transfer trip facilities for the new bypass breakers associated with the second platform, and breaker failure signals to Clayburn and Kelly Lake Stations. Reconfigure transfer trip facilities related to generation shedding associated with the new bypass CBs equivalent to what exists today.

A.1.2 Creekside Series Capacitor Station on 5L42

Upgrade Creekside Series Capacitor Stations by reconnecting existing capacitors on one set of platforms and provide additional capacitors on separate platforms to increase the rating with no change to compensation level. The station characteristics are:

Compensation	55%
Series reactance	36.8 ohms
Nameplate current rating	2730 A
Continuous overload rating	3000 A (8 hrs in 12 hrs)
Reactive Rating	803 MVAR (~520 & 280 MVAR per segment)
Bank Configuration	MOV gapless (~100 MJ per platform)
Nom. operating voltage	500 kV
Max. continuous voltage	550 kV

Provide new protection and control for equipment on new platforms, and assume existing protection and control on the existing platforms is acceptable. Provide transfer trip facilities for the new bypass breakers associated with the second

platform, and breaker failure signals to Cheekye and Kelly Lake Stations. Reconfigure transfer trip facilities related to generation shedding associated with the new bypass CBs equivalent to what exists today.

Add local and remote Control and Indication for the new bypass CBs, and revise SCADA.

Add local and remote Control and Indication for the new bypass CBs, and revise SCADA.

A.1.3 American Creek I & II Series Capacitor Stations on 5L81 & 5L82

Upgrade American Creek I & II Series Capacitor Stations by installing a second set of platforms and distributing the capacitors equally between them. The characteristics of each station are:

Compensation	47/49%
Series reactance	40 ohms
Nameplate current rating	3000 A
Continuous overload rating	3300 A (8 hrs in 12 hrs)
Reactive Rating	1080 MVAR (2 segments of 540 MVAR)
Bank Configuration	MOV gapless (approx 100 MJ per platform)
Nom. operating voltage	500 kV
Max. continuous voltage	550 kV

Provide new protection and control for equipment on new platforms, and replace existing protection and control on the existing platforms. Provide transfer trip facilities for the new bypass breakers associated with the second platform, and breaker failure signals to Ingledow and Nicola Stations for AMC I and to Meridian and Nicola Stations for AMC II. Reconfigure transfer trip facilities related to generation shedding associated with the new bypass CBs equivalent to what exists today.

Add local and remote Control and Indication for the new bypass CBs, and revise SCADA.

A.1.4 Guichon Series Capacitor Station on 5L87

Upgrade Guichon Series Capacitor Stations from 2400 A nameplate to 2730 A. The initial 2400 A project is underway.

A.2 Transmission Circuit Upgrades and Additions

A.2.1 Upgrade 5L40, 5L41, 5L42 and 5L44

Upgrade the contingency summer rating of 5L41, 5L42 and 5L44 to 3.0 kA. The three lines can be upgraded by raising existing towers, adding new towers and where practical recountouring the right-of-way. Also, upgrade 5L40 CBs to 3 kA.

- 5L41: 12 months project duration & 1 week outage duration.
- 5L42: 8 months project duration & 1 weeks outage duration.
- 5L44: 10 months project duration & 1.5 weeks outage duration.
- Replace ING 5CB7 (5L40), 5CB8 (5L40) and 5CB11 (5L44) with 3 kA CBs.
- Replace 5L44 protection with new protection capable of single pole trip and reclose.

A.2.2 Upgrade 5L81

Upgrade 5L81 line positions at ING and NIC to 4 kA continuous.

- Upgrade ING 5CB9 and 10 and associated equipment (between 5MB1 and 2) to 4 kA continuous.
- Upgrade NIC 5CB18 and 28 and associated equipment (between 5MB2 and 4) to 4 kA continuous.
- Revise 5L81 protection to suit.

A.2.3 Upgrade 5L82

Upgrade 5L82 line positions at MDN and NIC to 4 kA continuous.

- Upgrade MDN 5CB7 and 8 and associated equipment (between 5MB1 and 2) to 4 kA continuous.
- Upgrade NIC 5CB12 and 22 and associated equipment (between 5MB1 and 3) to 4 kA continuous.
- Revise 5L82 protection to suit.

A.2.4 Upgrade 2L1, 2L90 and 2L91

Upgrade the summer rating of 2L1 to 0.98 kA, and 2L90 & 2L91 to 0.7 kA.

- 2L1: upgrade the clearances at 12 locations; there may be difficulties in obtaining approval for upgrading the circuit.
- 2L90 and 2L91: initial assessments required although no major work is anticipated.

A.3 SVC and Shunt Capacitor Additions

A.3.1 Ingledow SVC

Add SVC rated -200 to +300 MVARS connected to the Ingledow Station 500 kV bus.

Protection of the SVC and associated transformer will be provided as part of the SVC itself. Provide local and remote control additions, from both SCC and relevant ACC, for new MODS and CBs for the SVC including control, indication, and alarms.

At SCC revise SCADA/EMS power system models to include the new equipment. Also revise network application functions including DTS, VSA, TSA and RAS setup scheme. Revise RAS systems at the stations to add more initiating signals. At Mica and Revelstoke Generating Stations, provide redundant Generation Shedding Setup Panels.

A.3.2 Ingledow, Meridian, and Nicola 500 kV Shunt Capacitor Banks

These reinforcements replace the Ingledow and Ashton Creek shunt capacitors identified in the initial study. Add 500 kV, 250 MVAR switchable shunt capacitor banks at Ingledow (3), Meridian (3), and Nicola (1) Stations.

Make 500 kV bus reconnections and add 500 kV main bus CVTs. Provide associated protection (including unbalance and breaker failure protection), control and telecom facilities. Provide local and remote control additions, from both SCC and relevant ACC, for new MODS and CBs for the shunt capacitor banks including control, indication, and alarms. One capacitor bank at Ingledow Station will be reserved for switching by the new SVC. One capacitor bank at Meridian Station will be reserved for switching by the Burrard Station SCs.

At SCC revise SCADA/EMS power system models to include the new equipment. Also revise network application functions including DTS, VSA, TSA and RAS setup scheme. Revise RAS systems at the stations to add more initiating signals.

A.4 Remedial Action Scheme Additions and Upgrades

Upgrade/Modify Remedial Action Schemes (RAS) for Undervoltage-Load-Shedding, Direct Load Shedding for Interior to Lower Mainland N-2 events, and Transfer Trip of 2L27 to protect 2L22 and 2L27 from thermal overload.

Add RAS for Alberta generation shedding for 2L293 contingency with 5L92 out-of-service, and double outages of 5L51 & 5L52, 5L81 & 5L82, or 5L91 & 5L98. Add a RAS for Selkirk area and Alberta generation shedding for a 5L76 & 5L79 double contingency with 5L98 out-of-service.

The RAS facilities for Alberta generation shedding will be provided as signal(s) to the BC-AB border. The Transmission Customer is responsible for procuring Alberta generators, equivalent to the amount of transmission service, for generation shedding. For double outages of 5L51 & 5L52, 5L81 & 5L82, or 5L91 & 5L98, BC generators may be substituted for Alberta generators.

A.5 Costs and Schedules

The $k costs below are Capital Direct with TLoB External Loadings and no IDC. The estimates have an accuracy of –15% & +30%. Where possible, TLoB will expedite the reinforcements for an earliest in-service date.

Description	Total	02/03	03/04	04/05	05/06
AMC (5L82) upgraded to 3.0 kA nominal	10617	550	1657	8411	
CHP (5L41) upgraded to 2.73 kA nominal	8061	374	1264	6424	
CRK (5L42) upgraded to 2.73 kA nominal	6405	415	1236	4754	
5L42 upgraded to 3.0 kA Summer	1002	359	642		
2L1 upgraded to 0.98 kA Summer	350	350			
ING 1 x 3 kA CB (5L44)	1226	136	395	694	
ING 1 x 250 MVAR 500 kV CX	3058	251	696	2111	
MDN 1 x 250 MVAR 500 kV CX	2847	395	1282	1169	
Add/Upgrade/Modify RAS	3000	1200	1800		
Totals for 170 MW ATC	**36565**	**4030**	**8972**	**23563**	
AMC (5L81) upgraded to 3.0 kA nominal	11216	664	1995	8558	
5L44 upgraded to 3.0 kA Summer	1973	703	1269		
2L90 upgraded to 0.7 kA Summer	246	121	126		
2L91 upgraded to 0.7 kA Summer	197	97	100		
ING 2 x 3 kA CB (5L40)	2452	272	791	1388	
NIC 1 x 250 MVAR 500 kV CX	3083	208	692	2184	
Totals for 220 MW ATC	**55733**	**6094**	**13945**	**35693**	
GUI (5L87) upgraded to 2.73 kA nominal	1837			735	1102
MDN 1 x 250 MVAR 500 kV CX	2847		395	1282	1169
Totals for 290 MW ATC	**60416**	**6094**	**14340**	**37710**	**2272**
5L41 upgraded to 3.0 kA Summer	3106			1115	1991
MDN 2 x 4 kA CB (5L82)	3401		449	1474	1478
NIC 2 x 4 kA CB (5L82)	4133		183	619	3331
ING -200/+300 MVAR 500 kV SVC	29619		1051	3412	25155
ING 1 x 250 MVAR 500 kV CX	3058		251	696	2111
MDN 1 x 250 MVAR 500 kV CX	2847		395	1282	1169
Totals for 390 MW ATC	**106580**	**6094**	**16669**	**46309**	**37507**
ING 2 x 4 kA CB (5L81)	4406			481	1401
NIC 2 x 4 kA CB (5L81)	4133			183	619
ING 1 x 250 MVAR 500 kV CX	3058			251	696
Totals for 425 MW ATC	**118177**	**6094**	**17584**	**49026**	**45472**