TTC/ATC

In this section:

1.0 DEFINITIONS

Capacity Benefit Margin (CBM): The amount of transmission transfer capability reserved by load serving entities to ensure access to generation from interconnected systems to meet generation reliability requirements.

Contingency: The unexpected failure or outage of a system component, such as a generator, transmission line, circuit breaker, switch, or other electrical element. A contingency may also include multiple components, which are related by situations leading to simultaneous component outages.

Nomogram: A graphic representation of a value as a function of specific factors. For example, a graphic representation of ING > CUS transfer versus light BC Hydro load and number of on-line equivalent Burrard Synchronous Condensers.

WECC Operating Transfer Capability (OTC): The maximum amount of electric power that can be transferred reliably over a transmission path for a specific season established by the WECC OTC Study Committee. This rating is the maximum that can be demonstrated to flow under realistic and optimistic conditions within a specific season, which can be demonstrated to meet the appropriate reliability criteria. The WECC OTC cannot exceed the Path Rating.

Path Rating: The maximum path rating in MW that has been demonstrated to WECC through study results or actual operation, whichever is greater. This rating is the maximum that can be demonstrated to flow under realistic and optimistic conditions, which can be demonstrated to meet the appropriate reliability criteria.

Remedial Action Scheme (RAS): Automatic systems installed on the electric systems that require no intervention on the part of system operators. For example, in the event of loss of transmission system element, a remedial action scheme may automatically disconnect a generator from the transmission system to prevent transmission system overload or other problem.

Total Transfer Capability (TTC): The amount of electric power that can be transferred over the interconnected transmission network in a reliable manner while meeting all of a specific set of defined pre- and post-contingency system conditions.

Transmission Reliability Margin (TRM): The amount of total transfer capability necessary to ensure that the interconnected transmission network is secure under a possible range of uncertainties in system conditions.

2.0 TOTAL TRANSFER CAPABILITY (TTC) METHODOLOGY

The calculation of TTC is based on the physical requirements governing sound utility practice before, during and after network element outages. The method by which BC Hydro determines the amount of Firm and Non-Firm TTC for operating purposes will be discussed.

Section 2.2 elaborates on the general principles of TTC within the specific context of the BC Hydro transmission network. In addition an outline of the methodology used to calculate TTC on the BC – Alberta paths and BC – US paths is presented.

2.1 WECC Path Ratings for BC Hydro's Interties

Within the Western Interconnected System, the Path Rating is calculated using the Rated System Path method discussed in WECC's, March 1995, "Procedures for Regional Project Review and Rating Transmission Facilities" and the NERC, June 1996, "Report on Available Transfer Capability Definition and Determination."

Prior to each operating season, the WECC investigates the expected operating conditions for the next season and establishes a seasonal rating as the WECC OTC. BC Hydro cannot operate above the WECC OTC during that season. BC Hydro's TTC, anytime during the season, cannot be greater than the WECC OTC.

2.1.1 BC – Alberta Intertie

- One 500 kV Cranbrook – Langdon tie (5L94)
- Two 138 kV Natal to Altalink lines (1L274 & 1L275)

Although the BC – Alberta intertie consists of one 500kV tie and two 138kV ties of lesser capacity, transient stability limitations require that on a 5L94 contingency the remaining two 138kV ties be tripped except during low transfer conditions. This coupling implies that the intertie effectively consists of only the 500kV line at most transfer levels.

BC – Alberta

The WECC approved path rating for the BC – Alberta path is 1200 MW. This level of transfer would lead to excessive load shedding in Alberta (after loss of the intertie) and is only allowed under joint agreement between BC and Alberta system operators.

Alberta – BC

The WECC approved path rating is 1000 MW. Most of the times there are limitations inside Alberta, which prevent operation at this level.

2.1.2 BC – US Intertie

- Two 500 kV Ingledow – Custer ties (5L51 and 5L52 - called west-side ties)
- One 230 kV Nelway – Boundary tie (2L112, an east-side tie)
- One 230 kV Waneta – Boundary tie (L71, an east-side tie)

BC – US
The WECC approved path rating is 3150 MW of which 2850 MW is the limit on the west-side tie lines. The 3150 MW depends on the availability of remedial action schemes, including an automatic generator shedding remedial action scheme. This path rating is transient stability limited under low load conditions. The limit is lower during heavier load and outage periods.

US – BC
WECC approved path rating is 2000 MW.

As stated earlier, the TTC on a BC Hydro path cannot exceed the OTC for that path.

2.2 Principles for Determination of TTC

TTC is direction specific and as such export and import values are calculated for each intertie. The definition of TTC that BC Hydro follows is roughly equivalent to the First Contingency Total Transfer Capability as defined in the May 1995 "Transmission Transfer Capability" NERC document.

BC Hydro operates its system and computes TTC in accordance with the methodologies and criteria specified by the NERC and WECC. More specifically, BC Hydro determines the TTC so that the following conditions are met:

1. The existing steady state, or equivalently the pre-contingency state, of any system configuration must be steady state stable with normal operating procedures in effect. In addition, all equipment, all system loading and all voltages must be within normal limits.
2. The network must be transiently stable after a single contingency event. That is, it must be capable of absorbing the dynamic power swings and remain stable immediately following a disturbance that results in the loss of any single electric system element, such as a transmission line, transformer or generating unit. It must also meet the WECC disturbance-performance table of allowable effects on other systems.
3. The network must be steady state stable and all equipment within rating following the single contingency, prior to the time frame where control room

operators are able to implement any system adjustments (typically 20 - 30 minutes). During this period, all dynamic power swings will have subsided and all equipment flows and voltages must be below emergency ratings.

4. After post-contingency re-adjustment of the system, the requirement for the pre-contingency state must be satisfied (condition 1 above). Transfer capability between regions across interties is again based on the loss of the next most constraining equipment outage.

5. In some cases, NERC and WECC criteria or guides require consideration of specified multiple contingencies, such as the outage of transmission circuits using common towers or rights-of-way, in the determination of transfer capability limits. If the resulting transfer limits for these multiple contingencies are more restrictive than the single contingency considerations described above, the more restrictive reliability criteria or guides must be observed. An example is that the loss of the two Ingledow to Custer 500kV circuits (5L51 and 5L52) at times is the most limiting contingency on BC Hydro's export and import limits to/from the US.

Transient stability, voltage stability, voltages and thermal limit constraints limit the capability of the BC Hydro transmission network; therefore, TTC is the minimum of these constraints. As system operating conditions change, the most restrictive limit on TTC may change from one system limit (e.g. transient stability) to another system limit (e.g. voltage stability). Generally, BC Hydro's planning engineers add equipment so that, with all facilities in-service, the probable average hour load forecasts can be served without the use of RAS for a single contingency. Because of this, the system is often able to maintain reasonable transfer levels during outage conditions or serve higher loads due to colder weather by making use of RAS before resorting to curtailment.

2.3 BC Hydro 's Non-Firm TTC Methodology

The Non-Firm TTC is the level which meets the reliability criteria, but which may require that RAS or curtailments be applied to reliably survive contingencies and continue to operate after a permanent outage.

These are the operating limits specified in the system operating orders for the interties. These operating orders specify the RAS requirements to support various levels of transfer. In addition, there are nomograms that show the relationship between transfers with Alberta and transfers with the US. The maximum limits for the interties are equal to the WECC Path Ratings.

2.3.1 BC – Alberta

Please refer to BC Hydro System Operating Order 7T-17. In general, factors affecting the transfer capability of the BC – Alberta path include load levels, generation patterns and transmission elements in service. As load and generation varies in the eastern area of BC, the transfer capability from BC to Alberta will also vary.

The BC – Alberta path TTC is typically lower than the WECC path rating. For day plus one, the Pre-schedule limit is the lower of the BC TTC limit and the Alberta TTC limit calculated by the Alberta Electric System Operator, or AESO (see AESO Operating Policies and Procedures OPP-304). In Real-time, the TTC of the intertie is set to the lower of the BC Hydro limit and the limit specified by the AESO.

2.3.2 Alberta – BC

Please refer to BC Hydro System Operating Order 7T-17. In general, factors affecting the transfer capability of the Alberta – BC path include load levels, generation patterns and transmission elements in service. The transfer capability from BC to Alberta varies with generation levels in the eastern area of BC and by the Alberta load level.

The Alberta – BC path TTC is typically lower than the WECC path rating. For day plus one, the Pre-schedule limit is the lower of the BC TTC limit and the Alberta TTC limit calculated by the AESO (see AESO Operating Policies and Procedures OPP-304). In Real-time, the TTC of the intertie is set to the lower of the BC Hydro limit and the limit specified by the AESO.

The Alberta – BC path is a component of net transfer into the BC Hydro control area, which is limited by frequency excursion after a simultaneous forced outage of 5L51 and 5L52. Therefore, there may be restrictions on AB – BC transfers due to this overall restriction.

2.3.3 BC – US

Please refer to BC Hydro Operating Order 7T-18 and WECC Path rating explained previously. Non-Firm TTC is the minimum of BC Hydro voltage stability, transient stability, and thermal or BPA limits. This path is from the Interior of BC to the US, and the factors that affect the transfer capability include load and generation levels, particularly in the Lower Mainland/Vancouver Island region, and transmission elements in service. Generally, the transfer capability from BC (i.e. “interior”) to US varies with the load and generation levels in the Lower Mainland, particularly during the peak periods.

2.3.4 LM > US

Please refer to BC Hydro System Operating Order 7T-18. Non-Firm TTC is the lower of intertie thermal limits or BPA limits, and may result in higher Non-Firm TTC than that from BC to the US.

2.3.5 US > BC

Please refer to BC Hydro System Operating Order 7T-18 and WECC Path rating explained previously. The US – BC path TTC is the lower of the BC Hydro or the BPAT limits up to the 2000 MW WECC path rating.

The US – BC path is a component of net transfer into the BC Hydro control area, which is limited by frequency excursion after a simultaneous forced outage of 5L51 and 5L52. Therefore, there may be restrictions on US – BC transfers due to this overall restriction.

2.4 BC Hydro's Firm TTC Methodology

Generally, BC Hydro applies (n-1) criteria to determine Firm TTC, which is the level that can continue to be served immediately after a single permanent forced outage. This requirement applies to the system with all facilities in-service during all transfer conditions. In addition, the system with one element out-of-service for maintenance during lighter transfers should be able to accommodate the Firm TTC (RAS is permitted).

The determination of Firm (and Non-Firm) TTC depends on projections of expected generation pattern, load demand and system topology. Any change in these factors will impact TTC. TTC calculations for different time frames may consider different factors.

2.4.1 BC – Alberta

The bulk transmission between BC and Alberta is through one radial 500 kV line consisting of 5L92 (Selkirk Substation to Cranbrook Substation) and 5L94. The Firm TTC is 545MW as per Attachment C of BC Hydro's OATT.

2.4.2 Alberta – BC

Please refer to BC – Alberta above.

The most limiting contingency for TTC from Alberta to BC is the loss of 5L98. Sales of Firm capacity from Alberta to BC may also be restricted by the overall net transfer into BC constraint. The Firm TTC is 450 MW as per BC Hydro System Operating Order 7T-17.

2.4.3 BC – US

The Firm TTC is the transfer capability after an outage of one of the Two 500 kV Ingledow – Custer ties (5L51 or 5L52) or Interior to Lower Mainland 500kV line forced outage (2400 MW). Please refer to BC Hydro System Operating Order 7T-18.

2.4.4 LM – US

The Firm TTC is the transfer capability after an outage of one of the Two 500kV Ingledow – Custer ties (5L51 or 5L52) for 500kV line forced outage (2400 MW). Please refer to BC Hydro System Operating Order 7T-18.

2.4.5 US – BC

The Firm TTC is the transfer capability after an outage of one of the Two 500 kV Ingledow – Custer ties (5L51 or 5L52) or existing WECC path rating (2000 MW). Please refer to BC Hydro System Operating Order 7T-18. At times, sales of Firm capacity from US to BC may also be restricted by the overall net import into BC constraint.

3.0 AVAILABLE TRANSFER CAPABILITY (ATC) CALCULATION

Mathematically, ATC is defined as the Total Transfer Capability less the Transmission Reliability Margin, less the Capacity Benefit Margin and less the sum of existing transmission commitments (which includes BC Hydro domestic load).

ATC on BC Hydro's electrical interconnections with systems in Alberta and the US are posted on the BC Hydro OASIS site.

For Short-Term Point-to-Point transmission service, BC Hydro will make commercially reasonable efforts to consider adjacent control area outages in its ATC postings.

3.1 Transmission Reliability Margin (TRM) use in BC Hydro

In the Western Interconnection methodology, ATC reductions by TRM may include allowances for unscheduled flow, simultaneous limitations associated with operation under a nomogram, uncertainty in load forecast and unplanned outages (for paths in which contingencies have not already been considered in establishing the path rating).

BC Hydro uses TRM as a margin to ensure TTC is not exceeded in Real-time operation due to inadvertent imports and exports resulting from power system dynamics.

BC Hydro normally uses 50 MW TRM for the US Intertie (both directions), and normally uses 65 MW TRM for the Alberta Intertie (both directions). TRM may be adjusted up or down in real time depending on the system conditions of BC Hydro and adjacent Balancing Authorities.

3.2 Capacity Benefit Margin (CBM) use in BC Hydro

BC Hydro is part of the Northwest Power Pool (NWPP) Reserve Sharing Group and follows its Contingency Reserve Sharing Procedure.

As the NWPP Contingency Reserve Sharing Procedures now takes into account transmission constraints, BC Hydro will no longer make an allowance for CBM over its interties by withholding Short-Term Firm transmission capability from the transmission market.

3.3 Formulae

Firm ATC (Pre-schedule) = Firm TTC - Margins (CBM + TRM) - reserved Firm transmission service

Non-Firm ATC (Pre-schedule) = Non Firm TTC – Margins (TRM) - reserved Firm transmission service - reserved Non-Firm transmission service + counterflow energy schedules (energy flowing in opposite path)

Non-Firm ATC (Real-time) = Non-Firm TTC - Margins (TRM) - reserved Firm transmission service - reserved Non-Firm transmission service + counterflow energy schedules (energy flowing in opposite path) + unused Firm transmission service

For example:

Next Day HE15

- BC > US Non-Firm TTC = 2765 MW
- BC > US Firm TTC = 1930 MW
- TRM = 50 MW
- CBM = 0
- Reserved Firm transmission service BC > US = 450 MW
- Reserved Non-Firm transmission service BC > US = 350 MW

Firm ATC (Pre-schedule) BC > US = 1930 – 50 – 450 = 1430 MW

Non-Firm (Pre-schedule) ATC BC > US = 2765 – 50 – 450 – 350 = 1915 MW

Real-time HE15

- Real-time energy schedules using Firm transmission service on BC > US = 200 MW; unused Firm transmission service is 250 MW
- Real-time energy schedules on US > BC path = 100 MW

Non-Firm (Real-time) ATC BC > US = 2765 – 50 – 450 – 350 + 250 (unused) + 100 (counterflow) = 2265 MW

4.0 COUNTERFLOW ATC

Counterflow ATC is available at the precise time the counterflow energy is scheduled.

5.0 RELEASE OF UNUSED TRANSMISSION IN PRE-SCHEDULE FOR GRANDFATHERED AGREEMENTS

5.1 Line 71

Teck Metals Ltd has up to 370 MW of firm scheduling rights on the BC – US intertie. Teck Metals Ltd may release those firm rights back to BC Hydro, which then makes the capacity available to the market on OASIS.

Teck Metals Ltd or its agent is to provide information to BC Hydro Grid Operations as follows for scheduling purposes:

(a) 2 Working Day-Ahead - hourly amounts of transmission capacity within Teck Metals Ltd scheduling rights to be reserved for Teck Metals Ltd energy schedules on the second following working day, to be provided no later than 14:00 (PPT) 2 working days before the day of service. Note that on Wednesday, scheduling rights will be reserved for Teck Metals Ltd energy schedules for this same time frame but will also include Saturday. BC Hydro Grid Operations will release the unused capacity on or after 14:00 (PPT) to the market on OASIS.

(b) Working Day-Ahead - hourly amounts of transmission capacity within Teck Metals Ltd scheduling rights to be reserved for Teck Metals Ltd energy schedules on the following working day, superseding but not exceeding the amounts provided on the 2 working day-ahead basis described above. . Note that on Thursday, scheduling rights will be reserved for Teck Metals Ltd energy schedules for this same time frame but will also include Saturday. Teck Metals Ltd will provide this advice no later than 11:00 (PPT) 1 working day before the day of service. BC Hydro Grid Operations will release the unused capacity on or after 11:00 (PPT) to the market on OASIS.

5.2 Canadian Entitlement Agreement

BC Hydro has firm scheduling rights reserved on the US – BC intertie under its Network Integration Transmission Service for the return of energy under the Canadian Entitlement Agreement. BC Hydro or its agent is to provide BC Hydro Grid Operations the hourly amounts of transmission capacity to be reserved for the return of energy under the Canadian Entitlement Agreement, for scheduling purposes, no later than 11:00 (PPT) 1 working day before the day of service. BC Hydro will make the unused capacity available to the market on or after 11:00 (PPT) on OASIS.

6.0 REAL TIME GRANT REMAINING CAPACITY

Real-time, pre-confirmed, hourly transmission requests are granted remaining ATC if there is insufficient ATC to accept the transmission request, but there is still some ATC available.

A pre-confirmed transmission request that is granted remaining capacity is given a COUNTEROFFER wherein the customer has 5 minutes to respond.

After pressing the Customer Update button, the Transmission Customer has four choices (REBID, CONFIRMED, WITHDRAWN, and COUNTEROFFER). The Transmission Customer can select CONFIRMED and press the Submit Changes button to confirm the transmission request. Or, the Transmission Customer can select WITHDRAWN to withdraw from the COUNTEROFFER. If the Customer selects REBID or COUNTEROFFER and then presses the Submit Changes button, the transmission request will be INVALID or ignored and retracted, respectively. In addition, if the Transmission Customer does not respond within the allotted timeframe (5 minutes), the opportunity is lost and the transmission request will be RETRACTED. If there is no ATC available for the requested period, the transmission request will be REFUSED due to insufficient ATC.

Note: If a Transmission Customer submits a pre-confirmed, hourly Non-Firm transmission request in Real-time for the next hour after XX:10, the capacity granted will be Non-Firm ATC excluding the Transmission Customer's own unused transmission or the requested capacity, whichever is less.

For example:

	Unused Transmission	
ATC	*Customer A*	*Customer B*
200 MW	***50 MW***	***25 MW***

If Customer B submits a transmission request for 400 MW, COUNTEROFFER will be initiated and Customer B will be granted remaining capacity of 250 MW (200 ATC + 50 MW unused transmission from Customer A) in which Customer B has 5 minutes to respond.

Note: If Customer A schedules energy on its original transmission rights, Customer B's transmission reservation of 250 MW will be curtailed to 200 MW (250 MW – 50 MW that Customer A scheduled energy on).

IMPORTANT NOTE: After XX:25 of the current hour, Grant Remaining Capacity function will only grant remaining ATC provided that no curtailment results to other customers.

Document Change History

Issue	Reason for Issue	Date
1	Updated procedures and template. Previously Business Practice 2.	November 1, 2010
2	Updated to modify an example of Non-Firm ATC calculation, and to reflect changes of Firm TTC from 1930MW to 2400MW on BC-US and LM-US paths, and from 1930MW to 2000MW on the US-BC path.	February 1, 2011

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