



**British Columbia Transmission
CORPORATION™**

Feasibility Study

Green Power Corridor Phase III Generation Project

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**Transmission System Planning
British Columbia Transmission Corporation**

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Executive Summary

Steady-state analyses (powerflow and short circuit only) were conducted for a study of the system upgrades that would be required for interconnection of the proposed 800 MW generation project. The report provides a review and identifies any transmission system upgrades that would be necessary to connect the proposed generation project to the Transmission System at the point of interconnection (POI) at Malaspina substation.

In order to connect the proposed generation project to the Transmission System, the following conclusions are identified in this feasibility study :

- No overload and no voltage violation in the BCTC Transmission Network has been observed for the normal system conditions under heavy winter, heavy summer and light summer load conditions.
- No overload and no voltage violation in the BCTC Transmission Network has been observed for the applicable contingency system conditions under heavy winter, heavy summer and light summer load conditions.
- The Malaspina substation would require the addition of 230 kV circuit breakers to connect the two 230 kV transmission lines from the proposed project, and also the addition of a 230 kV shunt capacitor rated 110 MVar.
- Replacement of the two 500/230 kV transformers at Malaspina substation with higher-rated transformers (each 1200 MVA) would be required to interconnect the generation project to the Transmission System at the point of interconnection.

This is a "limited scope" study which was restricted to only powerflow and short circuit analysis per the BCTC Open Access Transmission Tariff (OATT). This study did not include transient and dynamic stability, harmonic mitigation, electro-magnetic transient program (EMTP) analysis, or other analytical calculations which normally form part of a comprehensive system study.

Based on the limited scope of study, the estimated cost to interconnect the Green Power Corridor Phase III generation project at the specified POI would be approximately \$57 million in 2007 dollars and an estimated time to construct, once the Standard Interconnection Agreement is signed, would be 36 months. The accuracy of this cost estimate is -50%/+100%.

The future Interconnection Impact Study and Facilities reports will include a much more comprehensive set of analytical calculations and also provide a more detailed cost estimate of the system upgrade requirement for this generation project.

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Malaspina substation is the major load-supply station for the 132 kV and 230 kV system in the Gibsons-Sechelt-Powell River area. The substation's 500 kV connection is into the Cheekye-Malaspina-Dunsmuir 500 kV transmission line system (two lines) that delivers power from the mainland to Vancouver Island. Cheekye 500 kV station is on the 500 kV transmission line(s) between Kelly Lake substation (Interior) and Meridian substation (in Lower Mainland), a line that is one of the four 500 kV lines from the interior of BC to the load centre in southwest BC.

2. Purpose of Study

The purpose of this study is to assess the requirements for interconnecting the Green Power Corridor Phase III generation project into the Transmission System based on the impact to the transmission network. The feasibility study identified system constraints and network upgrades required for the reliable operation of the proposed generation project and the Transmission System.

3. Study Assumptions

This study was carried out based on the proposed generation project's model, data and information provided in the interconnection request process. The 2012 heavy winter peak, heavy and light summer load base cases were used.

The interconnection request's information about the project's 230 kV transmission system indicated that under a single outage on the transmission lines between the Bute Inlet station and the POI, the remaining line would not be adequate to deliver its maximum summer generating output solely for thermal line rating reasons. This implied that in the high generation periods in the summer months it would be necessary to shed generating units at some of the project's generating plants for the outage of one of these two 230 kV lines.

The interconnection request did not indicate whether the two 220 km 230 kV lines from Bute Inlet station to the POI at Malaspina are expected to have series compensation but that reinforcement would be necessary. Series compensation of these two lines (50% compensation) was assumed in the study, as well as additional voltage support with a 110 MVar shunt capacitor at Malaspina 230 kV bus and 110 MVar of shunt capacitor at Bute Inlet 230 kV bus.

4. System Studies

The scope of the Feasibility Study is limited to powerflow and short circuit calculations as defined in the BCTC Open Access Transmission Tariff. Analytical calculations such as transient and dynamic stability, harmonic mitigation, electro-magnetic transient program (EMTP) analysis, or other calculations which normally form part of a comprehensive system study, would be addressed in the Interconnection System Impact Study and Interconnection Facilities Study.

Powerflow and short circuit analyses were carried out to evaluate the feasibility of the proposed interconnection and to identify the connection requirements.

4.1 Steady State Pre-outage Powerflow Study

Pre-outage powerflows were prepared to assess the impact of the generation project's connection. The study included three basic load/generation conditions: the 2012 heavy winter, heavy and light summer load conditions. The project's total generation was assumed to be 784 MW in the summer operating conditions as given for the individual generating plant's maximum outputs; this is a total output close to the stated 800 MW maximum output of the project. For the winter conditions the total output was the winter maximum output of 350 MW. The powerflow study cases assumed that the entire group of twelve generating stations were all in-service in the year 2012 even though their expected commercial operation dates range from 2012 to 2015.

The study area was the existing 230 kV and 132 kV load and generation region connected to the Malaspina substation plus the 500 kV transmission system from Malaspina to the BC Hydro load centre in southwest BC. In the Malaspina station's service area the total generation is expected to be increased by addition of other future generation to a level that will equal and at times even exceed the total load in the region. The two existing 500/230 kV transformers at Malaspina are each rated 600 MVA. With the proposed project's additional 800 MW of total generating capacity also added, the region would have an even higher generation surplus in summer months that would need to be delivered to the 500 kV system through the 500/230 kV transformers.

Figure 2 shows a sample powerflow diagram of the proposed 230 kV system with the upgrades in place and the proposed generation at a total of 784 MW, close to the 800 MW total capacity. The diagram shows a scenario with maximum generation at the Vancouver Island and Malaspina areas' existing and future generating stations including the proposed project. The BC Hydro loads were at light summer levels to illustrate the most difficult operating conditions for loadings on the Malaspina transformers and on the 500 kV transmission system from Malaspina toward the load centre in southwest BC. Another scenario, not illustrated here, for a heavy summer load situation showed Malaspina transformer loading that would be almost the same.

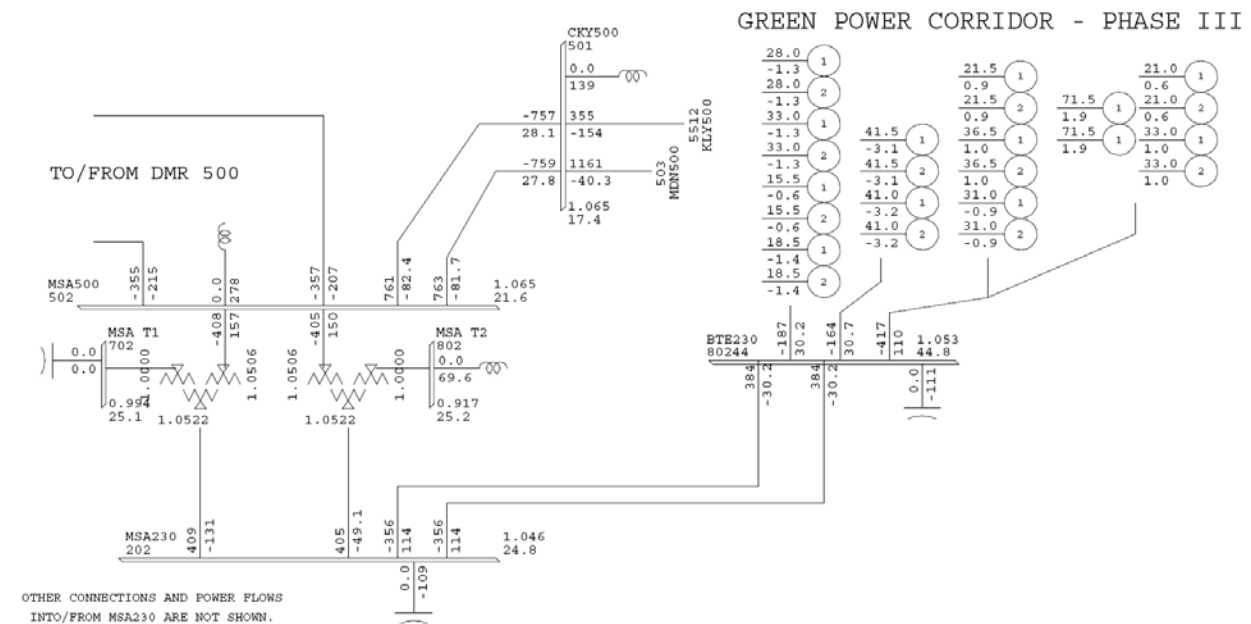


Figure 2: BC Hydro network configuration with interconnected Green Power Corridor Phase III

The Bute Inlet 230 kV station may need a shunt reactor, possibly 50 MVar rated, to assist with voltage control in the proposed project's 230 kV transmission system during energizing from the Malaspina station end or when energizing the radial lines from Bute Inlet station. The topic of line and transformer energizing in the proposed project's 230 kV transmission system is not reviewed in this feasibility study.

4.2 Short Circuit Study

A cursory investigation of the increased fault levels due to the interconnection of the proposed generation project did not indicate that equipment ratings on the Transmission System would be exceeded. The impact, however, on the equipment ratings at the other non-BC Hydro generating stations in the area was beyond the scope of this study and was not assessed.

The estimated system impedances and the three phase and single phase fault levels with an accuracy of +/-20% near the POI at Malaspina substation are :

Case 1 - With new 1200 MVA 500/230 kV transformers at Malaspina but assuming that the Green Power Corridor Phase III generation is off-line :		
	Maximum fault level	Low fault level
At MSA230	Z1= 0.48 + j 8.27 ohms Z0= 0.49 + j 8.0 ohms System normal, all elements in-service	Z1= 0.52 + j 10.86 ohms Z0= 0.62 + j 10.91 ohms One MSA 500/230 kV transformer out-of-service
Case 2 - With new 1200 MVA 500/230 kV transformers at Malaspina and assuming that all the Green Power Corridor Phase III generation is on-line :		
	Maximum fault level	Low fault level
At MSA230	Z1= 0.47 + j 7.31 ohms Z0= 0.5 + j 7.69 ohms System normal, all elements in-service	Z1= 0.53 + j 9.27 ohms Z0= 0.64 + j 10.34 ohms One MSA 500/230 kV transformer out-of-service

The Ultimate Fault Level should be used for basic station design such as bus strength, ground grid, and for any major equipment that the owner does not want to replace when the present fault level increases to the ultimate. No planned data exists for increasing this ultimate fault level.

Ultimate Fault Level at the Malaspina station 230 kV bus :	
Three phase fault	10,000 MVA
Single line to ground fault	10,000 MVA

4.3 Powerflow First Contingency Study

Most single contingency system conditions would not have transmission line loading problems or voltage violation conditions due to the addition of the Green Power Corridor Phase III generation project. A loading problem would result from the possible outage of a Malaspina 500/230 kV transformer during the high generation period in summer. To prevent the overload an upgrading of the Malaspina station's existing 500/230 kV transformer capability would be required.

The summer powerflow conditions as in Figure 2 show that with a total generation of 784 MW (close to the 800 MW total capacity) the power delivery at the POI would be about 712 MW, indicating a transmission resistive loss of about 9% along the proposed project's 230 kV transmission system. With this level of power delivered to the POI and with the required system upgrades in place, the pre-outage and post-outage powerflow conditions in selected powerflow cases demonstrated the need for the transformer replacements; the powerflow cases are summarized in Table 4.1.

Table 4.1: Summary of powerflow analysis with the system upgrades in place.

Scenarios, for BC Hydro system load level.	GPC Phase III (MW)	Loading Percentage, with system normal.	Loading Percentage, with one MSA transformer out-of-service.
		MSA 500/230 transformers, each rated 1200 MVA	MSA 500/230 transformer, rated 1200 MVA
2012 heavy winter loads	350	11%	17%
2012 heavy summer loads	784	35%	68%
2012 light summer loads	784	36%	72%

Table 4.1 indicates that even after the addition of the proposed generation the winter operating condition would have only a small loading from the Malaspina 230 kV bus toward the 500 kV system, due to the low total generation in the area and the high off-loading of the local loads. However the summer situations would have a much higher total generation and lower levels of off-loading so that the power transfer through the 500/230 kV transformers would be much higher. With the addition of the proposed generation and with all the other generation in the area at maximum output the transformers would be loaded to about 36% of their rating when both transformers are in-service (new 1200 MVA-rated transformers). The single contingency outage of one transformer during the high generation periods in summer would be acceptable; the remaining transformer would be loaded at about 72% of its 1200 MVA rating.

On the 500 kV transmission system there would be enough capability for the increased level of power transfer from the Malaspina substation to the rest of the BC Hydro 500 kV system. An outage of one 500 kV line from Malaspina to Cheekye or from Cheekye to Meridian (one of two main 500/230 kV substations in the Lower Mainland) would not be a concern for overloads in the remaining 500 kV transmission paths from Malaspina toward the rest of the BC Hydro system.

A remaining concern would be the existing 132 kV and 230 kV transmission system that underlies the 500 kV transmission path from Malaspina to Meridian in the lower mainland. With the addition of the proposed Green Power Corridor Phase III generation the scenario of high summer-time generation in the Malaspina substation area would create an undesired loading on this underlying transmission system, particularly in the Sechelt to Gibsons to Cheekye 132 kV line. The 132 kV line's loading in the difficult high generation periods of the summer months would be acceptable in the "system normal" operating conditions, but a single contingency outage on the 500 kV transmission system could cause overload of the underlying 132 kV line. The worst case would be an outage of the Cheekye-Meridian 500 kV line when it is heavily loaded toward Meridian. The remedy for this overload problem would likely be a 132 kV line uprating to the extent that it is possible, and then use of an overload protection/control action by opening the 132 kV system when necessary, probably by a remedial action scheme. The cost of this remedy or evaluation of alternatives was not included in this feasibility study because the cost impact would be small compared to the major cost items in the list of required upgrades.

4.4 System Upgrades

Because the Malaspina station does not have sufficient space to add a third 500/230 kV transformer, the required transformer upgrade would be done by replacing the two existing 600 MVA transformers with ones each rated 1200 MVA. BC Hydro has standardized on 300, 600 and 1200 MVA 500/230 kV transformers for efficiency in sparing and exchanges, so the 1200 MVA rating would be the choice for the new transformers.

The following would be the major system upgrades necessary to integrate the proposed generation project into the system:

- Connection of the two 230 kV lines into the Malaspina 230 kV bus;
- Addition of one shunt capacitor at Malaspina 230 kV bus, rated 110 MVar at 242 kV.
- Replacement of the two 600 MVA 500/230 kV transformers at Malaspina with two transformers each rated 1200 MVA.

A more detailed assessment of the requirements at the interconnection substation, adjacent existing substations, and the protection, control and telecommunication facilities would be identified in the Interconnection System Impact Study and Interconnection Facilities Study.

5. Good-faith Cost Estimates

This feasibility study is restricted to powerflow and high-level short circuit studies in accordance with the OATT and therefore the scope of the study is limited.. A more rigorous evaluation of the interconnection (i.e. review of equipment ratings, additions or modifications, protection & control changes, and telecommunications requirements, etc, and their associated costs) is beyond the scope of this study and would be addressed at a later stage in the Interconnection System Impact Study and Interconnection Facilities Study.

A good-faith estimate for costs associated with the additions and changes at the Malaspina station as required to connect the Green Power Corridor Phase III generation is about \$57 million in 2007 dollars. An estimated time to construct, once the Standard Interconnection Agreement is signed, is 36 months. The accuracy of this estimate is -50%/+100%. This cost does not include costs of public consultation, environmental study, and contingencies.

6. Conclusions and Discussions

In order to connect the Green Power Corridor Phase III generation project into the Transmission System at the Malaspina 230 kV bus, the following conclusions were identified in this feasibility study :

- No overload and no voltage violation in the BCTC Transmission Network has been observed for the normal system conditions under heavy winter, heavy summer and light summer load conditions.
- No overload and no voltage violation in the BCTC Transmission Network has been observed for the applicable contingency system conditions under heavy winter, heavy summer and light summer load conditions.
- The Malaspina substation would require the addition of 230 kV circuit breakers to connect the two 230 kV transmission lines from the proposed project, and also the addition of a 230 kV shunt capacitor rated 110 MVar.
- Replacement of the two 500/230 kV transformers at Malaspina substation with higher-rated transformers (each 1200 MVA) would be required to interconnect the generation project to the Transmission System at the point of interconnection.

This feasibility study of the Green Power Corridor Phase III connection was based on the available data. Detailed system impact study including dynamic analysis can be performed as required in the later stages of study. Further information on cost estimates will be provided later in the Interconnection System Impact Study and Interconnection Facilities Study reports.