Dunvegan Hydroelectric Project
For Glacier Power Limited
Preliminary Interconnection Study

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1.0 PROJECT DESCRIPTION

Glacier Power Ltd., a wholly owned subsidiary of Canadian Hydro Developers Inc, is proposing to develop a run of river hydroelectric generating facility (the Project) located on the Peace River near NE ¼ 12-80-5-W6. Glacier Power has requested that the AESO conduct a preliminary interconnection assessment for the Project.

It is the AESO’s understanding that the Project would include the interconnection of 40 synchronous turbine/generating units, each with a capacity of 2.5 MW @ 25kV, for a total net output of 100 MW. The Project is expected to operate with a capacity factor of 70%. Glacier Power plans to commission the powerhouse and interconnect to the transmission system during the 3Q of 2008.

2.0 EXECUTIVE SUMMARY

The AESO has determined that the Alberta Interconnected Electric System (AIES) can accommodate the export of approximately 100 MW from the Project. The recommended interconnection should be an in/out line configuration taping 7L73-1 with point of supply to the AIES at the new Dunvegan substation. The proposed interconnection cost has an estimated order of magnitude capital cost of $3.1 million (+30%, 2004$). The AESO’s preliminary review indicated that all of this cost will be allocated to Glacier Power. An overview of the existing transmission system in the Grand Prairie and Peace River areas is shown in Figure A - 1, Appendix A. A simplified single line diagram of the proposed interconnection configuration is shown in SLD 445 – 1, Appendix A.

This report is a preliminary interconnection study that addresses steady-state performance in two primary domains; transmission line loading and system voltage deviation using typical N-1 transmission planning criteria.

According to the EUB’s Directive 028, any generation over 70 MW would require a dynamic study as part of generating facility application. Since the Project would have at least 100 MW of generation, a system stability study will be required.
3.0 PROPOSED INTERCONNECTION

In the following subsections, an overview of the existing transmission network near the Dunvegan site is discussed as well as options to interconnect the Dunvegan Hydro Plant with the AES. Given the size of the generating facility, the AESO is recommending a more robust interconnection than the one suggested by the Generator and is outlined in Section 3.2.

3.1 EXISTING SYSTEM

The transmission system in the northwest area is operated in accordance with the AESO’s 501 Northwest Area Operating Policy. The proposed Dunvegan Hydro Project will be located on Peace River in the Grande Prairie area which is part of the northwest area. The transmission network near the proposed site mainly consists of 144 kV. The project site is approximately 4 km from ATCO’s existing 7L73-1 144 kV line. The 7L73-1 Rycroft 730S to Boucher Creek 829S and 7L73-2 Boucher Creek 829S to Friedenstal 800S line sections are built with 266.8 kcmil conductor and the total length is 54 km. Friedenstal 800S is connected to West Peace River 793S through 7L75. Similarly Rycroft 730S is connected in the south with Clairmont Lake 811S through 7L68. Clairmont Lake 811S is also part of a 144 kV loop which also consists of generation at Poplar Hill and Elmworth. There is also a radial 144 kV feed from Rycroft 730S to Ksituan River 754S. According to ATCO the capacity of 7L73 Rycroft 730S to Friedenstal 800S 144 kV line is 100 MVA during summer and winter under normal conditions. This load limit has been determined by the CT limitation and can be increased with relative ease. The emergency loading limit during both the seasons is 130 MVA.

The line outage statistics for 7L73 in comparison with ATCO’s totals for 144 kV lines as well as CEA published data for 110 – 149 kV lines are shown in Tables 3.1-1 and 3.1-2.

Table 3.1 – 1: Sustained Forced Outage Statistics for 7L73, ATCO’s 144 kV Lines & CEA (110 – 149 kV Lines) – 5 Year Average

<table>
<thead>
<tr>
<th>Line</th>
<th>Length (km)</th>
<th>km-yr</th>
<th>No. of Outages</th>
<th>Total Duration (hrs)</th>
<th>Freq./100 km-yr</th>
<th>Mean Duration (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATCO’s 7L73</td>
<td>54</td>
<td>270</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>ATCO’s 144 kV</td>
<td>4,868.7</td>
<td>24,190.08</td>
<td>87</td>
<td>448.09</td>
<td>0.36</td>
<td>5.15</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEA Average* (110 - 149 kV)</td>
<td>-</td>
<td>228,646</td>
<td>2,581</td>
<td>80,521</td>
<td>1.1288</td>
<td>31.2</td>
</tr>
</tbody>
</table>

* From Table 2 of Section 2.2, Forced Outage Performance of Transmission Equipment, CEA Report, May 2003
Table 3.1 – 2: Transient Forced Outage Statistics for 7L73, ATCO’s 144 kV Lines & CEA (110 – 149 kV Lines) – 5 Year Average

<table>
<thead>
<tr>
<th>Line</th>
<th>Length (km)</th>
<th>km-yrs</th>
<th>No. of Outages</th>
<th>Freq./100 km-yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATCO’s 7L73</td>
<td>54</td>
<td>270</td>
<td>10</td>
<td>2.95</td>
</tr>
<tr>
<td>ATCO’s 144 kV</td>
<td>4,868.7</td>
<td>24,190.08</td>
<td>192</td>
<td>0.79</td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
<td>2,498</td>
<td>1.0925</td>
</tr>
</tbody>
</table>

* From Table 3 of Section 2.2, Forced Outage Performance of Transmission Equipment, CEA Report, May 2003

3.2 Option 1 - In and Out Configuration

One of the possible interconnection configurations is to make an in-and-out arrangement of the 7L73-1 Rycroft – Boucher Creek line at the Dunvegan generating station. The key transmission components will include the following:

Transmission

- construct two (or a double circuit) 144 kV transmission line of approximately 4 km length from the Dunvegan Hydro generating facility to 7L73-1 line using single 266.8 kcmil conductor per phase with an overall summer/winter capacity of 115/145 MVA;
- connect the newly constructed 144 kV line with the existing 7L73-1 to make an in-and-out arrangement;
- install fiber optic cable or any suitable measure for protection & control and telecommunication;
- replace the CTs that limit the line loading on 7L73-1;

Dunvegan Generating Station

- Install two 144 kV breakers on the two outgoing circuits from the generating station along with the related protection and control equipment;

This configuration will have an estimated order of magnitude capital cost of $3.1 million (+30%, 2004$). A simplified single line diagram of this interconnection configuration is shown in SLD 445 – 1 in Appendix A.
3.3 Option 2 - Dunvegan Switching Station

An alternative interconnection arrangement is to connect the Dunvegan Hydro Plant with the AIES using a switching station at the tap point on 7L73-1. The key transmission components in this interconnection option will include the following:

Transmission

- construct approximately 4 km of 144 kV transmission line from the Dunvegan generating plant to 7L73-1 using single 266.8 kcmil conductor per phase with an overall summer/winter capacity of 115/145 MVA;
- install fiber optic cable or any suitable measure for protection & control and telecommunication;

Switching Station

- construct a new switching station, 4 km from the proposed generating station on 7L73-1;
- install two 144 kV breakers to terminate 7L73 line;
- install one MOD switch for sectionalizing faulty line and for providing a visual isolation point of the tapped line;

The above development have an estimated order of magnitude capital cost of $3.2 million (≈30%, 2004$). A simplified single line diagram of this interconnection configuration is shown in SLD 445 – 2 in Appendix A.

3.4 Option 3 – T-tap on 7L73-1

In this option a three terminal configuration is proposed as shown in SLD 445-3 in Appendix A. It involves a 4 km long 144 kV line connecting Dunvegan generating station to the 7L73 line through a simple T-tap. As there are only line sectionalizers installed at Boucher Creek, therefore an additional circuit breaker along with all the associated protection and control equipment will have to be installed at Boucher Creek substation. Boucher Creek – Friedenstal line section in this case will still be in zone 2 clearance for line faults. Under these conditions it is uncertain if Dunvegan generators will remain stable in case of a fault. If transient stability studies indicate a stability problem then another breaker will have to be installed at Boucher Creek along with the associated teleprotection. The total cost for this option (with one proposed breaker) is 2.4 million (≈30%, 2004$). The addition of the second breaker (0.5 -0.75 M$) if required, will make the cost of this option approximately equal to the cost of Option 1.

3.5 Interconnection Recommendation

After reviewing all the interconnection options, it is recommended that Option 1, i.e. an in-and-out connection on the existing 7L73 to connect the proposed Dunvegan hydro plant, will be the most suitable option. The total peak capacity of the Dunvegan Hydroelectric plant will be 100 MW which is significant and requires a reliable interconnection configuration. The in-and-out arrangement provides the required reliability and is robust.
Please note that Glacier Power Ltd will be responsible to provide adequate space for a 144 kV substation and for the installation of their 144/25 kV step up transformation and accompany 144 kV breaker. ATCO Electric will be responsible for the construction of the 144 kV bus work and associated 144 kV circuit breakers and other communication facilities. The point of ownership for Glacier Power Ltd. is shown in SLD 445 – 1 in Appendix A.

Option 3 (with one proposed circuit breaker) offers a least cost solution for interconnection. However, apart from being the least reliable of the three options, the validity of this scheme has to be verified through transient stability studies in the second stage. If further transmission upgrades is established (i.e. installation of a second breaker at Boucher Creek 829S) then the total cost of this option will be approximately equal to that of Option 1. In this case Option 1 will have a technical and economic advantage over Option 3.

4.0 SYSTEM IMPACT ASSESSMENT

The steady state performance of the system with the proposed Dunvegan generation in place was analyzed for the 2008 summer light load period. This scenario was selected to simulate the worst case condition which would consist of peak generation dispatch from Dunvegan hydro plant during summer light load conditions. The Dunvegan hydro plant was connected to the system by making an in-and-out connection on the 7L73-1 Rycroft - Boucher Creek 144 kV line. Glacier Power Ltd. has informed that there will be 40 small units of 2.5 MW each. However for this study, all the generation was lumped at the 25 kV bus into one generator and dispatched at the full capacity of 100 MW.

After reviewing the base case and contingency load flow cases, AESO determined that the addition of the Dunvegan hydro plant will not have any problems in the system.

Following is a list of cases studied and a brief description of the resulting system performance; drawings showing load flow plots are included in Appendix B.

Figure B - 1: Without Dunvegan Hydro Power Plant - All Elements in Service
All bus voltages are within an acceptable operating range and there are no overloaded elements.

Figure B - 2: With Dunvegan Hydro Power Plant - All Elements in Service
Dunvegan power plant is dispatched at 100 MW. All bus voltages are within an acceptable operating range and there are no overloaded elements. Dunvegan – Rycroft section is loaded at 58 MW while Dunvegan – Boucher Creek section carries 42 MW.
Figure B - 3: Dunvegan – Rycroft 144 kV Out of Service
All bus voltages are within an acceptable operating range and there are no overloaded elements. In this case Dunvegan – Boucher Creek section carries 100 MW which is the existing loading limit.

Figure B - 4: Dunvegan – Boucher Creek – Friedenstal 144 kV Out of Service
All bus voltages are within an acceptable operating range and there are no overloaded elements. Dunvegan – Rycroft section is loaded at its existing limit of 100 MW.

Figure B - 5: Clairmont Lake 811 S to South Bezanson 862 S 144 kV Out of Service
All bus voltages are within an acceptable operating range and there are no overloaded elements.

Figure B - 6: 7L75, Friedenstal 800 S to West Peace River 793 S 144 kV Out of Service
All bus voltages are within an acceptable operating range and there are no overloaded elements.
APPENDIX A – Area and Single Line Drawings
Figure A-1  Northeast Alberta 2005 Transmission System
APPENDIX B – Load Flow and Contingency Analysis