Request for Information

Vancouver Island 230 kVac Supply
Submarine Cable System

1. Background

The BC Transmission Corporation is moving ahead with preparations to preserve an October 2008 in-service date for a new 600 MW 230 kVac transmission line between mainland British Columbia and Vancouver Island. BC Hydro Engineering is assisting with providing general engineering services to BCTC.

This RFI document requests additional information from leading submarine cable suppliers, to help define various technical parameters and realistic costs. The basic submarine cable type described herein is Self Contained Fluid Filled, Paper Polypropylene Laminate insulation (SCFF PPL). Suggestions for other cable types or installation methods are encouraged, if they provide the same transmission capacity, and are considered to be at least as reliable, less costly and technically superior or equivalent.

2. Application

The new interconnection would replace BC Hydro's existing 138 kVac submarine cable system, installed in 1956-58 and described in the attached file. A detailed description of the initial installation is given in Reference 1. The work would be carried out in two stages, with the first 230 kV circuit being commissioned in October 2008. It would replace the three most southerly 138 kV cables in Georgia Strait and Trincomali Channel. The second circuit would not be required for another 10-20 years, but provision needs to be made in the first stage. The completed installation must provide high reliability for an expected 60 year service life, using proven cable system technology.

3. System Characteristics and Transmission Capacity

The key system parameters are:

**Electrical withstands:**

- Frequency: 60 Hz
- Nominal rated voltage Uo/U (insulation design): 140/242 kVac rms
- 5% continuous overvoltage (insulation design): 147/253 kVac rms
- Basic Impulse Level: 1050 kV crest
- Fault capacity (SLG or 3 phase): 40 kA, 15 cycles

**Electrical load:**

- Assumed power factor of load: 1.0
- Assumed charging Mvars direction: 100% supply from one end
- Nominal rated total power (summer): \((600 \text{ MW}^2 + (\text{charging Mvars})^2)^{0.5}\)
Maximum ac voltage at maximum load 133/230 kVac
Daily load factor 1.0

4. Cable Routing and Site Conditions

The new cables would follow approximately the same route and use the existing terminal stations. Photos of the existing terminals are included in the attached file. Distances and water depths are as follows:

English Bluff Terminal (EBT) to Taylor Bay Terminal (TBY)
- 24.5 km sea cable length
- 1.0 km land cable length
- 200 m maximum water depth

Montague Terminal (MTG) to Maracaibo Terminal (MBO)
- 5.0 km cable length
- 0.5 km land cable length
- 60 m maximum water depth

5. Thermal Conditions

Thermal conditions at and near EBT are complex, and include the following cross-sections, from terminals to sea (see photos):

1. In free air
2. In open top chase under sunshades (0.6 m spacing)
3. In open chase covered with culverts under English Bluff Road (0.6 m spacing)
4. In original open top chase covered with precast slabs in park (0.6 m spacing)
5. In air in tunnel
6. Buried at beach at sea end of tunnel (0.6 m spacing, max 2.0 m deep)
7. Buried in intertidal zone (max 1.0 m deep)
8. Buried in subtidal zone to −3 m bathy (max 1.0 m deep)
9. Buried naturally in deep water, open sea (max 0.2 m deep)

Thermal conditions at and near TBY, MTG and MBO are less complex and include the following thermal cross-sections, from terminals to sea (see photos):

1. In free air
2. In open top chase under sunshades (0.6 m spacing)
3. In covered chase under sunshades (0.6 m spacing, 0.8 m cover)
4. Buried at beach at sea end of covered chase (0.6 m spacing, max 2.0 m deep)

5. Buried in intertidal zone (min 2 m spacing, max 1.0 m deep)

6. Buried in subtidal zone to -3 m bathy (min 2 m spacing, max 1.0 m deep)

7. Buried naturally in deep water, open sea (max 0.2 m deep)

Assumed maximum ambient temperatures (summer) and thermal resistivities are as follows:

<table>
<thead>
<tr>
<th>Location</th>
<th>Temperature</th>
<th>Thermal Resistivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>30°C</td>
<td></td>
</tr>
<tr>
<td>Land</td>
<td>20°C, 1.2°C-m/W</td>
<td></td>
</tr>
<tr>
<td>Top of intertidal zone</td>
<td>18°C, 0.8°C-m/W</td>
<td></td>
</tr>
<tr>
<td>Sea bottom</td>
<td>8°C, 0.8°C-m/W</td>
<td></td>
</tr>
</tbody>
</table>

For purposes of this request, it should be assumed that a larger 'land' cable is spliced to a smaller 'sea' cable, near the top of the intertidal zone. Final designs may find other ways to minimize the need for larger 'land' cables at the various landings.

6. Preferred Cable System Type and Characteristics

The cable shall be delivered in one continuous length, without factory joints, plus a 5 km length of spare cable. The following cable type is preferred, because of proven reliable performance for similar applications, relatively low losses, low charging current, light weight, small diameter and low resistance to armour wire corrosion. With proper design, it should also be convertable to 300 KVdc operation (see item 8. below).

Conductor (sea) 1400 mm$^2$ copper (subject to capacity needs)
Conductor (land) 2000 mm$^2$ copper (subject to later optimization studies)
Insulation Self contained fluid filled, paper/polypropylene laminate (SCFF-PPL)
Insulating fluid Biodegradable linear alkylbenzene (LAB) with minimum free benzene
Sheath Reinforced lead alloy
Armour Single layer, round copper wires (6 mm diam.)
Bedding/serving Bitumen impregnated polypropylene yarn

Each cable shall incorporate two integral stainless steel tubes containing a minimum of 12 optical fibres suitable for telecommunications and distributed temperature sensing applications. The tubes shall either be placed within one of the interstices of the armour wires, or replace armour wires.

The following accessories are also anticipated:

- Insulating fluid pressurizing systems at EBT, TBY, MBO and MTG, capable of feeding severed cable for 30 days, with early leak detection systems and variable flow limiting based on cable temperature (total of four - one per cable terminal).
- Land/sea cable rigid transition joints near the top of the intertidal zone at EBT, TBY, MBO and MTG (total of 12 + 4 spare)
- Flexible repair joints (3 spare)
- Outdoor terminations at EBT, TBY, MTG and MBO (total of 12 + 1 spare)
- Armour anchoring/earthing clamps (total of 12)

7. Cable System Standards, Recommendations and Qualification Tests

As a minimum, the cable systems shall have successfully completed prototype testing to verify compliance with the following standards and recommendations, or equivalent, for applications to at least 250 m water depth:

IEC 141-1 Tests on oil-filled and gas-pressure cables and their accessories up to and including 400 kVac

Electra 171 article Recommendations for mechanical tests on submarine cables, April 1997

The Electra 171 tests shall include the 'Sea Trial Test', including a flexible repair joint and a factory joint, if relevant.

8. AC/DC Convertibility

BCTC is considering possible future conversion of the 230 kVac cables to dc operation. It is anticipated that this would require replacement of the terminations, but otherwise the delivered cable system would ultimately be suitable for operation at 300 kV, 2000A, at very little extra cost. In this way the interconnection capacity could ultimately be increased to at least 2400 MW, with the addition of converters, leaving two cables for metallic returns or spares. Advice is sought on the nature and cost of development programs and additional prototype tests that would be required to have their proposed cable system(s) satisfy this future application.

9. Cable Installation

Marine surveys and preparation of cable laying charts will be by others. Cable installation shall be done with a specialized power cable or telecom laying vessel equipped with Class II dynamic positioning equipment. A work class ROV shall be used to monitor cable touchdown during cable laying. Special attention will be necessary for crossing the Galiano Ridge area, about 4 km east of TBY, to the TBY cable landing, to minimize the length of cable suspensions over rock outcrops.

The cables shall be buried to a depth of about 1 m through the intertidal zone and to the −3m contour offshore EBT. A mechanized waterjetting machine shall be used through this zone, which is covered with eelgrass, an important protected habitat for sea life. Suggestions for alternative low-impact burial methods are welcome. The cables shall also be buried to a depth of about 1 m through the intertidal zone and to the −3m contour at TBY, MTG and MBO.

10. Request for Specific Technical Information
A request for specific technical information is described in Appendix A. Supplemental appendices may be created to describe other alternatives.

11. Request for Budgetary Cost Estimates

A request for budgetary costing information is described in Appendix B. These costs will be used to produce internal project budgets and will be compared with other non-transmission alternatives. They should therefore be an accurate representation of real manufacturing and installation costs, as if BCTC were to award a contract for the described work. Price adjustment qualifications are welcome, for example to reflect currency and metal price fluctuations, or other uncertainties. Refinements to the cost items are also welcome.

12. Request for General Technical Information and Scheduling Information

A request for general technical information and scheduling information is described in Appendix C.

13. Call for Tenders

Present plans are to call for Tenders for supply and installation of the first circuit in late 2005. Advice is sought on whether this would provide sufficient time to complete the required Prototype tests, as described in the foregoing, if not already done for the basic SCFF PPL cable type, or suggested alternatives.

14. Appreciation

BCTC and BC Hydro Engineering are grateful for the assistance provided in response to this request.

References

2. Attached electronic files
Appendix A - Specific Technical Information

Provide the following technical information for the proposed cables and additional supplemental tables as required for alternative proposals:

1. Sea Cable
   a) Cross section drawing, including principal component material descriptions and dimensions
   b) Description of the electrical parameters:
      - conductor cross-sectional area
      - conductor dc resistance
      - conductor ac resistance
      - inductive reactance
      - insulation permittivity
      - insulation dissipation factor
      - insulation capacitance
      - insulation charging current
      - dielectric losses
      - total losses
   c) Description of the thermal and physical parameters:
      - maximum continuous conductor operating temperature – normal
      - maximum continuous conductor operating temperature – emergency
      - cable weight in air
      - cable weight in water
      - maximum static tension
      - minimum bending radius, untensioned
      - minimum bending radius, under maximum static tension

2. Land Cable
   a) Cross section drawing of land cable, including principal component material descriptions and dimensions
   b) Description of the electrical parameters:
      - conductor cross-sectional area
      - conductor dc resistance
      - conductor ac resistance
      - inductive reactance
      - insulation permittivity
      - insulation dissipation factor
      - insulation capacitance
      - insulation charging current
      - dielectric losses
      - total losses
   c) Description of the thermal and physical parameters:
      - maximum continuous conductor operating temperature – normal
      - maximum continuous conductor operating temperature – emergency
- cable weight in air
- cable weight in water
- maximum static tension
- minimum bending radius, untensioned
- minimum bending radius, under maximum static tension

3. Description of insulating fluid, including biodegradation rates and toxicology information, with testing references.

4. Description of proposed fluid pressurizing system.

5. Description of the cable system prototype testing program, duration and approximate cost, if required to prove suitability for this application.

6. Description of the prototype testing program, duration and approximate cost, if required to prove suitability for future 300 kVdc, 2000A operation.

7. Description of other installations where a cable system similar to that proposed, is in operation.
Appendix B - Budgetary Cost Information

Provide the following cost estimating information for the proposed cable system and additional supplemental tables, as required for alternative proposals:

One 630 MW 230 kVac SCFF cable circuit
(3 cables) from English Bluff Terminal to Taylor Bay Terminal and from Montague Terminal to Maracaibo Terminal

<table>
<thead>
<tr>
<th>MATERIALS AND EQUIPMENT</th>
<th>QUANTITY</th>
<th>UNIT</th>
<th>UNIT COST</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>230 kVac 630 MW submarine sea cables</td>
<td>97,500</td>
<td>metres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>230 kVac 630 MW submarine land cables</td>
<td>4,500</td>
<td>metres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>230 kVac outdoor terminations c/w supports</td>
<td>12</td>
<td>each</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil pressurizing systems</td>
<td>4</td>
<td>each</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land/sea cable transition joints</td>
<td>12</td>
<td>each</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spare outdoor termination</td>
<td>1</td>
<td>each</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spare flexible repair joints</td>
<td>2</td>
<td>each</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spare rigid repair joints</td>
<td>4</td>
<td>each</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spare sea cable</td>
<td>5,000</td>
<td>metres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distributed Temperature Sensing/Dynamic Rating System</td>
<td>4</td>
<td>each</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL**

<table>
<thead>
<tr>
<th>CONSTRUCTION</th>
<th>QUANTITY</th>
<th>UNIT</th>
<th>UNIT COST</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Install 230 kVac 630 MW land cables</td>
<td>97,500</td>
<td>metre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install 230 kVac 630 MW sea cables</td>
<td>4,500</td>
<td>metre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bury sea cable near EBT in intertidal zone</td>
<td>2,000</td>
<td>metre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bury sea cable near TBY in intertidal zone</td>
<td>200</td>
<td>metre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bury sea cable near MTG in intertidal zone</td>
<td>100</td>
<td>metre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bury sea cable near MBO in intertidal zone</td>
<td>100</td>
<td>metre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install oil pressurizing systems</td>
<td>4</td>
<td>each</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install land/sea cable transition joints</td>
<td>12</td>
<td>each</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install outdoor terminations c/w supports</td>
<td>12</td>
<td>each</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offload spare 5 km cable at BCH facility</td>
<td>1</td>
<td>Lump sum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Install Distributed Temperature Sensing/Dynamic Rating System</td>
<td>4</td>
<td>each</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optionally - remove 3 old cables in sea</td>
<td>97,500</td>
<td>metre</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL**
Assume:
Georgia Strait crossing: 25.5 km, -200 m deep
Trincomali Channel Crossing: 5.0 km, -60 m deep
Shore civil work by BC Hydro
Terminal preparation by BC Hydro
No duties or taxes included
Prices in 2004 $CAN
Appendix C - General Technical and Schedule Information

1. Have you manufactured and installed 230 kVac XLPE insulation for projects with similar crossing lengths and depths?

2. Could you provide 230 kVac XLPE insulation cable systems suitable for future conversion to 300 kVdc operation?

3. HDD has been suggested as a method for possibly avoiding slope instability problems due to earthquakes offshore EBT. The pipe length would be about 1,000 – 2,000 m, with a slope angle of about 5 degrees. Assuming that the pipe could be successfully installed, with the water exit at about –100m, what are the cable installation, maintenance and repair issues that need to be considered?

4. Do you have experience with installing similar submarine cable into horizontal directionally drilled (HDD) pipes? If so, please elaborate on maximum length, pipe material, slope angle, cable information, etc.

5. Provide a preliminary schedule, including the duration for major project tasks, such as:
   - Cable system design and prototype testing, if necessary
   - Cable and accessory manufacturing
   - Pressurizing system manufacturing
   - Old cable removal
   - Transportation to site
   - Cable laying
   - Cable terminating & jointing
   - Pressurizing system installation
   - System commissioning and testing
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