

**Integrated Resource Plan**

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**Appendix 3A-6**

**2013 Resource Options Report Update**

**Resource Options Mapping (ROMAP) Report**

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2010 Resource Options Update

# Resource Options Mapping Update

Final Report  
May 2011



## 2010 Resource Options Update

# Resource Options Mapping Update

Final Report  
May 2011

KWL File No. 478.098-300

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**2010 RESOURCE OPTIONS UPDATE  
BC HYDRO & POWER AUTHORITY**

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**STATEMENT OF LIMITATIONS**

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This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

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(Note: Figures 2-1 to 2-17 are provided in separate files on the BC Hydro Integrated Resource Plan Website)

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# **Executive Summary**

## **EXECUTIVE SUMMARY**

BC Hydro commissioned a study to update the existing resource option mapping database (ROMAP), a geographical information system (GIS) database, for their 2010 electricity generation resource options update and the 2011 Integrated Resource Plan (IRP).

The study compiled over 7700 potential resource options in BC. These sites have a potential installed capacity of over 60,000 MW and annual energy of nearly 200,000 GWh.

ROMAP is a spatially enabled GIS version of BC Hydro's Resource Option Database (RODAT), containing the key details about potential generation resources.

The energy resources data assembled in the resource options mapping database (ROMAP) as a part of this project include potential:

- Biomass (Biogas);
- Biomass (Municipal Solid Waste (MSW));
- Biomass (Wood Based);
- Geothermal;
- Large Hydro (Site C);
- Pumped Storage;
- Resource Smart;
- Run-of-River;
- Solar;
- Natural Gas Fired Generation;
- Coal Fired Generation with Carbon Capture and Sequestration (CCS);
- Tidal;
- Wave; and
- Wind (on shore and off shore).

Potential resources located in protected areas (exclusion zones) were not included in the analysis.

At gate costs were supplied by BC Hydro. Road and power line costs were estimated for each project taking the least cost route (avoiding exclusion areas). The estimated cost for each of the projects includes access roads and power lines interconnecting to the BC Hydro and Fortis BC grids.

As this study involved identifying a complete inventory of potential resource options, the unit energy costs (UECs) presented include economically feasible and economically infeasible UECs.

There is a large quantity of renewable energy resources potential in BC with approximately 4,500 MW and 24,000 GWh estimated to be under \$100/MWh (6% discount rate).

This report reflects the resource options data as of February 3, 2011, however the BC Hydro database may have been modified by the integrated resource planning (IRP) process which may not be reflected in this report.



## **Section 1**

# **Introduction**

## 1. INTRODUCTION

### 1.1 BACKGROUND

BC Hydro retained Kerr Wood Leidal Associates Ltd. (KWL) to update the existing resource option mapping database (ROMAP) GIS database for BC Hydro's 2010 electricity generation resource options update for the 2011 Integrated Resource Plan (IRP).

This report reflects the resource options data as of February 3, 2011, however the BC Hydro database may have been modified by the integrated resource planning (IRP) process which may not be reflected in this report.

### 1.2 SCOPE

The scope of this study was the preparation of generation resource option data for BC Hydro optimization models. Specific tasks included:

- update of the ROMAP database of generation resources with data supplied by BC Hydro; and
- GIS analysis of access (roads and barge) and power line / interconnection costing.

The data prepared as a part of this project will be utilized as input to the resource options portfolio analysis. The Resource Option Map Database (ROMAP) updated for this study was provided electronically to BC Hydro.

## **Section 2**

# **Resource Options Database & Mapping**

## 2. RESOURCE OPTIONS DATABASE & MAPPING

### 2.1 RESOURCE OPTIONS MAP DATABASE (ROMAP)

The Resource Options Map Database (ROMAP) is a spatially-enabled version of BC Hydro's Resource Option Database (RODAT), containing the key details about potential generation resources. ROMAP was constructed using ArcGIS 10, using the file geodatabase data model. This database format is interchangeable with other relational database formats, including dBase, MS Excel/Access, SQL Server and Oracle.

### 2.2 GENERATION RESOURCE OPTIONS UPDATED

This section describes the attribute fields in the generation resource datasets. This is the key dataset used in this study, and only includes sites where a project concept has been developed. There are currently 7,758 potential energy resource sites listed in the database.

All resource types that were not excluded as a part of the Clean Energy Act and could foreseeably generate energy at a utility scale commercial-level within the next thirty years were considered. Any existing or committed projects were not included in this analysis. Potential resources were not excluded on the basis of economic, environmental except where noted in this study.

The 2011 IRP included updates to most resource options. The energy resources data assembled in the resource options mapping database (ROMAP) as a part of this project include potential:

- Biomass (Biogas);
- Biomass (Municipal Solid Waste (MSW));
- Biomass (Wood Based);
- Geothermal;
- Large Hydro (Site C);
- Pumped Storage;
- Resource Smart;
- Run-of-River;
- Solar;
- Natural Gas Fired Generation;
- Coal Fired Generation with Carbon Capture and Sequestration (CCS);
- Tidal;
- Wave; and
- Wind (on shore and off shore).

Figures 2-1 through 2-14 show the mapped generation resource options according to type<sup>1</sup>.

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<sup>1</sup> Note: Figures 2-1 to 2-17 are provided in separate files on the BC Hydro Integrated Resource Plan Website

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## 2.3 RESOURCE OPTIONS DATASET SUMMARY

The tables below summarize the resource options in the ROMAP database before exclusions (e.g., legally protected areas and technically infeasible areas). Table 2-1 provides a summary of all the resource options by transmission region (see Figure 2-15<sup>1</sup> for the transmission regions). Table 2-2 provides a summary of all the projects by resource type. Table 2-3 provides a summary by transmission region of all resource options by type.

## 2.4 EXCLUSION AREAS

Legally protected areas and known undevelopable areas (e.g., glaciers) were identified as areas for exclusion consideration. The resource option generation sites (at-gate) were screened for whether they fell within following exclusion areas. Exclusions were also considered for roads and power lines. The exclusion and undevelopable areas used for this project are outlined in Tables 2-4 and 2-5.

**Table 2-1: Energy Resource Potential in BC by Transmission Region**

| Transmission Region      | Number of Projects | Average Annual Energy (GWh/yr) | Annual Firm Energy (GWh/yr) | Installed Capacity (MW) |
|--------------------------|--------------------|--------------------------------|-----------------------------|-------------------------|
| Central Interior         | 644                | 7,460                          | 4,090                       | 2,540                   |
| East Kootenay            | 483                | 4,270                          | 3,450                       | 1,330                   |
| Kelly Nicola             | 371                | 15,920                         | 9,980                       | 9,240                   |
| Lower Mainland           | 375                | 16,130                         | 13,350                      | 108,160                 |
| Mica                     | 191                | 3,010                          | 2,640                       | 1,380                   |
| North Coast              | 3,155              | 74,360                         | 19,820                      | 23,210                  |
| Peace River              | 1,126              | 27,710                         | 11,090                      | 8,370                   |
| Revelstoke Ashton Creek  | 286                | 5,360                          | 3,300                       | 2,310                   |
| Selkirk                  | 275                | 3,420                          | 2,620                       | 1,010                   |
| Vancouver Island         | 837                | 30,820                         | 13,390                      | 87,850                  |
| Technically Inaccessible | 15                 | 9,090                          | 280                         | 2,660                   |
| <b>Total</b>             | <b>7,758</b>       | <b>197,550</b>                 | <b>84,010</b>               | <b>248,060</b>          |

Notes:

1. This report reflects the resource options data as of February 3, 2011, however the BC Hydro database may have been modified by the integrated resource planning (IRP) process which may not be reflected in this report.
2. Values summarized in this table have been rounded for presentation purposes.
3. Transmission region above is based on the potential interconnection locations of the resource options. See Table 2-6 for generation site locations of technically inaccessible resource options.

Technically inaccessible resource option locations are presented in Table 2-6 by transmission region.

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**Table 2-2: Energy Resource Potential in BC by Resource Type**

| Resource Name                  | Number of Projects | Average Annual Energy (GWh/yr) | Annual Firm Energy (GWh/yr) | Installed Capacity (MW) |
|--------------------------------|--------------------|--------------------------------|-----------------------------|-------------------------|
| Biomass (Biogas)               | 12                 | 130                            | 130                         | 20                      |
| Biomass (MSW)                  | 3                  | 500                            | 500                         | 60                      |
| Biomass (Wood Based)           | 21                 | 11,200                         | 11,200                      | 1,410                   |
| Geothermal                     | 18                 | 6,270                          | 6,270                       | 820                     |
| Large Hydro (Site C)           | 1                  | 4,610                          | 4,000                       | 910                     |
| Ocean (Tidal)                  | 13                 | 1,460                          | 0                           | 630                     |
| Ocean (Wave)                   | 16                 | 2,510                          | 0                           | 1,080                   |
| Pumped Storage                 | 194                | 0                              | 0                           | 188,500                 |
| Resource Smart                 | 6                  | 180                            | 180                         | 580                     |
| Run-of-River                   | 7,282              | 62,860                         | 49,890                      | 17,400                  |
| Solar                          | 10                 | 60                             | 0                           | 50                      |
| Coal Fired Generation with CCS | 1                  | 3,900                          | 3,900                       | 750                     |
| Natural Gas Fired Generation   | 6                  | 6,600                          | 7,940                       | 1,260                   |
| Wind (Offshore)                | 54                 | 58,010                         | 0                           | 17,950                  |
| Wind (Onshore)                 | 121                | 39,260                         | 0                           | 16,660                  |
| <b>Total</b>                   | <b>7,758</b>       | <b>197,550</b>                 | <b>84,010</b>               | <b>248,060</b>          |

Notes:

1. This report reflects the resource options data as of February 3, 2011, however the BC Hydro database may have been modified by the integrated resource planning (IRP) process which may not be reflected in this report.
2. Values summarized in this table have been rounded for presentation purposes.

**Table 2-3: Energy Resource Potential in BC by Transmission Region and Resource Type**

| Transmission Region                   | Resource Name                  | Number of Projects | Average Annual Energy (GWh/yr) | Annual Firm Energy (GWh/yr) | Installed Capacity (MW) |
|---------------------------------------|--------------------------------|--------------------|--------------------------------|-----------------------------|-------------------------|
| Central Interior                      | Biomass (Biogas)               | 1                  | 20                             | 20                          | 0                       |
|                                       | Biomass (Wood Based)           | 1                  | 250                            | 250                         | 30                      |
|                                       | Run-of-River                   | 632                | 4,850                          | 3,830                       | 1,370                   |
|                                       | Solar                          | 1                  | 10                             | 0                           | 10                      |
|                                       | Wind (Onshore)                 | 9                  | 2,340                          | 0                           | 1,130                   |
| <b>Central Interior Total</b>         |                                | <b>644</b>         | <b>7,460</b>                   | <b>4,090</b>                | <b>2,540</b>            |
| East Kootenay                         | Biomass (Wood Based)           | 2                  | 320                            | 320                         | 40                      |
|                                       | Run-of-River                   | 478                | 3,690                          | 3,130                       | 1,140                   |
|                                       | Solar                          | 1                  | 10                             | 0                           | 10                      |
|                                       | Wind (Onshore)                 | 2                  | 250                            | 0                           | 140                     |
| <b>East Kootenay Total</b>            |                                | <b>483</b>         | <b>4,270</b>                   | <b>3,450</b>                | <b>1,330</b>            |
| Kelly Nicola                          | Biomass (Biogas)               | 2                  | 30                             | 30                          | 0                       |
|                                       | Biomass (Wood Based)           | 2                  | 540                            | 540                         | 70                      |
|                                       | Geothermal                     | 1                  | 140                            | 140                         | 20                      |
|                                       | Pumped Storage                 | 4                  | 0                              | 0                           | 4,000                   |
|                                       | Resource Smart                 | 1                  | 80                             | 80                          | 30                      |
|                                       | Run-of-River                   | 338                | 3,860                          | 3,010                       | 1,070                   |
|                                       | Solar                          | 1                  | 10                             | 0                           | 10                      |
|                                       | Natural Gas Fired Generation   | 4                  | 4,840                          | 6,180                       | 950                     |
| <b>Kelly Nicola Total</b>             |                                | <b>371</b>         | <b>15,920</b>                  | <b>9,980</b>                | <b>9,240</b>            |
| Lower Mainland                        | Biomass (Biogas)               | 3                  | 30                             | 30                          | 0                       |
|                                       | Biomass (MSW)                  | 1                  | 290                            | 290                         | 30                      |
|                                       | Biomass (Wood Based)           | 2                  | 3,360                          | 3,360                       | 420                     |
|                                       | Geothermal                     | 5                  | 2,510                          | 2,510                       | 320                     |
|                                       | Pumped Storage                 | 105                | 0                              | 0                           | 105,000                 |
|                                       | Run-of-River                   | 253                | 7,340                          | 5,560                       | 1,730                   |
|                                       | Solar                          | 1                  | 10                             | 0                           | 10                      |
|                                       | Natural Gas Fired Generation   | 1                  | 1,600                          | 1,600                       | 200                     |
| <b>Lower Mainland Total</b>           |                                | <b>375</b>         | <b>16,130</b>                  | <b>13,350</b>               | <b>108,160</b>          |
| Mica                                  | Pumped Storage                 | 1                  | 0                              | 0                           | 500                     |
|                                       | Run-of-River                   | 189                | 3,000                          | 2,640                       | 870                     |
|                                       | Solar                          | 1                  | 10                             | 0                           | 10                      |
| <b>Mica Total</b>                     |                                | <b>191</b>         | <b>3,010</b>                   | <b>2,640</b>                | <b>1,380</b>            |
| North Coast                           | Biomass (Wood Based)           | 7                  | 2,040                          | 2,040                       | 260                     |
|                                       | Geothermal                     | 3                  | 2,110                          | 2,110                       | 270                     |
|                                       | Ocean (Wave)                   | 1                  | 420                            | 0                           | 140                     |
|                                       | Run-of-River                   | 3084               | 19,640                         | 15,670                      | 5,650                   |
|                                       | Solar                          | 1                  | 10                             | 0                           | 10                      |
|                                       | Wind (Offshore)                | 36                 | 41,140                         | 0                           | 12,870                  |
|                                       | Wind (Onshore)                 | 23                 | 9,010                          | 0                           | 4,020                   |
| <b>North Coast Total</b>              |                                | <b>3155</b>        | <b>74,360</b>                  | <b>19,820</b>               | <b>23,210</b>           |
| Peace River                           | Biomass (Wood Based)           | 3                  | 1,030                          | 1,030                       | 130                     |
|                                       | Geothermal                     | 1                  | 140                            | 140                         | 20                      |
|                                       | Large Hydro (Site C)           | 1                  | 4,610                          | 4,000                       | 910                     |
|                                       | Run-of-River                   | 1074               | 2,500                          | 2,020                       | 830                     |
|                                       | Solar                          | 1                  | 10                             | 0                           | 10                      |
|                                       | Coal Fired Generation with CCS | 1                  | 3,900                          | 3,900                       | 750                     |
| <b>Peace River Total</b>              |                                | <b>1126</b>        | <b>27,710</b>                  | <b>11,090</b>               | <b>8,370</b>            |
| Revelstoke Ashton Creek               | Biomass (Biogas)               | 1                  | 10                             | 10                          | 0                       |
|                                       | Geothermal                     | 1                  | 140                            | 140                         | 20                      |
|                                       | Resource Smart                 | 1                  | 30                             | 30                          | 500                     |
|                                       | Run-of-River                   | 278                | 3,620                          | 3,130                       | 1,030                   |
|                                       | Solar                          | 1                  | 10                             | 0                           | 10                      |
|                                       | Wind (Onshore)                 | 4                  | 1,560                          | 0                           | 750                     |
| <b>Revelstoke Ashton Creek Total</b>  |                                | <b>286</b>         | <b>5,360</b>                   | <b>3,300</b>                | <b>2,310</b>            |
| Selkirk                               | Biomass (Biogas)               | 2                  | 30                             | 30                          | 0                       |
|                                       | Biomass (MSW)                  | 1                  | 110                            | 110                         | 10                      |
|                                       | Biomass (Wood Based)           | 2                  | 310                            | 310                         | 40                      |
|                                       | Geothermal                     | 3                  | 420                            | 420                         | 60                      |
|                                       | Resource Smart                 | 1                  | 30                             | 30                          | 0                       |
|                                       | Run-of-River                   | 262                | 2,090                          | 1,730                       | 670                     |
|                                       | Solar                          | 1                  | 10                             | 0                           | 10                      |
|                                       | Wind (Onshore)                 | 3                  | 430                            | 0                           | 230                     |
| <b>Selkirk Total</b>                  |                                | <b>275</b>         | <b>3,420</b>                   | <b>2,620</b>                | <b>1,010</b>            |
| Vancouver Island                      | Biomass (Biogas)               | 3                  | 20                             | 20                          | 0                       |
|                                       | Biomass (MSW)                  | 1                  | 100                            | 100                         | 10                      |
|                                       | Biomass (Wood Based)           | 2                  | 3,360                          | 3,360                       | 420                     |
|                                       | Geothermal                     | 2                  | 530                            | 530                         | 70                      |
|                                       | Ocean (Tidal)                  | 12                 | 1,430                          | 0                           | 620                     |
|                                       | Ocean (Wave)                   | 15                 | 2,090                          | 0                           | 940                     |
|                                       | Pumped Storage                 | 84                 | 0                              | 0                           | 79,000                  |
|                                       | Resource Smart                 | 3                  | 50                             | 50                          | 50                      |
|                                       | Run-of-River                   | 693                | 12,260                         | 9,170                       | 3,030                   |
|                                       | Solar                          | 1                  | 10                             | 0                           | 10                      |
|                                       | Natural Gas Fired Generation   | 1                  | 160                            | 160                         | 100                     |
|                                       | Wind (Offshore)                | 7                  | 8,100                          | 0                           | 2,470                   |
|                                       | Wind (Onshore)                 | 13                 | 2,710                          | 0                           | 1,140                   |
| <b>Vancouver Island Total</b>         |                                | <b>837</b>         | <b>30,820</b>                  | <b>13,390</b>               | <b>87,850</b>           |
| Technically Inaccessible              | Geothermal                     | 2                  | 280                            | 280                         | 40                      |
|                                       | Ocean (Tidal)                  | 1                  | 40                             | 0                           | 10                      |
|                                       | Run-of-River                   | 1                  | 0                              | 0                           | 0                       |
|                                       | Wind (Offshore)                | 11                 | 8,770                          | 0                           | 2,610                   |
| <b>Technically Inaccessible Total</b> |                                | <b>15</b>          | <b>9,090</b>                   | <b>280</b>                  | <b>2,660</b>            |
| <b>Total</b>                          |                                | <b>7758</b>        | <b>197,550</b>                 | <b>84,010</b>               | <b>248,060</b>          |

Notes:

- This report reflects the resource options data as of February 3, 2011, however the BC Hydro database may have been modified by the integrated resource planning (IRP) process which may not be reflected in this report.
- Values summarized in this table have been rounded for presentation purposes.
- Transmission region above is based on the potential interconnection locations of the resource options. See Table 2-6 for generation site locations of technically inaccessible resource options.

**Table 2-4: Summary of Exclusion Areas**

| Exclusion Areas - Legally Protected Areas  | Source   | Screening Criteria<br>ROADS                   | Screening Criteria<br>POWER LINES | Screening Criteria<br>RESOURCE OPTIONS |
|--|--|---|-----------------------------------|--|
| <b>Biodiversity Areas</b>  | Province of British Columbia, Integrated Land Management Branch (ILMB), GeoBC, Land and Resource Data Warehouse (LRDW) | None allowed                                  | None allowed                      | None allowed                           |
| <b>Wildlife Management Areas</b><br><i>areas for which administration and control has transferred to the Ministry of Environment (MoE) via the Land Act due to the significance of their wildlife/fish values and designated as Wildlife Management Areas under the Wildlife Act</i> |  | None allowed                                  | None allowed                      | None allowed                           |
| <b>Conservancy Areas</b><br><i>conservancy areas designated under the Park Act or by the Protected Areas of British Columbia Act, whose management and development is constrained by the Park Act</i>  |  | None allowed                                  | None allowed                      | None allowed                           |
| <b>National Parks</b>  |  | None allowed                                  | None allowed                      | None allowed                           |
| <b>Legally Protected Areas</b><br><b>Ecological Reserves, Protected Areas, Provincial Parks, Recreation Areas</b>  |  | None allowed                                  | None allowed                      | None allowed                           |
| <b>Canadian Forces Bases</b>   |  | CFB Esquimalt (Navy)<br>CFB Comox (Air Force) | None allowed                      | None allowed                           |
| <b>Migratory Bird Sanctuaries</b>  | Environment Canada   | None allowed                                  | None allowed                      | None allowed                           |
| <b>National Marine Conservation Areas (NMCAs)</b><br>No electricity generation is permitted  | Province of British Columbia, ILMB, GeoBC, LRDW  | Not applicable                                | None allowed                      | None allowed                           |
| <b>Federal Marine Protected Areas (MPAs)</b><br>1. Bowie Seamount MPA, 180 km offshore of Gwaii Haanas;<br>2. Endeavour Hydrothermal Vent MPA, 250 km offshore of Vancouver Island   |  | Not applicable                                | None allowed                      | None allowed                           |
| <b>Provincial Marine Protected Areas (MPAs)</b><br>Provincial Park, Conservancy, <i>Environment and Land Use Act</i> Protected Areas, Recreation Area (128 are marine in total) and Ecological Reserves (20 marine, called Marine Ecological Reserves - e.g., Race Rocks)            |  | Not applicable                                | None allowed                      | None allowed                           |

**Table 2-5: Summary of Undevelopable Areas**

| Exclusion Areas – Undevelopable Areas | Source  | Screening Criteria<br>ROADS | Screening Criteria<br>POWER LINES | Screening Criteria<br>RESOURCE OPTIONS |
|---------------------------------------|---|-----------------------------|-----------------------------------|--|
| <b>Glaciers</b>                       | Province of British Columbia, GeoBC, Corporate Watershed Base (CWB) | None allowed                | None allowed                      | None allowed                           |



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**Table 2-6: Technically Inaccessible Energy Resource Potential in BC by Transmission Region**

| Transmission Region   | Resource Name   | Number of Projects | Average Annual Energy (GWh/yr) | Annual Firm Energy (GWh/yr) | Installed Capacity (MW) |
|---|-----------------|--------------------|--------------------------------|-----------------------------|-------------------------|
| Central Interior  | Geothermal      | 1                  | 140                            | 140                         | 20                      |
| <b>Central Interior Total</b>   |                 | 1                  | 140                            | 140                         | 20                      |
| Lower Mainland  | Ocean (Tidal)   | 1                  | 40                             | 0                           | 10                      |
|   | Wind (Offshore) | 1                  | 970                            | 0                           | 280                     |
| <b>Lower Mainland Total</b>   |                 | 2                  | 1,000                          | 0                           | 290                     |
| North Coast   | Run-of-River    | 1                  | 3                              | 2                           | 1                       |
|   | Wind (Offshore) | 6                  | 4,300                          | 0                           | 1,300                   |
| <b>North Coast Total</b>  |                 | 7                  | 4,300                          | 0                           | 1,300                   |
| Peace River   | Geothermal      | 1                  | 140                            | 140                         | 20                      |
| <b>Peace River Total</b>  |                 | 1                  | 140                            | 140                         | 20                      |
| Vancouver Island  | Wind (Offshore) | 4                  | 3,500                          | 0                           | 1,030                   |
| <b>Vancouver Island Total</b>   |                 | 4                  | 3,500                          | 0                           | 1,030                   |
| <b>Total</b>  |                 | <b>15</b>          | <b>9,090</b>                   | <b>280</b>                  | <b>2,660</b>            |
| Notes:  |                 |                    |                                |                             |                         |
| 1. Transmission region stated above is based on generation site location for technically inaccessible resource options. |                 |                    |                                |                             |                         |
| 2. Values summarized in this table have been rounded for presentation purposes.   |                 |                    |                                |                             |                         |

## 2.5 DENSITY OF RESOURCE OPTIONS

The density of the capacity and energy of the resource options was mapped to identify regions of high energy and capacity. The density analysis was achieved using the kernel density function of ArcGIS described in more detail in Appendix A.

A ‘kernel density’ function was used to convert the discrete energy resource options data into a smooth, continuous surface of energy resource density. This method creates a geographic surface, under which the volume of energy or capacity is equal to the sum of the inputs.

The density analysis was conducted excluding all projects in legally protected areas or in otherwise undevelopable areas (glaciers). In addition to that, the following resource options were excluded from the density analysis to avoid spatially skewing the results:

- Pumped Storage;
- Natural Gas;
- Site C;
- Coal with Carbon Capture and Sequestration; and
- Resource Smart.

Figures 2-16 and 2-17 provide a plot of the density of the energy and capacity respectively.<sup>1</sup>

## **Section 3**

# **Individual Roads and Power Line (R<sub>1</sub>T<sub>1</sub>) Costing**

### 3. INDIVIDUAL ROADS AND POWERLINE (R<sub>1</sub>T<sub>1</sub>) COSTING

Access roads and power lines often comprise a significant portion of project cost and environmental and economic impact. As a part of this project, individual access road or barge (R1) and power line including interconnection, (T1) costs were estimated for each potential resource option based on least-cost routing, avoiding legally protected areas and extreme construction conditions (e.g., glaciers and very steep terrain) utilizing GIS.

Since this assessment is an inventory level study, the analysis and estimates of costs are intended to provide the magnitude of costs; suitable for ranking options being considered. The estimated costs represent KWL's judgment in light of experience, knowledge and available information for this inventory study.

The cost estimates include:

- Access costs (road and or barge);
- Power line including connection to existing grid;
- Allowance for environmental and engineering costs;
- Bonding and insurance;
- Land allowance;
- Land taxes;
- Interest during construction; and
- Operation and maintenance.

The cost estimates do not include the following site-specific considerations:

- Permitting, licensing or environmental assessment;
- Geotechnical allowances;
- Market shortages of labour and/or materials; and
- Delays due to difficult construction conditions, terrain or weather.

The cost estimates include a 30% contingency allowance. All costs are presented in 2011 dollars (Canadian), and do not include local, provincial or federal taxes.

BC Hydro supplied at-gate costs for the generation site without access roads or power lines and interconnection.

### **3.1 CAPITAL COSTS**

#### **ROAD, POWER LINE AND INTERCONNECTION COSTS**

Information relating to the estimation of the cost for roads, power lines, and interconnection can be found in Appendix B.

#### **CONSTRUCTION CAMP AND TRANSPORTATION**

No additional allowance was made for construction camp and transportation for the generation site in the ROMAP process for roads and powerlines.

#### **ENGINEERING, ENVIRONMENTAL AND OTHER**

Project specific costs such as those for engineering or environmental management require detailed site information to determine. For inventory level estimates in this report, typical allowances expressed as a percentage of total capital cost are given to account for these cost items. In this study, allowances for each site category were as follows:

- Bonding and Insurance - 2% of Capital Cost;
- Environmental - 5% of Capital Cost; and
- Engineering - 15% of Capital Cost.

#### **LAND ALLOWANCE**

A land allowance cost in the form of a one-time cost that was included in consideration of the cost to purchase, lease or obtain permission through negotiations to use the land for construction and operation. A cost of 5% of the capital cost was included as an allowance for these highly variable, and difficult to predict costs.

### **3.2 UNIT COST ESTIMATES FOR ROADS AND POWER LINES**

This section summarizes the dependant variables and assumptions used to determine unit costs for the following project components.

#### **Power Line**

Dependent variables:

- Voltage of power line;
- Capacity; and
- Terrain for construction.

Assumptions:

- All power lines constructed at 25 kV or above;
- 25 and 69 kV lines may be single pole, roadside construction; and
- Slope of terrain ranges from 0 to 75%.

**Access Road(s)**

Dependent variables:

- Availability of materials;
- Terrain for construction; and
- Difficulty of construction.

Assumptions:

- All new roads are 6 m wide;
- Includes clearing and decking of timber;
- Forestry type road construction with 0.3 m gravel topping;
- Portion of cut volume requires blasting; and
- Road grade ranges from 0 to 30%.

### **3.3 ANNUAL COST ANALYSIS**

This section includes estimates of annual costs for operations and maintenance.

**Estimated O&M Cost**

Operations and maintenance costs were estimated to be 2% of total capital costs for access roads and 1.1% of total capital costs for power lines.

**Land Taxes**

Property taxes were estimated to be 3% of the assessed property value, which was assumed to be 80% of the capital cost of the road and power line infrastructure.

**Interest during Construction**

Project lead-time interest was calculated by taking all development costs and dividing them into equal annual payments. Interest was then calculated annually until project COD is reached.

Project construction period interest was calculated by taking all construction costs (including equipment) and dividing them into equal annual payments. Interest was then calculated annually until project COD is reached.

### 3.4 UNIT ENERGY COST

Unit energy costs were calculated by amortizing the total capital cost as described in Section 3.2 for each project at a 6% real discount rate (and 8% as sensitivity) over the resource option project life, adding the annual costs described in Section 3.3 and dividing by the annual energy estimate for the site.

### 3.5 ROAD AND POWER LINE EXCEPTIONS

There were a number of exceptions made to the road and power line costing:

1. The following resource options had no roads, no power lines, and no interconnection costs calculated from GIS methods:
  - Site C; and
  - Resource Smart.

This is because there is more detailed and accurate data available at BC Hydro for these resources.

2. The following resource options will have no roads or power lines, but were allowed to potentially have interconnection (T1) costs:
  - Biomass (Wood Based);
  - Biomass (Biogas);
  - Biomass (MSW); and
  - Pumped Storage at Mica.

These resources were assumed to be in very close proximity to existing roads and power lines as they would be constructed at existing facilities, and hence should have minimal costs for roads and power lines.

The interconnection cost would be based on the interconnection location that the GIS selected. It would use the same interconnection cost methodology as the other resource options, just no power line cost.

3. There are two exceptions to the above for the following resource options in non-integrated areas:
  - Biomass (Wood Based) in Fort Nelson (WBBio\_ST\_LT\_NE):
    - Will not have a road because it is near an existing road; and
    - Will have a T1 power line and potentially T1 interconnection costs. The interconnection cost would be based on the interconnection location from

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2013 Resource Options Report Update Appendix 5-A**

2010 RESOURCE OPTIONS UPDATE  
BC HYDRO & POWER AUTHORITY

RESOURCE OPTIONS MAPPING UPDATE  
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GIS. It would use the same interconnection cost methodology as the other resource options.

- Biomass (Wood Based) in Dease Lake (WBBio\_ST\_LT\_NW)
  - Will not have a road because it is near an existing road; and
  - Will have a T1 power line and potentially T1 interconnection costsThe interconnection cost would be based on the interconnection location from GIS. It would use the same interconnection cost methodology as the other resource options.

## **Section 4**

# **Summary of Results**



## 4. SUMMARY OF RESULTS

The study compiled over 7,700 potential resource options in BC. These sites have a potential installed capacity of over 60,000 MW and annual energy of nearly 200,000 GWh.

### 4.1 RESOURCE OPTION UNIT ENERGY COST ESTIMATES

At Gate costs were supplied by BC Hydro. Road and power line costs were estimated for each project taking the least cost route (avoiding exclusion areas). The estimated cost for each of the projects includes access roads and power lines interconnecting to the BC Hydro and Fortis BC grids.

A supply curve for energy resource potential in BC is presented in Figures 4-1 and 4-2). The inventory identified potential sites that could contribute over 24,000 GWh/a of new green energy in BC for under \$100/MWh.

The unit energy costs do not reflect what an independent power producer may offer to sell electricity to BC Hydro due to factors such as:

- Cost of capital;
- Contract terms;
- Taxation; and
- Other factors.

#### UNIT ENERGY COST SENSITIVITY

The unit energy costs (UECs) were calculated using 6% and 8% real discount rates. The 6% UEC values are used to report the results.

### 4.2 RESOURCE OPTION POTENTIAL BY TRANSMISSION REGION

As this study involved identifying a complete inventory of potential resource options, the unit energy costs presented include both the most cost-effective and least cost-effective projects.

Table 4-1 lists 61 projects with estimated unit energy cost under \$100/MWh. These projects total nearly 4,500 MW of capacity and over 24,000 GWh/year of average annual energy.

Table 4-1 below presents the potential for sites under \$100/MWh by transmission region.

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RESOURCE OPTIONS MAPPING UPDATE  
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**Table 4-1: Resource Option Potential in BC for Under \$100/MWh (Total UEC at 6%)**

| Transmission Region                  | Resource Name                  | Number of Projects | Average Annual Energy (GWh/yr) | Annual Firm Energy (GWh/yr) | Installed Capacity (MW) |
|--------------------------------------|--------------------------------|--------------------|--------------------------------|-----------------------------|-------------------------|
| Central Interior                     | Biomass (Biogas)               | 1                  | 20                             | 20                          | 0                       |
| <b>Central Interior Total</b>        |                                | <b>1</b>           | <b>20</b>                      | <b>20</b>                   | <b>0</b>                |
| East Kootenay                        | Run-of-River                   | 3                  | 260                            | 240                         | 80                      |
| <b>East Kootenay Total</b>           |                                | <b>3</b>           | <b>260</b>                     | <b>240</b>                  | <b>80</b>               |
| Kelly Nicola                         | Biomass (Biogas)               | 2                  | 30                             | 30                          | 0                       |
|                                      | Run-of-River                   | 6                  | 870                            | 660                         | 230                     |
|                                      | Natural Gas Fired Generation   | 2                  | 4,390                          | 5,640                       | 790                     |
| <b>Kelly Nicola Total</b>            |                                | <b>10</b>          | <b>5,300</b>                   | <b>6,330</b>                | <b>1,030</b>            |
| Lower Mainland                       | Biomass (Biogas)               | 3                  | 30                             | 30                          | 0                       |
|                                      | Geothermal                     | 4                  | 2,370                          | 2,370                       | 300                     |
|                                      | Run-of-River                   | 17                 | 1,330                          | 1,030                       | 320                     |
|                                      | Natural Gas Fired Generation   | 1                  | 1,600                          | 1,600                       | 200                     |
| <b>Lower Mainland Total</b>          |                                | <b>25</b>          | <b>5,330</b>                   | <b>5,020</b>                | <b>830</b>              |
| North Coast                          | Geothermal                     | 3                  | 2,110                          | 2,110                       | 270                     |
|                                      | Run-of-River                   | 2                  | 150                            | 120                         | 40                      |
| <b>North Coast Total</b>             |                                | <b>5</b>           | <b>2,260</b>                   | <b>2,240</b>                | <b>310</b>              |
| Peace River                          | Geothermal                     | 1                  | 140                            | 140                         | 20                      |
|                                      | Large Hydro (Site C)           | 1                  | 4,610                          | 4,000                       | 910                     |
|                                      | Coal Fired Generation with CCS | 1                  | 3,900                          | 3,900                       | 750                     |
|                                      | Wind (Onshore)                 | 2                  | 1,110                          | 0                           | 310                     |
| <b>Peace River Total</b>             |                                | <b>5</b>           | <b>9,750</b>                   | <b>8,040</b>                | <b>1,990</b>            |
| Revelstoke Ashton Creek              | Biomass (Biogas)               | 1                  | 10                             | 10                          | 0                       |
|                                      | Run-of-River                   | 1                  | 70                             | 50                          | 20                      |
| <b>Revelstoke Ashton Creek Total</b> |                                | <b>2</b>           | <b>70</b>                      | <b>60</b>                   | <b>20</b>               |
| Selkirk                              | Biomass (Biogas)               | 2                  | 30                             | 30                          | 0                       |
|                                      | Geothermal                     | 1                  | 140                            | 140                         | 20                      |
|                                      | Resource Smart                 | 1                  | 30                             | 30                          | 0                       |
| <b>Selkirk Total</b>                 |                                | <b>4</b>           | <b>190</b>                     | <b>190</b>                  | <b>20</b>               |
| Vancouver Island                     | Biomass (Biogas)               | 2                  | 10                             | 10                          | 0                       |
|                                      | Resource Smart                 | 2                  | 50                             | 50                          | 20                      |
|                                      | Run-of-River                   | 2                  | 780                            | 570                         | 170                     |
| <b>Vancouver Island Total</b>        |                                | <b>6</b>           | <b>840</b>                     | <b>640</b>                  | <b>200</b>              |
| <b>Total</b>                         |                                | <b>61</b>          | <b>24,020</b>                  | <b>22,760</b>               | <b>4,470</b>            |

Notes:

1. This report reflects the resource options data as of February 3, 2011, however the BC Hydro database may have been modified by the integrated resource planning (IRP) process which may not be reflected in this report.
2. Values summarized in this table have been rounded for presentation purposes.

### 4.3 CLOSING

There is a large quantity of renewable energy resources potential in BC with nearly 200,000 GWh, of which 24,000 GWh is estimated to be available at under \$100/MWh (6% discount rate).

There are several regions around the province with concentration of energy and capacity of resource options.

The data prepared as a part of this project will be utilized as input to the resource options portfolio analysis of the 2011 IRP.

Figure 4-1: Supply Curve for Resource Potential - Total UEC (6%<sup>1</sup>)

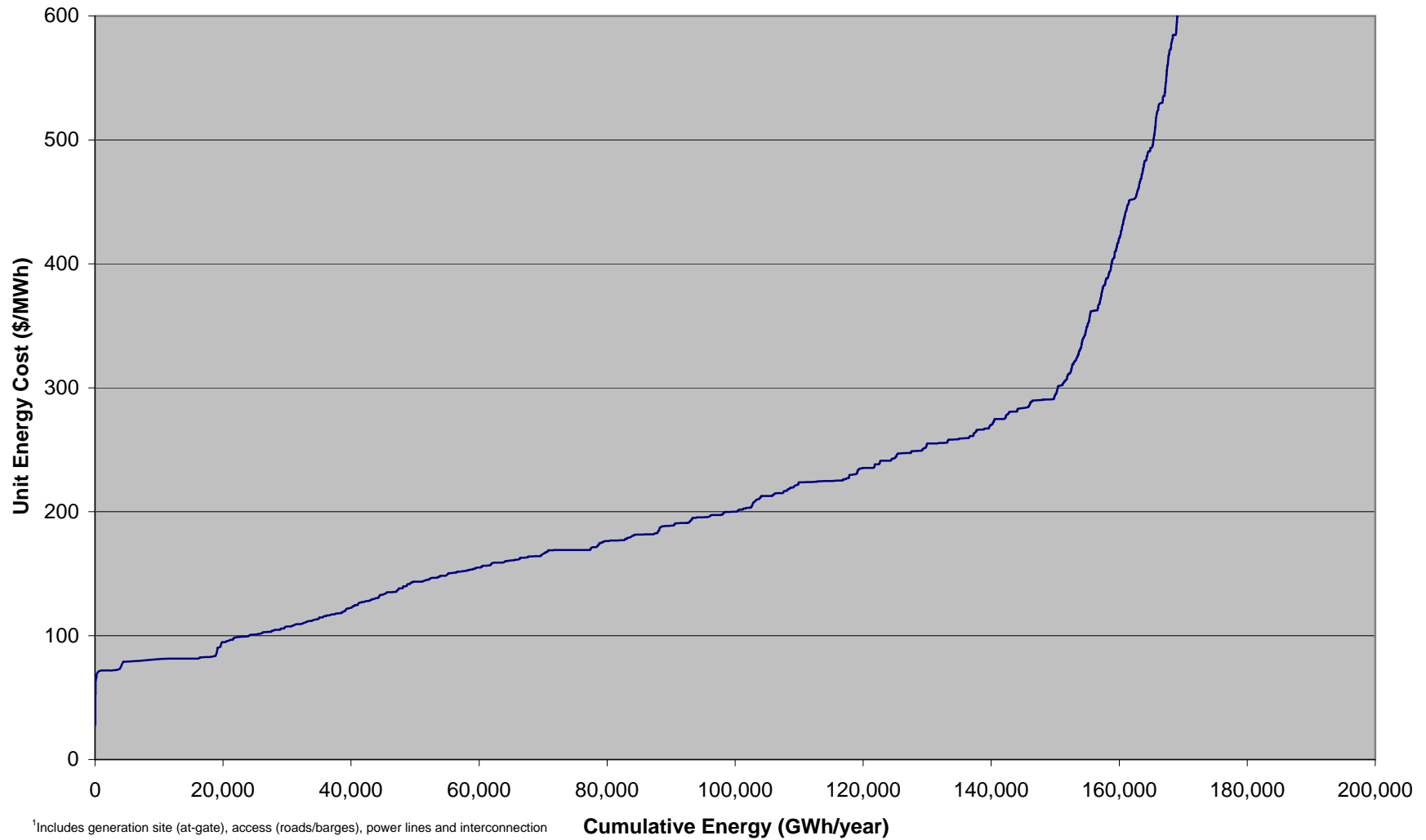
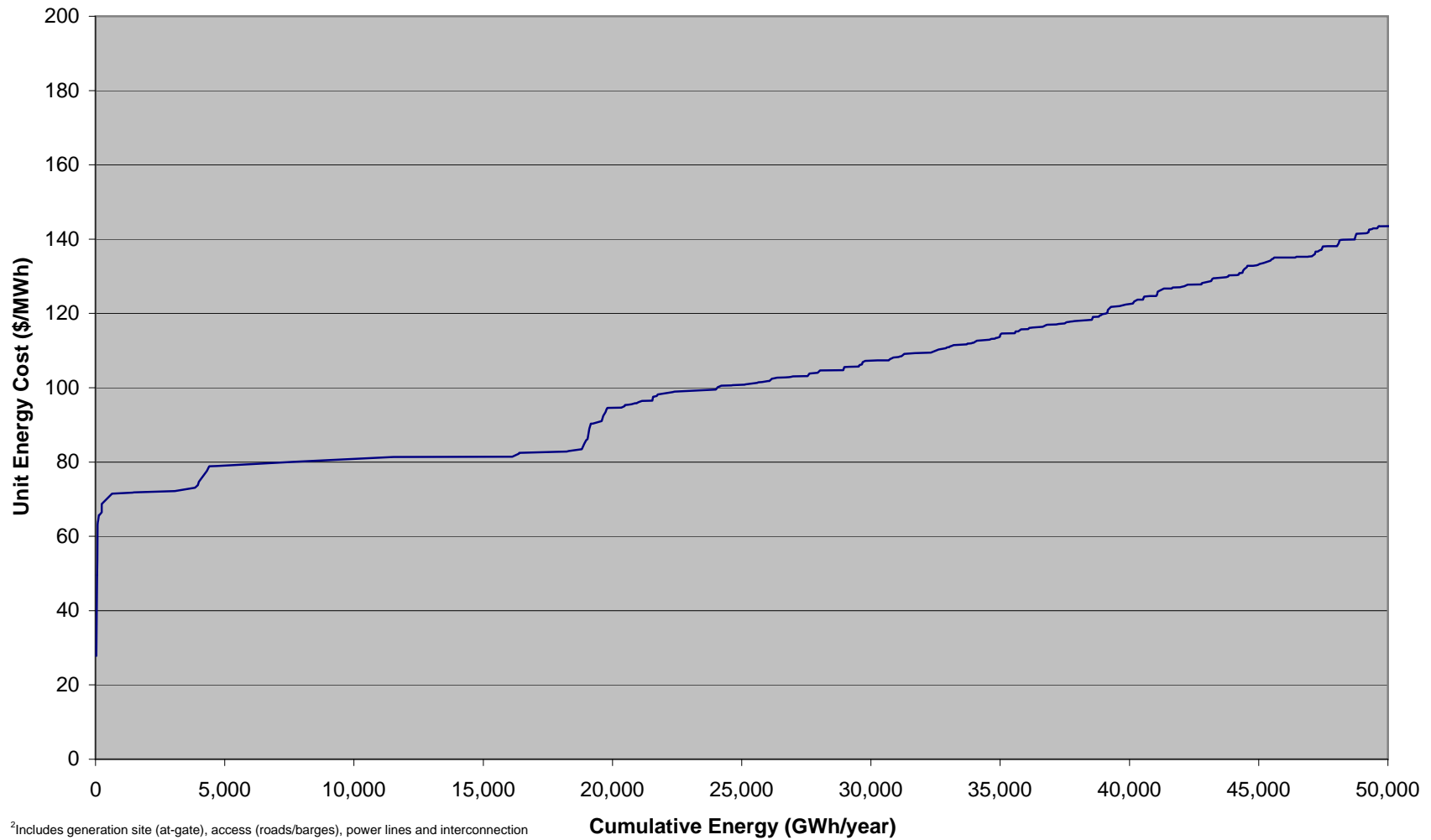


Figure 4-2: Supply Curve for Resource Potential - Total UEC (6%<sup>2</sup>)



<sup>2</sup>Includes generation site (at-gate), access (roads/barges), power lines and interconnection

## **Section 5**

# **Report Submission**

## 5. REPORT SUBMISSION

Prepared by:

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