Calculation of the Grid Emission Intensity Factor for Alberta

―Using the Wind Energy Working Group’s Proposed Methodology—

Results and Analysis prepared for:
Alberta Environment

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Proposed GHG Offset Credit Methodology for Renewables - January 2008
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Detailed Calculations of Grid Intensity Factor & Components ............................................ 8
EDC Associates has been retained by Alberta Environment to provide electric energy system modeling tools and expertise to help derive the Grid Intensity Factor (GIF) for Alberta as using the proposed methodology offered by the Wind Energy Working Group. The purpose of this work is to provide some base metrics with respect to Green House Gas (GHG) emission intensity to determine an industry and government acceptable GHG offset credit calculation method that is fair and representative. The result of this process is to provide GHG emission intensity to be applied and used for wind and/or other zero emission renewable energy sources where the ultimate calculation from the final chosen methodology will be a GHG emission credit tonne/MWh.

There are three intermediate results required to calculate the final Grid Intensity Factor: Operating Margin (OM), Grid Average (GA) and Build Margin (BM). The GIF breaks down as a weighted average of OM, GA and BM, with the respective weights for each component to be determined. The tables below present the numerical values for each of the three intermediate determinants calculated based on Alberta specific data.

Table 1 - 2004 to 2006 Operating Margin

<table>
<thead>
<tr>
<th>Operating Margin</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Margin</td>
<td>0.761</td>
<td>0.795</td>
<td>0.808</td>
<td>0.788</td>
</tr>
</tbody>
</table>

The operating margin represents the average emission rate of units 'on the margin' in Alberta, which is defined as those units setting the marginal price.

Table 2 – 2004 to 2006 0.539Grid Average Intensity Factor

<table>
<thead>
<tr>
<th>Grid Average</th>
<th>Tonnes of Emissions</th>
<th>Total MWh</th>
<th>Grid Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>49,491,646</td>
<td>56,296,030</td>
<td>0.879</td>
</tr>
<tr>
<td>2005</td>
<td>49,774,494</td>
<td>57,358,794</td>
<td>0.868</td>
</tr>
<tr>
<td>2006</td>
<td>50,695,924</td>
<td>58,639,655</td>
<td>0.865</td>
</tr>
<tr>
<td>Total</td>
<td>149,962,064</td>
<td>172,294,479</td>
<td>0.870</td>
</tr>
</tbody>
</table>

The grid average intensity factor represents total emissions divided by total MWh for all energy in Alberta, excluding behind the fence load.

Table 3 - 2004 to 2006 Build Margin

<table>
<thead>
<tr>
<th>Build Margin</th>
<th>Tonnes of Emissions</th>
<th>Total MWh</th>
<th>Grid Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>1,547,406</td>
<td>3,997,657</td>
<td>0.387</td>
</tr>
<tr>
<td>2005</td>
<td>4,189,844</td>
<td>7,151,708</td>
<td>0.586</td>
</tr>
<tr>
<td>2006</td>
<td>4,949,971</td>
<td>8,676,586</td>
<td>0.570</td>
</tr>
<tr>
<td>Total</td>
<td>10,687,221</td>
<td>19,825,951</td>
<td>0.539</td>
</tr>
</tbody>
</table>

The build margin represents the total emissions from facilities built between 2002 and 2006 divided by the total MWh from those same facilities for each of 2004 through 2006.
Introduction

EDC Associates has been retained by Alberta Environment to provide electric energy system modeling tools and expertise to help derive the grid emission intensity factor for Alberta as using the proposed methodology offered by the Wind Energy Working Group. The purpose of this work is to provide some base metrics with respect to Green House Gas (GHG) emission intensity using several different calculation methodologies in order to determine an industry and government acceptable GHG offset credit calculation method that is fair and representative. The result of this process is to provide GHG emission intensity to be applied and used for wind and/or other zero emission renewable energy sources where the ultimate calculation from the final chosen methodology will be a GHG emission credit tonne/MWh.

After several iterations of data mining and analysis, a methodological approach has been put forward for discussion. This proposed methodology accounts for the overall emission intensity of the electric energy transported over the Alberta Integrated Electric System (AIES) or the grid from all producers as well as by what capacity has recently been added to the system or the new build margin. As such the proposed approach has three components; 1) the emission intensity of units on the margin (the operating margin component), and 2) the emission intensity of recent generation capacity additions (capacity addition component).

Proposed GHG Emission Calculation Methodology

The proposed methodology combines three key characteristics of the Alberta electricity system. The final result is identified as the Grid Intensity Factor (GIF) that represents the tonnes of GHG emissions that will be deemed to be offset by investment in renewable energy sources. The components of the proposed GIF are as follows:

\[
\text{GIF} = Y\% \times \text{Operating Margin Component} + (100\% - Y\%) \times \text{Capacity Addition Component}
\]

1. Operating Margin (OM) component:

\[
\text{OM} = \% \text{ of time on the 'margin' by technology type multiplied by representative intensity factor for each technology type.}
\]

This is calculated for 2004 through 2006 and the final OM figure is the arithmetic average of the three yearly numbers.

2. Capacity Addition (CA) Component, is made up of two parts:

   a. Grid Average (GA) emission intensity factor:

\[
\text{GA} = \text{energy by unit multiplied by unit specific intensity and then divided by the sum of total energy produced.}
\]

The GA is calculated for each of 2004 through 2006, and the final GA figure is the energy volume weighted average of these three years.

   b. Build Margin (BM) component:

\[
\text{BM} = \text{energy production (net MWh) weighted average of GHG intensity for all units commissioned for service between 2002 and 2006.}
\]

For example, if 1,000,000 MWh with 0.5 tonnes/MWh intensity and 4,000,000 MWh with 1 tonne/MWh intensity were produced by new facilities, the BM would be 0.9 tonnes/MWh. Again, the final result is the energy volume weighted total average from 2004 through 2006.

Given these definitions, GIF is therefore calculated as:

\[
\text{GIF} = \{Y\% \times OM + (100\% - Y\%) \times (Z\% \times GA + (100\% - Z\%) \times BM)\}
\]

---

1 Made up of representatives from: AltaGas, Enmax, Enbridge, Epcor, Nexen, Shell, Suncor, TransAlta and TransCanada.
The formula breaks down as a weighted average of OM, GA and BM where the weighting is determined by Y% and Z%. If Y% is 0%, then OM does not carry and weight and only the GA and BM will determine the result. On the other hand, if Z% is 0%, then GA does not carry any weight and only the OM and BM carry any weight. Simply by varying Y and Z percentages, the relative importance of any one of the three factors can be altered.

**Clarifications**

Given the definitions above, a number of clarifications are required to render the calculations transparent and ensure the formula will be robust in the future.

**Operating Margin Component**

The operating margin has two components—the percent of time each technology is on the margin setting price and the representative emission intensity factor for that technology.

1. Capacity weighted average intensity factor for each technology type is used to calculate the average intensity factor for each of the fuel types identified as price setters. The specific values for each year and fuel type are included in the Appendix of this report.

2. The operating margin is calculated using MSA price setting data found in the 2004 through 2006 Year In Review reports available at [http://www.albertamsa.ca/8.html](http://www.albertamsa.ca/8.html). The specific data is found in the Figure titled: “Price Setters by Fuel Type (All Hours)”. The values for each year can also be found in the Appendix of this report.

**Capacity Margin Component**

The capacity margin has two components, the grid average and the build margin.

**Grid Average**

The grid average calculation is relatively straightforward being the energy production weighted average of the emission intensity for all technologies that produced it. Several caveats must be noted in the calculation.

1. Imports are included in the total MWh, but the emissions remain in the originating district. In effect, imports have an intensity of 0 tonnes/MWh.

2. City of Medicine Hat is included in the calculation, both exports to Alberta and internal emissions.

3. Behind the fence load and its associated generation is ignored in the calculation.

**Build Margin**

The build margin is based on a production weighted average intensity factor for all capacity built between 2002 and 2006.

1. The Build Margin is basically a subset of the Grid Average made up of recent capacity additions.

2. Upgrades to existing capacity (Sheerness, Battle River and Sundance units) are weighted by the size of the upgrade. If the upgrade occurred mid year, the upgrade is also weighted by the portion of the year it was operational.

3. Behind the fence load and generation are again excluded.

**Data Sources**

In order to ultimately calculate the Grid Intensity Factor, the following data sources are used:

1. Unit specific GHG intensity factors:

   EDC Associates Ltd. (EDC) has developed, as part of several past assignments for the Clean Air Strategic Alliance in conjunction with the electric industry—which has recently been reviewed and updated by the Toxics Watch Society, a detailed list of unit specific GHG intensity factors. This
detailed database, vetted by many of the generators in the province, has been made available to Alberta Environment and has been circulated for review and comment.

2. Generating unit specific energy production:
   This data is readily available from the Alberta Electric System Operator (AESO) via its website, where EDC has captured and entered this data into its own database over time (starting from Power Pool inception in 1996).

3. Operating Margin (OM) calculation:
   Data for generation on the margin by fuel/technology type is readily available at a very high level from the Alberta Market Surveillance Administrator (MSA), which aggregates the very detailed data provided to it by the AESO under strict confidence. The MSA data presents an annual average amount of time on the margin for four fuel/technology types: coal, cogeneration, gas (excluding cogeneration) and hydro. The data is found in the 2004 through 2006 Year In Review reports available at [http://www.albertamsa.ca/8.html](http://www.albertamsa.ca/8.html) in the Figures titled: “Price Setters by Fuel Type (All Hours)”.

4. List of Generation Developed between 2002 and 2006:
   EDC tracks generation development in the province in a very detailed fashion. This data is verified with generation developers and EDC will provide its list of recently commissioned generation projects and their respective net-to-grid output capacity (MW) for further verification and for the purpose of the calculations presented in this report.
The tables below illustrate the calculations behind the build margin and the operating margin.

### Table 4 - Build Margin Detailed Calculations

<table>
<thead>
<tr>
<th>Company / Project</th>
<th>Location</th>
<th>Fuel Type</th>
<th>Existing Site Load (MW)</th>
<th>Output to AERS (MW)</th>
<th>GHG Intensity</th>
<th>2004 Total MWh</th>
<th>2004 Emissions</th>
<th>2005 Total MWh</th>
<th>2005 Emissions</th>
<th>2006 Total MWh</th>
<th>2006 Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP Bear Creek - LBC/SDO</td>
<td>Grand Prairie</td>
<td>Gas</td>
<td>80 0 0 0 0 0 0 0 0</td>
<td>228,511 231,350</td>
<td>0.418</td>
<td>333,460</td>
<td>27,772</td>
<td>278,416</td>
<td>32,466</td>
<td>290,372</td>
<td>36,917</td>
</tr>
<tr>
<td>ATCO/West Edmonton</td>
<td>Wetaskiwin</td>
<td>Wind</td>
<td>4 0 0 0 0 0 0 0 0</td>
<td>1,723 1,723</td>
<td>0.610</td>
<td>1,723</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
</tr>
<tr>
<td>Syncrude (Mildred Lake G12)</td>
<td>Ft. McMurray</td>
<td>Gas</td>
<td>85 0 0 0 0 0 0 0 0</td>
<td>85,049 85,049</td>
<td>0.418</td>
<td>85,049</td>
<td>3,405</td>
<td>3,405</td>
<td>3,405</td>
<td>3,405</td>
<td>3,405</td>
</tr>
<tr>
<td>Creststreet Delta</td>
<td>Elk Island</td>
<td>Wind</td>
<td>7 0 0 0 0 0 0 0 0</td>
<td>5,994 5,994</td>
<td>0.610</td>
<td>5,994</td>
<td>350,000</td>
<td>350,000</td>
<td>350,000</td>
<td>350,000</td>
<td>350,000</td>
</tr>
<tr>
<td>Syncrude (Mildred Lake G11)</td>
<td>Ft. McMurray</td>
<td>Gas</td>
<td>85 0 0 0 0 0 0 0 0</td>
<td>85,049 85,049</td>
<td>0.418</td>
<td>85,049</td>
<td>3,405</td>
<td>3,405</td>
<td>3,405</td>
<td>3,405</td>
<td>3,405</td>
</tr>
<tr>
<td>ATCO Battle River 5 Upgrade</td>
<td>Battle River</td>
<td>Wind</td>
<td>20 0 0 0 0 0 0 0 0</td>
<td>1,723 1,723</td>
<td>0.610</td>
<td>1,723</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
<td>100,000</td>
</tr>
</tbody>
</table>

### Table 5 - Annual Operating Margin Calculations

#### Operating Margin 2004

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Intensity (Capacity Avg.)</th>
<th>% of Time Set Price</th>
<th>Operating Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>1.063 1.063</td>
<td>45% 45%</td>
<td>0.478 0.478</td>
</tr>
<tr>
<td>Cogen</td>
<td>0.410 0.410</td>
<td>18% 18%</td>
<td>0.074 0.074</td>
</tr>
<tr>
<td>Other Gas</td>
<td>0.500 0.500</td>
<td>36% 36%</td>
<td>0.209 0.209</td>
</tr>
<tr>
<td>Hydro</td>
<td>1.000 1.000</td>
<td>1% 1%</td>
<td>0.000 0.000</td>
</tr>
</tbody>
</table>

Total: 100% 0.761

#### Operating Margin 2005

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Intensity (Capacity Avg.)</th>
<th>% of Time Set Price</th>
<th>Operating Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>1.063 1.063</td>
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<td>0.500 0.500</td>
<td>36% 36%</td>
<td>0.209 0.209</td>
</tr>
<tr>
<td>Hydro</td>
<td>1.000 1.000</td>
<td>1% 1%</td>
<td>0.000 0.000</td>
</tr>
</tbody>
</table>

Total: 100% 0.795

#### Operating Margin 2006

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Intensity (Capacity Avg.)</th>
<th>% of Time Set Price</th>
<th>Operating Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>1.063 1.063</td>
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<td>0.500 0.500</td>
<td>36% 36%</td>
<td>0.209 0.209</td>
</tr>
<tr>
<td>Hydro</td>
<td>1.000 1.000</td>
<td>1% 1%</td>
<td>0.000 0.000</td>
</tr>
</tbody>
</table>

Total: 100% 0.808