Assessment of the quality of Indiana coal for Integrated Gasification Combined Cycle Performance (IGCC)

Progress report – March 2007

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Project components:

- **New data collection**
  - Mineral matter (ash) composition
  - Ash melting point and slag viscosity
  - Petrographic composition
  - Chlorine content in coal

- **Data integration and updated evaluation of Indiana coals for IGCC**

- **Associated maps (Map 1 and Map 2 completed)**

Project duration – July 1, 2006 – June 20, 2008
Recent Activities

- **Map 3** – *Major point sources of CO$_2$ emissions and conceptual geological sequestration strategies in Indiana* – revised, more point sources added, finalized

- **Map 4** – Coal availability
Data collection and interpretation

- Additional coal samples analyzed with emphasis on determining:
  - mineral matter (ash) composition
  - slagging characteristics
  - Cl and Hg content
- Purpose: to identify the best coals for use in the leading slagging gasifiers (entrained flow gasifiers;)
- Database of coal quality parameters updated
Major sources of CO₂ emissions [tonnes/year]

- More than 15,000,000
- 10,000,000 to 15,000,000
- 5,000,000 to 10,000,000
- 1,000,000 to 5,000,000
- 500,000 to 1,000,000
- 100,000 to 500,000
- 1,000,000 to 5,000,000

We modified ranges to accommodate additional sources of emissions. This way the map includes all major point sources of CO₂ emissions.
In addition to the previously existing table of CO₂ emission from coal-fired power plants, two additional tables were added:

1) emissions from industrial and municipal coal-fired plants, and
2) emissions from gas-fired power plants

<table>
<thead>
<tr>
<th>ID</th>
<th>Company Name</th>
<th>County</th>
<th>CO₂ emissions (tonnes/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>56</td>
<td>Duke Energy</td>
<td></td>
<td>8,133,539</td>
</tr>
<tr>
<td>57</td>
<td>SIGECO - F.B. Culley Generating Station</td>
<td>Warrick</td>
<td>6,006,515</td>
</tr>
<tr>
<td>58</td>
<td>DaimlerChrysler Corporation Foundry</td>
<td></td>
<td>5,486,660</td>
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<tr>
<td>59</td>
<td>Ironside Energy, LLC</td>
<td></td>
<td>1,041,348</td>
</tr>
<tr>
<td>60</td>
<td>Harbor East</td>
<td></td>
<td>885,042</td>
</tr>
<tr>
<td>61</td>
<td>ISG Burns Harbor LLC</td>
<td>Porter</td>
<td>735,320</td>
</tr>
<tr>
<td>62</td>
<td>US Steel Corp. Works</td>
<td></td>
<td>707,871</td>
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<tr>
<td>63</td>
<td>Whiting Clean Energy, Inc.</td>
<td></td>
<td>510,884</td>
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<tr>
<td>64</td>
<td>Mittal Steel (ISG Harbor West)</td>
<td></td>
<td>502,018</td>
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<tr>
<td>65</td>
<td>C.C. Perry K Steam Plant</td>
<td></td>
<td>427,813</td>
</tr>
<tr>
<td>66</td>
<td>Portside Energy Corporation</td>
<td>Porter</td>
<td>213,925</td>
</tr>
<tr>
<td>67</td>
<td>Duke Energy - Noblesville</td>
<td></td>
<td>208,762</td>
</tr>
<tr>
<td>68</td>
<td>Mirant Sugar Creek LLC</td>
<td></td>
<td>189,605</td>
</tr>
<tr>
<td>69</td>
<td>GE Plastics Mt. Vernon Inc.</td>
<td>Posey</td>
<td>183,560</td>
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<tr>
<td>70</td>
<td>Grain Processing Corporation</td>
<td></td>
<td>180,875</td>
</tr>
<tr>
<td>71</td>
<td>Steel Dynamics / Iron Dynamics</td>
<td></td>
<td>173,962</td>
</tr>
<tr>
<td>72</td>
<td>Nucor Steel Corp.</td>
<td></td>
<td>163,076</td>
</tr>
<tr>
<td>73</td>
<td>Alcoa Inc. - Warrick Operations</td>
<td>Warrick</td>
<td>140,522</td>
</tr>
<tr>
<td>74</td>
<td>PSEG Lawrenceburg Energy Company, Inc.</td>
<td></td>
<td>116,832</td>
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<tr>
<td>75</td>
<td>Cargill, Inc.</td>
<td></td>
<td>114,686</td>
</tr>
<tr>
<td>76</td>
<td>I/N Tek I/ Combined</td>
<td></td>
<td>106,185</td>
</tr>
<tr>
<td>77</td>
<td>Steel Dynamics, Inc. (SDI) Bar Products</td>
<td>Hendricks</td>
<td>105,524</td>
</tr>
</tbody>
</table>

SUBTOTAL OF LISTED: 26,334,523

ALL NATURAL GAS-BURNING SOURCES: 30,402,977
This way, the map includes all major point sources of CO$_2$ emissions

<table>
<thead>
<tr>
<th>Emission sources</th>
<th>CO$_2$ emissions (tonnes/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal-burning electric power plants</td>
<td>118,684,416</td>
</tr>
<tr>
<td>Major coal-burning industrial and institutional plants</td>
<td>4,052,962</td>
</tr>
<tr>
<td>Natural gas industrial generators</td>
<td>30,402,977</td>
</tr>
<tr>
<td>Wood-burning industries</td>
<td>421,834</td>
</tr>
<tr>
<td>Oil-burning industries*11</td>
<td>96,949</td>
</tr>
<tr>
<td>TOTAL</td>
<td>153,659,138</td>
</tr>
</tbody>
</table>
Further evaluation to determine applicability of these four conceptual geological sequestration strategies is ongoing.

Potential geologic sequestration include four options:

1) Adsorption within coal seams that are too deep or too inferior in quality to mine,
2) Isolation in mature or depleted oil and natural gas reservoirs,
3) Storage in deep, saline-water-filled formations,
4) Adsorption in organic-rich shales.
1) Adsorption within coal seams that are too deep or too inferior in quality to mine
2) CO₂ storage potential in oil fields in Indiana

- Predominantly miscible (depth > 2,500 feet)
- Predominantly near-miscible (depth ~ 2,500 feet)
- Predominantly immiscible (depth < 2,500 feet)
3) CO₂ storage potential in the Mt. Simon sandstones in Indiana

![Map showing CO₂ storage potential in Indiana](image)

- **Depth range**:
  - Less than 3,000 feet
  - 3,000 to 4,000 feet
  - 4,000 to 5,000 feet
  - 5,000 to 6,000 feet
  - 6,000 to 7,000 feet
  - 7,000 to 8,000 feet
  - 8,000 to 9,000 feet
  - 9,000 to 10,000 feet
  - 10,000 to 11,000 feet
  - 11,000 to 12,000 feet
  - 12,000 to 13,000 feet
  - 13,000 to 14,000 feet
  - 14,000 to 15,000 feet
  - Greater than 15,000 feet
4) CO\textsubscript{2} storage potential in New Albany Shales in Indiana
## Coal availability maps

<table>
<thead>
<tr>
<th>Coal bed</th>
<th>Original</th>
<th>Mined-out</th>
<th>Remaining</th>
<th>Restricted</th>
<th>Total available (Remaining - Restricted)</th>
<th>Available as % of original</th>
<th>Available for surface mining</th>
<th>Available for underground mining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danville</td>
<td>6.55</td>
<td>0.36</td>
<td>6.19</td>
<td>5.33</td>
<td>0.83</td>
<td>13.89</td>
<td>0.35</td>
<td>0.52</td>
</tr>
<tr>
<td>Hymera</td>
<td>5.53</td>
<td>0.55</td>
<td>4.98</td>
<td>4.10</td>
<td>0.87</td>
<td>17.47</td>
<td>0.15</td>
<td>0.81</td>
</tr>
<tr>
<td>Springfield</td>
<td>13.31</td>
<td>1.31</td>
<td>12.00</td>
<td>4.65</td>
<td>7.35</td>
<td>61.25</td>
<td>0.82</td>
<td>6.94</td>
</tr>
<tr>
<td>Houchin Creek</td>
<td>5.92</td>
<td>0.0022</td>
<td>5.92</td>
<td>5.56</td>
<td>0.36</td>
<td>6.08</td>
<td>0.18</td>
<td>0.17</td>
</tr>
<tr>
<td>Survant</td>
<td>8.47</td>
<td>0.31</td>
<td>8.17</td>
<td>6.86</td>
<td>1.31</td>
<td>16.03</td>
<td>0.22</td>
<td>1.10</td>
</tr>
<tr>
<td>Colchester</td>
<td>5.14</td>
<td>0.001</td>
<td>5.14</td>
<td>4.95</td>
<td>0.19</td>
<td>3.70</td>
<td>0.11</td>
<td>0.10</td>
</tr>
<tr>
<td>Seelyville</td>
<td>14.61</td>
<td>0.33</td>
<td>14.28</td>
<td>7.68</td>
<td>6.60</td>
<td>46.22</td>
<td>0.30</td>
<td>6.30</td>
</tr>
<tr>
<td></td>
<td>59.53</td>
<td>2.8632</td>
<td>56.68</td>
<td>39.13</td>
<td>17.54</td>
<td>30.95</td>
<td>2.13</td>
<td>15.94</td>
</tr>
</tbody>
</table>

*Note: in billion short tones*
Thickness of the Danville Coal in Indiana
(after Conolly and Zlotin, 2000)

- 28 to 42 inches
- 42 to 66 inches
- Less than 28 inches
- Insufficient data
- Greater than 66 inches

Cities
Township border
Availability of the Danville Coal for surface mining in Indiana (after Conolly and Zlotin, 2000).

- Yellow: Coal available for surface mining
- Black: Coal mined out
- Gray: Depth to coal greater than 200 feet
- Green: Mining restricted by land-use features
- Red: Mining restricted by technological factors
Availability of the Danville Coal for underground mining in Indiana (after Conolly and Zlotin, 2000).

- Yellow: Coal available for underground mining
- Black: Coal mined out
- Gray: Depth to coal less than 100 feet
- Green: Mining restricted by land-use features
- Red: Mining restricted by technological factors
Thickness of the Danville Coal in **Sullivan County**
(after Conolly and Zlotin, 2000)
Availability of the Danville Coal for surface mining in Sullivan County
(after Conolly and Zlotin, 2000)

TOTAL ESTIMATED AVAILABLE SURFACE MINABLE RESOURCES IN SULLIVAN COUNTY FOR DANVILLE COAL:
78,953 THOUSANDS OF SHORT TONS
Availability of the Danville Coal Member for underground mining in Sullivan County (after Conolly and Zlotin, 2000).

TOTAL ESTIMATED AVAILABLE UNDERGROUND MINABLE RESOURCES IN SULLIVAN COUNTY FOR DANVILLE COAL: 108,107 THOUSANDS OF SHORT TONS
Suggestions on maps very welcome.