CORRIM Special Session: Biofuel Environmental Performance

Presented at
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66th International Convention
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Washington, DC

Consortium for Research on Renewable Industrial Materials
Research developing life cycle assessments for every stage of processing covering wood products/biofuels and their uses.
Pellets Production Alternatives and Their Impacts

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Maureen Puettmann
Life-Cycle Inventory for Wood Pellet Manufacturing in Wisconsin

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LCI of Wood Pellets in the US Southeast

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Rick Bergman\(^2\)
Adam Taylor\(^1\)
David Harper\(^1\)
Don Hodges\(^1\)

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\(^5\)WoodLife Environmental Consultants, LLC

Funding: Wood Education and Resource Center, Northeastern Area State and Private Forestry, Forest Service, U.S. Department of Agriculture
LCI of Switchgrass Pellets in the US Southeast

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David Harper¹

Don Hodges¹
Maureen Puettmann²

¹University of Tennessee
²WoodLife Environmental Consultants, LLC

Funding: Southeastern Sungrant Center
Wisconsin Pellet Fuel Manufacturers

Wisconsin Fuel Pellet Manufacturers
and Forest Land Cover

Forest Lands
- Private Forest
- State Forest
- County Forest
- Forested Wetland
- National Forest

Political Boundaries
- City or Village
- County Border

Fuel Pellet Manufacturers*

*Note - As of July 2008. Not all fuel pellet manufacturers use forest products as their inputs. Several manufacturers use residues from agricultural production or other manufacturers.

Active
- American Wood Fibers
- Bay Lakes Companies, LLC
- Dejno’s Inc.
- Earth Sense Energy Systems
- Elkhorn Industries, Inc.
- Fiber Recovery Inc
- Marth Wood Shaving Supply
- Pellet America Corp
- PJ Murphy Forest Products
- Performance Wood
- Kickapoo Bio Fuels
- Agrecol
- Great Lakes Renewable Energy, Inc.
- Badger Pellet
- Risley Pellet Solutions (see note below)

City
- Schofield
- Oconto Falls
- Kenosha/Antigo
- Dale
- Superior
- Ringle
- Marathon/Peshigo
- Appleton
- Ladysmith
- Seymour
- Viro
- Evansville
- Hayward
- Sheboygan

Tons/year
- 20,000
- 20,000
- N/A
- Repackager
- 36,000
- N/A
- 100,000
- N/A
- 5,000
- 5,000
- 1,000
- N/A

Seeking Permits or Under Construction
- Forest Source
- Indeck Ladysmith, LLC
- Wisconsin Wood Energy Products
- Superior Wood Products
- Inc

Note: A fire burned Risley Pellet Solutions in February 2007. Future status is uncertain.
Life-Cycle Inventory

Three Feedstock Scenarios

• Wood Pellets from Whole Logs:
  – Timber harvested by the pellet manufacturers

• Wood Pellets from Wet Co-Product:
  – Chips from sawmill >35% Moisture

• Wood Pellets from Dry Co-Product:
  – Sawdust and shavings from sawmill <35% Moisture
Boundary Definitions

- Harvested Timber
  - Primary Wood Mill
    - Mill Residues
      - Primary Wood Products
  - Energy Generation
    - Receiving/Handling
      - Size Reduction
        - Drying
          - Pelletizing
            - Wood Fiber
  - System Boundary for On-Site Emissions
    - Premium Wood Pellets
      - System Boundary for cumulative (total) emissions
        - Combustion in Pellet Stove
          - "ENERGY OUTPUT"
  - Water Effluents
  - Air Emissions
    - "MATERIAL OUTPUT"
# Fuel Consumption (On-Site)

<table>
<thead>
<tr>
<th>Fuel Consumption by Process of Premium Wood Pellet Production in WI</th>
<th>Wood Pellets from Whole Logs</th>
<th>Wood Pellets from Wet Co-Product</th>
<th>Wood Pellets from Dry Co-Product</th>
<th>WI Weighted Average</th>
<th>% Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wood Pellet Production</strong></td>
<td>Weighted</td>
<td>Average</td>
<td>Weighted</td>
<td>Average</td>
<td>Weighted</td>
</tr>
<tr>
<td>Diesel</td>
<td>1.84</td>
<td>1.67</td>
<td>0.81</td>
<td>1.21</td>
<td>2.59</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>0.07</td>
<td>0.07</td>
<td>0.03</td>
<td>0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>Propane</td>
<td>0.16</td>
<td>0.16</td>
<td>0.14</td>
<td>0.15</td>
<td>0.00</td>
</tr>
<tr>
<td>Electricity</td>
<td>187.83</td>
<td>173.58</td>
<td>143.01</td>
<td>159.56</td>
<td>31.67</td>
</tr>
<tr>
<td>Wood (Oven-Dry)</td>
<td>149.78</td>
<td>136.10</td>
<td>3.66</td>
<td>59.62</td>
<td>65.74</td>
</tr>
<tr>
<td><strong>Total Fuel Energy</strong></td>
<td>MJ</td>
<td>3743.19</td>
<td>3411.64</td>
<td>619.38</td>
<td>1813.79</td>
</tr>
</tbody>
</table>

## Transportation

| Diesel Transportation | tkm | 99.29 | 231.01 | 241.40 | 199.87 | 100 |
| **Total Fuel Energy** | MJ | 99.29 | 231.01 | 241.40 | 199.87 | 100 |
| **Total On-Site Energy** | MJ | 3842.48 | 3642.65 | 860.78 | 2013.66 | x |
# Cradle-To-Gate Fuel Consumption

<table>
<thead>
<tr>
<th>Cradle-to-Gate Inputs per Short Ton Premium Wood Pellets Output</th>
<th>Wood Pellets from Whole Logs</th>
<th>Wood Pellets from Wet Co-Product</th>
<th>Wood Pellets from Dry Co-Product</th>
<th>Wisconsin Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Usage (Cradle-to-Gate)</td>
<td>MJ %</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electricity (kWh)</td>
<td>187.83</td>
<td>222.69</td>
<td>315.60</td>
<td>270.21</td>
</tr>
<tr>
<td>Diesel (Liters)</td>
<td>9.76</td>
<td>7.29</td>
<td>11.07</td>
<td>11.34</td>
</tr>
<tr>
<td>Natural Gas (Liters)</td>
<td>0.07</td>
<td>20.25</td>
<td>47.51</td>
<td>31.50</td>
</tr>
<tr>
<td>Propane (Liters)</td>
<td>0.16</td>
<td>0.16</td>
<td>0.27</td>
<td>0.16</td>
</tr>
<tr>
<td>Gasoline (Liters)</td>
<td>0.13</td>
<td>0.24</td>
<td>0.57</td>
<td>0.48</td>
</tr>
<tr>
<td>Wood Fuel (kg)</td>
<td>149.78</td>
<td>136.17</td>
<td>164.23</td>
<td>154.57</td>
</tr>
<tr>
<td>Transportation (tkm)</td>
<td>99.29</td>
<td>231.01</td>
<td>241.40</td>
<td>199.87</td>
</tr>
<tr>
<td>Total Fuel Energy (MJ)</td>
<td>4,154</td>
<td>4,048</td>
<td>5,113</td>
<td>4,697</td>
</tr>
<tr>
<td>Total Fuel Energy (BTU)</td>
<td>3,936,915</td>
<td>3,836,517</td>
<td>4,845,977</td>
<td>4,452,034</td>
</tr>
</tbody>
</table>

*HHV of one short ton of premium wood pellet fuel: 17,303 MJ or 16,400,000 BTU*
# Fossil Fuel Inputs per MJ Output

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>0.001</td>
<td>0.140</td>
<td>0.013</td>
<td>0.030</td>
</tr>
<tr>
<td>Nat Gas</td>
<td>0.002</td>
<td>0.052</td>
<td>1.383</td>
<td>0.058</td>
</tr>
<tr>
<td>Crude Oil</td>
<td>0.032</td>
<td>0.066</td>
<td>0.011</td>
<td>1.429</td>
</tr>
<tr>
<td>Uranium</td>
<td>0.000</td>
<td>0.050</td>
<td>0.004</td>
<td>0.010</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>0.035</strong></td>
<td><strong>0.307</strong></td>
<td><strong>1.411</strong></td>
<td><strong>1.527</strong></td>
</tr>
</tbody>
</table>
GHG Emissions per MJ of Residential Heat
<table>
<thead>
<tr>
<th>INPUTS</th>
<th>Materials</th>
<th>Units</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood residues</td>
<td>kg</td>
<td></td>
<td>907</td>
</tr>
<tr>
<td>Polyethylene (50 bags)</td>
<td>kg</td>
<td></td>
<td>5.01</td>
</tr>
<tr>
<td>Corn oil (lubricant)</td>
<td>L</td>
<td></td>
<td>1.25</td>
</tr>
<tr>
<td>Ground water</td>
<td>L</td>
<td></td>
<td>21.70</td>
</tr>
<tr>
<td>Electricity</td>
<td>kWh</td>
<td></td>
<td>132.12</td>
</tr>
<tr>
<td>Liquefied petroleum gas</td>
<td>L</td>
<td></td>
<td>0.08</td>
</tr>
<tr>
<td>Wood residues to boiler</td>
<td>kg</td>
<td></td>
<td>29.97</td>
</tr>
</tbody>
</table>
Wood (normalized impact)

Switchgrass (normalized to wood)

Smog
Respiratory effects
Acidification
Global warming potential

- Wood
- Oil
- Electricity
- Bag
- Switchgrass
- Oil
- Transport
- Natural gas
- Electricity

Wood vs. Switchgrass (normalized impact)
Bio-energy in 1 ton of switchgrass pellets (16.4 GJ)
- Fossil energy to grow SG (0.6 GJ)
- Fossil energy to pelletize SG (2.5 GJ)

Bio-energy in 1 ton of wood pellets (17.3 GJ)
- Fossil energy to make the wood residues (3.9 GJ)
- Fossil energy to pelletize (2.3 GJ)

Bio-energy in 1 ton of wood pellets (17.3 GJ)
- Fossil energy to make the wood residues - value allocation (0.08 GJ)
- Fossil energy to pelletize (2.3 GJ)
Summary of Results

• Wood pellets use (73%, 82%, 129%, much!) less fossil fuel inputs than natural gas

• Electricity for pelletization is important
  – About 130 kWh/Mg

• With mass allocation
  – Wood Pellets from roundwood/switchgrass have the lesser environmental footprint
  – Should use value allocation
Questions and Discussion

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