Topics

• Bioenergy & Biomass Basics

• Charter Street Heating Plant Case Study

• Fuel Supply Development Lessons
Mission

The WBI helps the talent within Wisconsin create, evaluate, commercialize, and promote bioenergy solutions.
US Renewable Energy


Total = 99.304 Quadrillion Btu

- Petroleum 37%
- Natural Gas 24%
- Coal 23%
- Nuclear Electric Power 8%
- Renewable Energy 7%

Total = 7.300 Quadrillion Btu

- Hydropower 34%
- Wind 7%
- Geothermal 5%
- Solar 1%
- Biomass 53%

Note: Sum of components may not equal 100% due to independent rounding.
Bioenergy and Biobased Products Facilities

http://maps.nrel.gov/bioenergyatlas
# Wisconsin Renewable Energy

## Wisconsin Renewable Energy by Type

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Production ($10^9$ BTU)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro</td>
<td>5.4</td>
<td>13.98%</td>
</tr>
<tr>
<td>Wind</td>
<td>3.59</td>
<td>9.29%</td>
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<tr>
<td>Solar</td>
<td>0.035</td>
<td>0.09%</td>
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<tr>
<td>Biogas</td>
<td>10.2</td>
<td>26.41%</td>
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<tr>
<td>Ethanol</td>
<td>19.4</td>
<td>50.23%</td>
</tr>
<tr>
<td>Biomass</td>
<td>48.9</td>
<td>126.60%</td>
</tr>
</tbody>
</table>

Source: WI Office of Energy Independence
http://energyindependence.wi.gov
Wisconsin Woody Biomass

http://wiscbioenergy.org/atlas.php
Wisconsin Agricultural Residues

Existing Biofuel Producers - data sources
Agricultural Resources - data sources
- Farm Anaerobic Digesters
- CAFO Permit Locations
- Food Manufacturing Facilities
- Soybeans Harvested (2008)
- Corn Harvested (2008)
- Corn Stover at a 30% Recovery Rate (2008) bone dry Tons
  - 125,001 or More
  - 100,001 - 125,000
  - 75,001 - 100,000
  - 50,001 - 75,000
  - 25,001 - 50,000
  - 1 - 25,000
  - 0 (None or Not estimated)
- Hay Harvested (2008)
- CRP Lands (2007)
- CRP Acreage - 2007 to 2020
Potential Biomass Cropland - data sources
Forest-Based Resources - data sources
Environment - data sources
Political Boundaries
Utilities and Transportation - data sources

http://wiscbioenergy.org/atlas.php
Wisconsin Bioenergy Crops

- Existing Biofuel Producers - data sources
- Agricultural Resources - data sources
- Potential Biomass Cropland - data sources
  - Switchgrass, Underutilized
    - Potential Acres
      - 91 - 4,000
      - 4,001 - 8,000
      - 8,001 - 14,000
      - 14,001 - 23,000
      - 23,001 - 58,000
- Switchgrass, Hay/Fallow/CRP
- Switchgrass, Moderate Erosion or Drought Hazard
- Switchgrass, Significant Erosion or Drought Hazard
- Corn, Underutilized
- Corn, Hay/Fallow/CRP
- Corn, Moderate Erosion or Drought Hazard
- Corn, Significant Erosion or Drought Hazard
- Corn, Productive if Drained
- Willow, Suitable
- Willow, Suitable if Drained
- Willow, Unsuitable
- Forest-Based Resources - data sources
- Environment - data sources
- Political Boundaries

http://wiscbioenergy.org/atlas.php
### Common Bioenergy Conversions

#### Biological
- Fermentation – ethanol & other liquid fuels
- Anaerobic Digestion – biogas

#### Chemical
- Transesterification – biodiesel
- Catalysis – liquid fuels

#### Thermal
- Combustion – heat
- Pyrolysis
  - Fast - liquid & solid fuel
  - Torrefaction – solid fuel
- Gasification – synthesis gas
US Energy Consumption

Approximately 1/3 of energy consumption is thermal
Conversion Efficiency
Wood to Energy (available technology)
Biomass Considerations

Q: What biomass work well for thermochemical processes?

A: It’s all good!

– Agricultural Products
– Forest Products
– Animal waste

• Bone-dry Energy content (Btu/lb)
  • Coal (~12000)
  • Wood (~8500)
  • Ag Crops (~7500)
Combustible Biomass

- Plant matter
  - Woody or non-woody
  - Agricultural or forest
  - Residues or dedicated energy crops
- Trees
- Herbaceous plants
- Wood manufacturing wastes
- Agricultural residues
  - Straw, shells, hulls, stalks, etc.
- Animal and human residues
  - As biogas
Biomass Form

• Form varies with type of biomass
  – Wood residuals typical chips or pellets
  – Agricultural crops bales or pellets
  – Animal Waste – liquid or wet mass

• Desired form
  – Dense
  – Low contaminants - Ash, S, N, & Heavy metals
  – Dry
Pelleted Fuel

- Usually involves
  - Sorting
  - Drying
  - Shredding
  - Compressing
  - Cooling

- Results in uniform fuel with energy density up to 20x normal refuse
Impact of Moisture

- Moisture has two impacts
  - Lowers amount of “biomass” per MT
    - Transport
    - Storage
  - Lowers Heating Value
Some of WBI Projects

- Demonstration projects biomass supply
- Project siting tool
- WEI building
- Support for WIST, UWGB, EI of WI
- Bioenergy Summit
- Sponsored research and large federal grants
- 8 Bioenergy faculty
- New bioenergy curriculum
Charter Street Heating Plant
Current Charter Street Heating Plant

Current Capacity:
• 800,000 lbs/hr steam
• 26,000 tons chilled water
• 9 MW electric production
• Historically burned 130,000+ tons of coal per year
• 1960 vintage technology
• Air emissions - candidate under Prevention of Significant Deterioration program
Planned Upgrade

Heating Plant

• 3 gas boilers & 1 biomass boiler
• Gas boilers 2011/2012
• Fully functional by 2Q 2013
• New biomass boiler is designed to burn 100% biomass with natural gas back-up
• New capacity: 1.1 million lb/hr steam
• 29 MW electricity
Planned Biomass Boiler

- Biomass Boiler
  - 350,000 lbs/hr steam
  - Vibrating grate
  - Fed from 2 silos on site

- Biomass Sources
  - Designed to be flexible
  - Assist in business development for bioenergy

Biomass Benefits
- Economic benefit – create market for homegrown fuel
- Create Fuel Flexibility for the Plant
- Environmental benefit – No Coal
Disclaimer: Project halted January 23, 2011

Walker announces Charter Street plant will convert to natural gas

Advocates for biomass claim conversion could have helped create jobs around Wisconsin
Upgrades to Rail System for Biomass Fuel Delivery

1. Existing Main rail of Wisconsin & Southern Railroad.
2. Existing rail spur and switch (to remain operational).
3. Existing rail spur/grade crossing (to be abandoned).
4. Existing rail spur to remain as is.
5. Widen bridge over Park Street (for new main line).
6. Existing railroad and bike path bridge to remain (as is).
7. Railroad siding (16 full cars, 72' long).
8. Railroad siding (16 empty cars, 72' long).
9. Relocated / Reconstructed bike path.
Rail Car Unloader Operation
Biomass Fuel Silos
Future Air Quality Control Systems

1) New advanced air quality control equipment to meet strict new air quality regulations.

2) Tighter fuel specifications also required to meet strict new air quality regulations.
Lesson #1

• Before you have a project
  – Understand your fuel market and potential suppliers
  – Create partnerships for fuel supply
  – Many suppliers = more resources to manage
Developing CSHP Biomass Supply Chain

• Biomass available
  – Biomass inventory
  – Procurement request
  – Quality testing

• Obtain appropriate permits
  – Zoning / EIS
  – Emission permitting

• Communicate constraints
  – Biomass specifications
  – Logistics
  – Contract terms

• Identify supply partners
Biomass Inventory

- Project feasibility stage
- Assessed potential
  - biomass in surrounding area
  - aggregation sites
- W&S Rail constraints
Bioenergy Siting Tool

– Useful websites to help with this task
– Wisconsin site with unique biomass

http://wiscbioenergy.org/
Request for Information

- Questionnaire to have business identify interest and capability
- Provides contacts
  - Samples/data for permits
  - Additional discussion to develop RFP

- Results
  - Businesses responding:
    - 59 companies
    - $45 \times 10^{12}$ BTU/year.
    - $> 3.4$ million tons / year

- The plant requirements
  - $4 \times 10^{12}$ Btu / year.
  - $\sim 0.25$ million tons / year
RFI General Results

• Types of respondents
  – 50% were forest product fuels
  – 25% were ag residuals
  – 25% were waste/residuals
  – Bioenergy crops underdeveloped

• Size
  – Range: 1k MT/yr to 590k MT/yr
  – Average mass: 80k MT/yr
  – Average energy: $1.1 \times 10^{12}$ Btu/yr
Biomass Pricing

• There was a wide range of biomass fuel pricing beliefs ranging from $2 to $11/MMBtu
• Average price of $6/MMBTU which corresponds to $86/dry ton
  – Woody @ $85/dry ton
  – Ag @ $96/dry ton
  – Waste product @ $75/dry ton
• Indicates that there is not much inexpensive biomass left.
Lesson #2

• Set your specifications balancing

  • Market Availability
  • Fuel Cost

and

  • Operational Requirements
  • Regulatory Requirements
Biomass – Materials vs. Fuels

Biomass Materials

- Raw Biomass Materials are NOT Fuel
- CSHP will NOT process raw biomass materials into Fuel

CSHP Biomass Fuels

- Biomass materials Must be Processed & Refined into Fuel
- Biomass Fuels Must Meet Fuel Specifications

Biomass Fuel Specifications

- Biomass Fuels MUST meet plant **Operating** needs
- Biomass Fuels Must meet plant **Regulatory** needs
Biomass Fuel Testing

• Obtain test data from suppliers and online databases
• Many have limited data for air pollutant precursors
• Conducted solid fuel testing to assist with air permit and RFP specification

<table>
<thead>
<tr>
<th></th>
<th>Average</th>
<th>Range</th>
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<tbody>
<tr>
<td><strong>Ultimate %</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>41</td>
<td>24 to 59</td>
</tr>
<tr>
<td>H</td>
<td>4.9</td>
<td>2.7 to 7.1</td>
</tr>
<tr>
<td>N</td>
<td>0.78</td>
<td>0.02 to 3.75</td>
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<tr>
<td>S</td>
<td>0.13</td>
<td>0.01 to 0.76</td>
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<tr>
<td>O</td>
<td>32</td>
<td>18 to 43</td>
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<tr>
<td><strong>Proximate %</strong></td>
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<tr>
<td>Moisture</td>
<td>18</td>
<td>3 to 50</td>
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<tr>
<td>Ash</td>
<td>3.1</td>
<td>0.4 to 7.9</td>
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<tr>
<td>V. M.</td>
<td>64</td>
<td>36 to 81</td>
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<tr>
<td>F. C.</td>
<td>14.3</td>
<td>7.9 to 19.2</td>
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<tr>
<td><strong>HHV(GCV)</strong></td>
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<tr>
<td>Btu/lb</td>
<td>6950</td>
<td>3977 to 9994</td>
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<tr>
<td><strong>Chlorine</strong></td>
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<td>mg/kg</td>
<td>372</td>
<td>17 to 1822</td>
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<tr>
<td><strong>Mercury</strong></td>
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<tr>
<td>mg/kg</td>
<td>ND</td>
<td>ND to 0.017</td>
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</tbody>
</table>
Biomass Fuel Specifications

• Create set of specifications balancing boiler needs and what is available

• Feedback loop with suppliers is critical
  • Heat Content
  • Moisture
  • Density
  • Ash
  • Fuel Particle Size
  • Sulfur Level
  • Nitrogen Level
  • Chloride Level
  • Mercury Level
Biomass Fuel Specifications

Operational Related

• Based on:
  – Fuel Delivery
  – Fuel Unloading
  – Fuel Storage
  – Fuel Handling
  – Boiler Fuel Feed
  – Boiler Fuel Combustion

• Include:
  – Heat Content
  – Moisture
  – Density
  – Ash
  – Fuel Size
Regulatory Related Fuel Specifications

• Air Permit Emissions Limits:

  • Sulfur Dioxide (SO₂) @ 0.05 lbs/mmBtu
  • Nitric Oxide (NOₓ) @ 0.068 lbs/mmBtu
  • Hydrogen Chloride* (HCl) @ 0.004 lbs/mmBtu
  • Mercury* (Hg) @ 0.0000008 lbs/mmBtu (0.8 x 10⁻⁶)

* Emission Limits related to new MACT (Maximum Available Control Technology) Regulations.
Lesson #3

• Gov. projects are political
• Energy projects are political
• Gov. energy projects are especially political
Public Support for a Public Project

• Communication is key
  – General community
  – Industry groups

• Quarterly public information sessions

• Articles/websites
Lesson #4

- Sustainably harvested biomass is not always well defined

- Best management practices for sustainable biomass and biofuel production
  - forest biomass
  - non-forest biomass

- Voluntary or contractal?
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