Biopower: Technology and Policy Challenges

NYSERDA EMEP November 2007
• **Biomass Resource**
  – What qualifies as Biomass?
  – How large is the Biomass Resource (U.S. and NY)?
  – What constitutes sustainable biomass production?
  – Under what conditions is biomass power production carbon neutral?

• **Biopower Emissions Beyond CO2**

• **Biopower Development Challenges and Policy Issues**
What Qualifies as Biomass?
Biomass Power Resources

**FEEDSTOCKS**

- **Forest Resources**
  - Unused logging slash
  - Primary mill residues
  - Forest fuels treatment biomass
    - Timberland
    - Other forest land
- **Agricultural Resources**
  - Crop Residues
  - Manure Solids & Biogas
  - Energy Crops
- **Urban Resources**
  - Biomass recovered from solid wastes
  - Biosolids
  - Landfill gas
  - Biogas from waste-water treatment plants

**POWER TECHNOLOGIES**

- Direct Fired/Steam Turbine
- Biomass Cofired in Fossil Fuel Power Plants
- Gasifier/IC Engine
- Gasifier/Combined Cycle
- Gasifier/Gas turbine
- Biogas IC Engines and Microturbines
- Biogas Fuel Cells
Feedstock Production

- Farmland
  - Forst and Woodlots
  - Round Wood, Pulp Chips, Grains & Cereals
  - Whole Tree Chips, Energy Crops, Crop & Wood Harvest Residuals, Forest Management Treatments, Animal manures

- Products
  - Food, Fiber, Chemicals, Wood Products, Plastics

- Municipalities
- Industry

Biomass Waste

Biomass Energy Feedstocks
Annual Biomass Production Potential

368 Million Tons wood biomass, 998 MMT Ag biomass (Wood Portion Mapped DOE/USDA Billion Ton Report-2005)

1.2 Billion tons coal produced in 2006 (EIA)
Biomass Resources Available in the United States

This study estimates the technical biomass resources currently available in the United States by county. It includes the following feedstock categories:
- Agricultural residues (crops and animal manure)
- Wood residues (forest, primary milled, secondary milled, and urban wood)
- All poultry by-products (meat mass from livestock and domestic wastewater treatment)
- Dedicated energy crops (switchgrass on Conservation Reserve Program lands)

September 2005
New York Biomass Power

New York Biomass Power Plants

<table>
<thead>
<tr>
<th>Year</th>
<th>2005</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW (capacity)</td>
<td>400</td>
<td>860</td>
</tr>
<tr>
<td>Source</td>
<td>Platts</td>
<td>NYSERDA 2003</td>
</tr>
</tbody>
</table>

> 5,000 GWh annually in 2012

- Biomass Production Area to generate power projected for 2012 is about 1,200 sq. miles
- Total NY land area 47,214 sq. miles
  - 29,000 sq. miles of forested area
  - 11,700 sq. miles are used by the 35,000 farms

USDA, National Agricultural Statistics Service, New York Field Office
Sustainable Bioenergy Production
Criteria for Sustainability

• Netherlands Energy Transition Task Force “Criteria for sustainable biomass production, Final report of the Sustainable Production of Biomass Project Group” July 14th 2006

• Criteria and indicators have been developed in 6 categories
  – Greenhouse gas balance
  – Competition with food production, local energy supply, medicines and building materials
  – Biodiversity
  – Economic prosperity
  – Social well-being
  – Environment
Sustainable Bioenergy Production to Use

- Feedstock production, harvest & transport
  - Assuring biological replenishment
  - Maintaining ecosystem health
  - Managing inputs (fertilizer, water)
  - Efficient transport

- Energy conversion
  - Higher efficiency reduces feedstock demand
  - New technologies aid removal of contaminants

- End uses
  - Higher efficiency end use reduces energy demand and environmental impacts
Feedstock production and harvest

- **Energy Crops**
  - Best management practices apply

- **Forest Harvests**
  - Forest and Harvest management certifications (SFI, FSC & Tree Farm)
  - State and Federal regulations apply

- **Forest Products and Agricultural Process Residues**
  - Contaminants from processing must be addressed
  - Raw material sources will be an issue

- **Urban and Industrial Wastes**
  - Complex mix of biomass materials
  - Stream separation and pretreatment are key
US Carbon Emissions

U.S. Historical Energy-Related CO₂ Emissions

Key Questions:
To what extent will electricity provide transport services?
To which sector will biomass resources be directed?

Biomass Role in Power and Carbon Balance

- US Biomass Power Generation was 61.8 MWh in 2005 (about 1.5% of total electricity produced)
  - Global potential for more than 10,000 million MWH
  - Biomass is dominant renewable resource in US on energy consumption basis (Heat, Power and Fuel)
- Among renewable energy technologies for electricity production, biomass is the carbon neutral, dispatchable, baseload electric generation option.

Biomass Power - Carbon Cycle

Net Zero Carbon applies to the GROWTH and CONVERSION portion of biomass energy - additional process steps can tip the balance either way.

GHG Emissions by Technology

Potential CCS Impact

Steven J. Smith, Antoinette Brenkert, Jae Edmonds, Biomass with Carbon Dioxide Capture and Storage (CCS), GTSP Presentation, May 23, 2006.

The MiniCAM is a long-term, partial-equilibrium model of the energy, agriculture, and climate system.
Other Emissions from Biomass Power
EGrid – SO2 Emissions Data

BioPower SO2 Emissions

SO2 Emissions (lb/MMBtu)

Heat Input (thousand MMBtu/yr)

NSPS Limit 0.15 lb/MMBtu

PSD Limit

ME: 1986
ME: 1987
CA: 1985
ME: 1988
FL: 1990
ME: 1993
NY: 1992
NY: 1993
Natural mercury levels in plants range from 0.001 to 0.1 ppm (dry weight).
Biomass Power Development

Benefits and Challenges
Biomass currently provides 2.8 Quads (H&P 2.5, Fuels 0.3)

Economic Sectors (Primary Quads - 2006)
EIA 2007

- Residential Services: 28
- Commercial Services: 21
- Industrial Utilities: 18
- Transportation: 32

Biomass Feedstocks
- Esterification
- Fermentation
- Hydrolysis & Steam Treatment
- Gasification, Pyrolysis & Digestion & Decomposition
- Reforming & Hydrotreating
- Solid Fuel Firing

Conversion and Delivery

Conversion Options – Solid Fuel Firing/Cofiring

Ottumwa, IA

Schiller, NH

Shasta, CA
Conversion Options - Gasification and BIGCC

USC Cogen
1.38 MW + 60 klbs/hr

Nuon Power, NL
~25 MW of 250MW total

Amer-9 NL
39 MWe of 650 MWe total
<table>
<thead>
<tr>
<th>Source</th>
<th>Net Output (MWe)</th>
<th>Net Heat Rate (Btu/kWh)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass direct-fired (stoker)</td>
<td>50</td>
<td>14,840</td>
<td>Renewable Energy Technology Characterizations, EPRI 1997</td>
</tr>
<tr>
<td>Coal – PC sub-critical</td>
<td>500</td>
<td>9,500 – 10,300 (1)</td>
<td>EPA Presentation 2006</td>
</tr>
<tr>
<td>Coal IGCC</td>
<td>500</td>
<td>8,170 – 8,700 (1)</td>
<td>EPA Presentation 2006</td>
</tr>
<tr>
<td>Biomass IGCC</td>
<td>50</td>
<td>9,000</td>
<td>Antares in-house resources (WGA report)</td>
</tr>
<tr>
<td>NGCC</td>
<td>400</td>
<td>7,500</td>
<td>EPRI 2000</td>
</tr>
</tbody>
</table>

1). Depends on coal type. Bituminous has lowest heat rate, lignite has the highest.
Conversion Efficiency – Biomass Plants

- IGCC Heat Rate
- Cogen Heat Rate
- Gen Sets Heat Rate
- EPI Gen Sets Heat Rate

Net Heat Rate (Btu/kWh) vs. Plant Scale (MWe)

- Engine Gensets vs. IGCC
Gasification Technology

- Gasification is a thermal process to convert a solid fuel into a gaseous fuel.
- Biomass gasification includes pyrolysis, gasification and some limited combustion.
- Gasification products may be burned to provide heat directly or indirectly to drive the gasification reactions.
- Gaseous fuel can be used in boilers, process heaters, turbines and engines and fuel cells. High conversion efficiencies are possible.
Challenges for Gasification

1. High moisture content of un-dried biomass
2. Commercial availability of gas clean-up technologies that are sufficiently robust and effective to allow use in a turbine or engine
3. Relatively high cost of gasification equipment, currently built on a custom basis
4. Limited industry experience in using biomass gasifiers in advanced power generation cycles
Biomass Supply Development
Biomass Resource Distribution

Corn and Wheat Residues in Northwestern States

Canada

Residues (Thousand Tonnes)
- 80 - 188
- 60 - 80
- 40 - 60
- 20 - 40
- 8 - 20

Power Potential (MW)
- 2 - 10
- 11 - 20
- 21 - 30
- 31 - 40
- 41 - 46

Transmission Lines
- by Voltage
  - Below 230
  - DC Lines
- Cities with Population > 5 K

NREL
Av. 2005

0 40 80 Kilometers
0 25 50 Miles
Maintaining Healthy Forests and Restoring Fire Adapted Forest Ecosystems
Forestland: 216 MM acres
Timberland: 141 MM acres
Timberland screened for Fire Severity Regime: 89 MM acres

Butte Creek Fuels Reduction Treatment Results

Treatment opportunities on WUI and non-WUI timberland: 23 MM acres

Fire Severity Regime Screens:
1. Forest type with a surface or mixed severity fire regimes
2. For WUI added limited treatment of high severity fire regimes

Final Screens:
1. Plots with higher fire hazard (CI < 25 mph or CI < 40 + TI < 25)
2. Inventoried roadless areas excluded
3. Counties with wetter climates excluded
Feedstock Transportation

Source: Langholtz et al. 2006
Current Systems – Trucks & Trains
Policy Challenges
Bioenergy Development

Cumulative Benefits of Biomass Energy Production

- Synergies with existing infrastructure – no new transmission capability
- Dispatchable
- Fire Risk Reduction
- Rural Economic Growth And Preservation
- Distributed Resources
- Productive Use of Byproducts
- Carbon Neutral
Challenges for Resource Development

- Distributed Resource / Availability
  - Many small suppliers plus a few large suppliers – aggregators are important
  - Competing uses
  - Variable feedstock quality
  - Measuring/monitoring sustainability

- Transportation - costs & logistics

- Time & investment for energy crop development

- Strategic Use Considerations
  - Imported Oil Reductions
  - Protecting Food Supplies
Biomass to Markets
Creating an Environment Conducive to Bioenergy Development

Feedstocks
- Build infrastructure to move raw feedstocks to new bioenergy projects

Permitting
- Consistent permitting rules that recognize all biomass benefits

Streamline interconnection for distributed biomass developers

Power, BioFuels, BioProducts
- Create incentives to make the switch
- Power contracts that reflect distributed, long-term benefits