Wood to Kilowatts

Cecil Massie, 6 Solutions, LLC

Fueling the Future:

The Role of Woody Biomass for Energy Workshop

April 2, 2009

Brainerd

Sponsored by:

University of Minnesota Extension, WesMin and Onanegozie RC&Ds, Natural Resource Conservation Service – Baxter, MN, Soil and Water Conservation District – Crow Wing County

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Wood to Kilowatts

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Fueling the Future Workshop
Brainerd, Minnesota
4/2/09
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• The chief challenge to using biomass to supply electricity in Minnesota not technical but geographic
  – Energy demand is where the people are
  – Supply is where the people aren’t
• Demographers estimate by 2020 75% of MN population will lie in a line from St. Cloud to Rochester
Minnesota Biomass and Population Maps

Biomass in the Corners

Population in the Metro
## Alternative Processes

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Spark Ignited Engine

- Suitable for small scale self generation
- Probably runs afoul of parallel generation prohibitions
  - May require a power purchase agreement with local power company
- May be used to drive specific connected loads such as compressors or hydraulic systems
- Gasification technology is still developing
Direct Combustion with Steam Turbine

Biomass

Solid Fuel Boiler

Stack Gas

Condenser

Steam Turbine

Generator

Cooling Tower to Atmosphere

Electricity
Direct Combustion

• Direct combustion is simplest process
  – Generate high pressure steam by burning wood
  – Generates power with steam turbine
  – Condensing system rejects waste heat to atmosphere through cooling towers
• Overall efficiency 35%
• Typically limited by biomass supply to 50 MW or less
Combined Heat and Power

Biomass
  ├── Solid Fuel
  │    └── Boiler
  ├── Stack Gas
  └── Condenser
      ├── Steam Turbine
      │    └── Generator
      │         └── Electricity
      └── Heating/Cooling
            └── District Energy
Combined Heat and Power

• Raises pressure at final condenser to make hot water for distribution through a heating district.
• Electric efficiency goes down, overall efficiency goes up to around 70%
• Heat load does not match power load most of the time resulting in less efficiency
  – Unused heat goes to cooling towers
IGCC

Biomass

- Gasifier

- Combustion Turbine/Generator

  - Heat Recovery Boiler

  - Condenser

  - Steam Turbine

  - Electricity

  - Cooling Tower
Integrated Gasification Combined Cycle
IGCC

• Builds on gas combined cycle technology by gasifying wood and then using a combustion turbine combined with a steam turbine.

• Higher efficiency than steam turbine alone

• Low heating value of the gas de-rates the turbine

• Capital intensive
Methanation and Transmission

Biomass

Methanation

Pipeline

Natural Gas Fired Combined Cycle Power Plant
• Methanation combines gasification with chemistry to convert biomass to pipeline quality natural gas replacement.

• Gas is transported by pipeline to combined cycle natural gas plant
  – May supply all or part of gas requirement
  – Compatible with existing natural gas plants

• Power plant and methanation plant are physically separated by long distance
Advantages of Methanation/Combined Cycle

• Overcomes logistical problems
  – No limit on scale – several methanation plants per generation site
  – Geographic diversity – build plants in different regions
  – Biomass diversity – different types in different plants
  – Keep biomass ash close to home for fertilizer

• Generation close to electricity demand
  – Lower transmission losses - 2% vs. 8%
  – Higher overall efficiency than IGCC

• Allows migration from natural gas to biomass over time by blending gas supplies
In Summary

- Scale is set by biomass quantity within economic region
- Technology selection is driven by biomass quality
  - Moisture
  - Size and variability
  - Debris
- Economics are driven by
  - Cost of fuel and transportation
  - Capital investment
  - PPA if required
  - Self generated energy value
Questions?

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