UNIVERSITY OF MINNESOTA
EXTENSION

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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Presented By:
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6Solutions LLC

Fueling the Future Workshop
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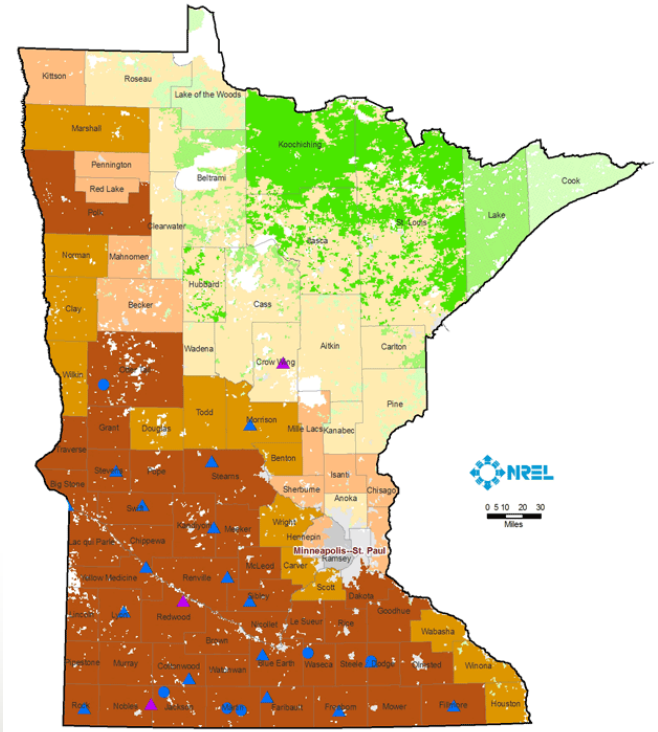
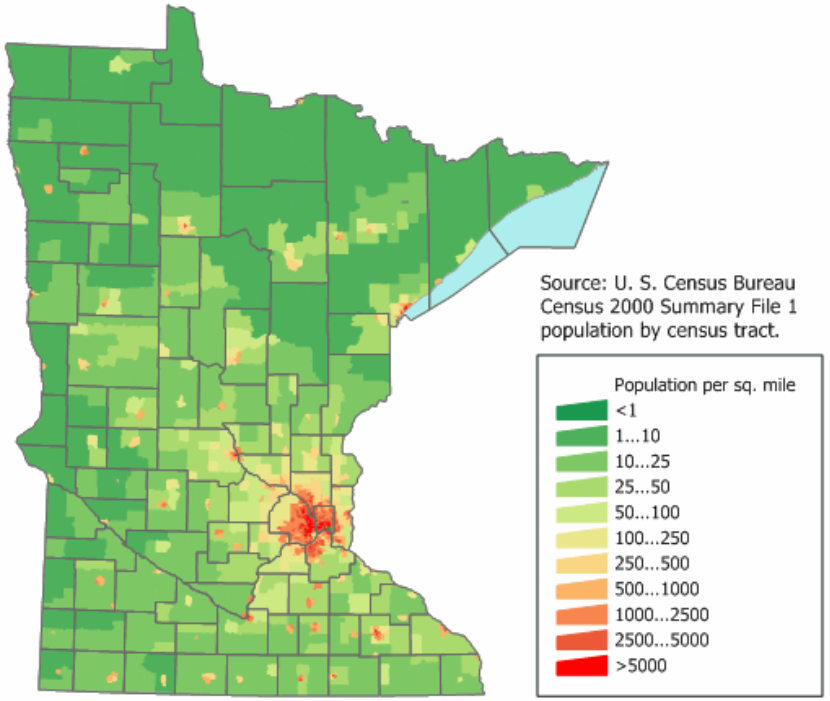
Introduction

- 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





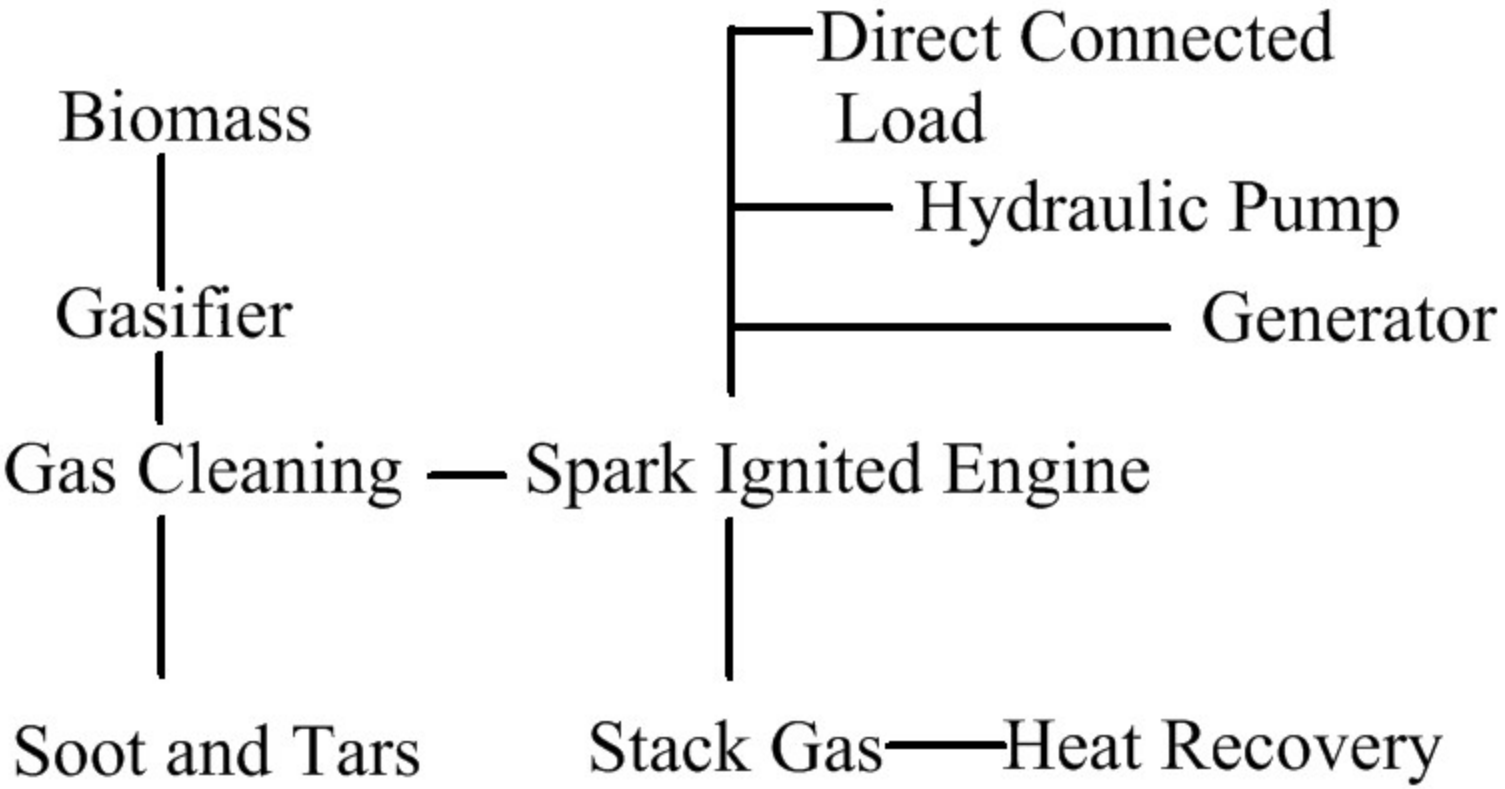
Biomass in the Corners

Population in the Metro

Alternative Processes

Biomass Conversion Process	**Power Process**	**Products**
Gasification	Spark Ignited Engine	Electricity Heat
Direct Combustion	Condensing steam turbine	Electricity
Combustion w Heat Recovery	Direct combustion w high pressure condenser	Electricity Hot Water
Gasification	Combustion turbine w steam cycle	Electricity
Methanation	Combined Cycle Gas Turbine	Electricity

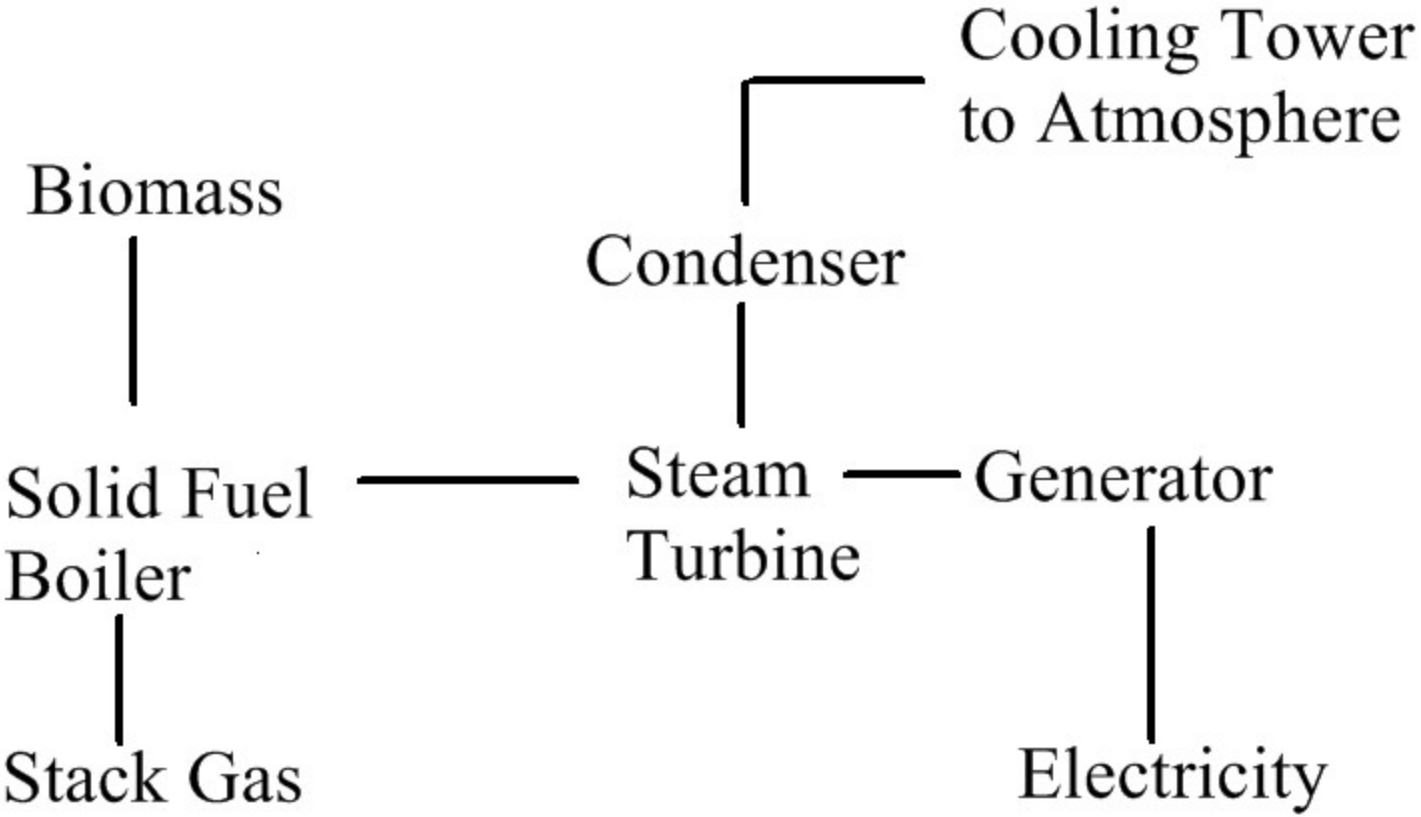
Spark Ignited Engine



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

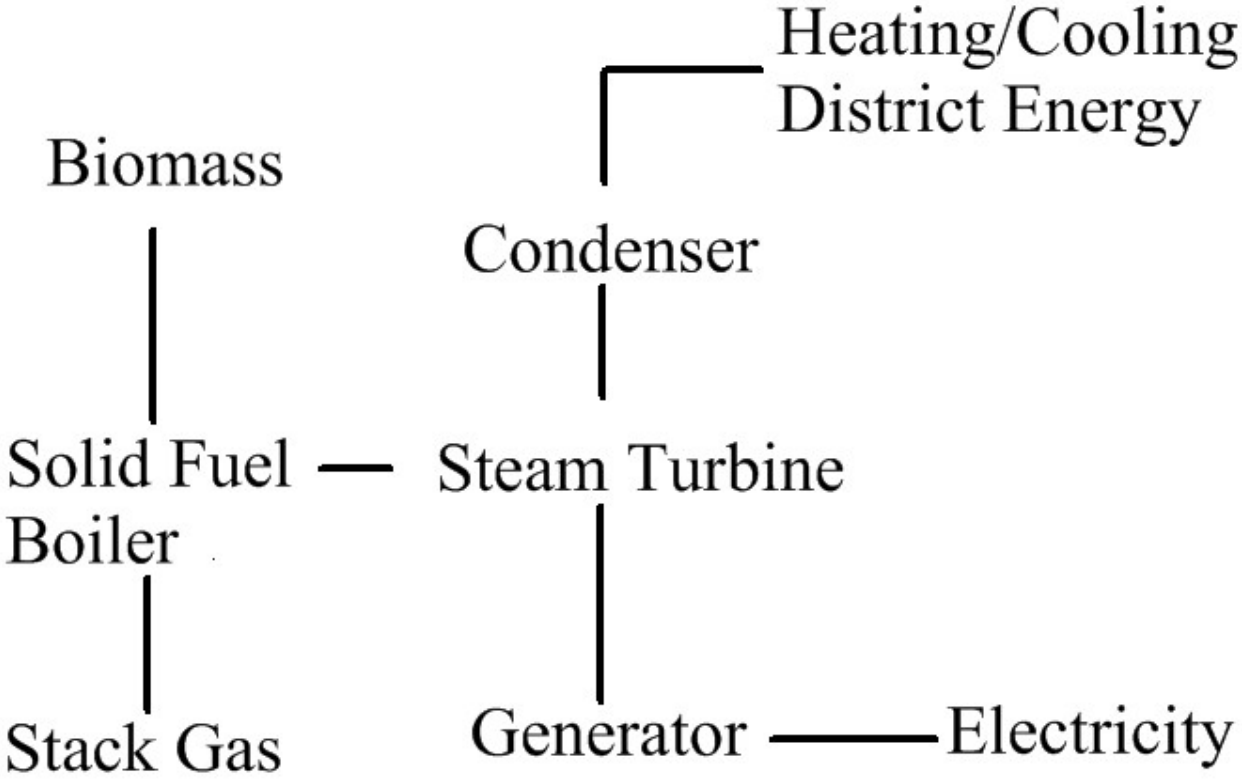
Direct Combustion w Steam Turbine



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

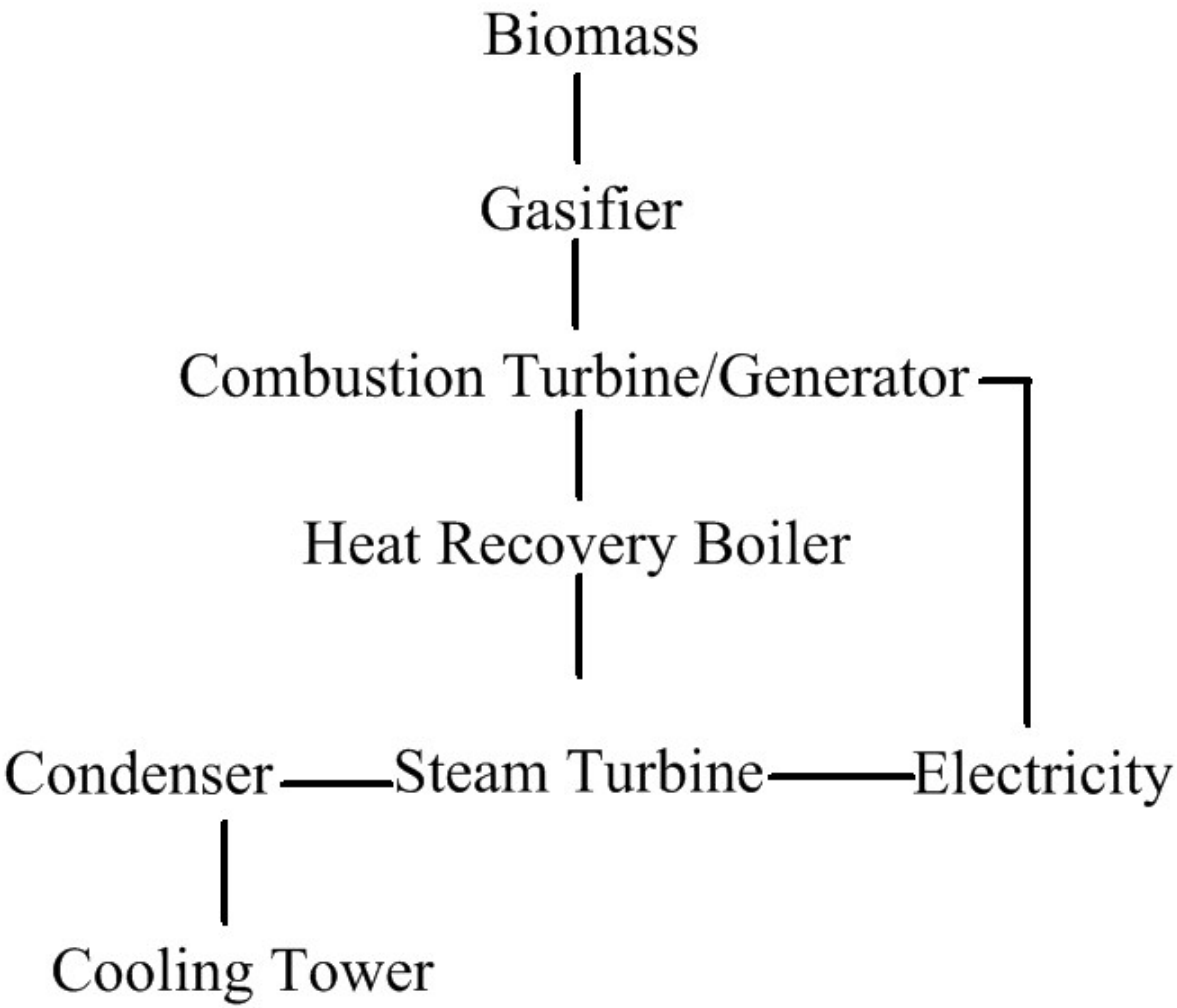
Combined Heat and Power



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

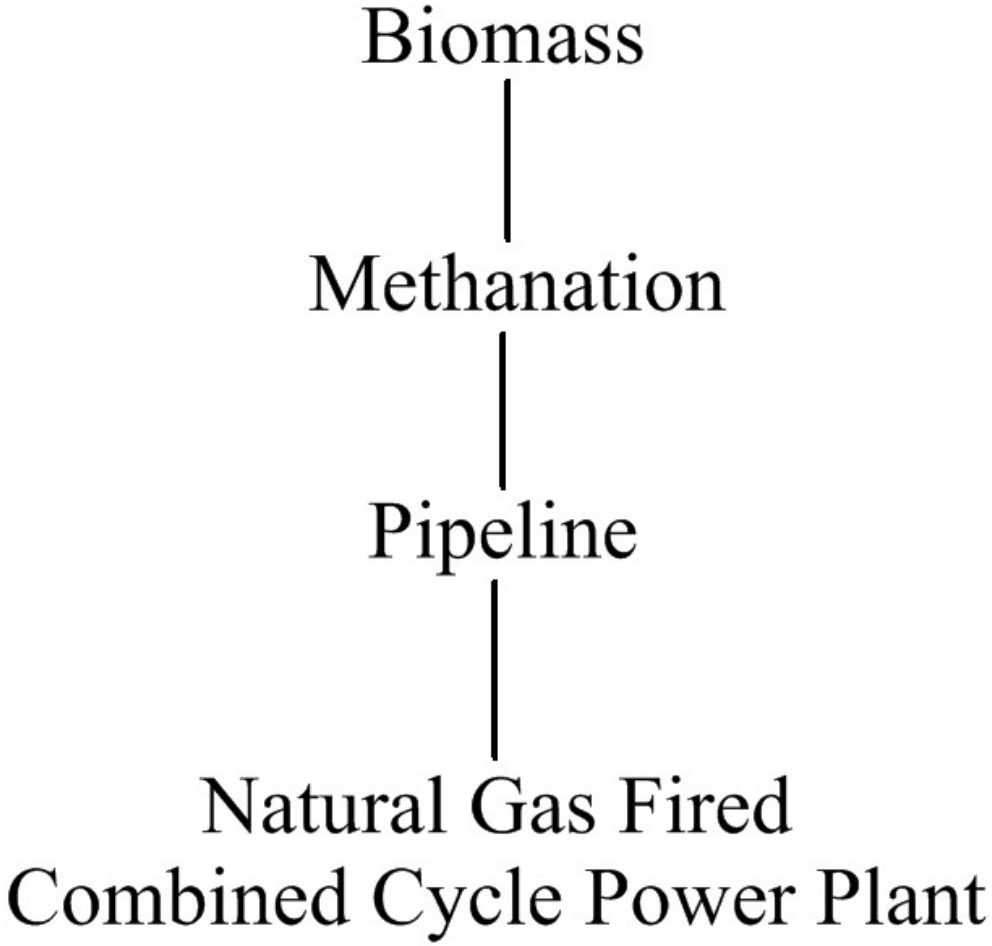
IGCC


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 gasifiying 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



Methanation w Natural Gas Combined Cycle 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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