

# DISTRIBUTED BIOMASS GASIFICATION COMBINED HEAT AND POWER (BGCHP) GENERATION



**Building Energy 11  
Conference Organized by  
Northeast Sustainable Energy  
Association  
Boston, MA**

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March 11, 2011**

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# Learning Objectives

- Biomass gasification (BG) process
- BG combined heat and power (BGCHP) plant systems
- Commercial suppliers of BG and CHP systems
- Biomass market overview
- BGCHP plant deployment issues
- BGCHP plant order-of-magnitude economics
- BGCHP generation potential in NY and NE ISO pools versus actual reality
- Reasons for lack of BGCHP deployment in NY and NE ISO pools

# DISTRIBUTED BIOMASS GASIFIERS

- Biomass as defined by NREL
  - Urban wood waste
  - Mill residues
  - Forest residues
  - Agricultural residues
  - Dedicated energy crops
- Biomass HHV (0 % moisture) - ~ 8,000 Btu/Lb
- Distributed (small) gasifiers
  - Use air to produce low Btu gas with a heating value of 140 – 160 Btu/SCF
  - Rated at < 50 million Btu/Hr (< 16 MW thermal) of product gas output or < 5,000 KW electric generation

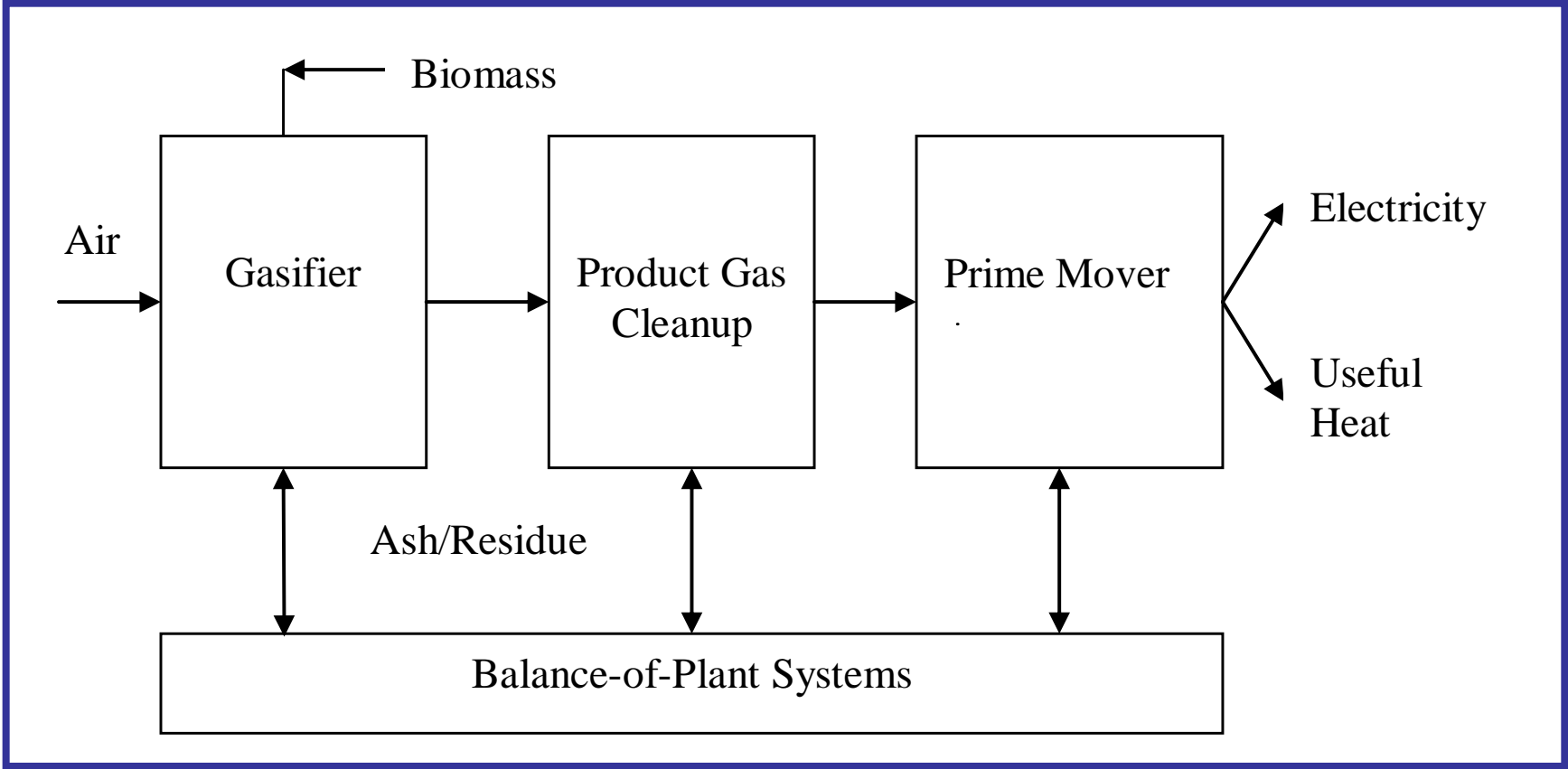
# BIOMASS GASIFICATION (BG) PROCESS

- BG is a four step chemical reaction process and not a combustion process
- Oxidation –
  - $C + O_2 = CO_2 + \text{Heat}$
  - $2H_2 + O_2 = 2H_2O + \text{Heat}$
- Reduction –
  - $CO_2 + C + \text{Heat} = 2CO$
  - $H_2O + C + \text{Heat} = H_2 + CO$
- Distillation (Pyrolysis) –
  - Volatile Matter + Cellulose + Heat = Tars + Hydrocarbons
- Feedstock drying

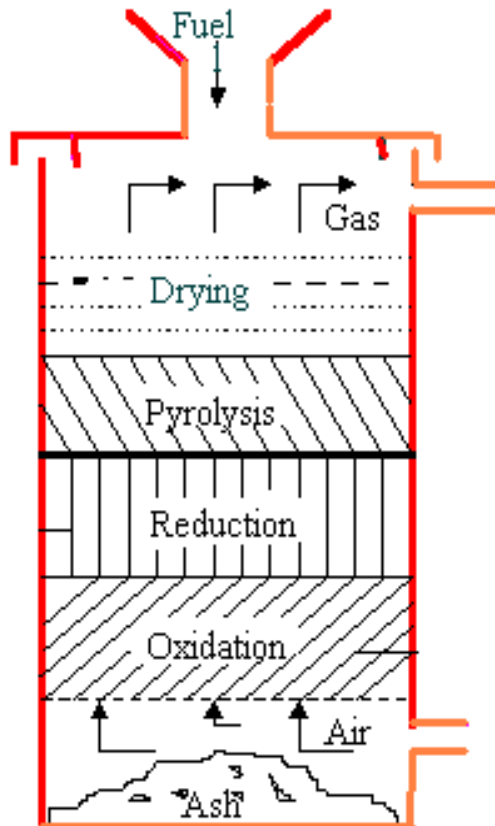
# Typical Wood Gas Composition

Component	% Volume
Methane (CH <sub>4</sub> )	1.5 – 2.5
Carbon Monoxide (CO)	18 – 24
Hydrogen (H <sub>2</sub> )	14 – 17
Carbon Dioxide (CO <sub>2</sub> )	10 – 11
Nitrogen (N <sub>2</sub> )	45 – 52

# BGCHP PLANT SYSTEMS

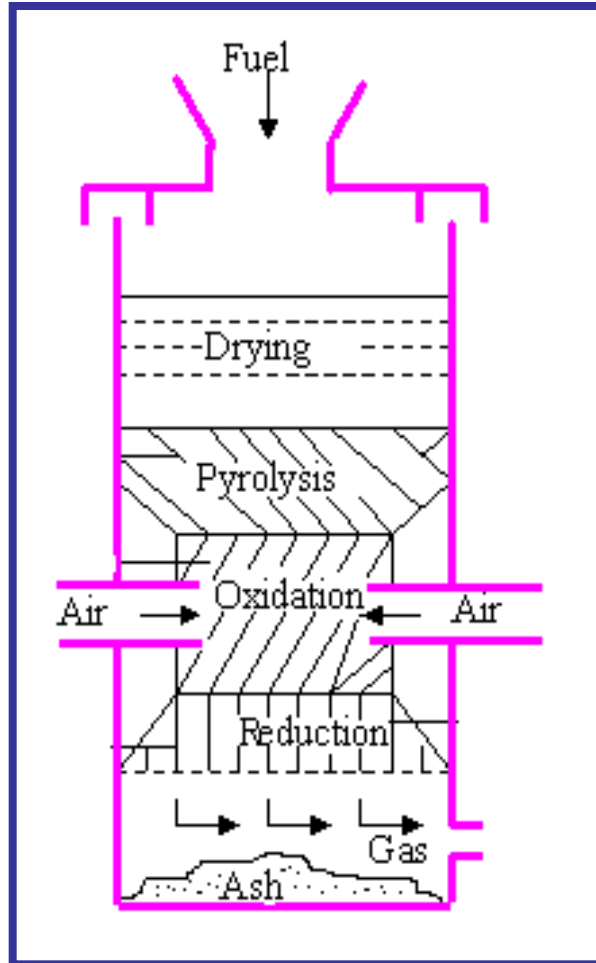


# GASIFIER OPTIONS - UPDRAFT



- Preferred feedstock -
  - $\frac{3}{4}$  - 2" Size
  - 30 – 40% Moisture
- 80 – 90% Btu conversion efficiency
- High tar content in product gas
- Suitable when product gas is used as fuel in boilers to generate heat or CHP using steam turbines

# GASIFIER OPTIONS - DOWNDRAFT



- Preferred feedstock -
  - 1/2 - 6" Size
  - 20% Moisture (Max)
- 70 – 80% Btu conversion efficiency
- Low tar content in product gas
- Suitable when product gas is used for CHP generation using an engine/generator (E/G)

# PRIME MOVER OPTIONS

- Steam turbine generators
- Compression ignited E/G – Requires 10 – 30% supplemental diesel fuel input
- Spark-ignited E/G – Requires 5 - 30% engine derating
- Future potential options
  - Microturbine
  - Solid oxide or molten carbonate fuel cell
  - Sterling engine

## SOME COMMERCIAL BG TECHNOLOGY SUPPLIERS

- Downdraft BG systems using woodchips sized biomass -
  - Indian Institute of Science (IISc), Bangalore ([cgpl.iisc.ernet.in](http://cgpl.iisc.ernet.in))
  - Ankur Scientific Energy Technologies, Baroda, India ([www.ankurscientific.com](http://www.ankurscientific.com))
  - Carbo Consult & Engineering, Johannesburg, South Africa ([www.carboconsult.com](http://www.carboconsult.com))
- Agitated bed BG systems using sawdust sized biomass -
  - Primenergy, Tulsa, OK ([www.primenergy.com](http://www.primenergy.com))

## SOME COMMERCIAL WOODGAS CHP TECHNOLOGY SUPPLIERS

- Spark Ignited CHP Systems
  - Guascor, Vitoria, Spain ([www.guascor-usa.com](http://www.guascor-usa.com)) up to 500 KW (electric)
  - GE Jenbacher ([www.gejenbacher.com](http://www.gejenbacher.com)) up to 5,000 KW (electric)
- Spark or Compression Ignited CHP Systems
  - Schmitt Enertec, Mayen, Germany ([www.schmitt-enertec.com](http://www.schmitt-enertec.com)) up to 200 – 1,000 KW (electric)

## SOME COMMERCIAL TURNKEY BGCHP SUPPLIERS

- Updraft BG system using woodchips sized biomass -
  - w/a Steam T/G - Chiptec, Burlington, VT ([www.chiptec.com](http://www.chiptec.com))
  - w/a Steam T/G or an E/G - Nexterra, Vancouver, Canada ([www.nexterra.ca](http://www.nexterra.ca))
- Downdraft BG system using woodchips sized biomass –
  - w/a Spark or Compression Ignited CHP Systems - Schmitt Enertec, Mayen, Germany ([www.schmitt-enertec.com](http://www.schmitt-enertec.com)) up to 200 – 300 KW (electric)

# BIOMASS MARKET OVERVIEW

- Majority of over 3,000 sawmills in U.S. are small family owned businesses
- Sawmill industry's fortune closely tied to housing construction, furniture manufacturing and furniture imports
- Industry sells its waste biomass on an ad-hoc basis to known buyers for resale/reuse in wood pellet manufacturing and gardening applications
- Transportation costs can be a hurdle in widespread use biomass
- Currently there is no structured market place for buying and selling waste biomass

## Some On-line Biomass Exchanges

- North American Biomass Exchange  
[NABiomassExchange.com](http://NABiomassExchange.com)
- Minnesota Biomass Exchange [Mnbiomassexchange.org](http://Mnbiomassexchange.org)
- Minneapolis Biomass Exchange [Mbioex.com](http://Mbioex.com)
- UP Woody Biomass Exchange  
[UPwoodybiomassexchange](http://UPwoodybiomassexchange)
- Biomass Commodity Exchange [BCEX](http://BCEX)

## BGCHP PLANT DEPLOYMENT ISSUES

- Host site constraints
- Environmental regulations
- KW (electric) to KW (thermal) ratio
- Delivered feedstock quality and cost
- Avoided electric and thermal energy costs
- Income from excess energy sales
- Income from renewable energy credit sales
- Production tax credits
- State grants/support
- Potential production benefits for Host

## POTENTIAL BGCHP DEPLOYMENT SITES

- Greenhouses – captive power + grid sales + heat and CO<sub>2</sub> for greenhouses
- Sawmills – captive power + grid sales + heat for dry kilns
- Industrial/institutional/commercial facilities –
  - On-site power + heat for existing thermal plant
  - Captive power + grid sales + heat
  - Co-firing with natural gas-fired CHP plants to reduce costs and gain fuel supply flexibility
- Utility steam electric power plants – incremental “green power output” and hot make-up water to reduce CO<sub>2</sub> emissions

## BGCHP PLANT - ORDER OF MAGNITUDE PERFORMANCE

- Nominal rating
  - 550 KWe (gross) and 500 KWe (net)
  - 780 KWt (2.7 MM Btu/hr) as 190 F hot water or 15 PSIG steam
- Required plant space – Approx. 10,000 Sq. Ft.
- Annual output
  - 4.0 MM KWh
  - 21,600 MM Btu (= 150,000 Gals of diesel saved)
  - 100 Tons of ash
- Annual Biomass input
  - 5,000 Tons (0% moisture)
  - 300 Truck deliveries

# BGCHP PLANT - ORDER OF MAGNITUDE ECONOMICS

	\$/Unit	\$/YR
Electricity Sold/Saved – 4 MM KWh	\$ 0.10/KWh	\$ 400,000
Fuel Saved– 150,000 Gals of diesel	\$ 2/Gal	\$ 300,000
Federal Production Tax Credit – 4 MM KWh	Not Available	\$ 0
Renewable Energy Credits Sale – 3 MM KWh (= grid sales)	\$ 0.03/KWh	\$ 90,000
Delivered biomass – 5,000 Tons (0% moisture)	\$ 40/Ton (= \$ 2.5/MM Btu)	\$ (200,000)
Gross Operating Margin		\$ 590,000
Simple Payback (depending on type of biomass and its moisture content)		4 – 6 yrs

# ELECTRIC GENERATION POTENTIAL AND REALITY IN NE AND NY ISO POOLS

- Annual resource availability estimated by NREL
  - Approximately 8 million dry tons at delivered price of \$ 0 – 40/dry ton
  - Equivalent to 16 million green tons at \$ 0 – 20/ton assuming 50% moisture
  - Equivalent to \$ 0 – 2.5 \$/MM Btu assuming 16,000 Btu/dry ton
- Annual generation potential: Approximately 2 – 6 million MWH assuming 33 - 100% resource utilization
- Actual generation: ~ 2,000 MWH in 2003 per EIA

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# REASONS FOR LACK OF BIOMASS-BASED GENERATION

- Unfriendly federal policies on production tax credit (PTC), for example, they
  - Favor biomass grown for energy generation (“closed-loop biomass”) over other waste biomass (“open-loop biomass”)
  - Set PTC for open-loop biomass at 1 Cent/KWh compared to 2.1 Cents/KWh for closed-loop biomass, solar, wind and geothermal power
  - Set 5 year PTC expiration date for open-loop versus 10 years for closed-loop biomass, solar, wind and geothermal power
  - Terminated PTC for open-loop biomass on December 31, 2009
- Need for NOx control in non-attainment areas
- Subsidized power sold to potential CHP sites, e.g. by NYPA in NYC

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## OTHER REASONS FOR LACK OF BIOMASS-BASED GENERATION

- Low prices of electricity and heat of last few years
- Competing demand for biomass use - home heating and other industries, for example, wood pellet, pulp & paper, and particle board
- Risk averse nature of small facilities/businesses
- “Big project/quick return” desire of large facilities/businesses
- “Deciders” not familiar with/aware of technology options
- Preference for PV, fuel cell and wind by state agencies
- Lack of support by state agencies, e.g. MA definition of “biomass as a renewable energy source”
- Inequality of state incentives - base load generation using biomass versus intermittent generation using PV and wind
- Improper management/follow-up of state funded projects
- Any other reasons ??????

Thank you for your time!  
Any Questions?

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