

# **Technologies and Economics of Gasification and Combustion of Alternative Energy Sources**

Presented by  
Cecil Massie  
May 19, 2006

AURI Conference at Redwood Falls, MN

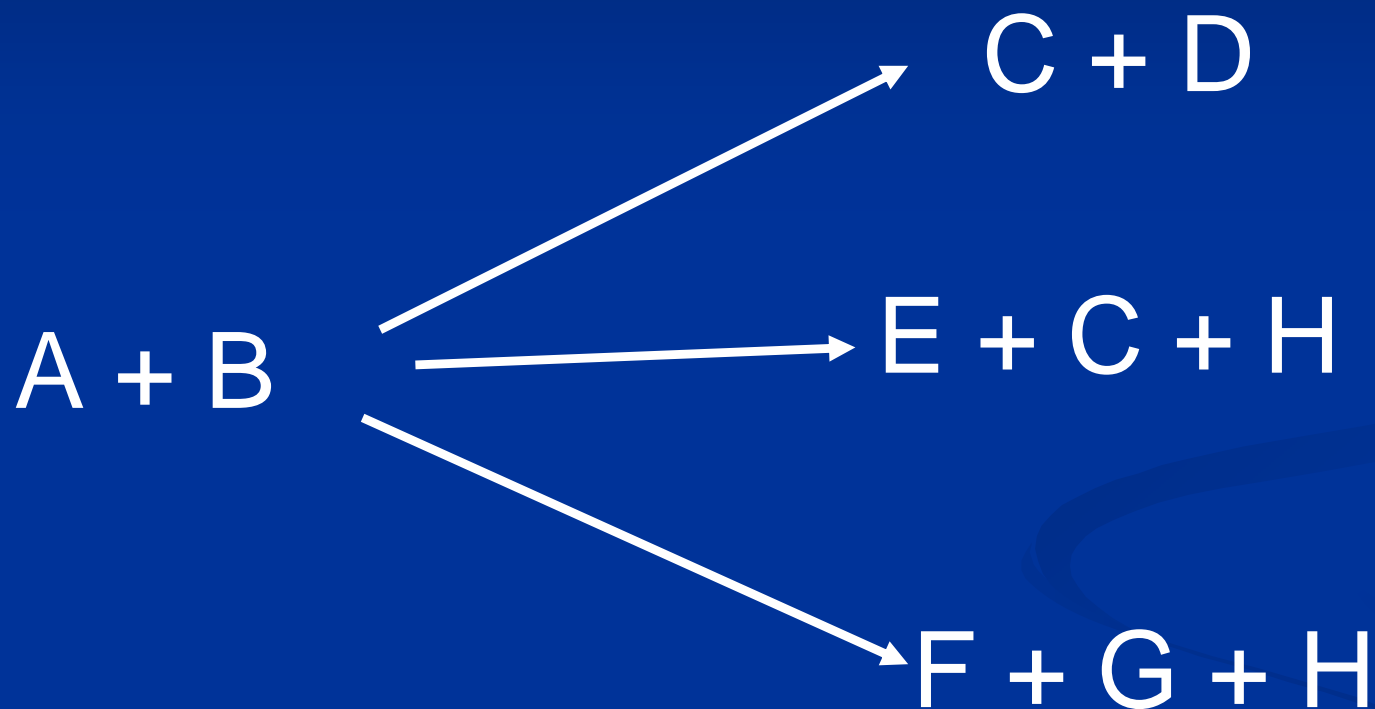
# Gasification

- Gasification is the process of converting a liquid or solid fuel into a gaseous fuel
  - Contrasted with combustion which converts a solid fuel into a gas but not a fuel gas
- Primary benefits
  - Allows use of biomass fuels as substitute for natural gas
  - Converts biomass to reaction mass for further synthesis

# Gasification Types

- Pyrolysis
- Thermal Cracking
- Air Fed
  - Updraft
  - Down draft
  - Pressurized
- Steam Reforming

# Organic Reactions Are Often Complex



# Organic Chemistry

More potential outcomes based on exact reaction conditions

Relative rates of reaction dominate over thermodynamically preferred routes

Complications are hard to manage but make possible tailoring conditions to preferred outcomes

# Corn Stover Composition

ULTIMATE (%)		
	Dry Weight Basis	Molal Basis
Carbon	48.01%	4
Hydrogen	5.47%	5
Nitrogen	2.19%	0.15
Sulfur	0.10%	0.003
Ash	5.25%	
Oxygen	38.98%	2.43
Total	100.00%	
Chlorine**	0.03%	

# Biomass Composition

- For each carbon there is one-fourth as much hydrogen as needed to make methane from all the carbon
- For each carbon there is about one-fourth of the oxygen needed to make carbon dioxide from all the carbon
- No single reaction product

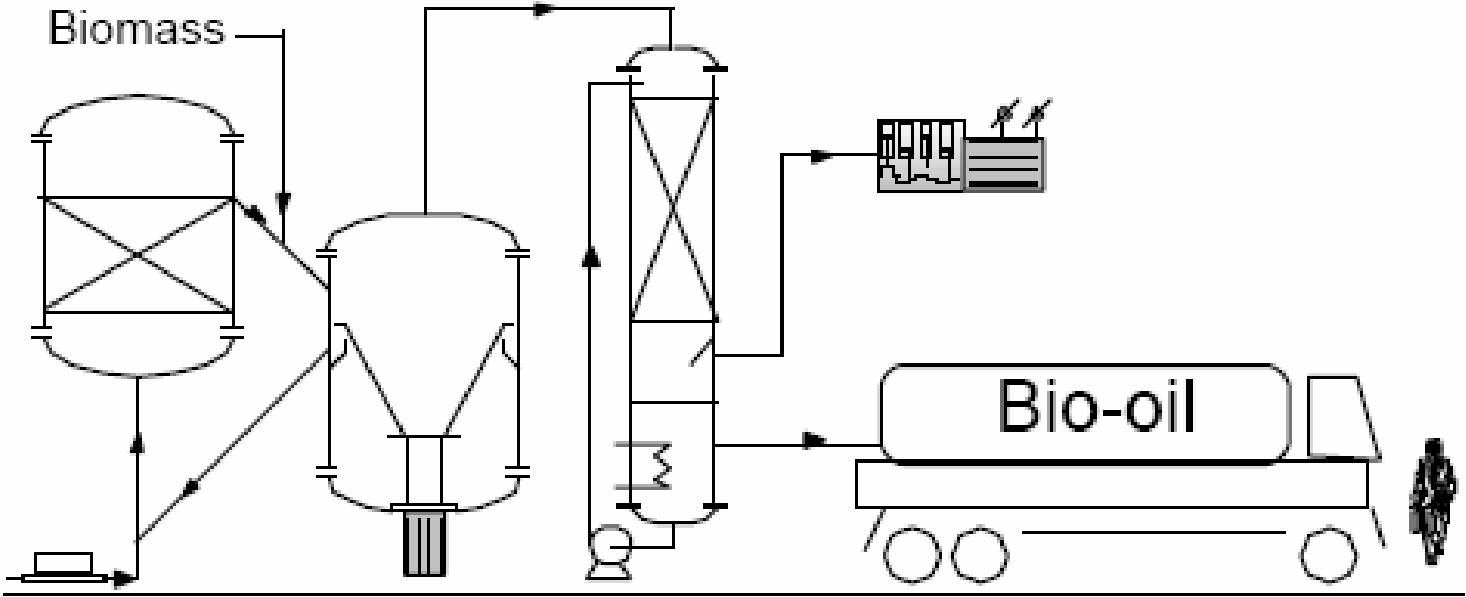
# Pyrolysis

- Pyrolysis is the process of heating in the absence of oxygen in order to cause the biomass to chemically rearrange.
- Can tolerate wide range of fuel conditions of moisture and particle size
- Endothermic - requires heat input usually from burning a portion of the fuel or char
- Primary output is liquid fuel

# Pyrolysis Densifies Biomass For Transport



Char combustor	Biomass pyrolyser	Bio-oil condensor	Gas engine
----------------	-------------------	-------------------	------------



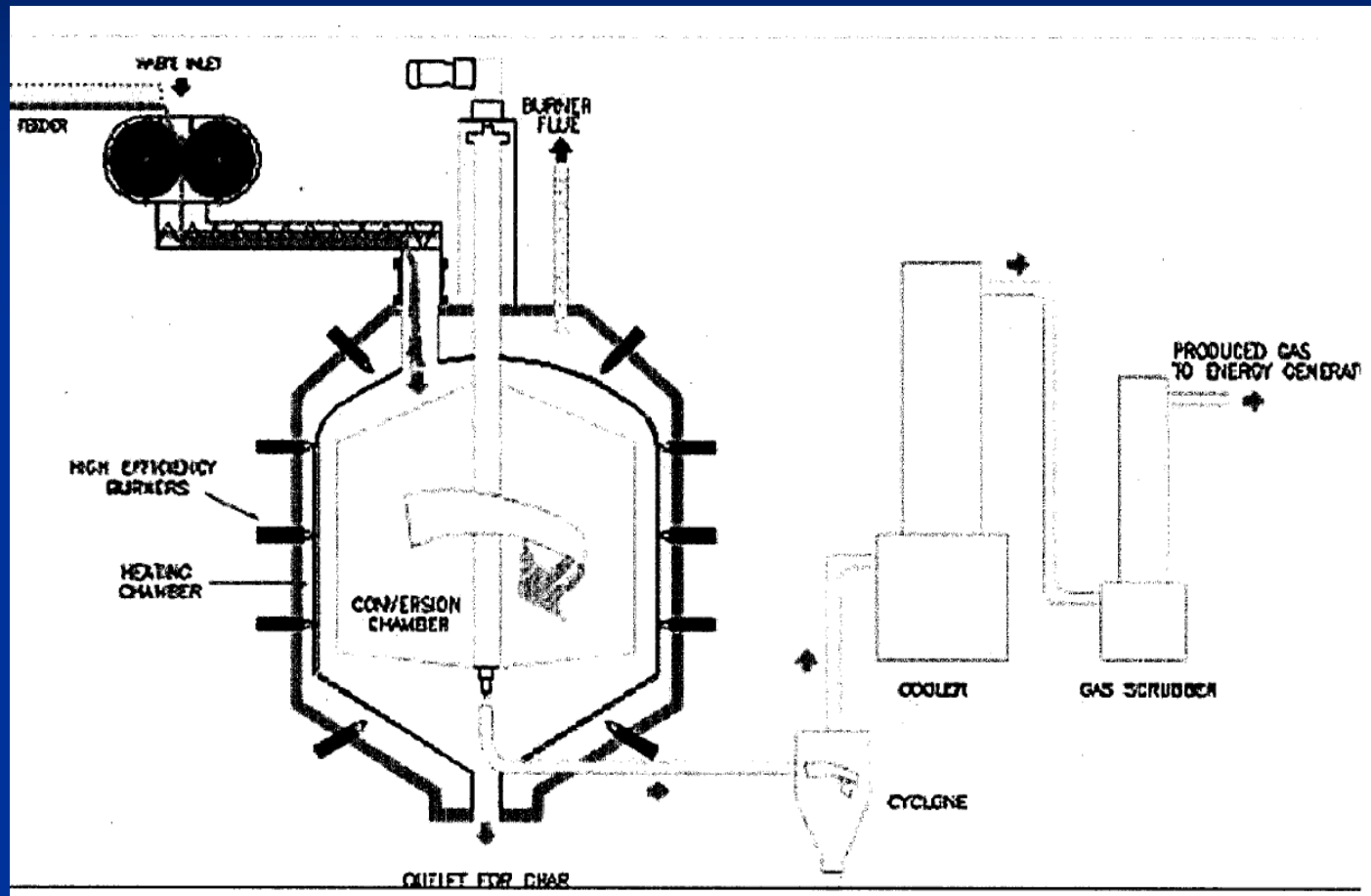
# Output Distribution

- Pyrolysis produces three types of fuels
  - 75% Liquid fuel/bio oil of varying composition
  - 15% Gas mixture containing hydrogen, methane and unsaturated organic vapors
  - 10% Char containing the residual carbon and ash
    - Can be burned to supply the process energy

# Thermal Cracking

- Thermal cracking is ultra-fast pyrolysis
- Fuel requirement
  - Low moisture content
  - Small particle size
- Objective is near instantaneous thermal penetration
- Output gas is mostly methane (45%) with hydrogen/carbon monoxide/nitrogen roughly equal
- Suitable for further reactions to make alcohols or SNG

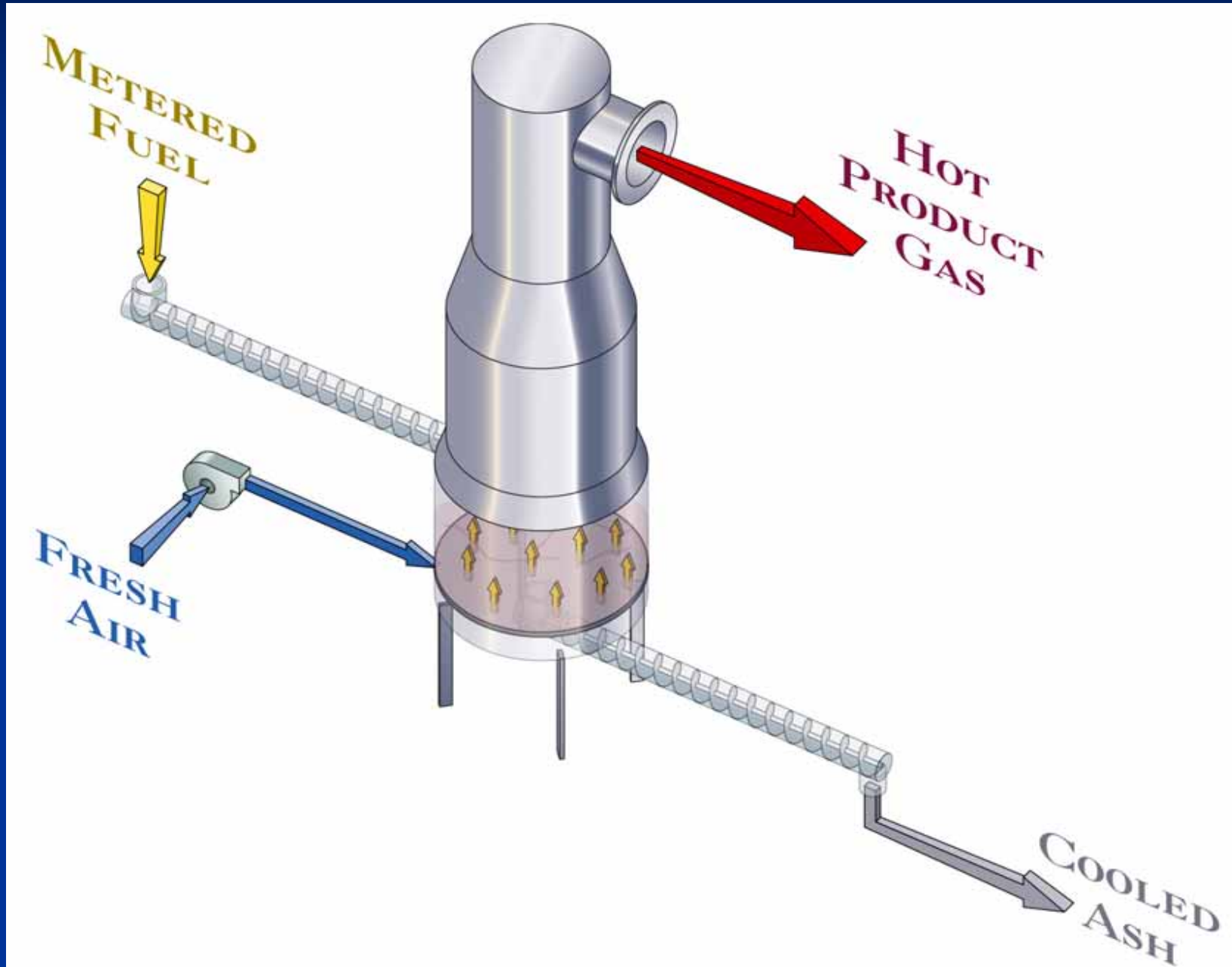
# GEMS Thermal Cracking



# Air Fed Gasification

- Best suited for production of fuel gas to be used on-site for thermal energy
- Fuel requirement
  - Moisture typically less than 30%
  - One dimension less than 1/8 inch
- Process is exothermic and self sustaining
- Product gas is predominately carbon monoxide, hydrogen and nitrogen
- NO<sub>x</sub> and SO<sub>x</sub> control

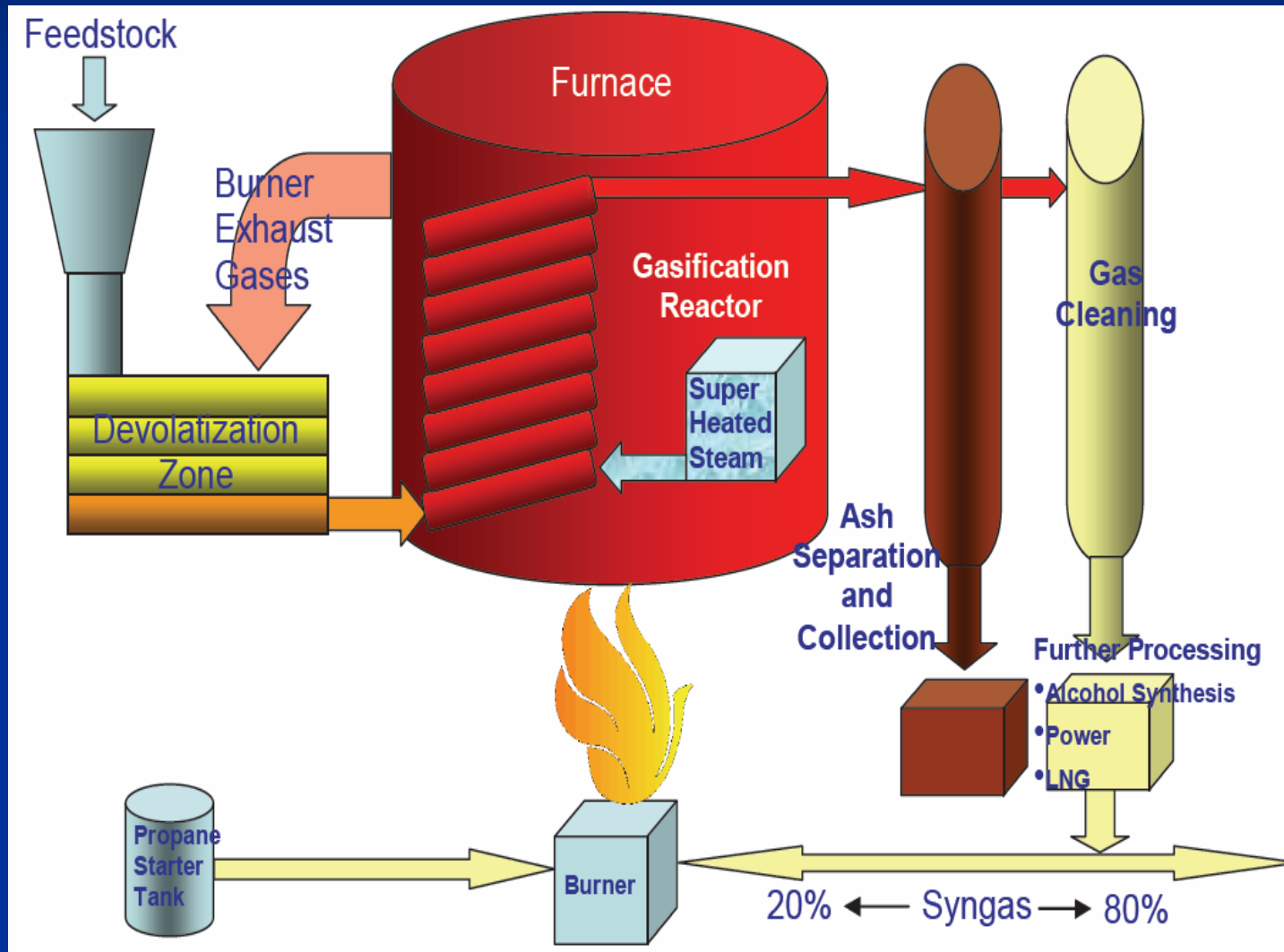
# *Primenergy Air Fed Gasifier*



# Steam Reforming Gasification

- At elevated temperature carbon will strip oxygen from water to form carbon monoxide and hydrogen
- Process is endothermic and uses roughly 20% of the heating value of the fuel for the process
- Product gases are hydrogen and carbon monoxide with small amounts of methane
- Suitable for reforming to alcohols/SNG

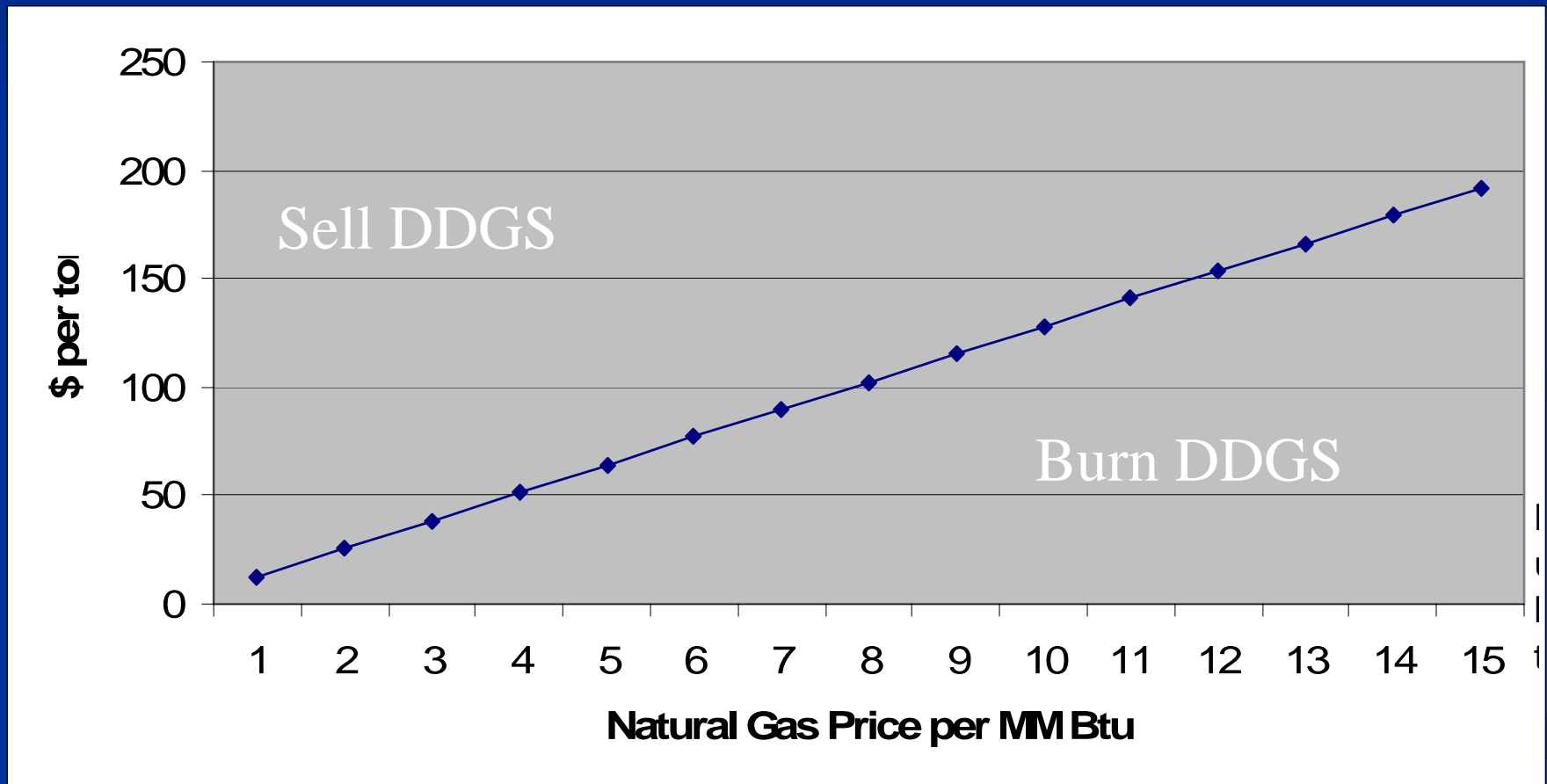
# BCT Steam Reforming Gasifier



# Economics

- Feed/biomass co-products are typically sold for less than the value of their energy content
  - DDGS, soybean hulls, barley hulls
- Biomass imported to a site will cost from \$2 to \$4 per million Btu recoverable
- A good rule of thumb is add \$2 to \$3 per million Btu to the cost of the fuel to cover capital and operating costs
- Barriers are high capital cost investment and air permitting

# Valuing DDGS vs NG



Multiply natural gas price by 12.8 for burner tip equivalent

# In Summary

- Gasification allows use of biomass fuels as substitute for natural gas
- Technology selection is driven by fuel supply and intended use
- Economics are generally favorable where the biomass is on site or available for less than \$4 per million Btu

# Thank You

Cecil T. Massie  
VP 6Solutions LLC  
612-819-2235  
c.massie@att.net