Biopower: Technology and Policy Challenges

NYSERDA EMEP November 2007

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Outline

- 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

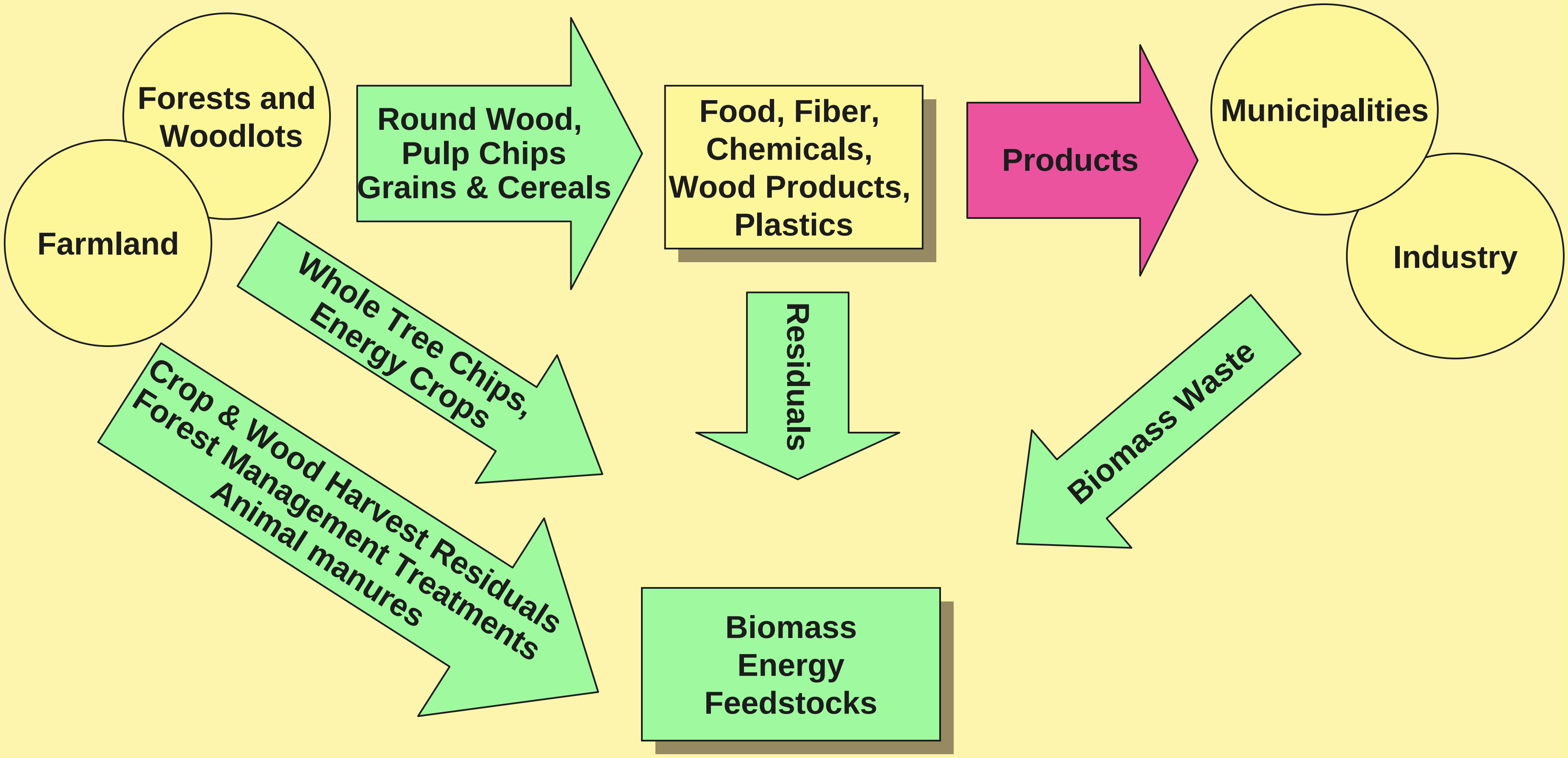
FEEDSTOCKS

- **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

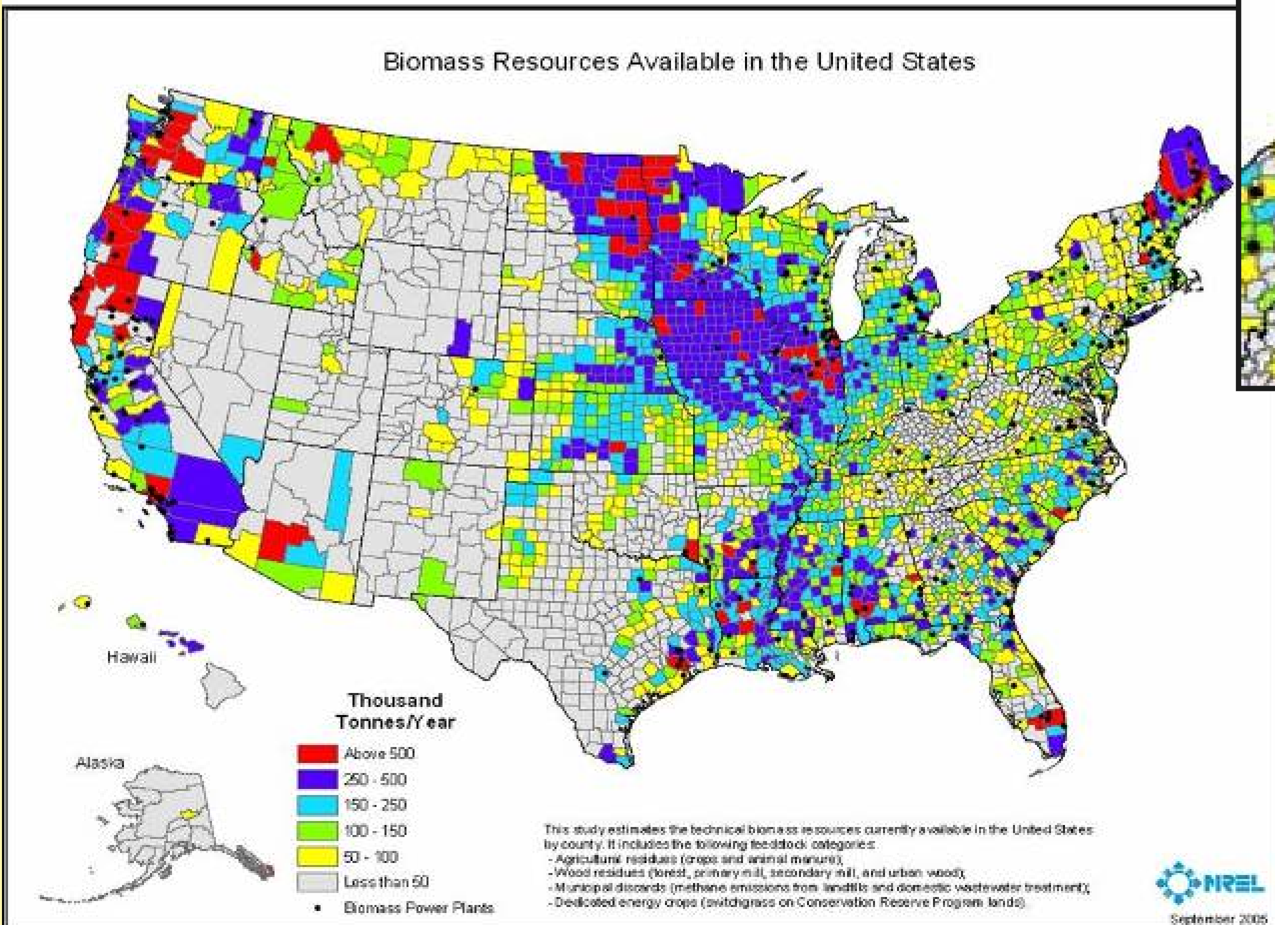


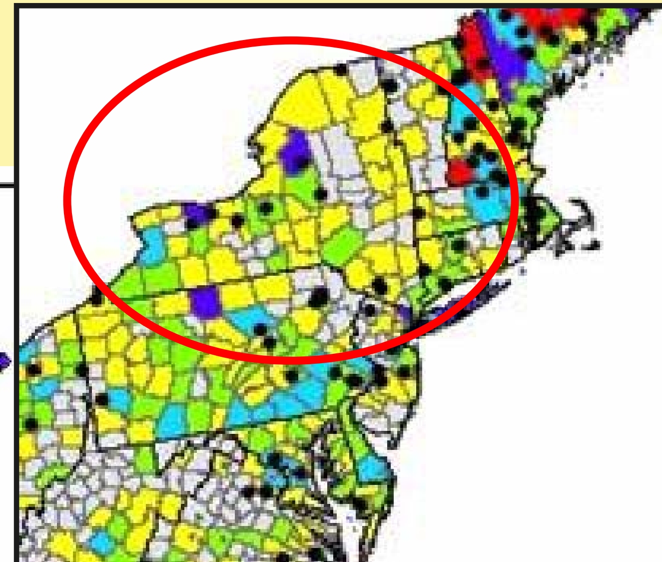
Annual Biomass Production Potential

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)

Agricultural & Wood Residues - US





New York Biomass Power

New York Biomass Power Plants

Year	**2005**	**2012**
MW (capacity)	400	860
Source	Platts	NYSERDA 2003

> 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**

Platt's North America Power Plant Database, October 2005, http://www.platts.com
Energy Efficiency and Renewable Energy Resource Development Potential in New York State, Vol. 1, prepared for NYSERDA, 2003.
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

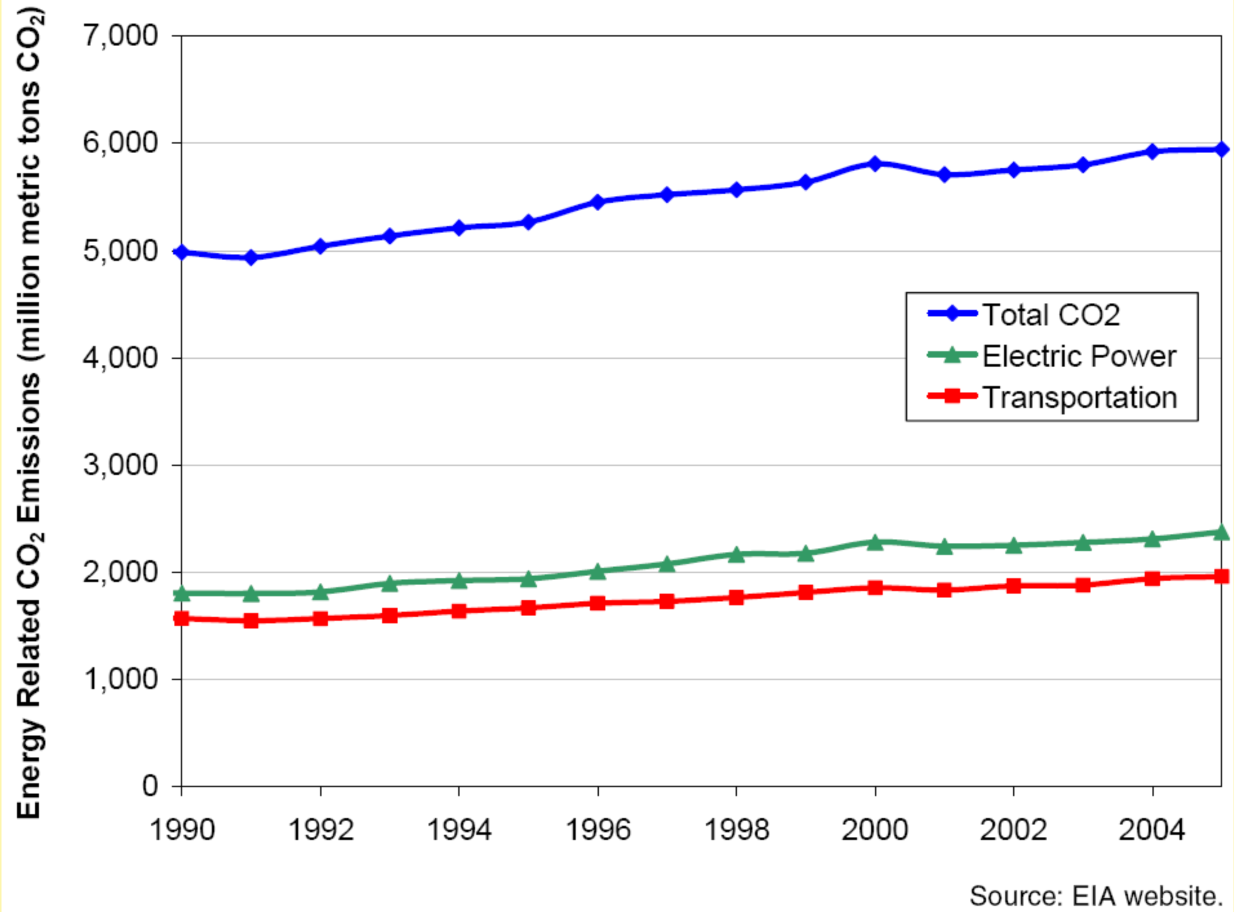
- Feedstock production, harvest & transport
  - Assuring biological replenishment
  - Maintaining ecosystem health
  - Managing inputs (fertilizer, water)
  - Efficient transport
- Energy conversion
  - Higher efficiency reduces feedstock demand
  - New technologies aid removal of contaminants
- End 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 CO_2 Emissions



Key Questions:

To what extent will electricity provide transport services?

To which sector will biomass resources be directed?

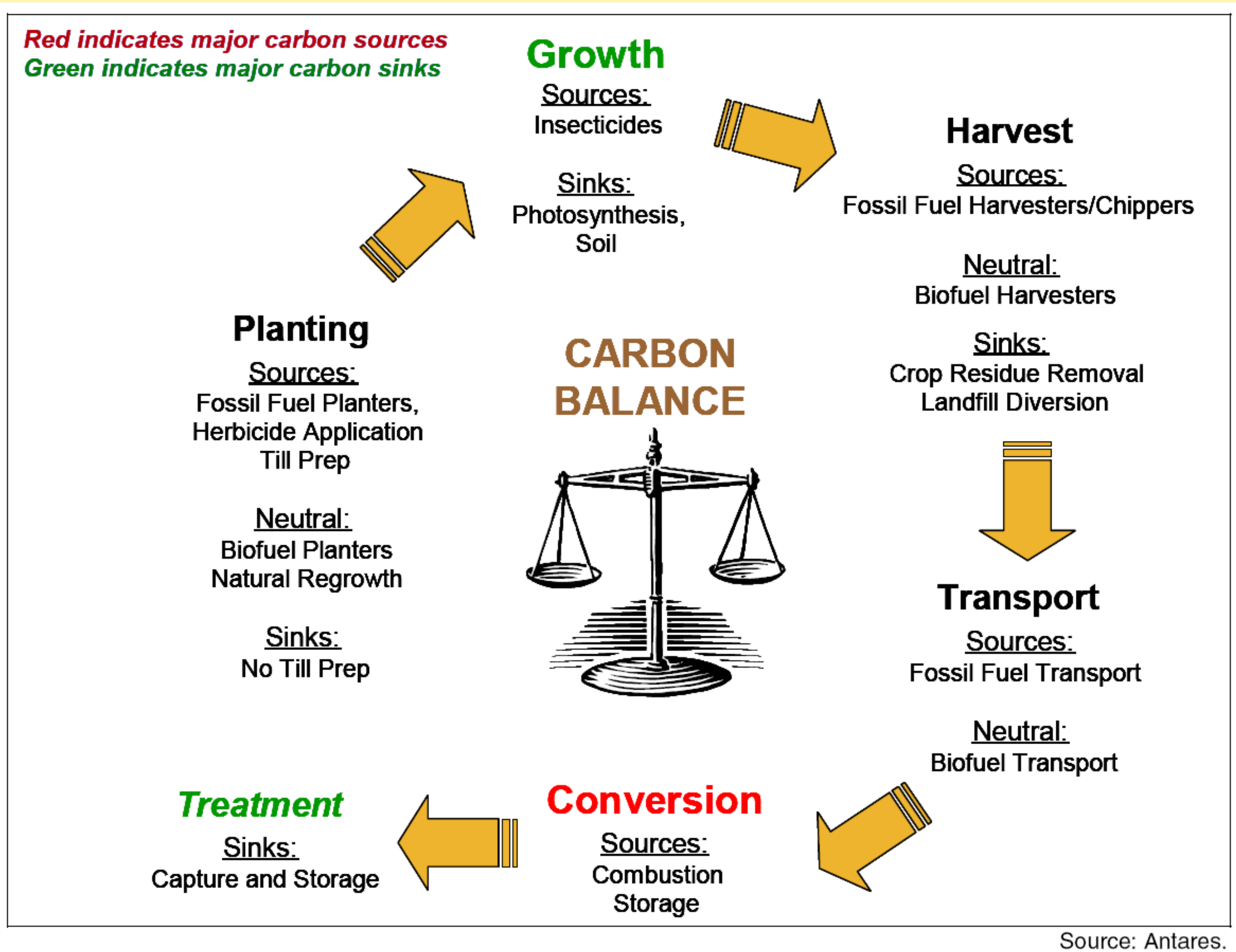
<u>Source</u>: *Program on Technology Innovation: An Assessment of the Future Potential for Biomass Electricity Generation in a Carbon-Constrained World.* EPRI, Palo Alto, CA: 2007. 1014828.

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.

Source: *Program on Technology Innovation: An Assessment of the Future Potential for Biomass Electricity Generation in a Carbon-Constrained World.* EPRI, Palo Alto, CA: 2007. 1014828.

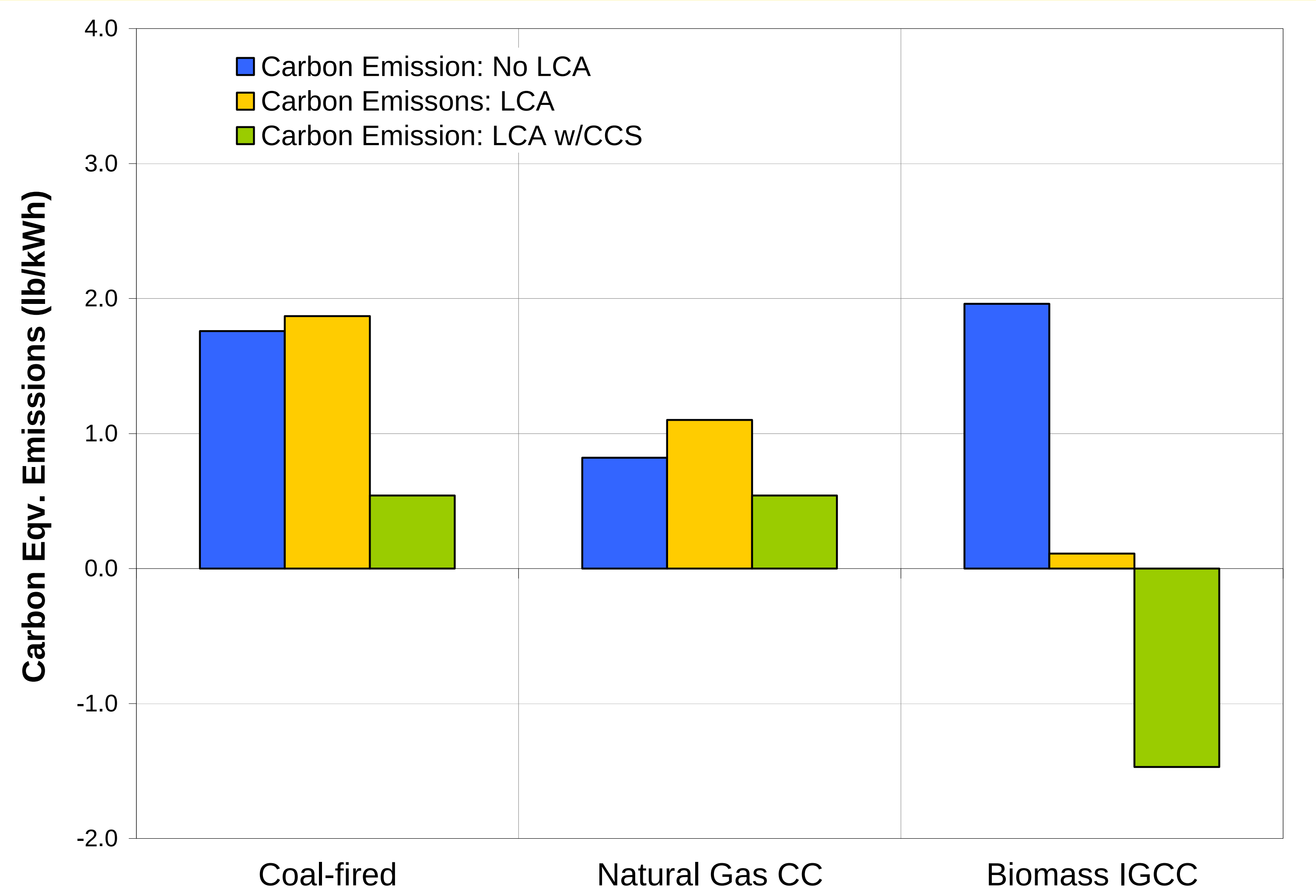
Biomass Power - Carbon Cycle



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

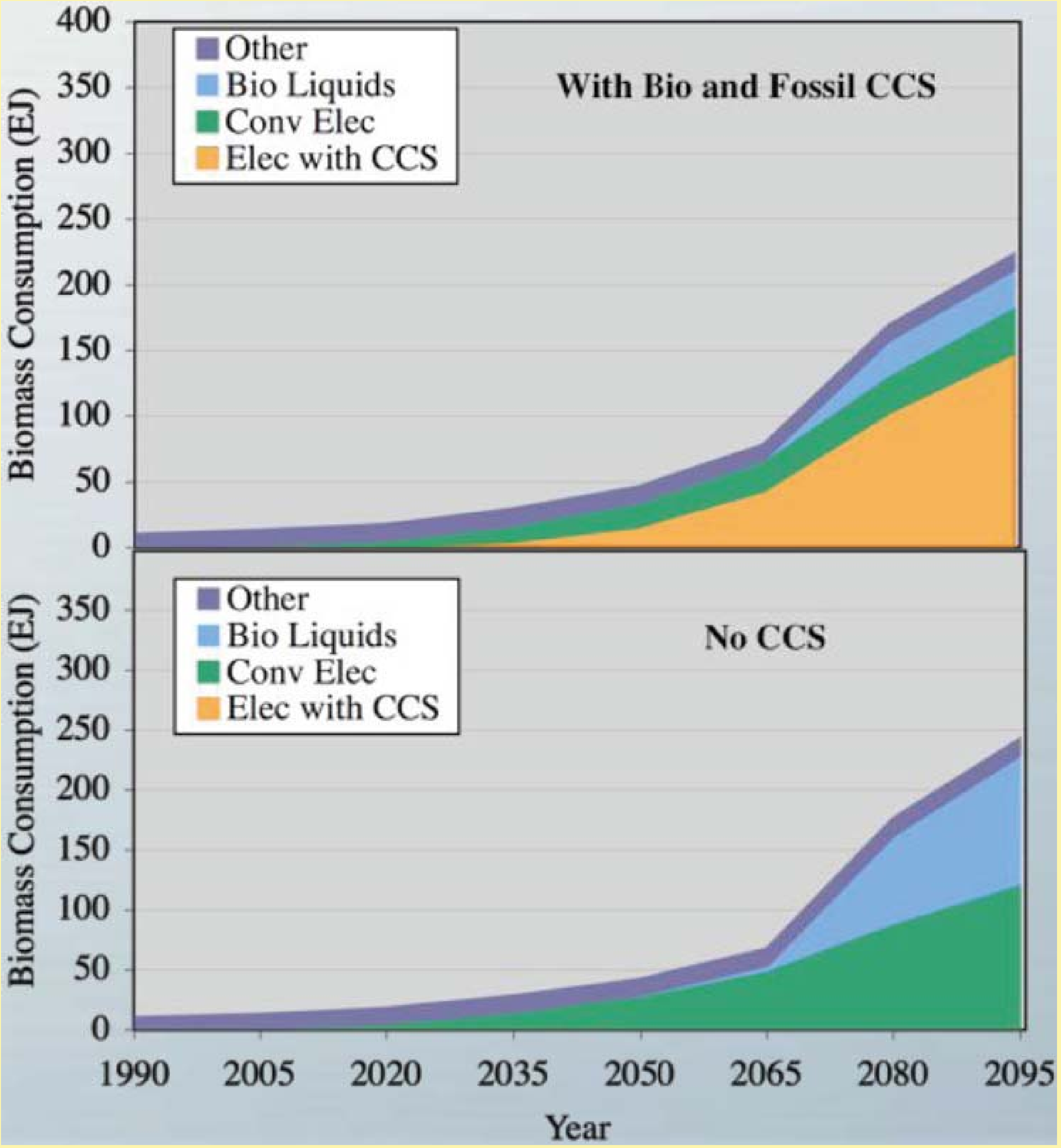
Source: *Program on Technology Innovation: An Assessment of the Future Potential for Biomass Electricity Generation in a Carbon-Constrained World.* EPRI, Palo Alto, CA: 2007. 1014828.

GHG Emissions by Technology



Based on Data from*: Program on Technology Innovation: An Assessment of the Future Potential for Biomass Electricity Generation in a Carbon-Constrained World.* EPRI, Palo Alto, CA: 2007. 1014828.

Potential CCS Impact

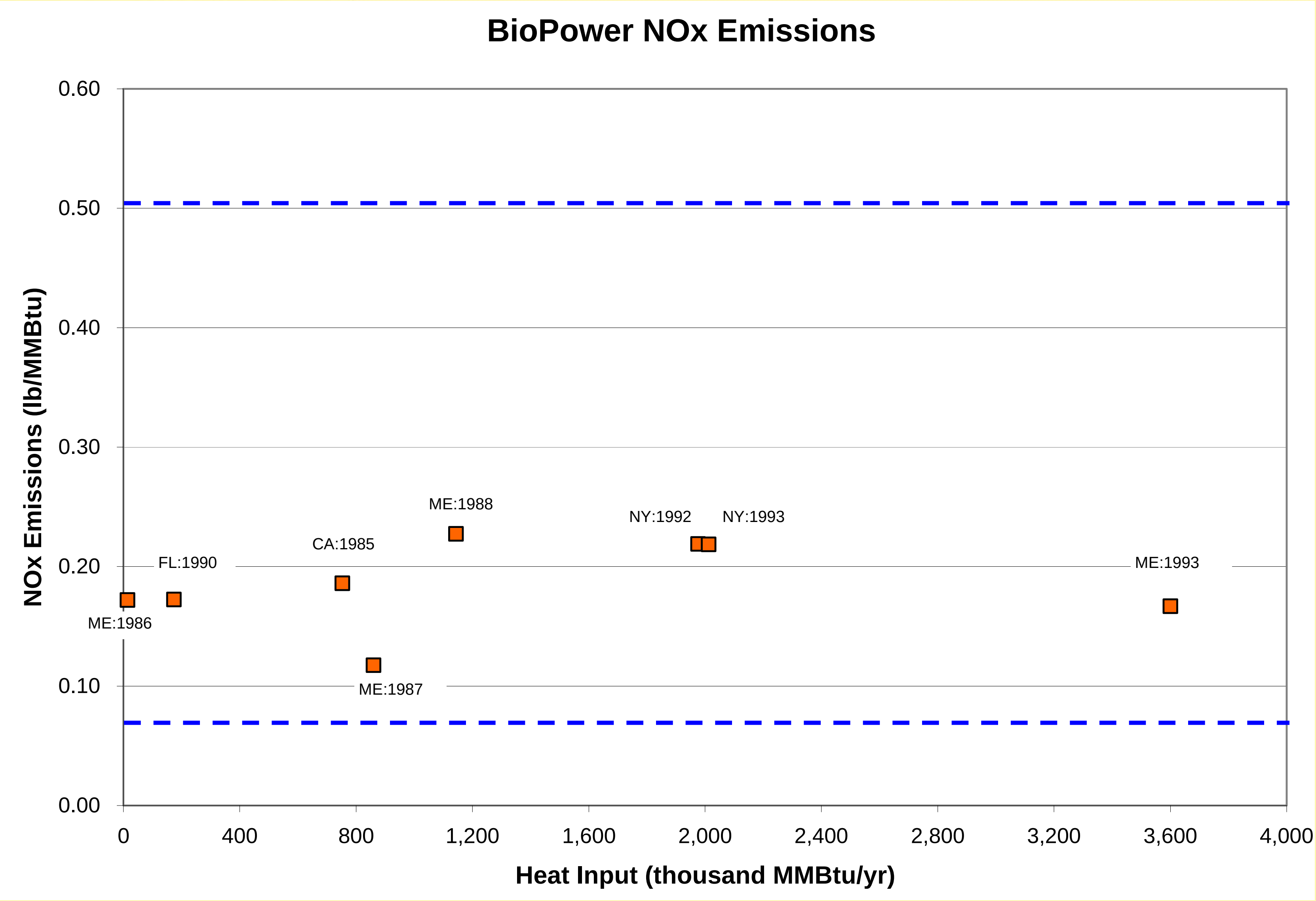


Steven J. Smith, Antoinette Brenkert, Jae Edmonds, Biomass with Carbon Dioxide Capture and Storage (CCS), GTSP Presentation, May 23, 2006.

The MiniCAM is a long-term, partial-equilibrium model of the energy, agriculture, and climate system.

Other Emissions from Biomass Power

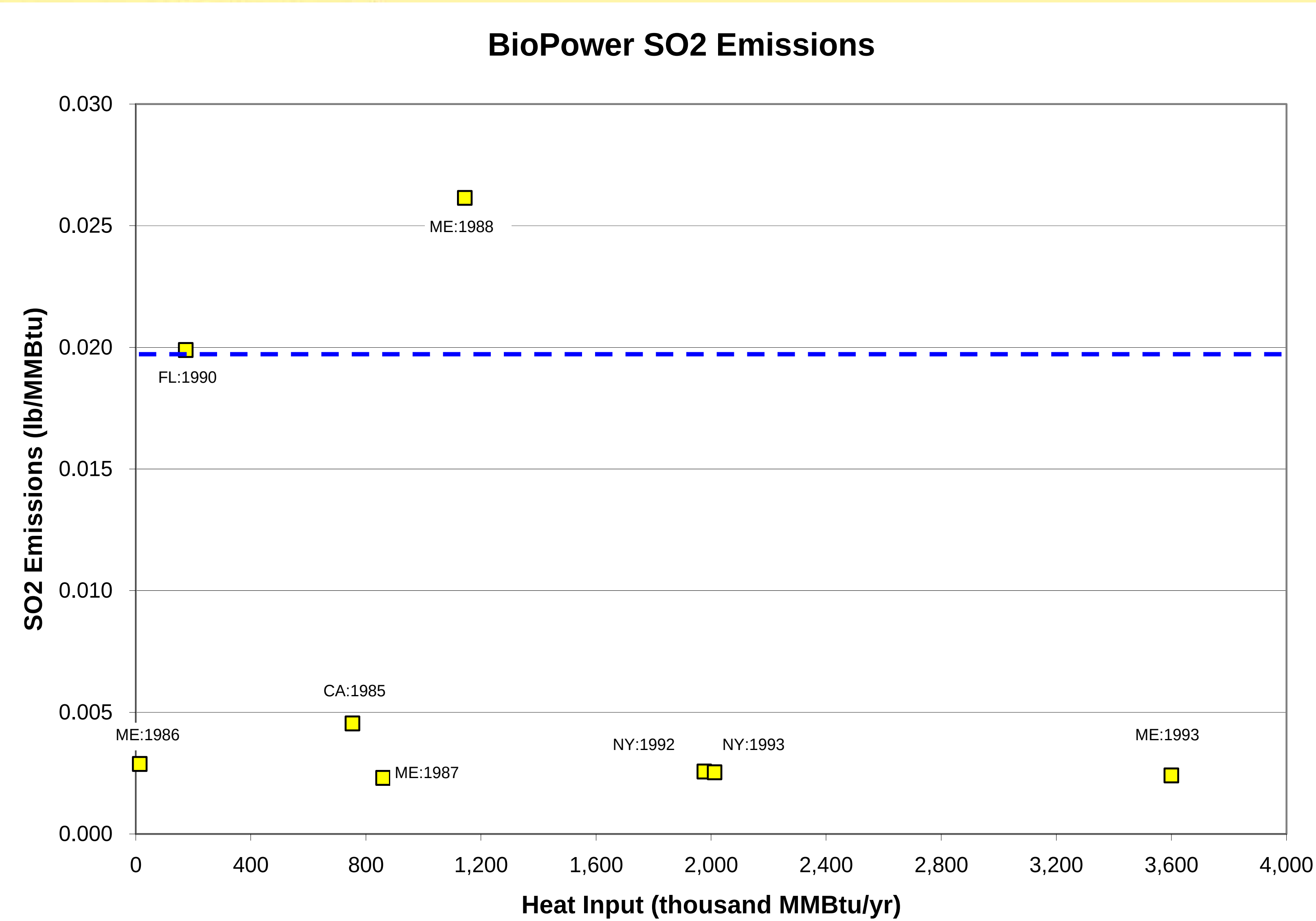
EGrid – NOx Emissions Data



NSPS Limit

PSD Limit

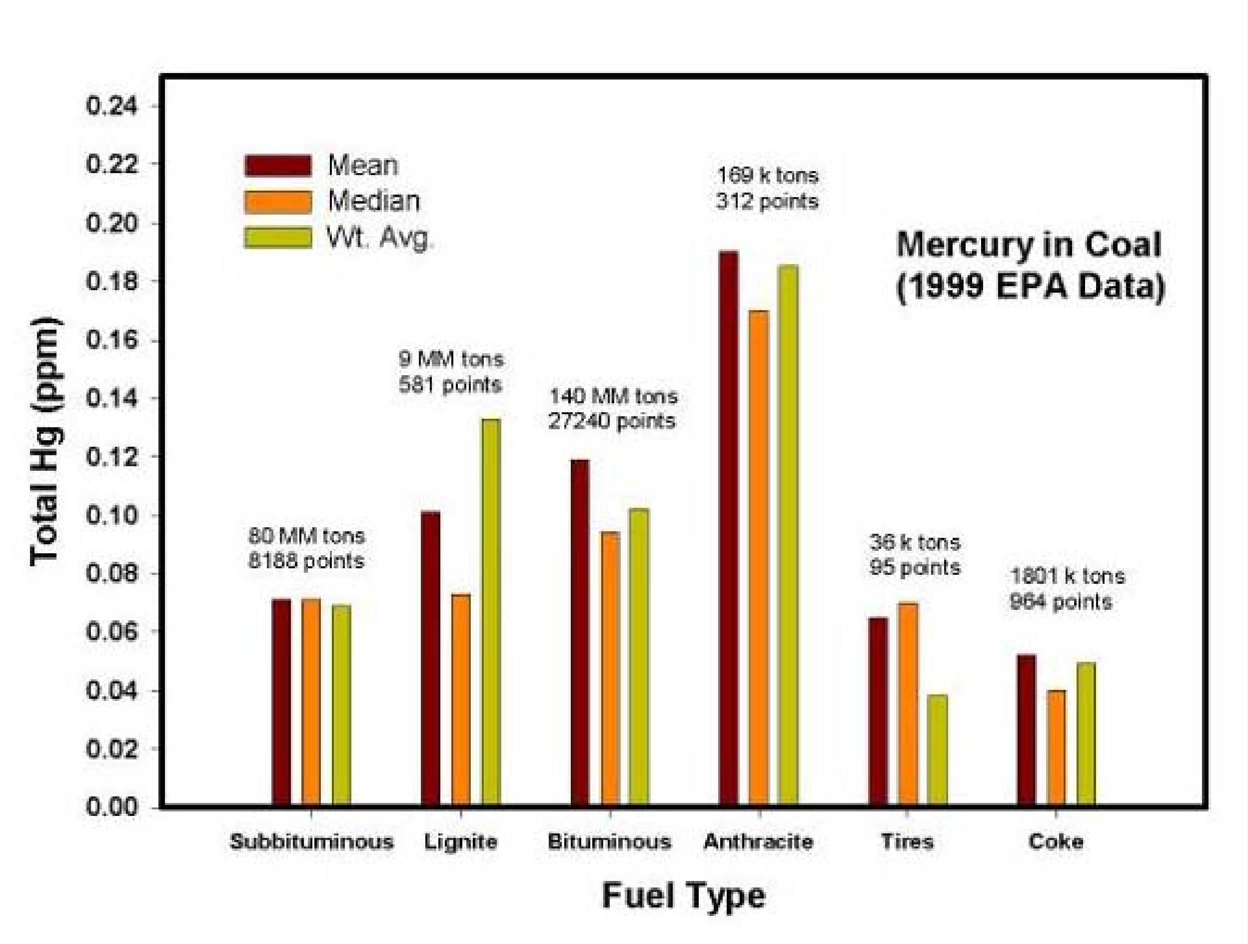
EGrid – SO2 Emissions Data



NSPS Limit 0.15 lb/MMBtu

PSD Limit

Mercury Concentration



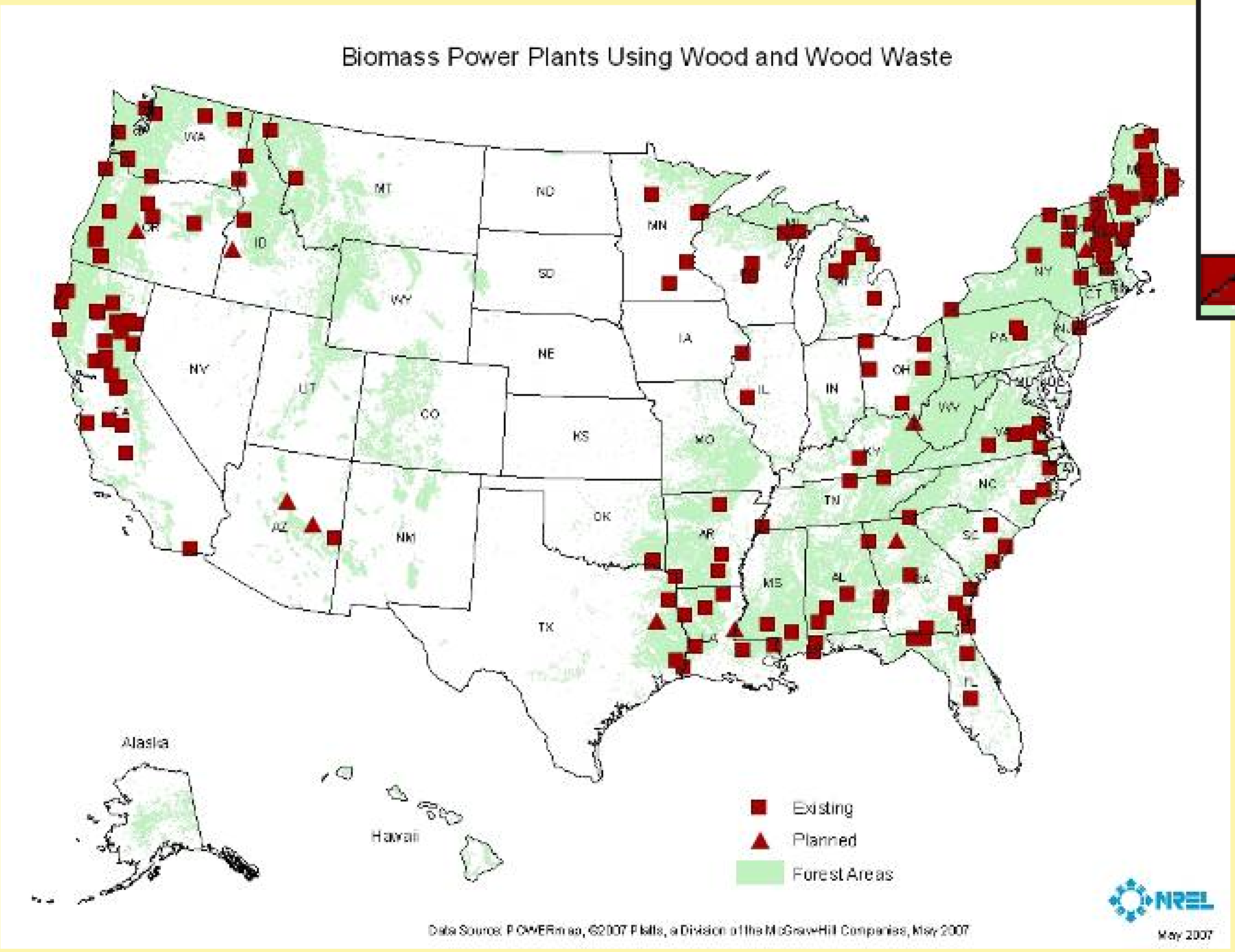
Natural mercury levels in plants range from 0.001 to 0.1 ppm (dry weight).

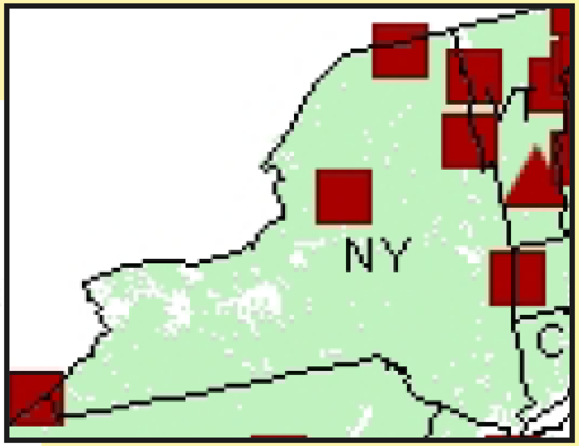
U.S. Environmental Protection Agency, Unified Air Toxics Program: Electric Utility Steam Generating Units Hazardous Air Pollutant Emission Study, 2000
Mercury Releases from Deforestation, University of British Columbia Department of and Mineral Process Mining Engineering

Biomass Power Development

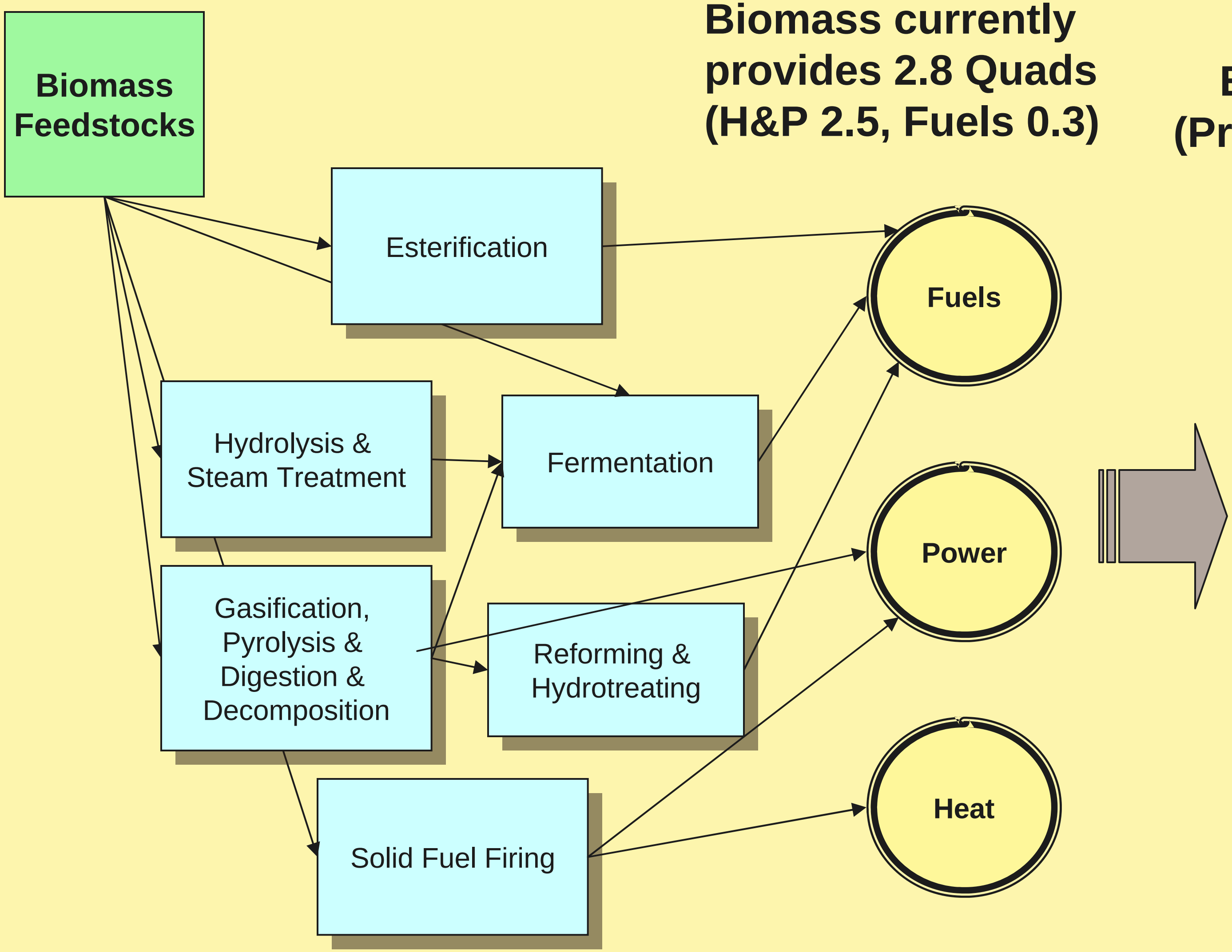
Benefits and Challenges

US Biomass Power Plants - 2007



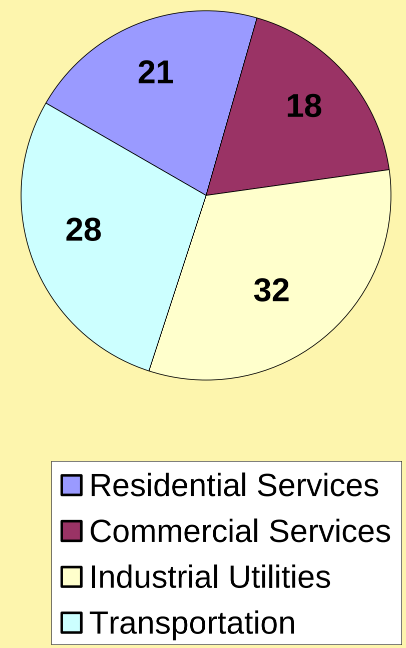


Conversion and Delivery



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

Economic Sectors (Primary Quads - 2006)
EIA 2007



Conversion Options – Solid Fuel Firing/Cofiring

Shasta, CA

Ottumwa, IA

Schiller, NH

Conversion Options - Gasification and BIGCC

USC Cogen
1.38 MW +
60 klbs/hr

Nuon Power, NL
~25 MW of
250MW total

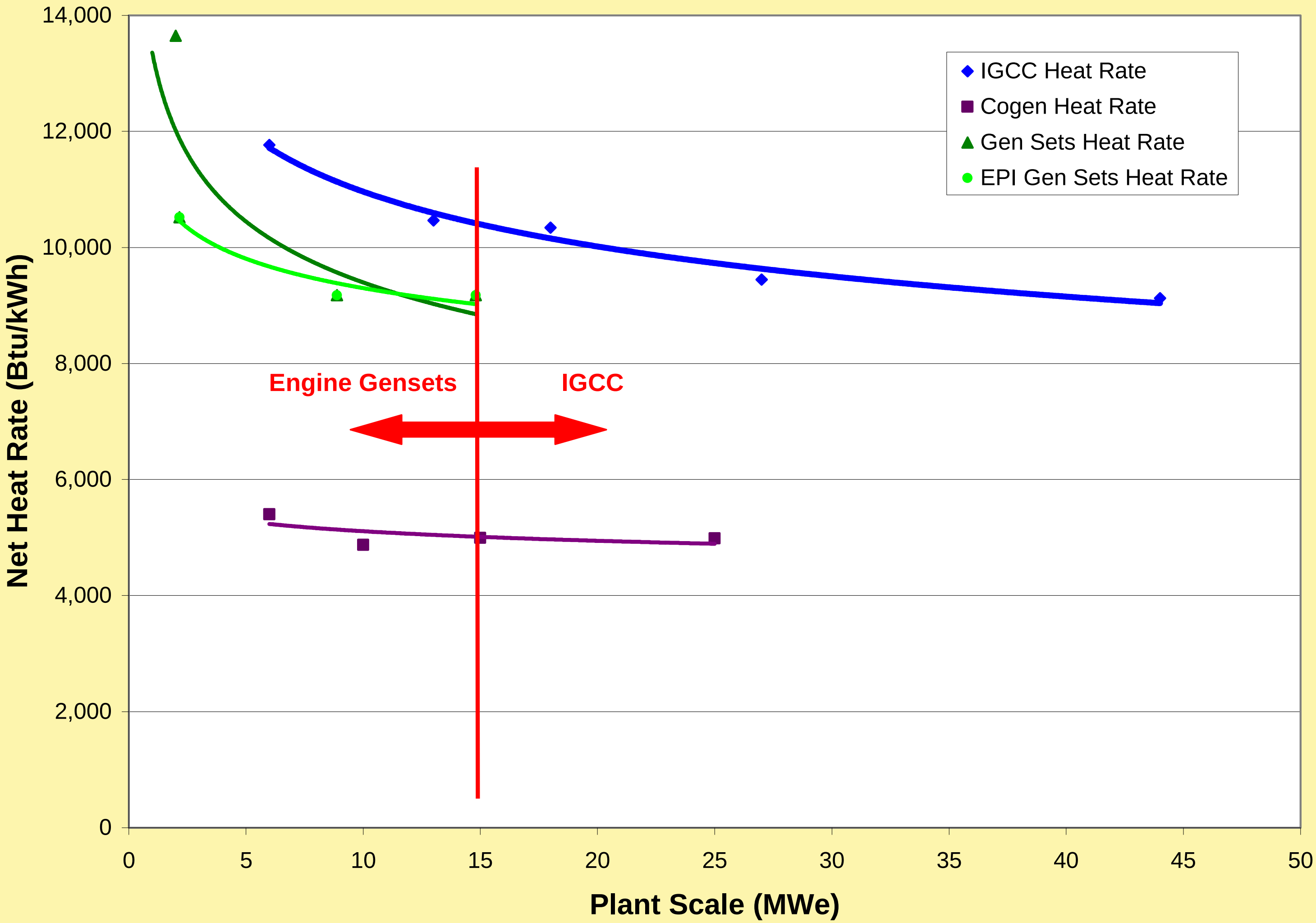
Amer-9 NL
39 MWe of
650 MWe total

Power Plant Efficiency

	Net Output (MWe)	Net Heat Rate (Btu/kWh)	Source
Biomass direct-fired (stoker)	50	14,840	Renewable Energy Technology Characterizations, EPRI 1997
Coal – PC sub-critical	500	9,500 – 10,300 (1)	EPA Presentation 2006
Coal IGCC	500	8,170 – 8,700 (1)	EPA Presentation 2006
Biomass IGCC	50	9,000	Antares in-house resources (WGA report)
NGCC	400	7,500	EPRI 2000

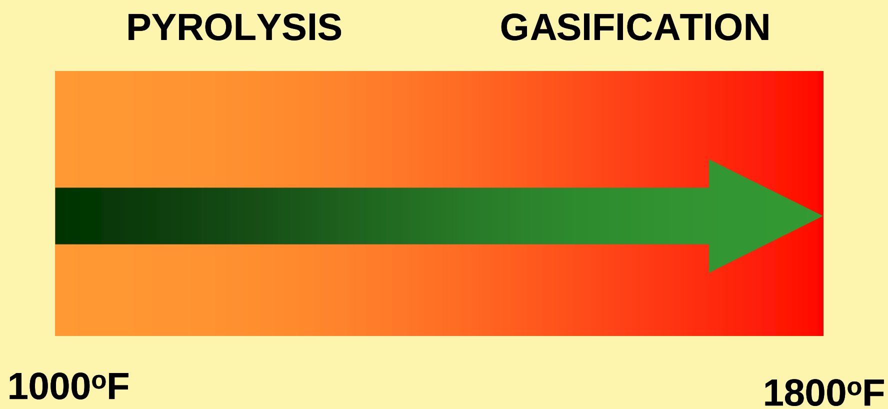
1). Depends on coal type. Bituminous has lowest heat rate, lignite has the highest.

Conversion Efficiency – Biomass Plants



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.

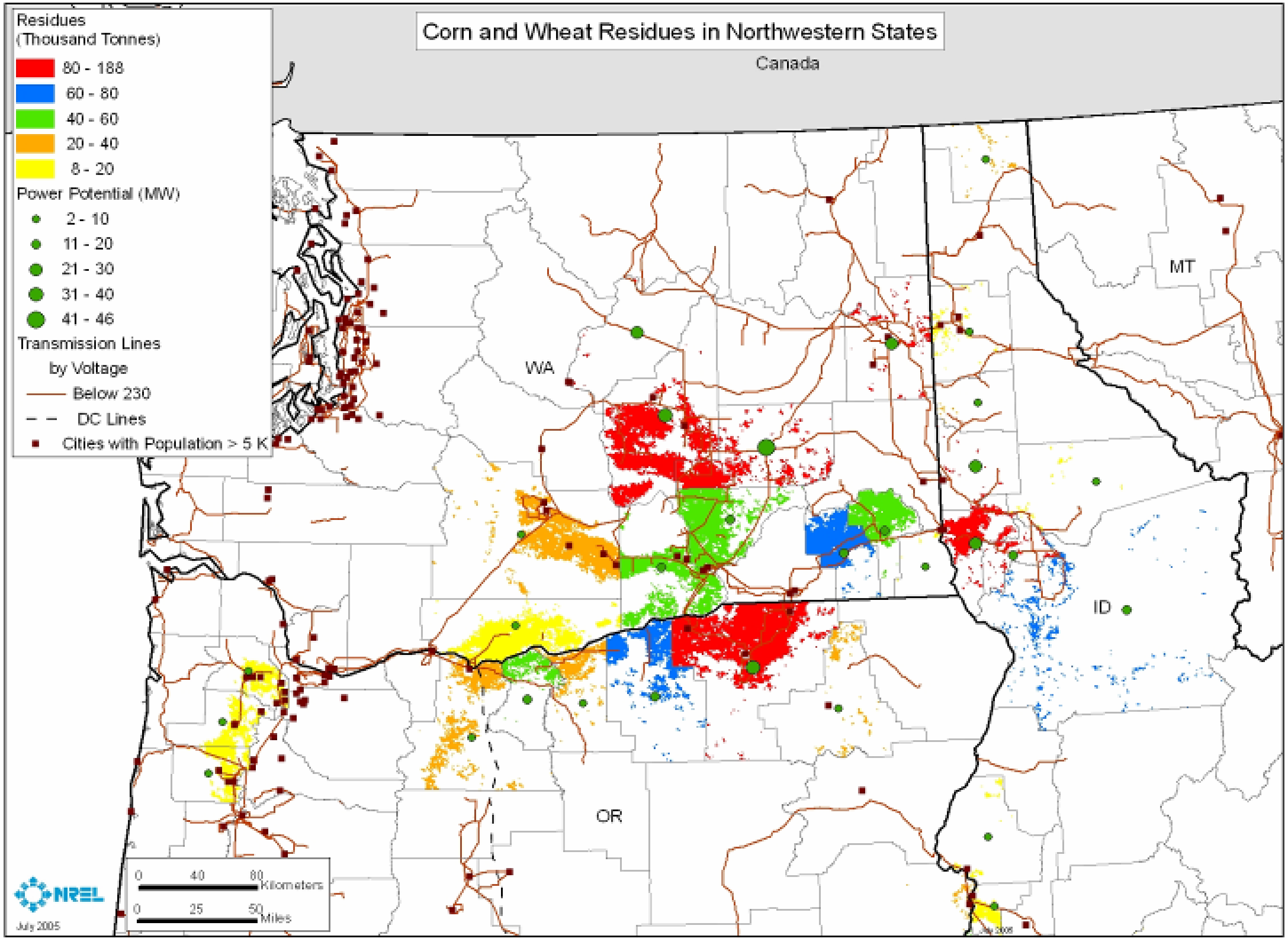


Challenges for Gasification

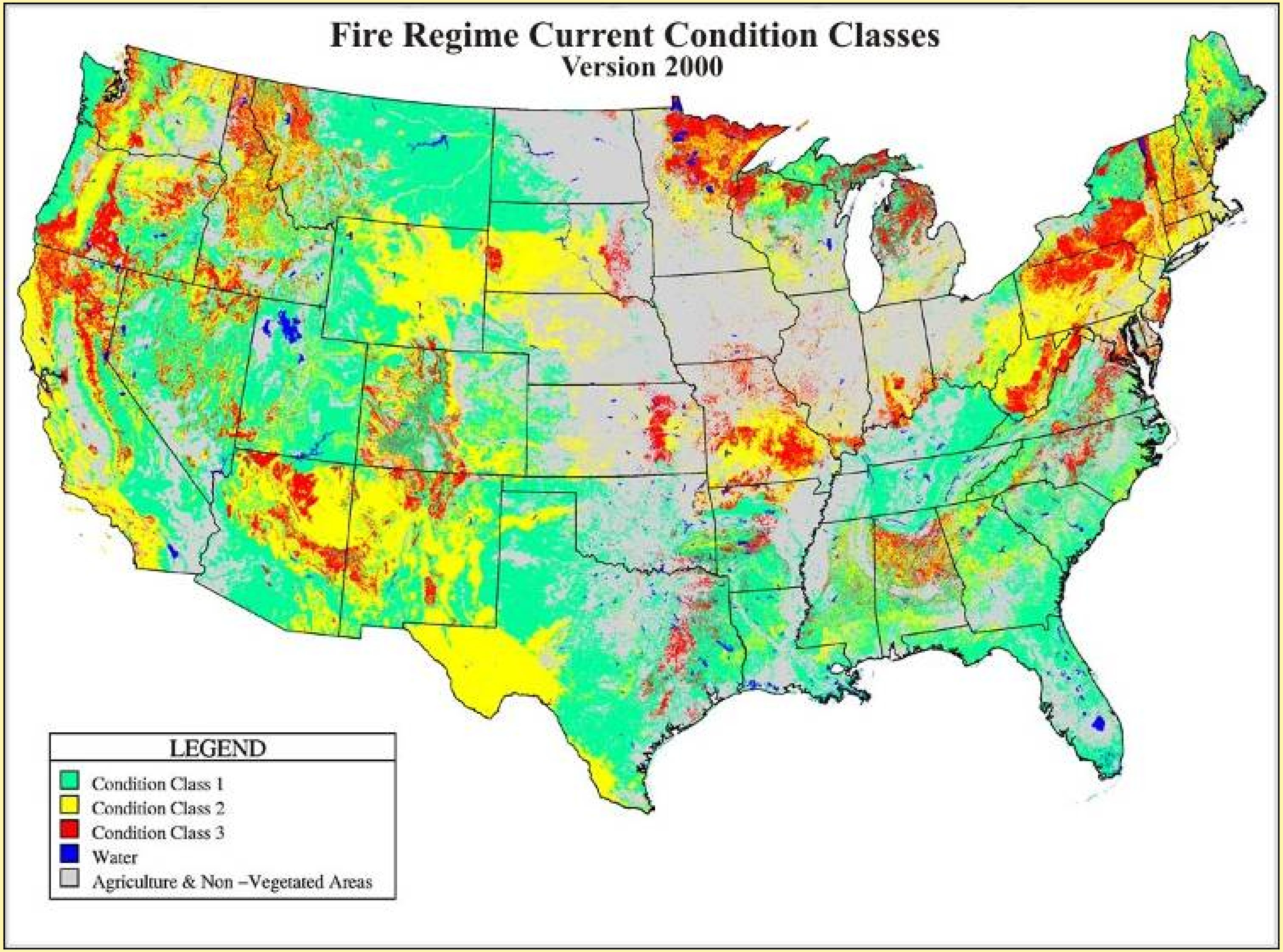
1. High moisture content of un-dried biomass
2. Commercial availability of gas clean-up technologies that are sufficiently robust and effective to allow use in a turbine or engine
3. Relatively high cost of gasification equipment, currently built on a custom basis
4. Limited industry experience in using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

Biomass Supply Development

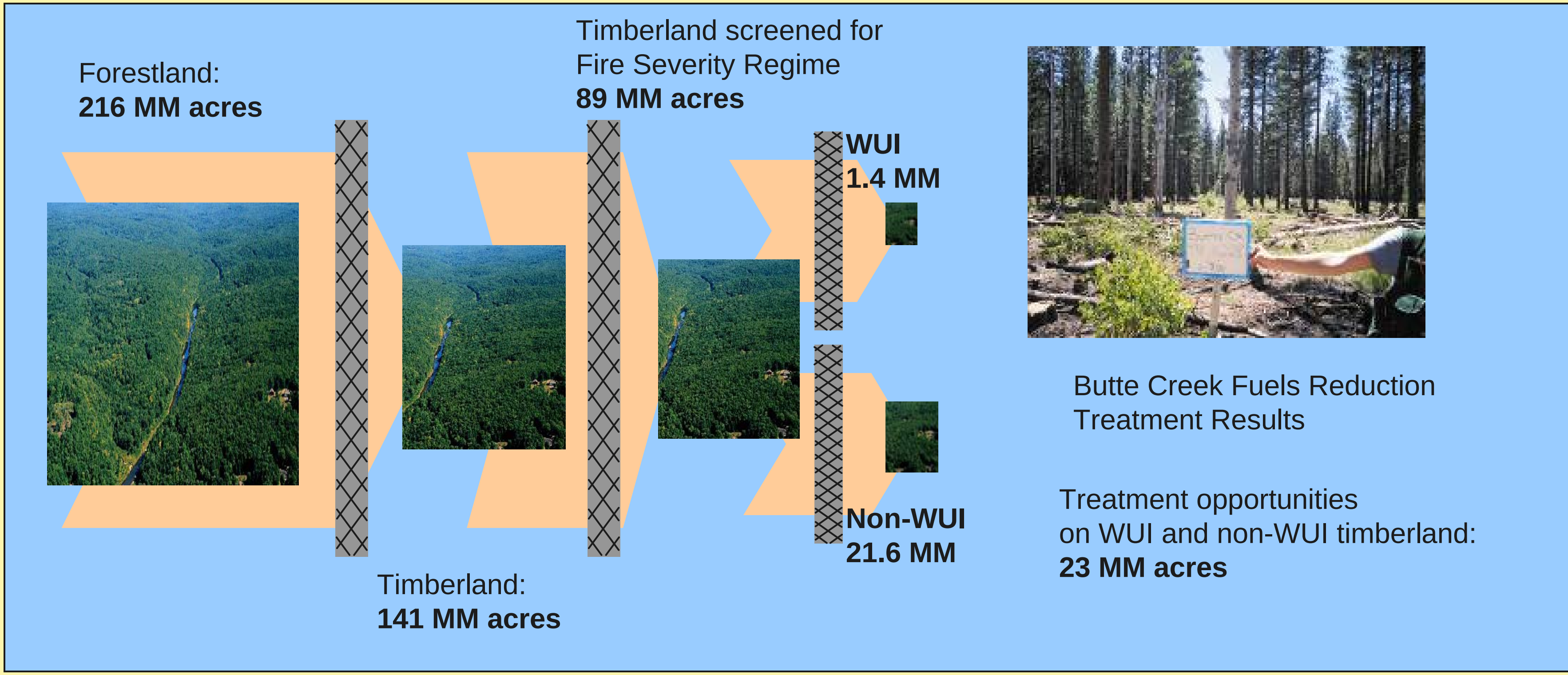
Biomass Resource Distribution



Maintaining Healthy Forests and Restoring Fire Adapted Forest Ecosystems



Fire Risk Reduction Opportunities



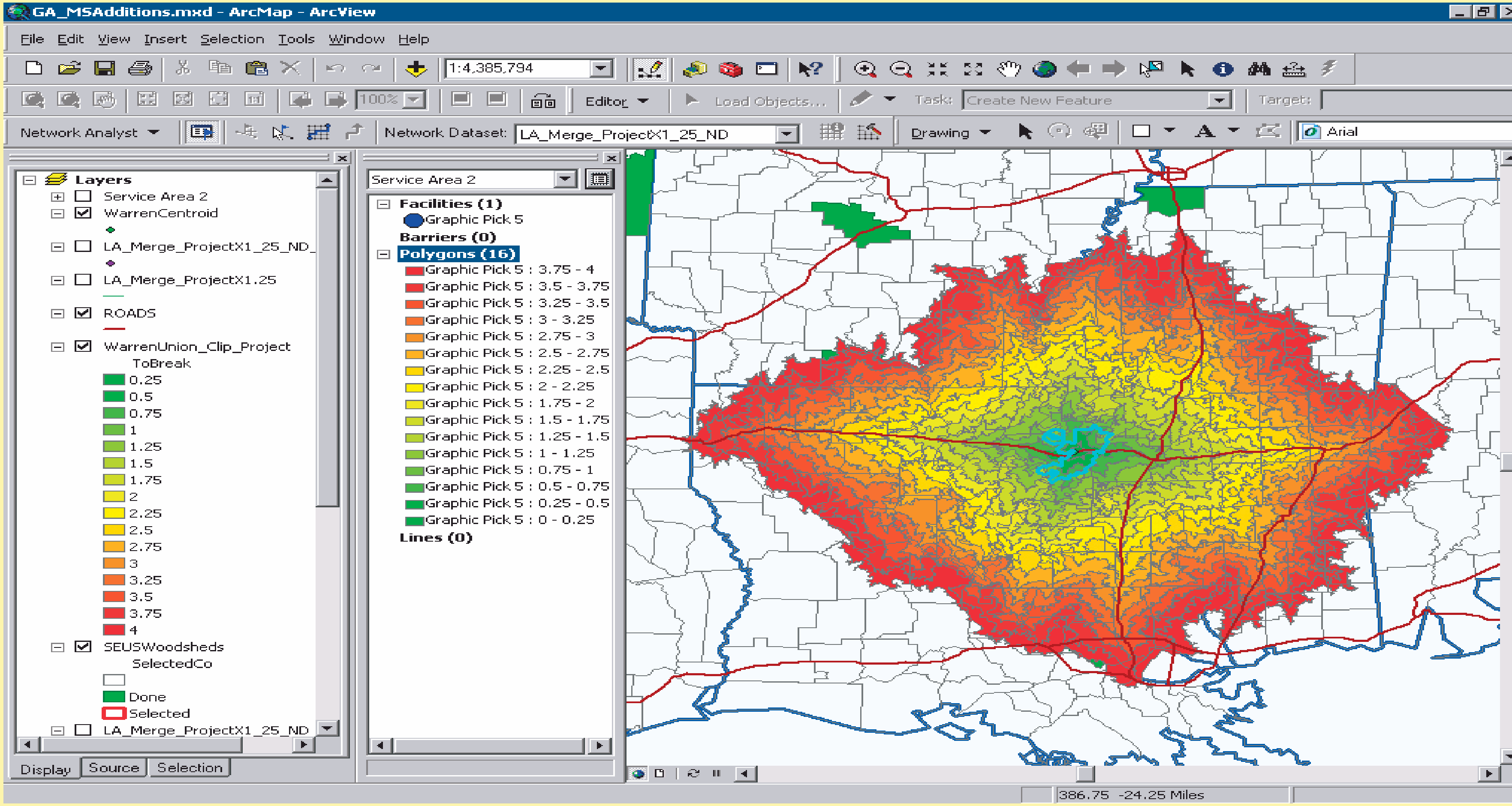
Fire Severity Regime Screens:

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

Final Screens:

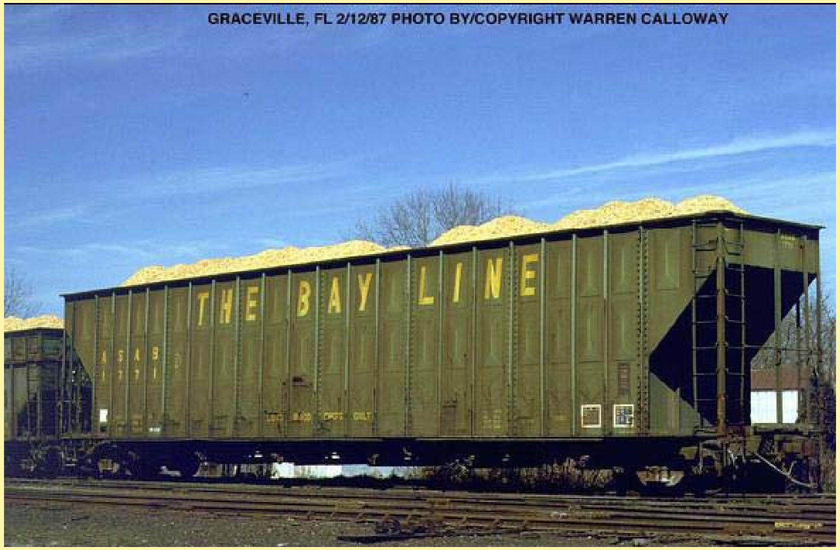
1. Plots with higher fire hazard (CI < 25 mph or CI < 40 + TI < 25)
2. Inventoried roadless areas excluded
3. Counties with wetter climates excluded

Feedstock Transportation



Source: Langholtz et al. 2006

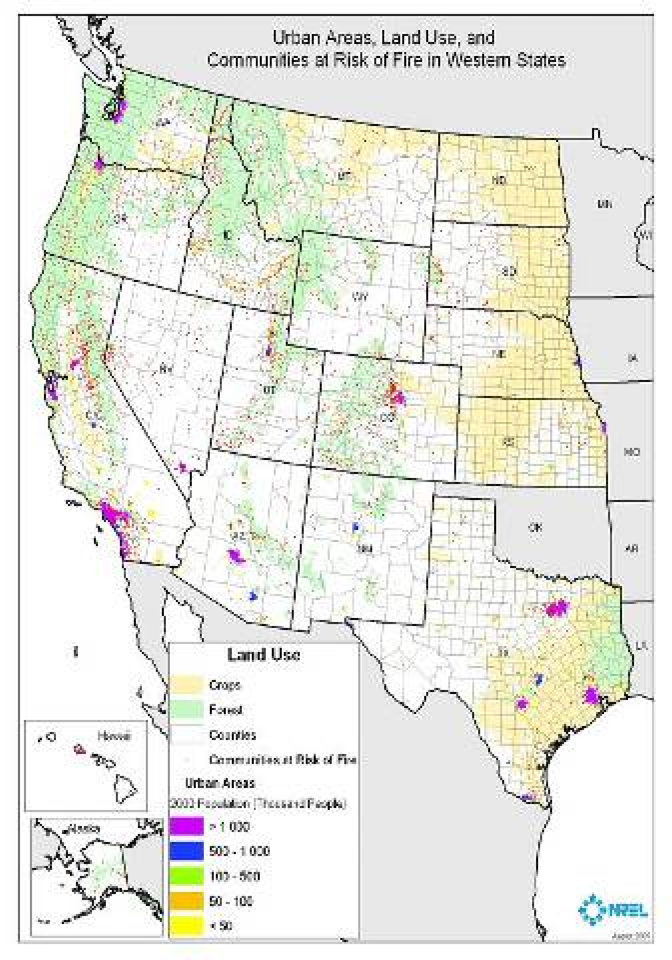
Current Systems – Trucks & Trains



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