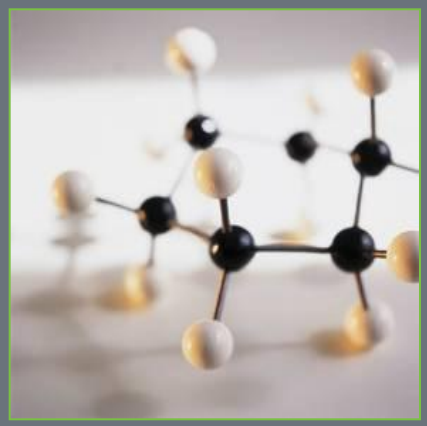
Utility-Scale Biomass: Cofiring and Densification

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy



Public Meeting of the Biomass R&D Technical Advisory Committee
March 3, 2011

Elliott Levine
Biopower Technology Manager
DOE Biomass Program

Sustainable Biofuels, Biopower, and Bioproducts

The Biomass Program is working to advance biomass technologies in support of DOE's mission to strengthen America's energy security, environmental quality, and economic vitality through:

Feedstocks

Developing lower cost feedstock logistics systems

Conversion technologies

Improving conversion efficiencies and costs

Integrated biorefineries

Systematically validating and deploying technology at first-of-a-kind facilities

Infrastructure

Evaluating vehicle emissions, performance, and deployment options

Biopower

Providing a clean, domestic, dispatchable renewable source of power

Advanced biofuels

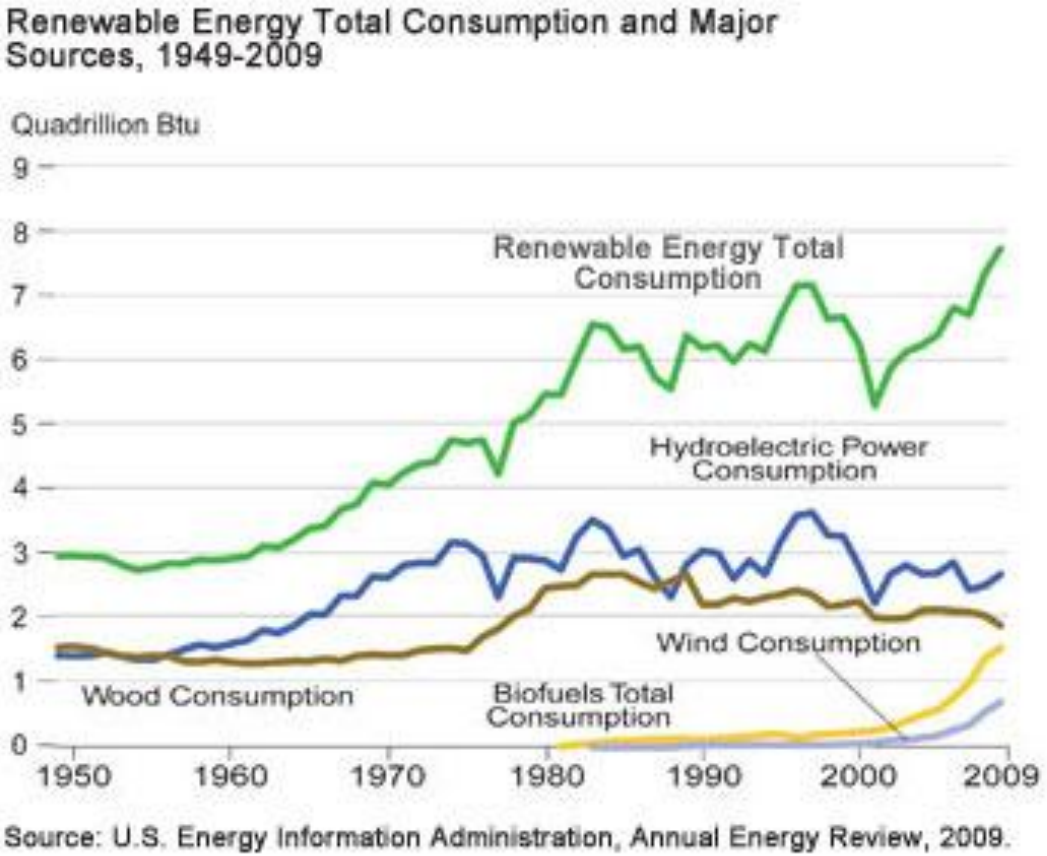
Expanding portfolio beyond cellulosic ethanol to hydrocarbon fuels

Biopower in the US Today

- Installed Capacity: 10.8 GW of biopower today
- Generation:
  - 1.4% of total US electric power
  - 33.9% of total US non-hydro renewable electric power
  - Among renewables, biopower ranks third after hydro and wind
  - Woody biomass power is 0.9% of total US electric power generation
  - 73% of electric power produced from woody biomass goes towards industrial CHP applications
- Most plants that cofire with wood are older, smaller (<25 MWe) and used when woody biomass is available, or where their situation has favorable economics
- Woody biomass power consumption declined after PURPA legislation expired

Various data sources

Renewable Energy Consumption Has Grown



Biomass Conversion Technologies

- **Co-fired:** Co-firing systems involve the mixing of biomass with fossil fuels in conventional power plants after some modification of the existing equipment
- **Direct-fired:** Most biopower plants use direct-fired systems, which burn biomass directly to produce steam
- **Gasification:** Through gasification, biomass is heated to convert solids into a synthesis gas, which is burned in conventional boilers or used in turbines to produce electricity.
- **Pyrolysis:** Through pyrolysis, biomass is heated and converted into a liquid, which can be used to generate electricity or further converted into fuels or chemical intermediates.
- **Combined Heat and Power (CHP):** Combined heat and power (CHP) systems have system efficiencies as high as 60-80%, and are an effective use of biomass, which enables recovery of waste heat for use in heating or cooling.

Biopower can also Improve the Business Case

INEOS Bioenergy

- Indian River County BioEnergy Center, Vero Beach, Florida - $100 million facility
- Feedstocks: 300 dry tons/day of vegetative, yard, and municipal solid waste yielding **8 million gallons/year of ethanol**
- Power: 6 MW (gross) of electricity produced--2 MW for export
- 175 jobs during construction and 50 jobs during operation
- Gasification followed by fermentation of synthesis gas
- Reduce greenhouse gases by more than 90% compared to fossil based diesel
- Completion and start-up in 2012

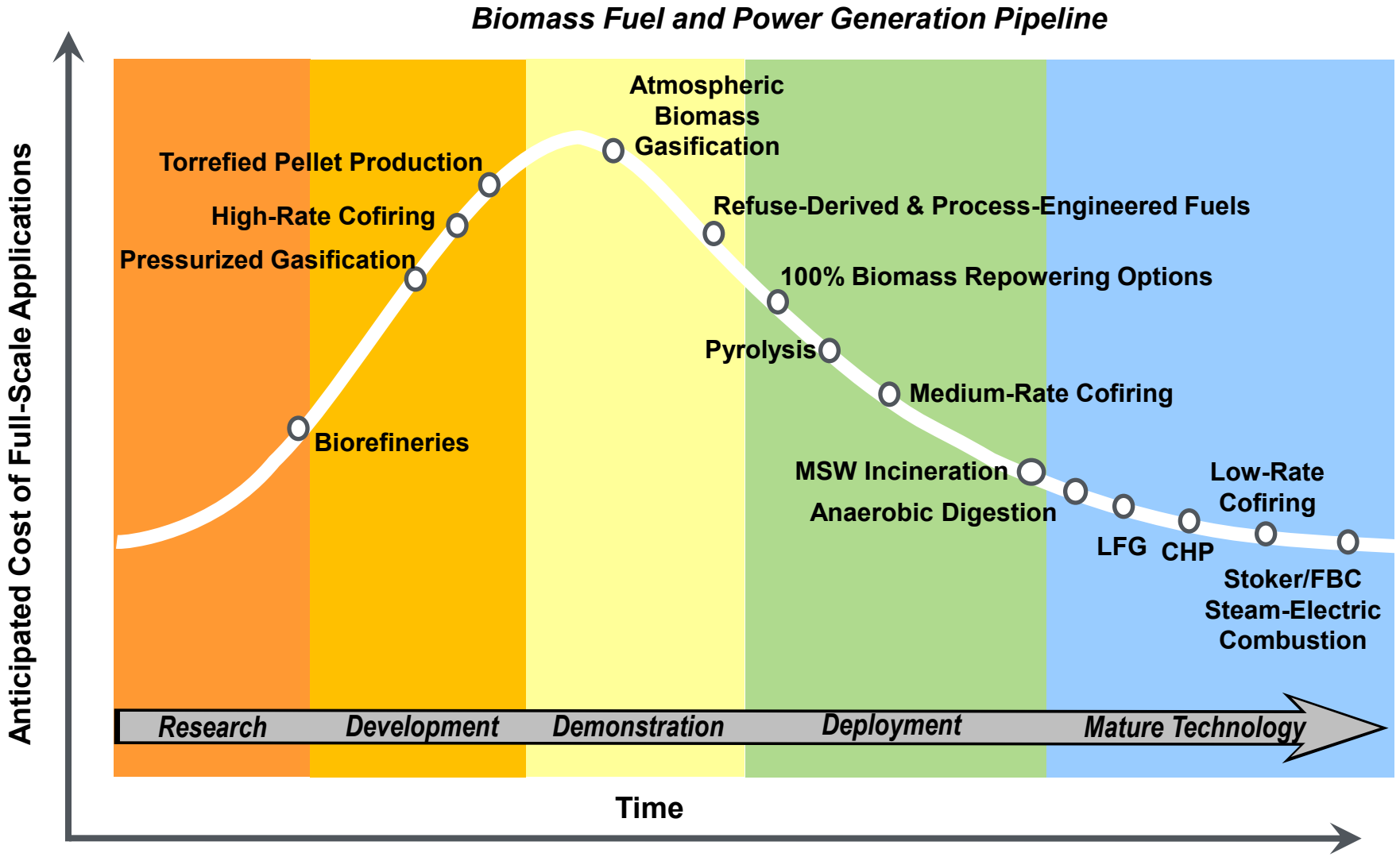
Utility-Scale Biopower Today

Many Repowering and Cofiring with biomass/coal projects are being put on hold. Large-scale co-firing projects are under consideration by utilities as a means to comply with RPS requirements, but barriers remain

- **Technical Risk:**
  - No single technology choice prevails—demonstrations are needed
  - Efficiency
  - Emissions and emissions compatibility
  - High-rate cofiring could degrade equipment
  - Sustainability
- **Economic Risk:**
  - Potentially higher cost of electricity generation
  - Feedstock availability
  - Torrefaction payoff
- **Regulatory Risk:**
  - Uncertainty of CO_2 as biogenic
  - EPA MACT certainty, Tailoring Rule
  - RPS acceptability

312MW Biomass Power Plant
Shadyside, OH, USA

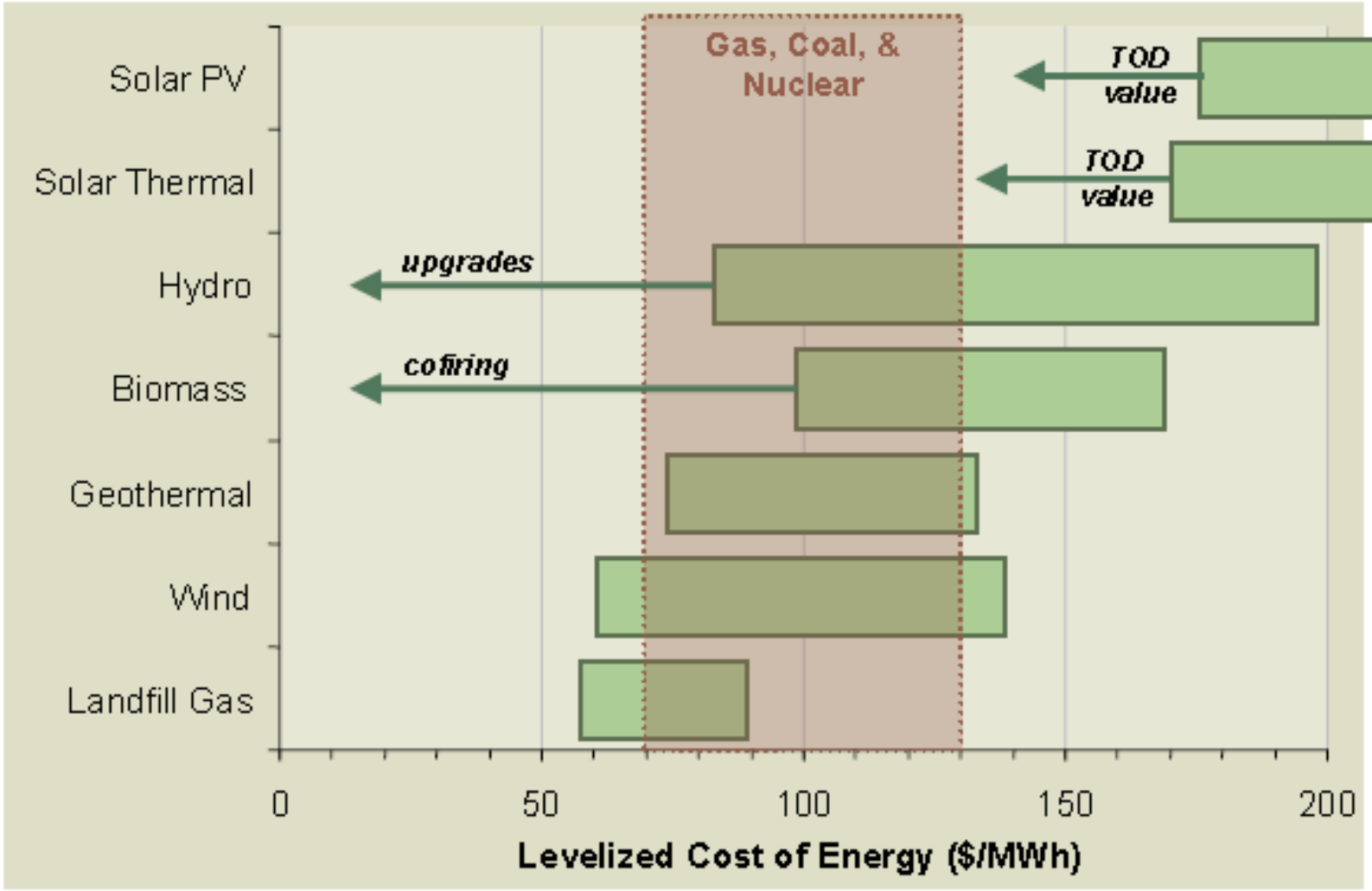
Technology Readiness for Biomass to Power (EPRI 2010)



Source: EPRI Biopower Generation White Paper, February 2010

Biomass Compared to Other Renewable Technologies

Cofiring Generally Makes Biopower More Competitive –

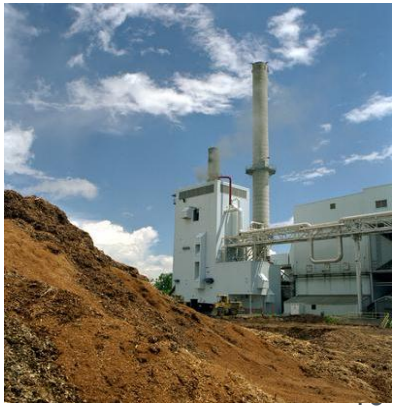


Source: Black and Vetch, Estimates for typical U.S. projects, presented at EUCI Biomass Conference (03/10)--ADAPTED

Biopower Initiative

New, proposed DOE initiative will accelerate the development and deployment of advanced biopower technologies. The Initiative is establishing partnerships with industry and supporting efforts to:

- Demonstrate and document the potential for co-firing biomass (at amounts up to 20% HHV) with coal as technically available for near-term deployment
- Demonstrate the use of densified biomass in advanced technology power systems.
- Conduct R&D on pretreatment and conversion technologies to develop processed biomass fuels optimized for integration with advanced power systems and reduced production costs



This FY2011 initiative is on hold pending disposition of continuing budget resolution.

Biopower activities have also been included in the FY2012 Federal budget released February 14, 2011.

Densification/Upgrading Biomass for Improved Biopower Use

Process	Benefit
• Pelletization: Drying and mechanical compression	• Improves energy density and storability of the feedstock
• Torrefaction: Feedstock drying, heat treating and pelletizing/briquetting	• Improves energy density, grindability, stability, and storability of the feedstock
• Gasification: Pyrolysis and partial oxidation, gas cleanup	• Provides a low to medium BTU fuel gas compatible with gas turbines and other advanced combustion systems
• Fast Pyrolysis: Pyrolysis to an energy-dense fuel oil	• Provides a liquid fuel that is easy to inject into conventional and advanced power generation systems

Biomass Torrefaction

Source: ECN

COMBINING TORREFACTION AND PELLETING LEADS TO SUPERIOR ENERGY DENSITY (GJ/M³)

Handling characteristics improve substantially

Torrefaction +	Pelleting =	Torrefied pellets
• Increased calorific value (~22 MJ/kg) when compared to wood (~+30%)	• Increased bulk density (~ 800 kg/m³) when compared to regular wood pellet (~+30%)	• Increased energy density (~19 GJ/m3) when compared to wood pellets (~+70%)
• Hydrophobic nature	• Hydrophobic nature	• Hydrophobic nature
• Easy grindability		• Easy grindability (*Hardgrove Grindability Index 38-48*)
• No biological activity		• No biological activity
• Homogeneous output from heterogeneous input		• Homogeneous output from heterogeneous input

OBP-Sponsored Biopower Activities

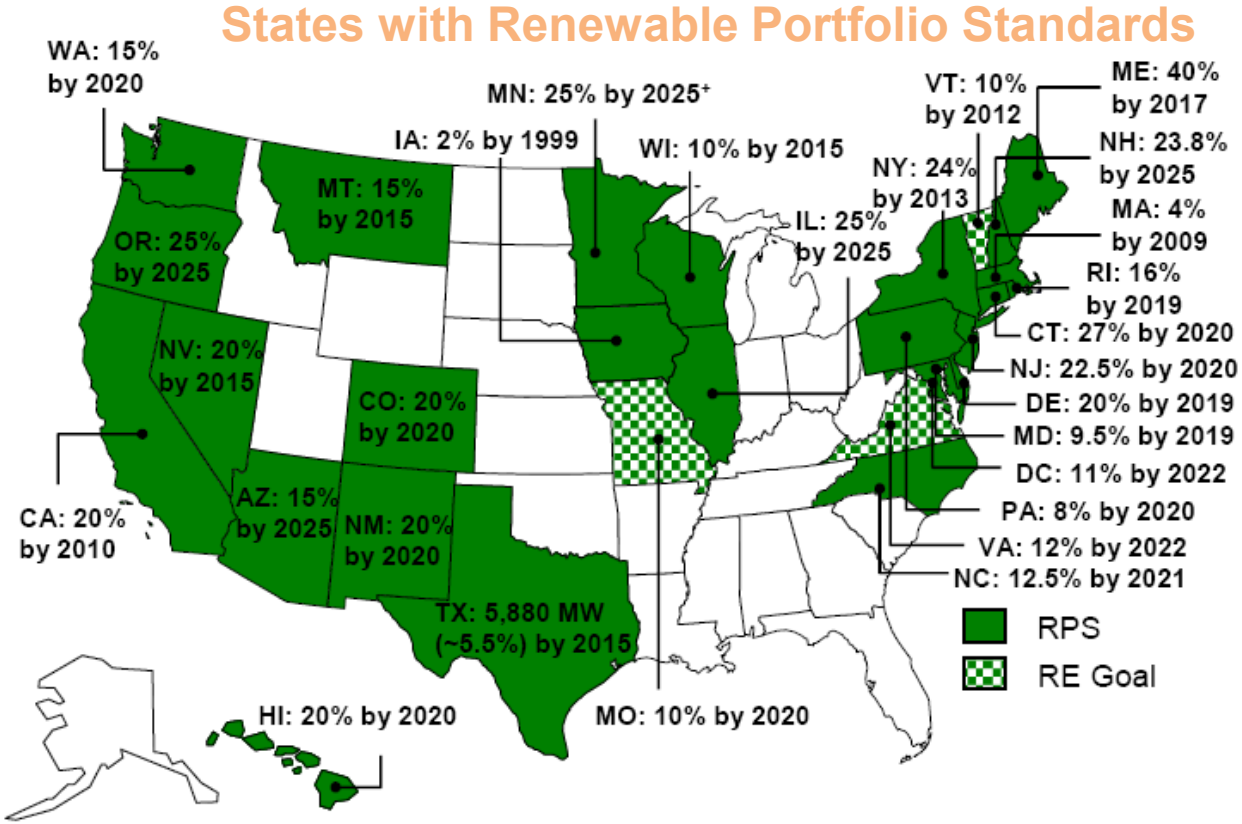
- Biopower Technical Strategy workshop
- 2010 Multi-Year Program Plan (MYPP)
- Engaged key stakeholders to understand RDD&D needs and interests
- Identified technical challenges for cofiring biomass with coal
- Identified market drivers and supply chain issues and legislative influences
- Developed fuel specifications for torrefied, pyrolyzed and gasified biomass

Biopower Technical Strategy Workshop

A workshop was held in December 2009 to identify barriers to biopower and top RD&D and analysis needs; report published in December 2010 (www1.eere.energy.gov/biomass/news_detail.html?news_id=16636)

Topical Area	Key Priorities
Pretreatment & Conversion	Cost-effective technology; characterize intermediates and products for pretreatment; theoretical analysis/modeling; bench, pilot, and demonstration projects; torrefaction feasibility studies
Large-Scale Biopower	Demonstrations of re-powering, cofiring, and advanced biopower, low-temperature gasification and hot gas cleanup; high-temp. materials; cost-effective combustion of bio-oil
Smaller-Scale Biopower	Synthesis gas cleanup; micro-scale biomass CHP; demonstrate integrated, advanced systems; cost-effective emissions control; market assessments
Feedstocks	High-yield feedstocks; optimized production/supply systems; large-scale environmental monitoring; modeling; sustainability indicators
Market Transformation	Technical assistance; coordinated promotion; analysis for decision making; education and award programs

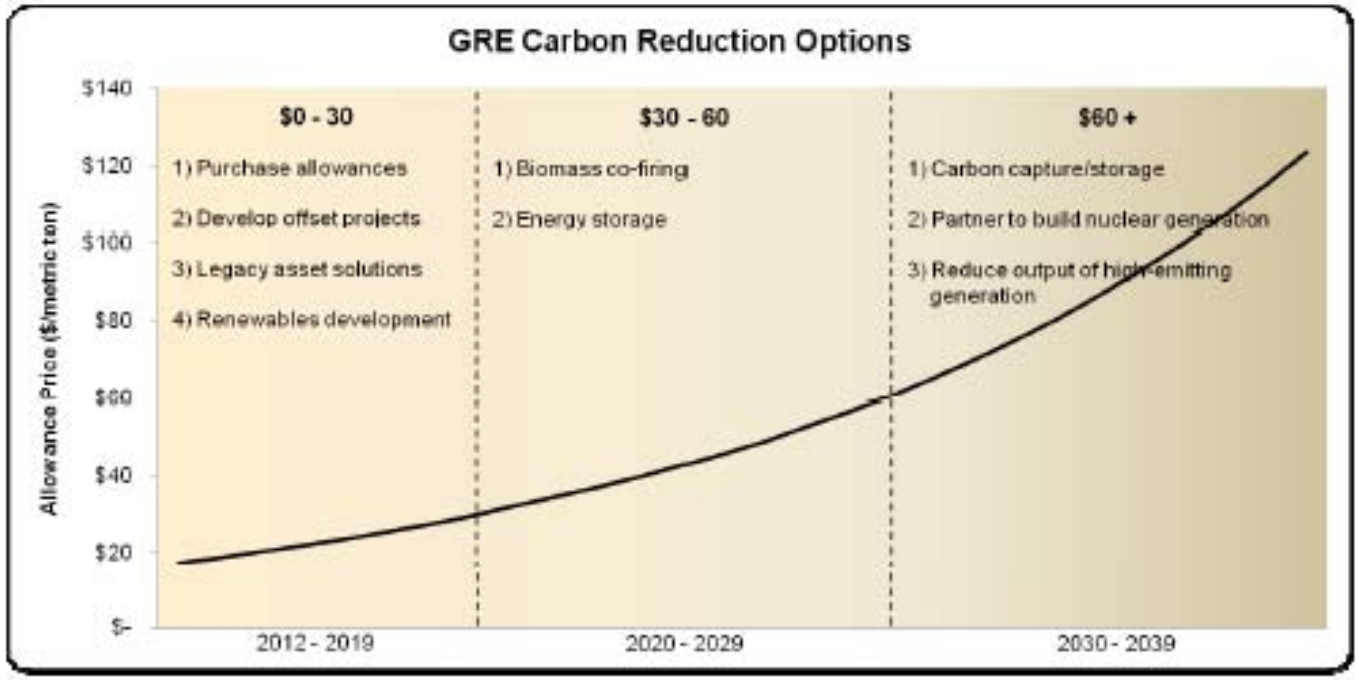
State RPS Standard's--Snapshot



The success of states implementing their RPS is marginal. Many of the states are considering changes in the technology or in the method of calculating the renewable component to achieve their mandates.

The amount of biopower generated in the U.S. fell after 2000 due to changes in the Public Utility Regulatory Policies Act (PURPA) passed in 1978. Many of the contracts negotiated during the 1980's expired or are expiring, and the cost of feedstock became too high to allow them to remain competitive at the avoided cost rate.

Industry View: Carbon Reduction Options and Costs



Source: Great River Energy, Carbon Management Roadmap , Presented at EICU Biomass Conference.

- **For Carbon valued less than 30 $/Metric Ton, allowances, off-sets, and the development of other renewable energies will be pursued.**
- **For Carbon valued in the range 30-60 $/Metric Ton, Biomass Co-firing becomes a viable option.**

Biopower Incentives and Market Uncertainties

Policies Today

- Federal production tax credit (PTC)
  - For open- and closed-loop biopower; $0.011/kWh for 10 years; needs to be placed in service by 12/31/13
- Section 1603 Treasury cash grants in lieu of production tax credits
  - 30% for open- and closed-loop, landfill gas, and waste-to-energy; 10% for biomass CHP; expires in 2011
- Farm Bill's Biomass Crop Assistance Program
- Many states include biopower in RPSs and renewables targets

Future Uncertainties

- Federal renewable electricity standard?
- Federal greenhouse gas regulation/legislation?
- Pending EPA maximum achievable control technology (MACT) standards for biomass boilers
- Differences to biopower acceptability in state RPS's
- Funding uncertainty for programs, including DOE's planned biopower initiative and Farm Bill programs

Challenges for Biopower

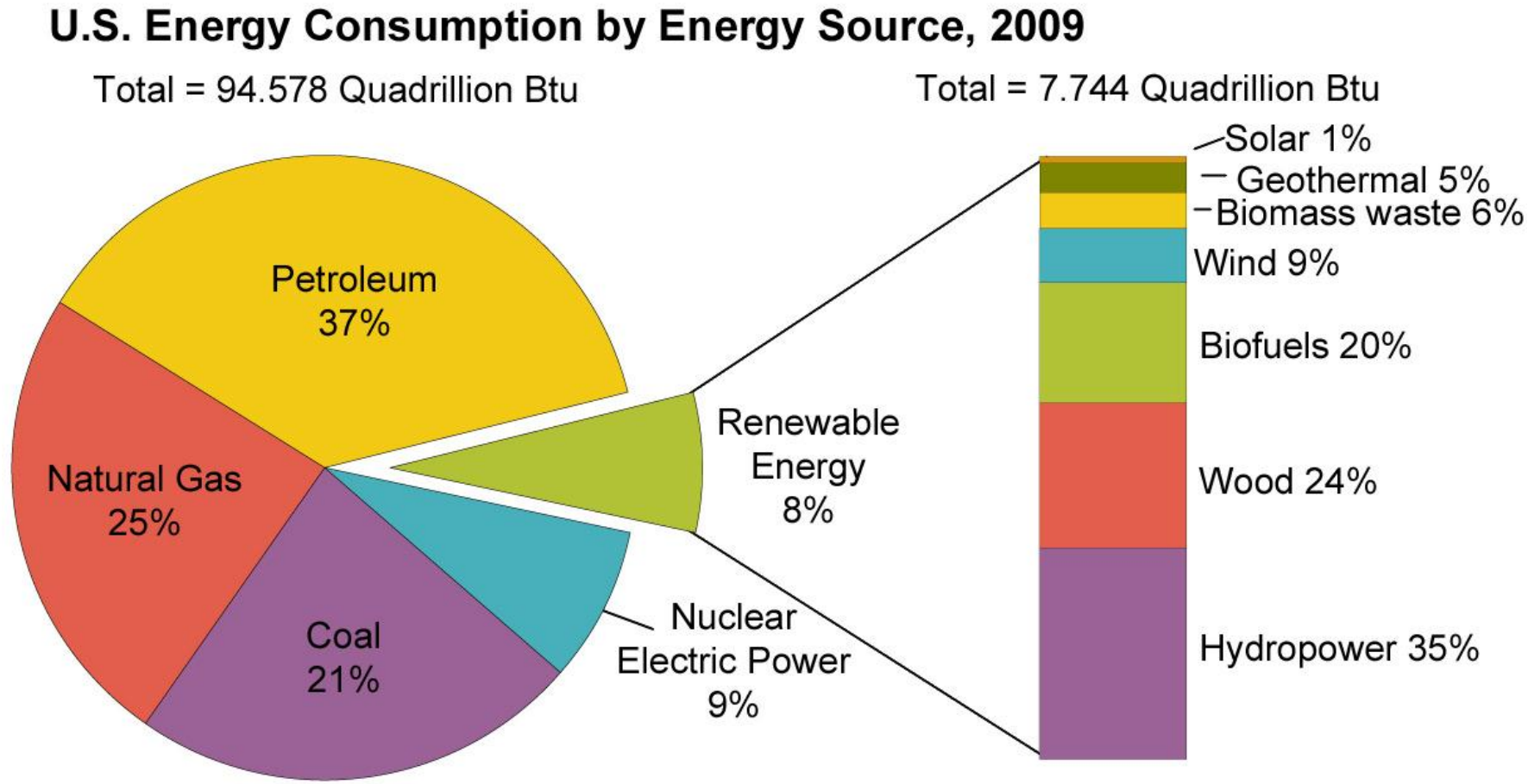
- **Cost:** Higher cost of biopower relative to coal-based electricity
- **Sustainable Feedstock Supply:** Uncertainty of reliable, consistent, year-round supplies of suitable and affordable biomass
- **Biomass Conversion and Performance:** Uncertain performance of feedstock impacts on existing boilers (e.g., corrosion, efficiency, emissions compatibility)
- **Policy and Regulatory Uncertainties:** Inconsistent policies and incentives across regions, including the lack of a national Renewable Portfolio Standard.
- **Techno-Economic Analysis:** Lack of well-characterized, techno-economic analysis on life cycle impacts and systems.
- **Technology Demonstration:** Lack of demonstrated performance for all technologies at all scales (especially co-firing, advanced biopower, next-generation feedstocks).

Wrap Up

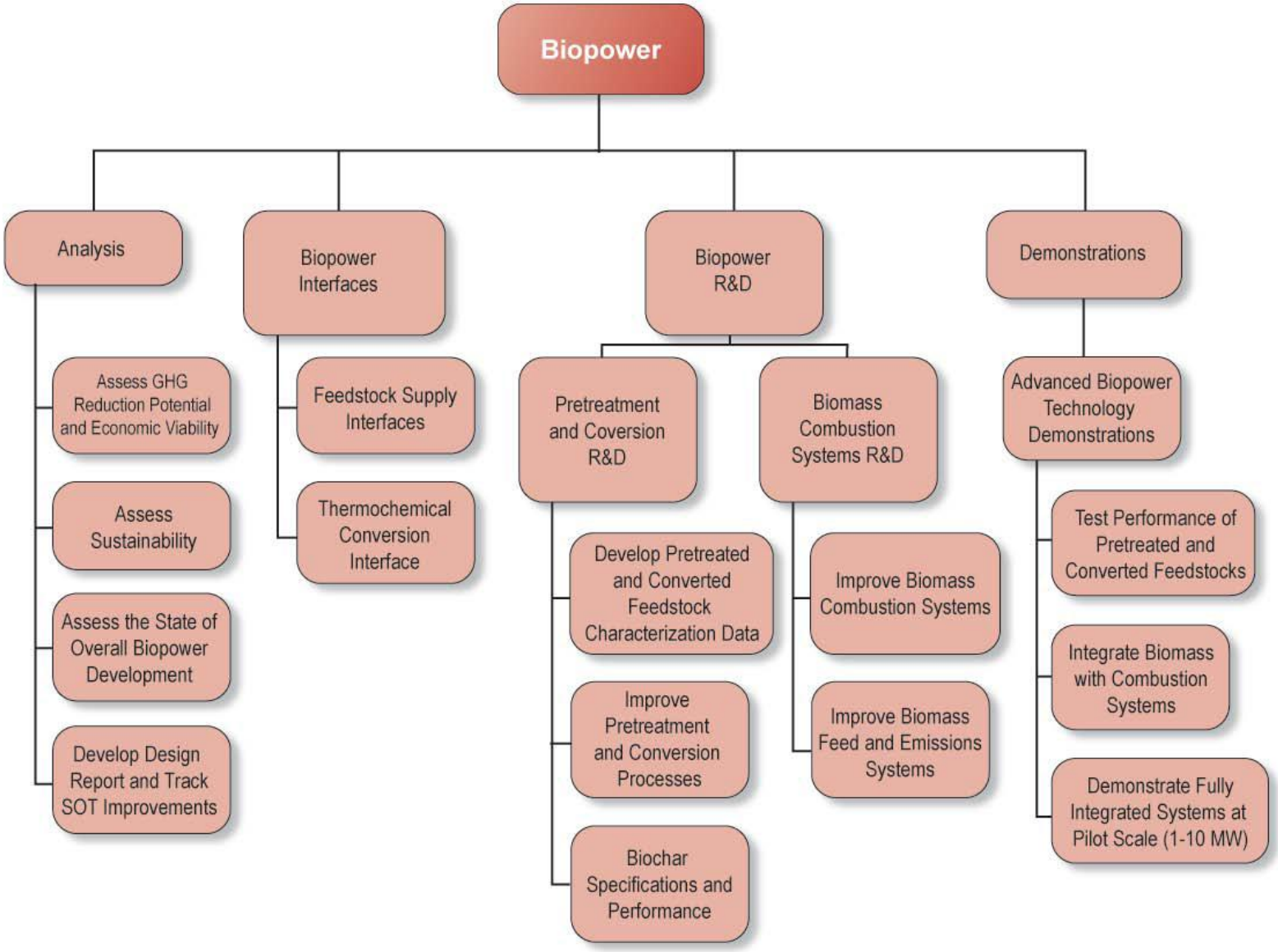
- Utility scale biopower cofiring can be a near-term renewable energy option for improving the environmental footprint of existing coal plants
- Biomass cofiring has potential benefits-GHG reduction, dispatchable power, jobs
- Biopower cofiring at existing plants needs to be economic to succeed
- Economic risks are tied to uncertainties including: technical, environmental and feedstock availability
- Enhancing biomass via densification may improve the supply, transport, storage and combustion-but has not been adequately explored in the US
- Regulatory certainty is crucial

- Back Up Slides

Renewable Sources Provide About 8% of Our Energy

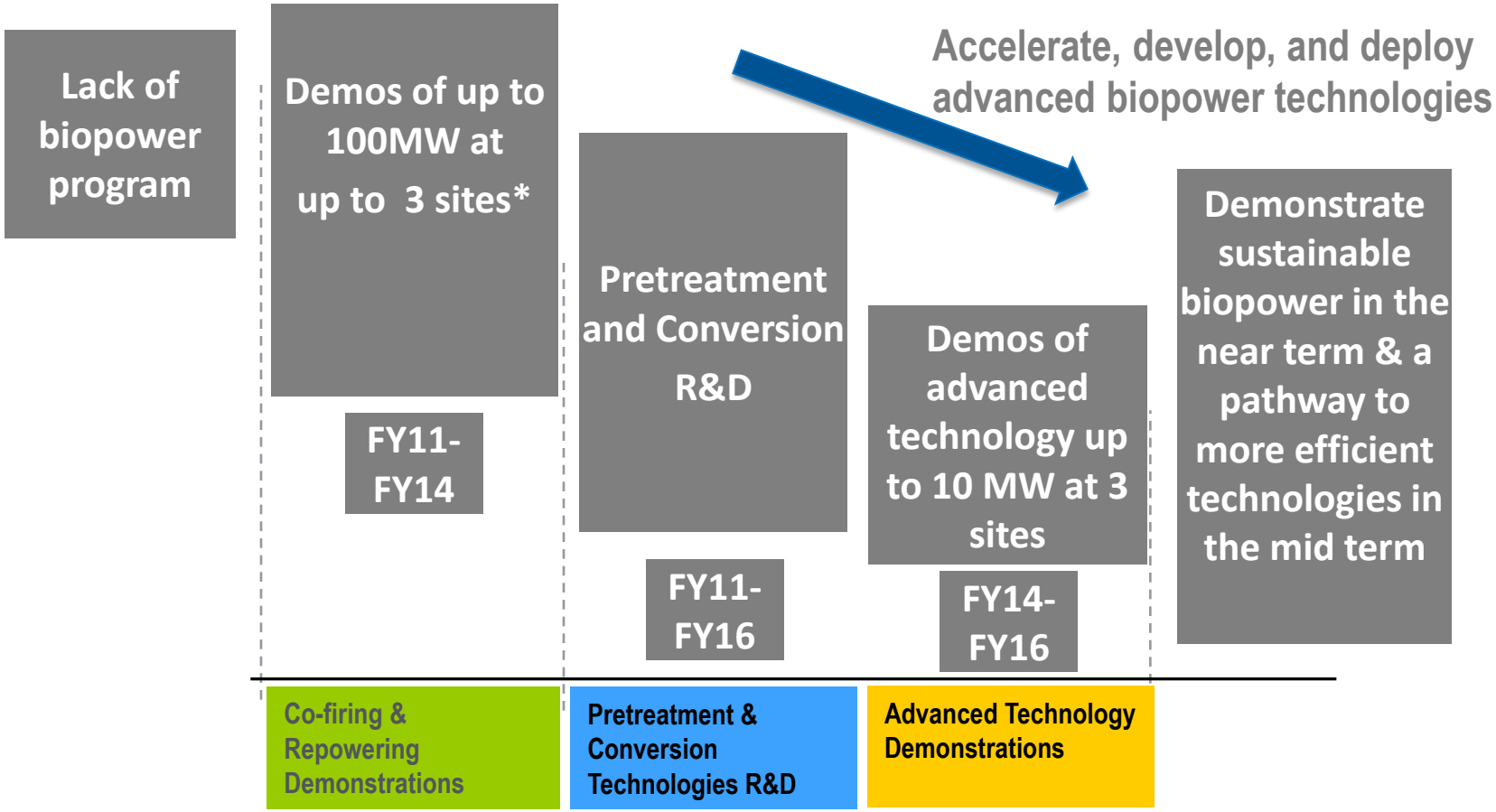


Note: Sum of components may not equal 100% due to independent rounding.
Source: U.S. Energy Information Administration, *Annual Energy Review 2009*, Table 1.3, Primary Energy Consumption by Energy Source, 1949-2009 (August 2010).


Biopower
Analysis
Biopower Interfaces
Biopower R&D
Demonstrations
Assess GHG Reduction Potential and Economic Viability
Assess Sustainability
Assess the State of Overall Biopower Development
Develop Design Report and Track SOT Improvements
Feedstock Supply Interfaces
Thermochemical Conversion Interface
Pretreatment and Coversion R&D
Biomass Combustion Systems R&D
Develop Pretreated and Converted Feedstock Characterization Data
Improve Pretreatment and Conversion Processes
Biochar Specifications and Performance
Improve Biomass Combustion Systems
Improve Biomass Feed and Emissions Systems
Advanced Biopower Technology Demonstrations
Test Performance of Pretreated and Converted Feedstocks
Integrate Biomass with Combustion Systems
Demonstrate Fully Integrated Systems at Pilot Scale (1-10 MW)

Biopower R&D and Deployment

Biopower Signature Initiative



FY12 Funding Request	$80 mil	$22 mil	$0 mil	Total $102 mil
Absolute Min. FY 2012 Funding Needed (DOE)	$19 mil	22 mil	$0 mil	Total $ 41 mil
* Overtarget Funding	$61 mil	$0 mil	$0 mil	Total $61 mil

Feedstock Handling Steps inside the Plant

1. Receiving the fuel
2. Unloading the fuel
3. Processing the fuel

Feedstock Handling Steps inside the Plant

4. Convey the fuel to bulk storage silos
5. Convey fuel from bulk to day storage silos
6. Grinding and milling of fuel
7. Mixing with coal and feeding burners

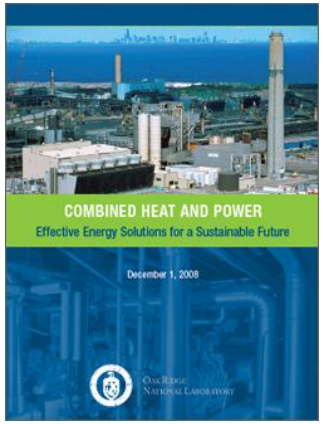
DOE/ITP Combined Heat and Power (CHP) Program

CHP is recognized as the best means to *simultaneously*

- Reduce GHG emissions
- Promote use of secure domestic and renewable energy sources
- Reduce exposure to energy price hikes and volatility

ITP activities include:

- Conducting R&D to improve efficiency, lower costs, and extend applications
- Facilitating deployment and addressing barriers
- Serving as an independent, credible voice on applications and benefits
- 8 Clean Energy Regional Application Centers for market transformation efforts



CHP offers a sizable near-term option for large energy efficiency improvements and CO_2 reduction

Source: EPA

DOE CHP Program: http://www1.eere.energy.gov/industry/distributedenergy/index.html

Candidate Applications for CHP

- Hospitals
- Colleges/Universities
- High Schools
- Residential Confinement
- High Rise Hotels
- Fitness Centers
- Food Processing Waste
- Farm Livestock Waste
- Waste Water Treatment
- Landfill Sites
- Pulp & Paper Mills
- Ethanol/Biodiesel Plants
- Chemical Manufacturing
- Metal Fabrication

Source: Presentation from Cliff Haefke, Midwest CHP Application Center, University of Illinois at Chicago at —Forever Energy Biomass for Sustainable Energy Solutions," July 17, 2008

http://www.chpcentermw.org/pdfs/080717_Haefke1.pdf

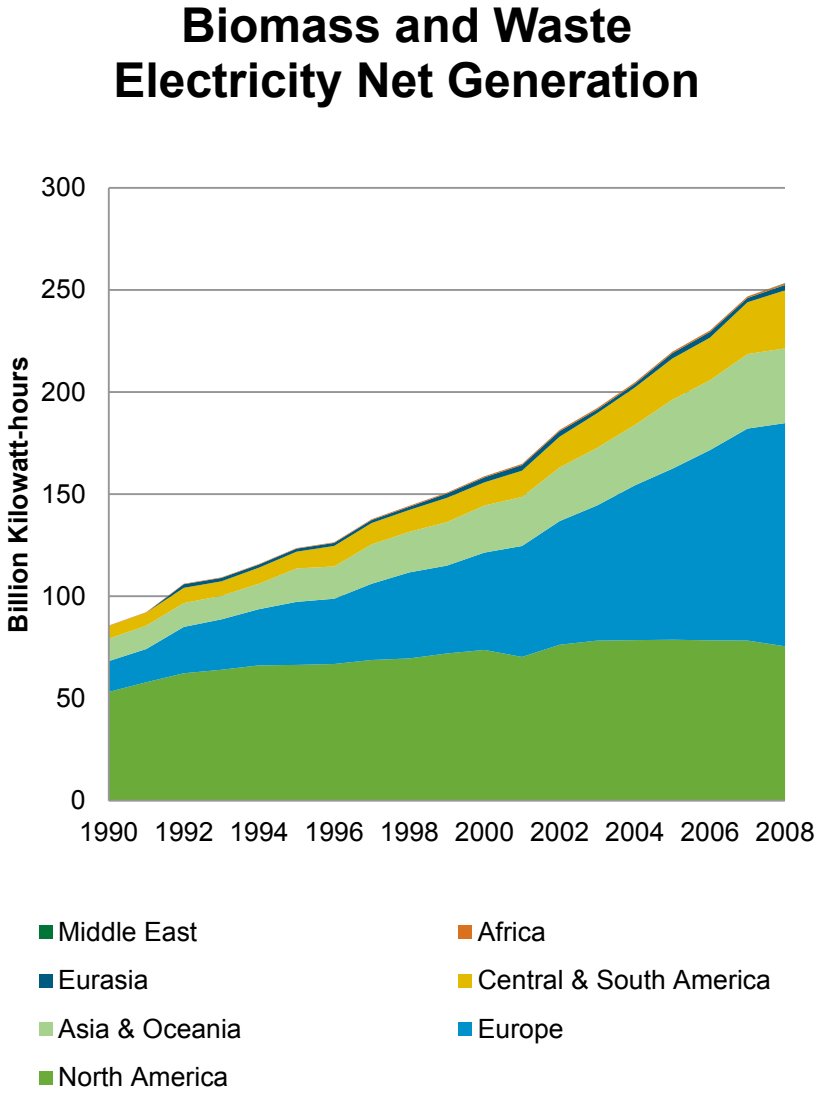
Biopower Performance Goals

Biopower performance goals correspond directly to the overall goal of demonstrating reduced GHG emissions through increasing the amount of biopower generation above the 2010 baseline by FY2020.

- By 2011, develop specifications for improved feedstock quality for materials suitable for use in advanced power generation approaches.
- By 2014, develop pretreatment and conversion technologies to produce upgraded biomass materials.
- By 2015, initiate operation of 10 MW advanced pilot-scale biopower generation and verify associated GHG reductions.
- By 2016, initiate operation of an additional 20 MW of advanced pilot-scale biopower generation and verify associated GHG reductions.
- By 2016, develop pretreatment and conversion technologies capable of increasing the share of biomass mixed with coal to at least 20 percent (heat input basis).

Evolving International Biomass Market

- Demand for biopower has almost tripled since 1990
- Europe is driving demand, with a goal of 20% renewable energy by 2020
- U.S. demand for biomass is expected to increase, as more biomass is needed to meet RFS2
- IEA projects that global demand for biomass will continue to grow through 2035



Recovery Act Provisions:
Facilitated Growth of Renewable Electricity

- Extension of the renewable electricity production tax credit (PTC) to the end of 2012
- For 2010, credit amounted to 2.2 cents/kWh for wind, closed-loop biomass and geothermal energy and 1.1 cents/kWh for the other eligible technologies for the first ten years of the life of the project
- Expansion of the business energy investment tax credit (ITC) in lieu of the PTC to all taxpayers eligible for the PTC
- Generally, credit is worth 30% of expenditures and is available to eligible systems in operation by specific due dates, which are 2016 for some technologies and 2012 for wind
- Availability of U.S. Treasury grant to eligible PTC technologies in lieu of either the ITC or PTC, for eligible property in service in 2009 or 2010, or placed in service by the specified credit termination date
- Other factors: State renewable portfolio standards and mandates, and concerns over global climate change and clean air

The European Experience

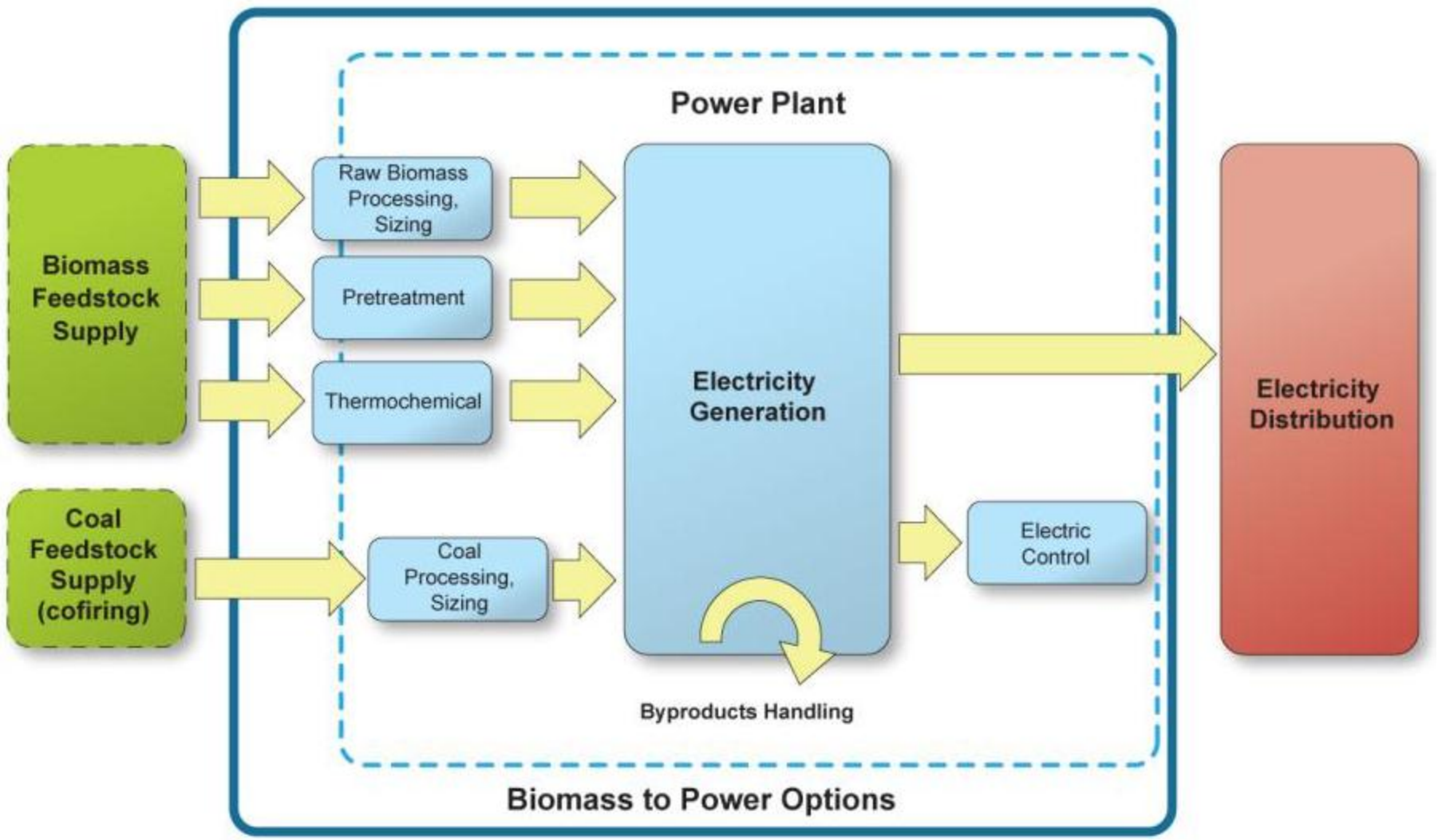
- Biomass for power is more expanding in Europe
- EU Incentives and mandates for Biopower are further along than in the US
- European incentives and higher electricity costs promote greater levels of Biopower deployment
- Opportunities exist for learning from their experiences in cofiring, torrefaction, CHP and more
- Presently some companies exporting pellets from the US (Georgia) and from the Northwest US to Europe
- The US has recently established a Dept of Commerce led Clean Energy Trade program: http://www.export.gov/reee/eg_main_023159.asp

Future Directions/Activities/ Priorities

FY2011 Budget:
Biopower ($50.0M): Held in continuing resolution.

FY2012 Budget:
Biopower ($22.5M): Initiate a competitive solicitation for co-firing biomass with coal and biomass densification RD&D, including a feedstock supply assessment to ultimately add 30MW new generation by 2016.

Schematic-Cofiring Biomass with Coal



State-Level Renewable Electricity Capacity and Generation

- Renewable generation grew from 2007 levels to 413 billion kWh in 2009, out of a U.S. total of 3,953 billion kWh
- Renewable electric capacity grew from 2007 levels to 125,800 MW in 2009, out of a U.S. total of ~1,027,600 MW
- Approximately one half of all states have an RPS mandate