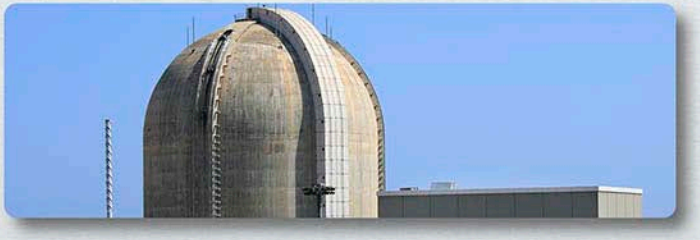

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Biomass Power Technology Options

Dave O'Connor
Senior Manager, Biomass Projects

Biomass 2011
July 26, 2011

Overview

- Introduction to EPRI
- Drivers for Power Producers
  - Technology
  - Economics
  - Policy
- Research Issues
- Conclusions

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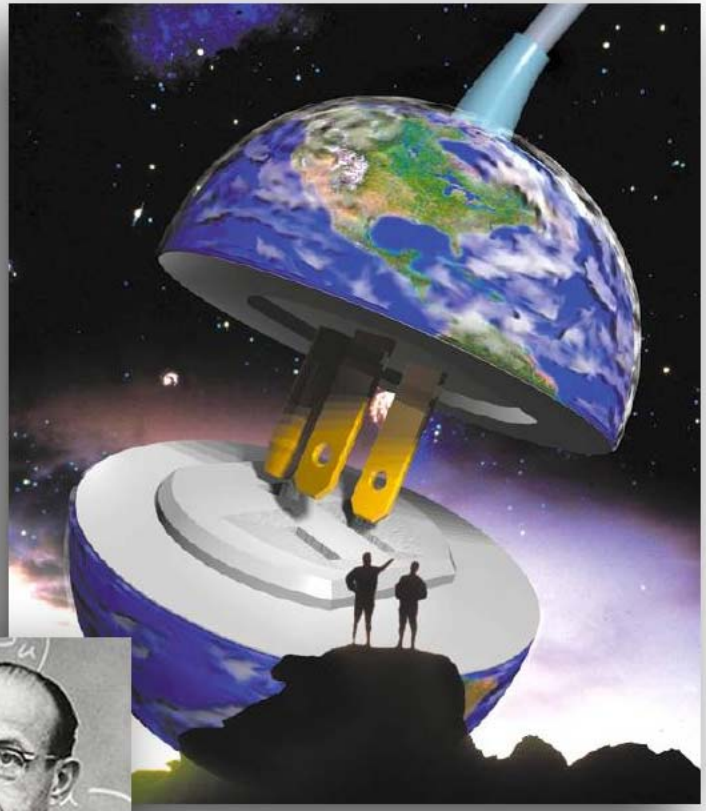
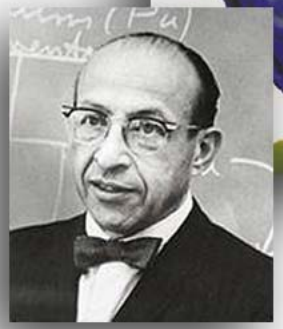
Our History…

- Founded in 1973
- Independent, nonprofit center for public interest energy and environmental research
- **Collaborative** resource for the electricity sector
- Major offices in Palo Alto, CA; Charlotte, NC; Knoxville, TN
  - Laboratories in Knoxville, Charlotte and Lenox, MA





Chauncey Starr
EPRI Founder

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EPRI ELECTRIC POWER RESEARCH INSTITUTE

Our Mission…

To conduct research on key issues facing the electricity sector…on behalf of its members, energy stakeholders, and society.

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Power Production in North America

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Types of Utilities

Public Utilities or Electric Utilities	Utilities which serve the public.
Investor-Owned Utilities (IOUs)	For-profit business owned by investors (stockholders and bondholders ≡ stakeholders). Also called privately owned or publicly traded.
Government-Owned Utilities	Non-profit utilities owned by cities (municipal utilities or munis); the Federal Government (power administrations); regions or districts (public utility districts or PUDs; river project or authority).
Rural Electric Cooperatives	Non-profit utilities owned by their consumer members. Subsidized by the rural utility service (RUS), historically called the Rural Electrification Administration (REA).

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And…Combination "Electric" Utilities

- Electric & Gas
- Electric & Heat
- Electric & Water
- Electric & Communications
- Independent Power Producers

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Overall Picture

- Organizations in the electric energy business ARE NOT all alike
  - They have different customers and stakeholders
  - They have different decision-making processes
  - They have different approaches to resolving issues
  - They have different cost structures
  - Many of them are in distinctly different businesses
  - They are regulated (somewhat) differently
- However, much of electric energy *power production* (business drivers & regulation) is similar

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Business Imperatives in the Power Production

Biomass Implications

Technology

What **COULD** be done?

Economics

What **SHOULD** be done?

Policy

What **WILL** be done?

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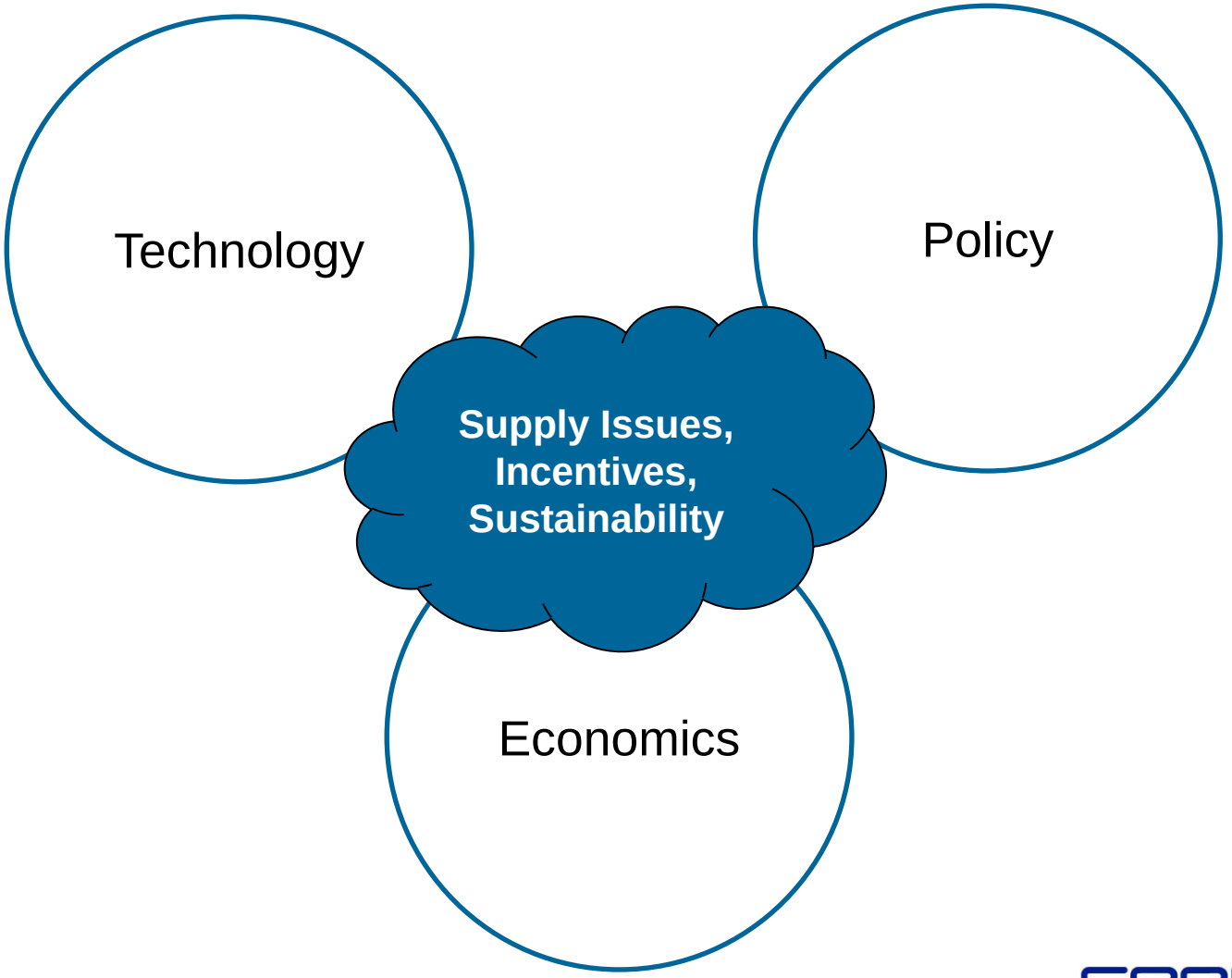
Business Imperatives in the Power Production

Interesting Intersections?



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Biomass Technology Options

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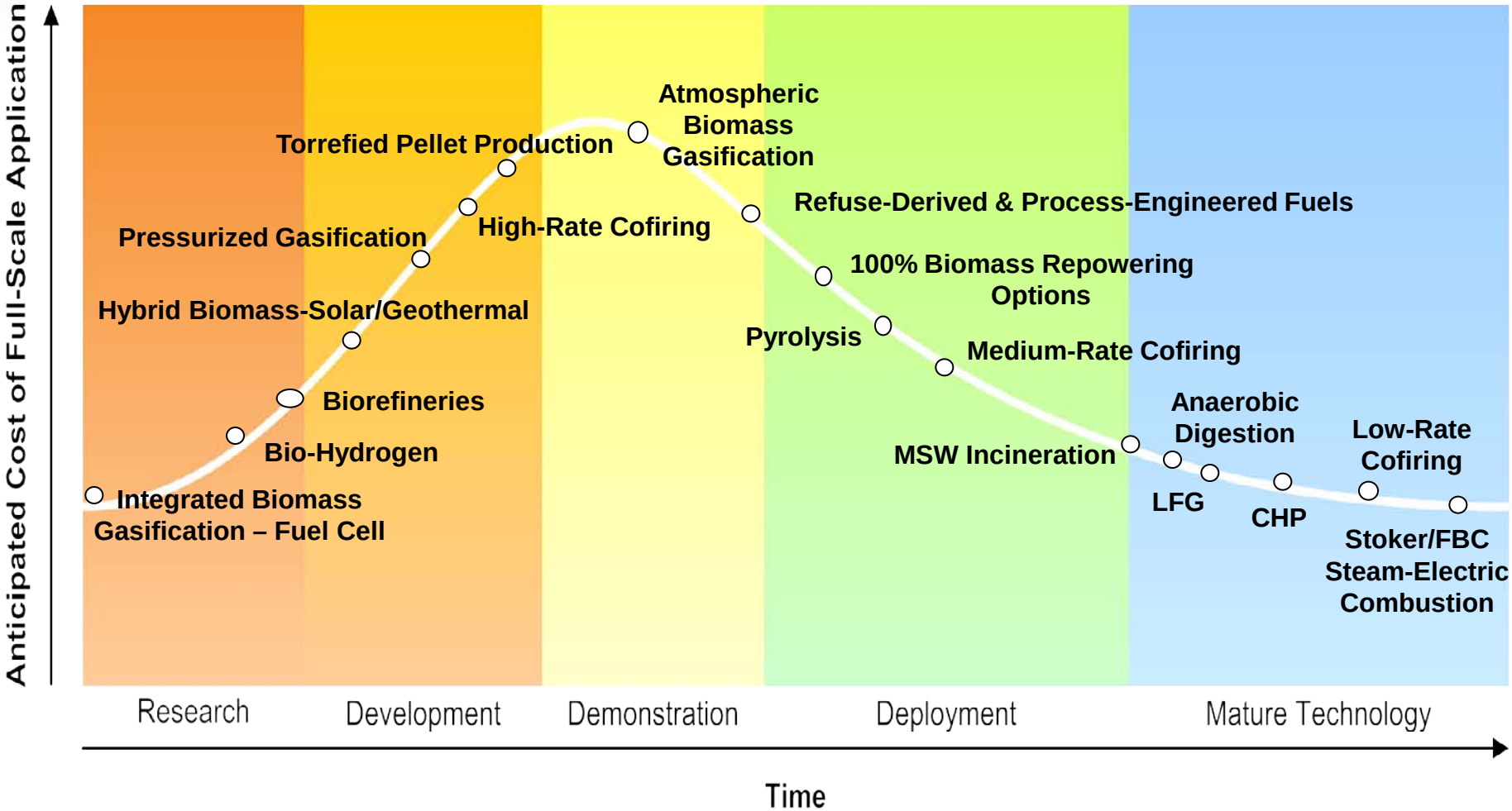
Biomass Technologies Deployment Curve

Generation



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Biomass Power Economics

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Cost Structure

- CAPITAL COST
  - Plant cost
  - Transmission, distribution, wires
  - Infrastructure and support equipment
  - Major equipment modifications and replacements
- OPERATING COST
  - Fixed Operating Cost
    - Staff
    - Certain maintenance activities
    - Non-capital costs that don't vary with generation
  - Variable Operating Cost
    - Fuel Consumption, Cost
    - Most non-labor maintenance
    - Certain externalities
      - Emission credits
      - Renewable certificates
      - Others

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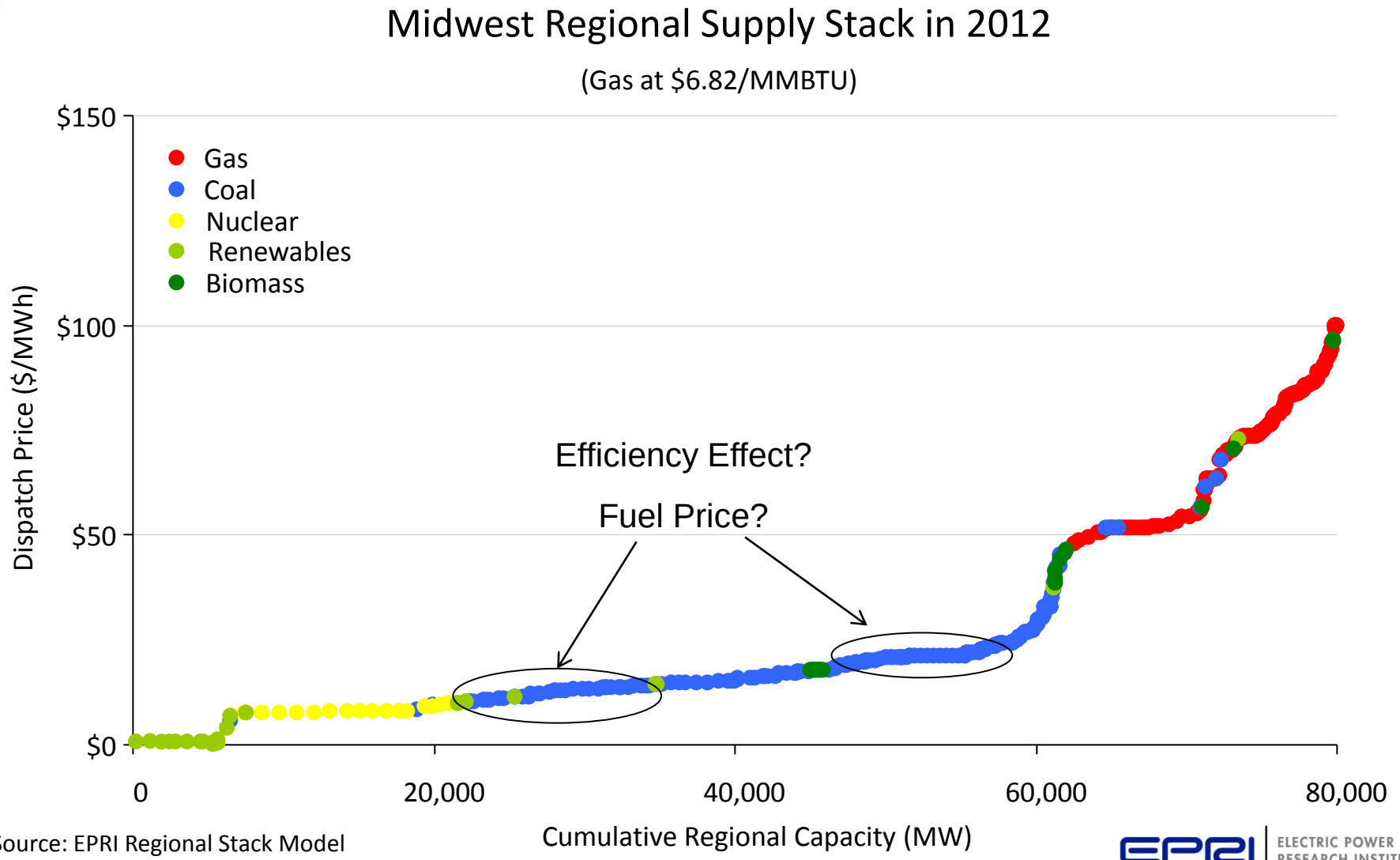
Biopower Capital Cost Summary, Operating Implications

Table 1 – Approximate Cost Ranges for Biomass Generation Options

Technology	Capital Cost, $/kWe	Relative Fuel and O&M Costs	Notes
Solid Fuel - Stoker & FBC	$2600-$3000	Low	50-MWe plant
Solid Fuel - Stoker w/ CHP	$2500-$4000	Low	25-MWe plant; 44 MWe of heating capacity
Solid Fuel - Integrated Gasifier	$3000-$3500	Low	50-MWe plant
Solid Fuel - Biomass Integrated Gasification-Combined Cycle	$3500-$4300	Low	50-MWe plant
MSW - Mass Burn Incinerator	$5000-$6000	Very Low - Low	25-MWe plant
Solid Fuel - Cofiring, Separate Feed	$300-$600	Low - Medium	10% fuel fraction for 200-MWe PC boiler, with cost reflecting only kWe running on biomass
Solid Fuel - Cofiring, Mixed Injection	$100-$500	Low - Medium	10% fuel fraction for 200-MWe cyclone or PC boiler, with cost reflecting only kWe running on biomass
Solid Fuel - 100% Biomass Retrofit/Repowering	$900-$1500	Low - Medium	Cost reflects only final kWe of biomass capacity; does not include additional refurbishment
LFG - ICE	$1350-$1500	Medium	5-MWe plant (five 1-MW units; includes gas pre-treatment)
Digester Gas - ICE	$1650-$1850	Medium	1-MWe plant (includes gas pre-treatment)
Digester Gas - CT	$1850-$2300	Medium - High	1-MWe plant (includes gas pre-treatment)
Liquid Fuel - ICE	$850-$1100	Very High	1-MWe plant firing rapeseed, jatropha, or animal fat fuels

How Are Generating Units Dispatched? Variable Operating Cost.



Source: EPRI Regional Stack Model

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Biomass Power and Policy

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Policy Issues for Biomass Power

- Carbon Constraints
- National Renewable Portfolio Standards
- State Renewable Portfolio Standards
- Liquid Fuels Mandates
- Jobs
- Supply Issues
  - Land use, competition, water
- Air Emission Regulations
  - Direct firing
  - Co-firing
- Carbon Neutrality of Biomass Supply

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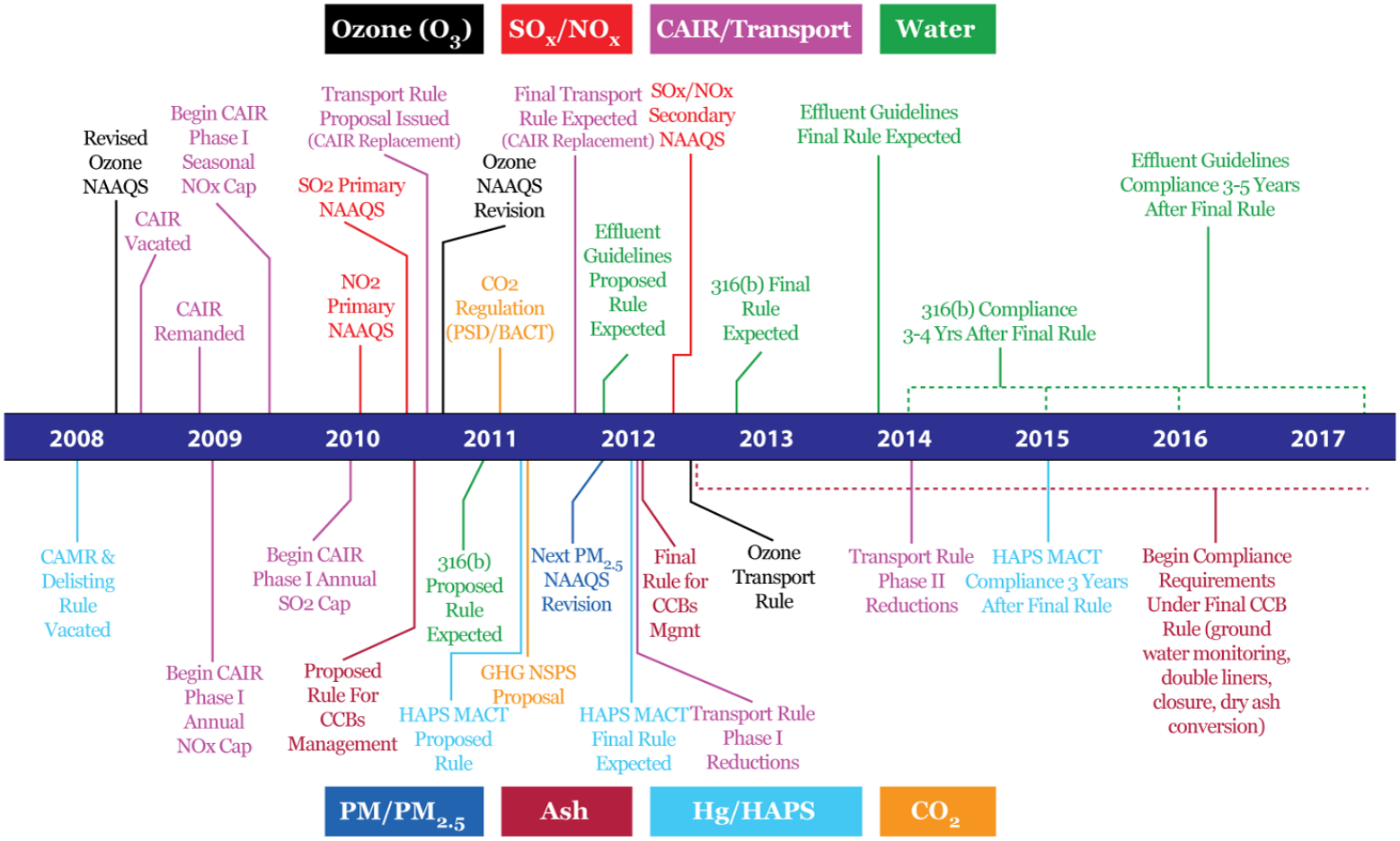
Possible Timeline for Environmental Regulatory Requirements for the Utility Industry

Pending EPA air and water pollution regulations for coal plants have been compared to a "train wreck" but this is hardly the case. The timeline below, originally produced by the Edison Electric Institute, primarily consists of procedural events and rules that will not impose a direct compliance obligation on coal units and otherwise serves only to spread confusion about EPA's actual regulatory schedule.



Sources: Edison Electric Institute 2010; Wegman, EPA 2003

For more information: **www.wri.org/eei-timeline-response**

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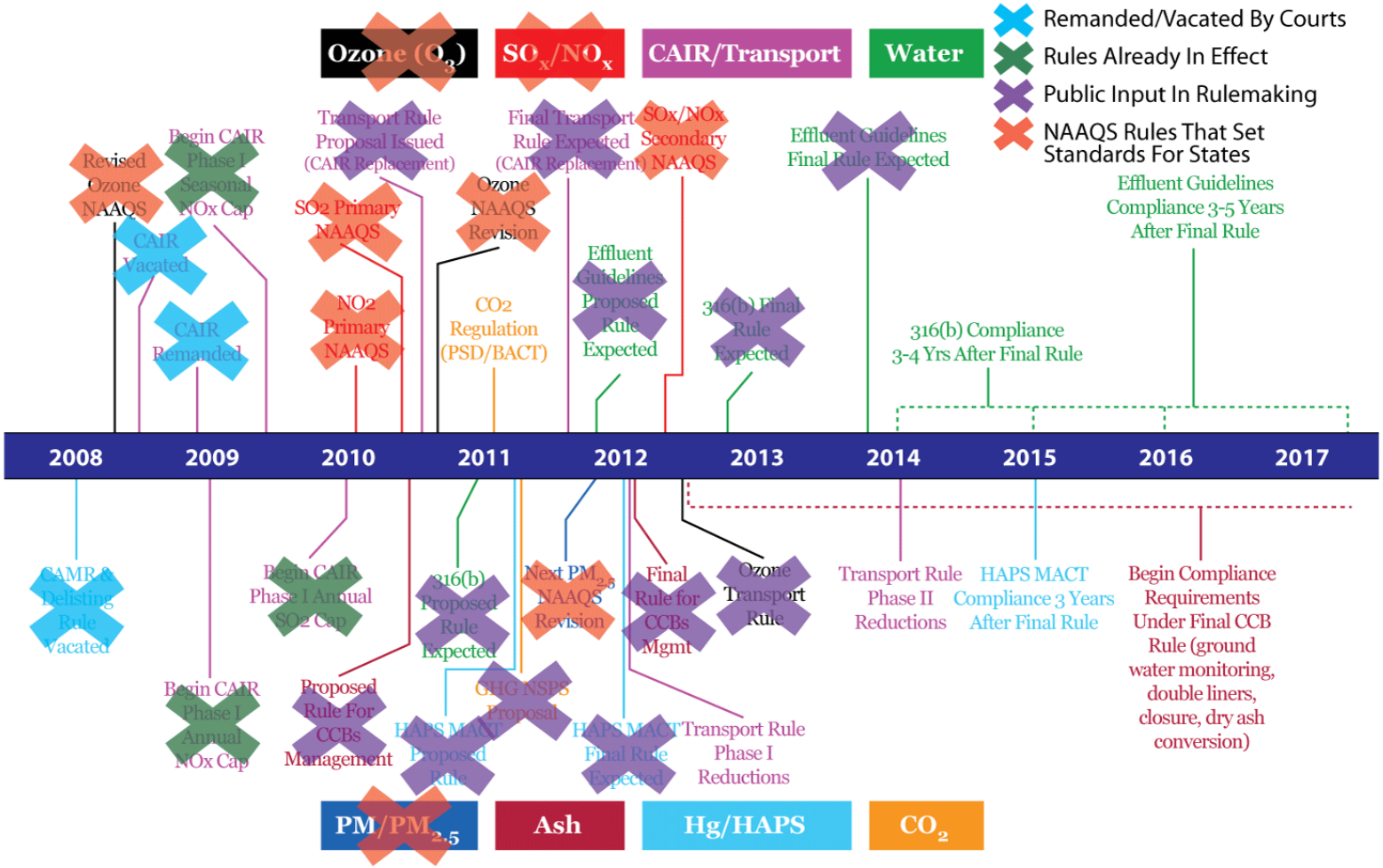
Environmental Regulatory Requirements For the Utility Industry, Removing All But New Compliance Obligations

There are four categories of EPA activity on the EEI timeline that should be removed leaving only the actual compliance obligations:



Sources: WRI Analysis based on Edison Electric Institute 2010, Wegman, EPA 2003.

For more information: **www.wri.org/eei-timeline-response**

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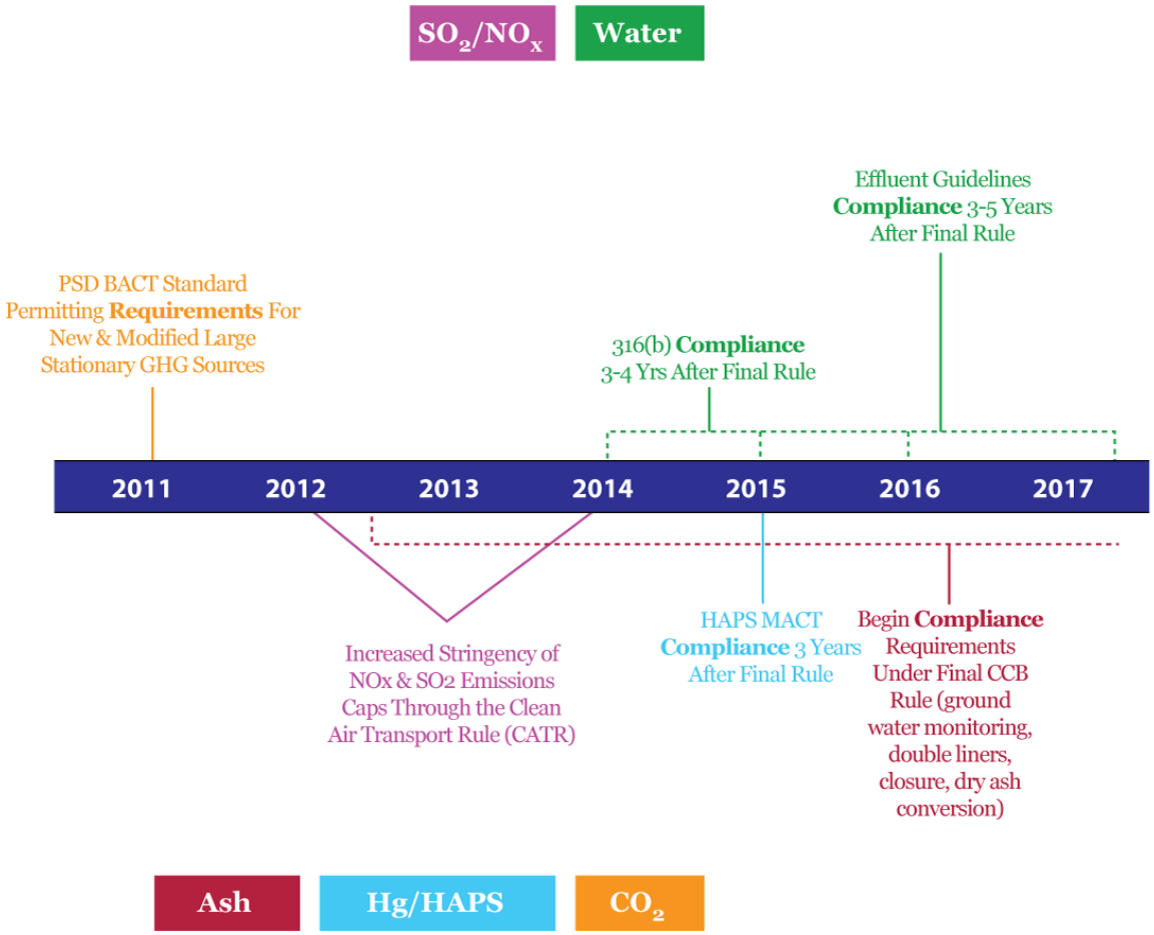
Regulatory Compliance Obligations for the Utility Industry

When only the actual compliance dates of new regulations are presented in the timeline, it becomes apparent that the EPA's regulatory process is clear and the utility industry has adequate time to prepare for pending compliance obligations.



Sources: WRI Analysis based on Edison Electric Institute 2010, Wegman, EPA 2003.

For more information: **www.wri.org/eei-timeline-response**

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The Basics of the 2011 Industrial Boiler MACT

- Industrial Boiler MACT: air emission regulations for non-fossil combustion units
- EPA had requested a 15 month extension, citing the large volume of comments and some fundamental changes to the proposed regulations
- The DC District Court gave them 30 days; the regulations came out March 22
- EPA has been clear that they anticipate aspects of this set of regulations to be "reconsidered"; they have not been clear about the "reconsideration" process or the timing
- Uncertainty going forward has hindered (but not eliminated) 100% biomass power deployment

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Current State of Environmental Regulation: Co-firing Implications

- Tailoring Rule
  - CO_2 from biomass is biogenic—for three years
  - Three years is great for research and discourse, OK for existing facilities—but NOT investment length
- Electric Generating Unit (EGU) MACT
  - Current rules are PROPOSED for existing and new units
  - From a co-firing perspective, it seems that biomass will have nil impact on emissions, emissions control decisions
  - Many small units may be shut down
- Under the expected regulatory regime, operating coal units in the near future will all have:
  - SCR
  - Scrubber
  - Mercury control
  - High efficiency particulate control

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How Will The Uncertainty Be Resolved, and What are the Implications?

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Biomass Power: Interesting Intersections

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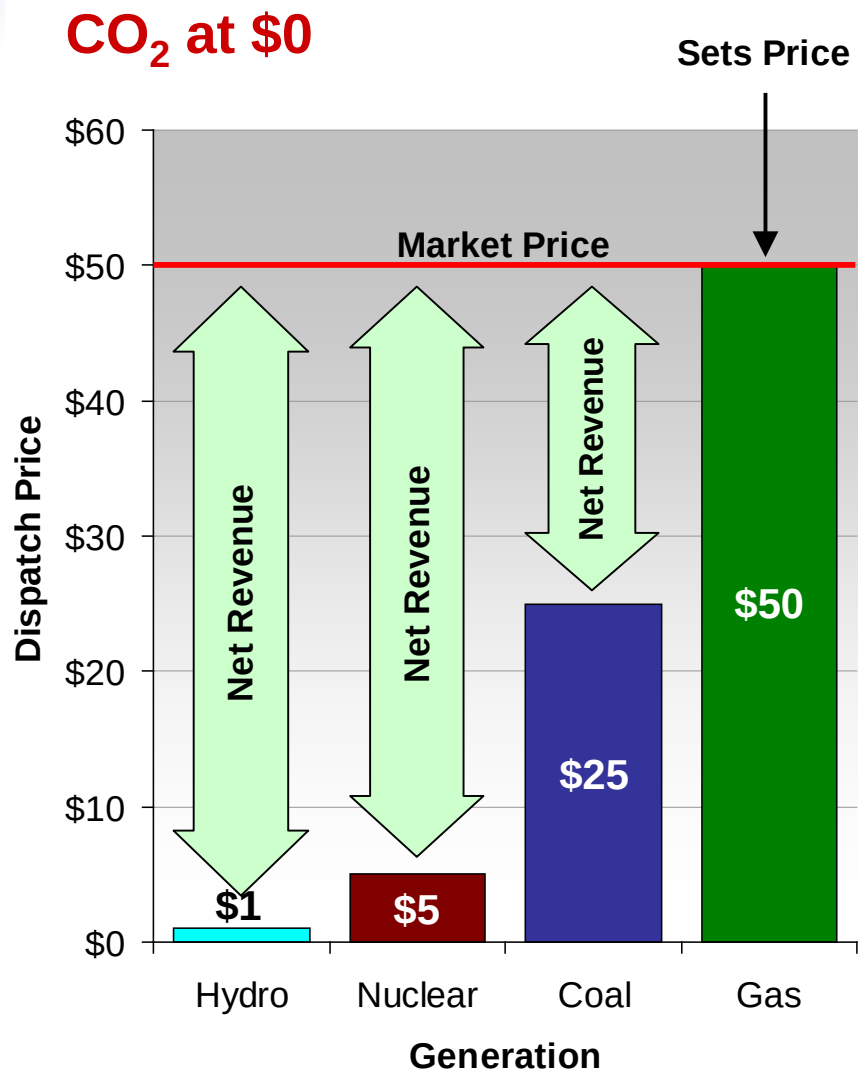
CO_2 Price Impacts Electric Market Price and Generator Net Revenue for Each Hour of Dispatch



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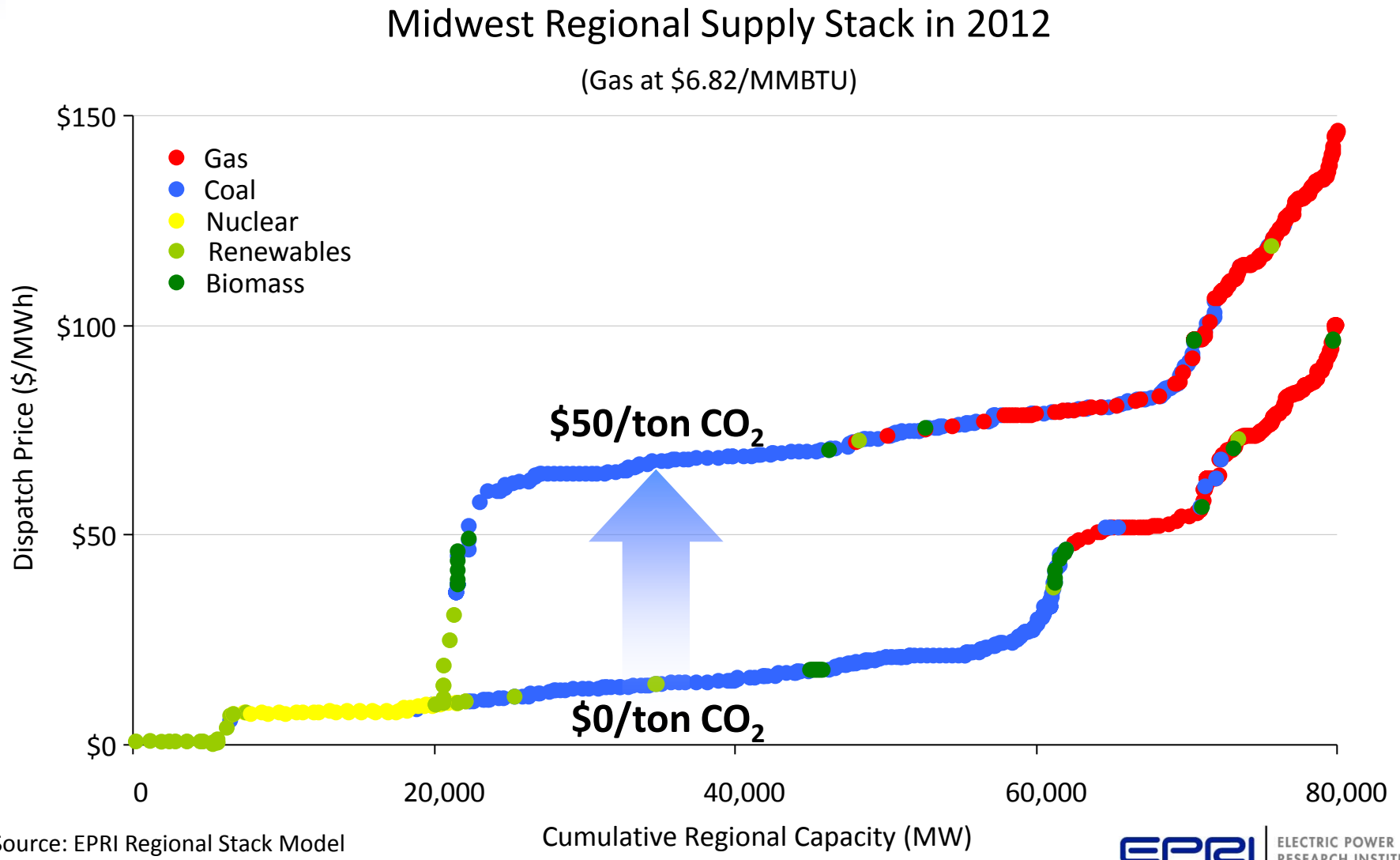
CO_2 Price Increases Dispatch Costs – Supply Stack Re-orders to Favor Less Emitting Generation



Source: EPRI Regional Stack Model

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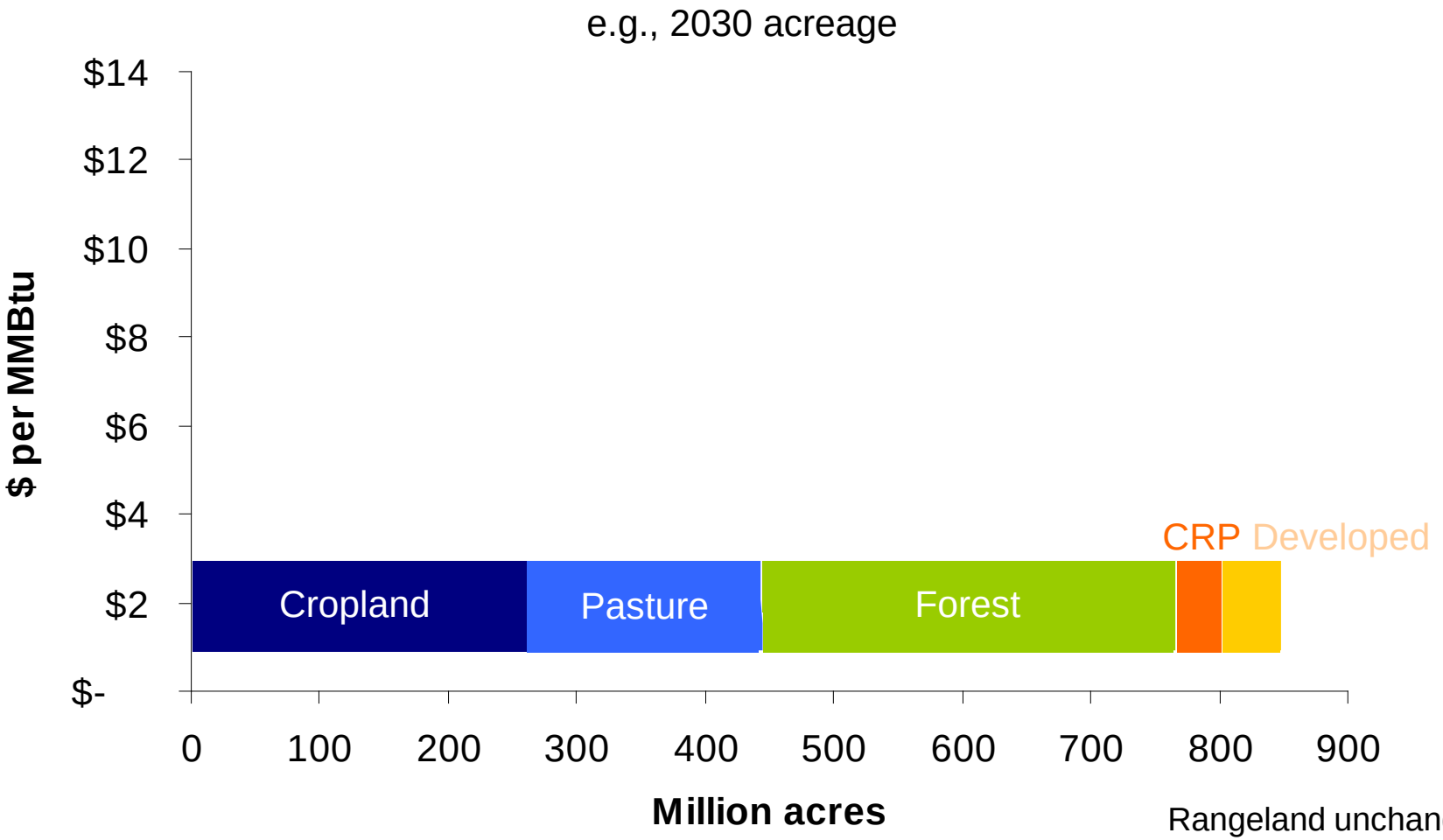
Nationally, Forest & Cropland Expand with Pasture Conversion as Bioelectricity Increases



Rangeland unchanged (not shown)

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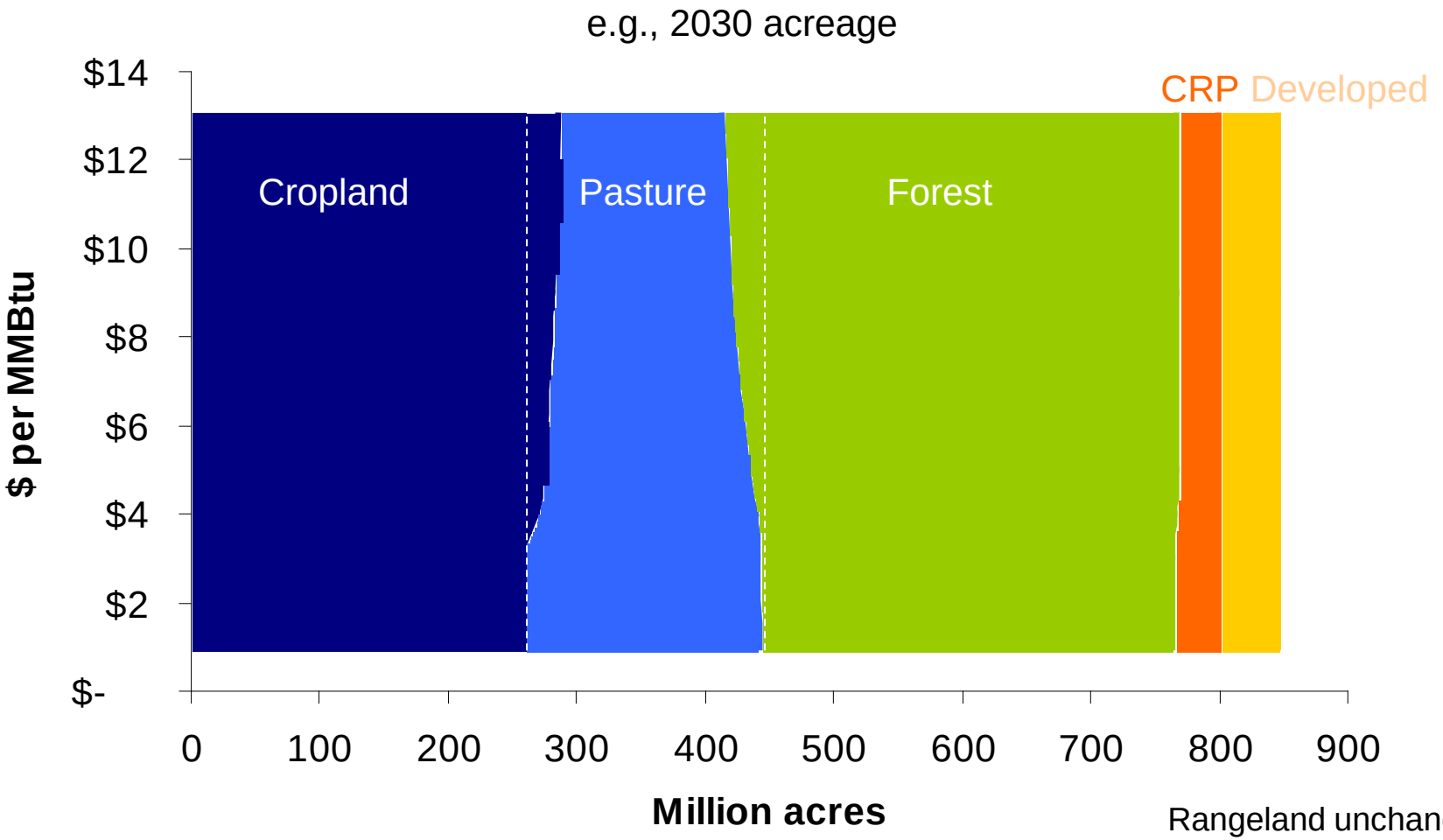
Nationally, Forest & Cropland Expand with Pasture Conversion as Bioelectricity Increases



Rangeland unchanged (not shown)

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Biomass Power: Research Issues

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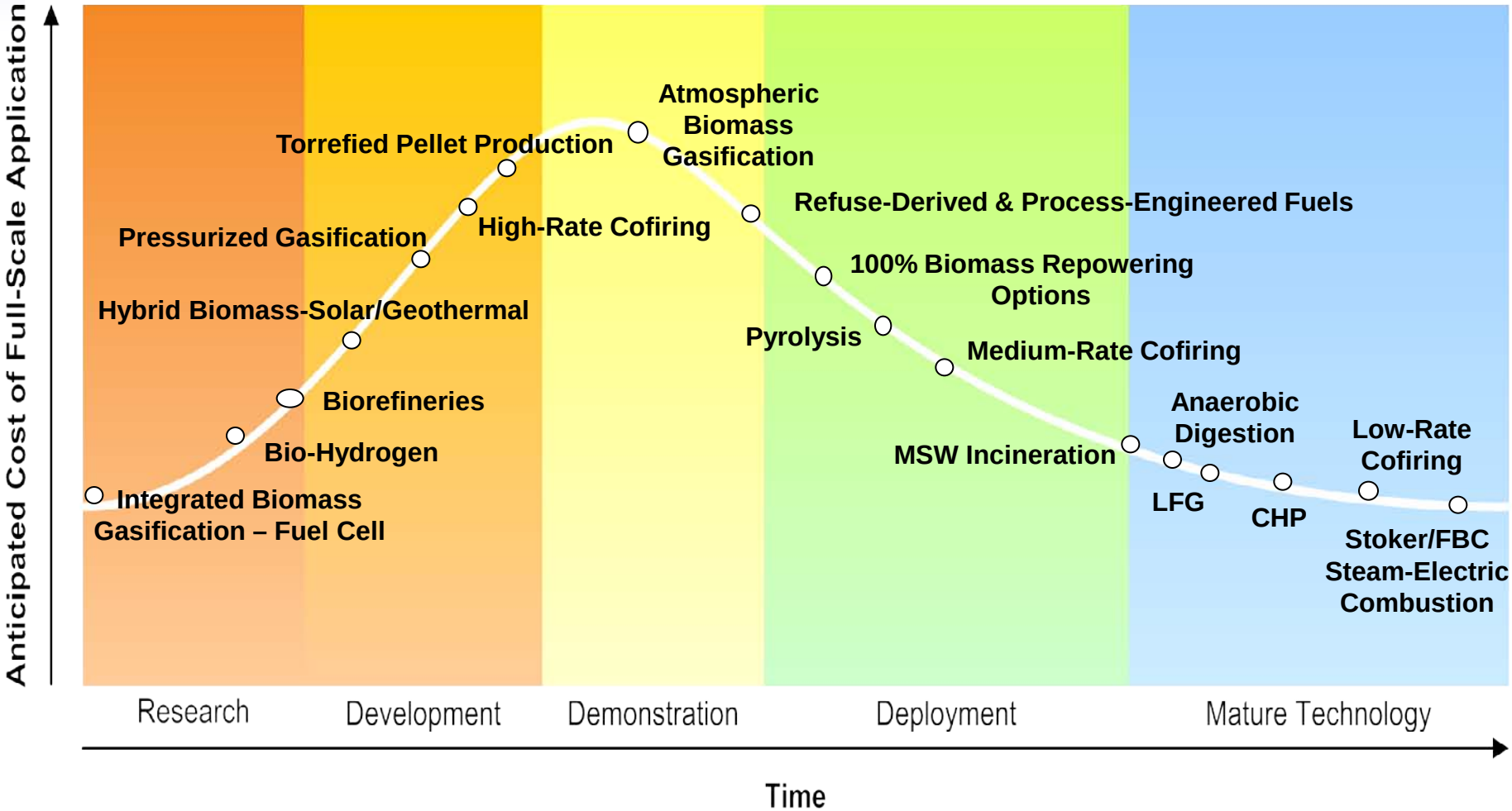
Biomass Technologies Deployment Curve

Generation



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Biopower Topics Currently Under Investigation

EPRI Generation Sector Projects

PLUS!!!

- Summary of Biopower Life Cycle Analyses
- Third Annual Biomass to Electricity Works
  - November 8-10, A
- Pressurized Bioma Gasification
- Repowering Us Injection
- Co-firing Direct Inj System Design
- Best Practices Biomass Handling
- Biofuels Crop Research

- Biomass Impacts on Environmental Control Equipment
- of Biofuel
- ss
- ady with artners
- s Test Burn
- Torrefier Tests

Environment Sector Work:

Supply Modeling

Penetration

Implications on Environment

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Large-Scale Test Burn of Torrefied Wood Chips

Develop Information on Torrefied Wood Firing

- Understand key performance and safety issues
  - Milling, Co-milling
  - Handling
  - Combustion
  - Emissions

Value

- Understand the implications of firing torrefied wood and the potential mitigating measures

Details and Contact

Dave O'Connor

- doconnor@epri.com, (650) 855-8970

Provide important details on torrefied wood combustion

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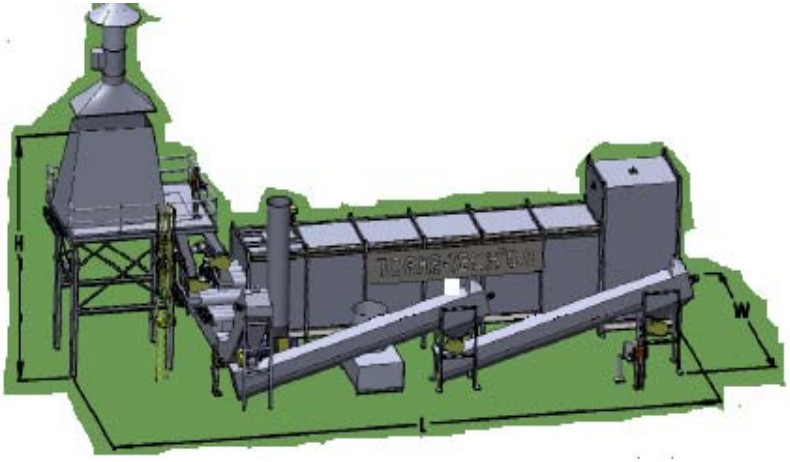
Torrefaction Pilot Testing

Objectives and Scope

- Independent testing of torrefaction technologies (output up to 2.5t/h) to assess product quality, flexibility, efficiency, mass yields emissions
- Produce torrefied chips and pellets to support burning tests at host power plants
- Participate in burning tests to extract lessons learned with these fuels

Value

- Reduce technical and economic risk of adopting torrefied biomass in co-firing applications.
- Expand the use and geographic range of economic biomass-to-energy production
- Assess performance of torrefaction process with a variety of feed stocks



Courtesy of Agritech Producers LLC

Details and Contact:

Luis Cerezo

- lcerezo@epri.com, (704) 595-2687

Expand economic use of pre-treated biomass in co-firing applications

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Biomass Power: Conclusions

- Many possible technically feasible options
  - Some commercial, some need considerable development
  - Marketplace likely to accommodate multiple solutions
- Economics currently dominated by fuel cost
  - Cost structure can change
- Regulatory uncertainty hinders development, investment
- Considerable work remains on virtually every aspect of biomass power

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Together…Shaping the Future of Electricity

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