

Reducing Greenhouse Gas Emissions from Coal-Powered Electricity with Biomass

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"Regulation of CO₂ Emissions from Power Plants: Flexibility and the Path Forward for Coal Dependent States" Conference at WVU Law February 24, 2014



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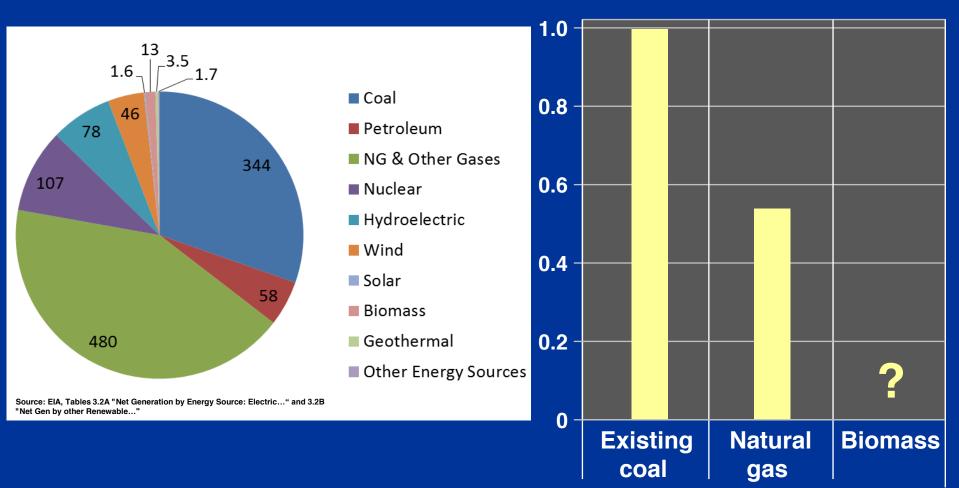
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Biomass is a Small Portion of Electricity But (Generally) Releases Less CO₂ Than Coal

U.S. 2012 Installed Capacity (GW)

<u>CO₂ emissions</u> (kg per kilowatt-hour)



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Using Plant Biomass as Fuel Is a Viable Near-Term Option for Renewable Electricity

Woody, e.g., forest residue



Crop residues, e.g., corn stover



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Purpose-grown, e.g., switchgrass



RAND Has Conducted a Series of Studies Examining the Potential of Using Biomass

- Supply issues and costs of biomass acquisition
- Logistical challenges of biomass acquisition
- Technical barriers of biomass-to-energy conversion
- The CO₂ implications of using biomass

RAND's approach combines more fundamental scientific analysis with assessments of technical feasibility and costs based on real experience

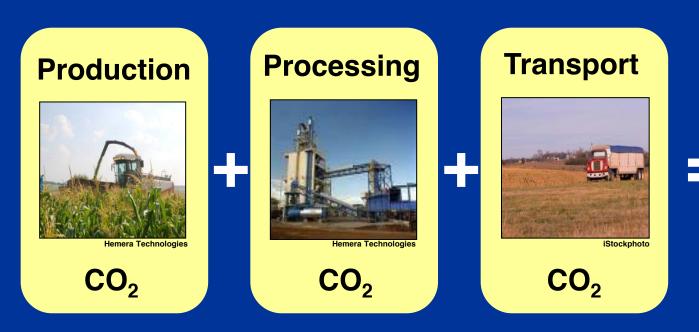
Today We Focus on Three Questions

- Can biomass reduce the CO₂ emissions generated by producing electricity?
- How much does it cost to use biomass for electricity?
- How cost-effective is biomass at reducing CO₂ relative to other low-CO₂ technologies?

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We Calculated Net CO₂ Emissions for Many Combinations of Scenario Choices



Net CO₂ emissions from biomass fuel acquisition

Net Production Emissions are Dependent on Carbon Cycle Both Above and Below Ground

Plants remove CO₂ gas from the atmosphere



Carbon stored in leaves and stems is returned to the atmosphere when burned (a neutral effect on atmospheric CO₂)

Carbon stored in roots and soil is removed from the atmosphere (a net reduction in atmospheric CO_2) Analyzing Production Emissions Revealed That Three Choices Are Most Important to This Stage

Crop choice

Geographic region

Prior land use

How do production choices affect CO₂ emissions?

Analysis of Biomass Energy Scenarios Illustrates the Importance of Electricity Producer Choices

Example: 100 MW coal-burning unit at an electricity facility in Western Pennsylvania

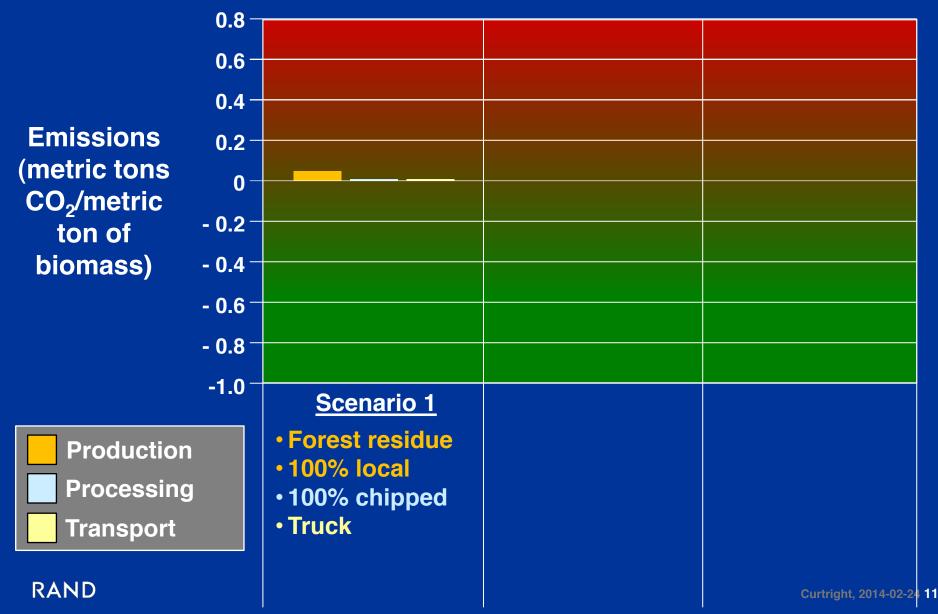
- Generates enough power for ~100,000 homes
- Substitute 5% of coal with biomass fuel
- Requires ~50,000 metric tons of biomass annually, or 5-10 truck loads of biomass daily



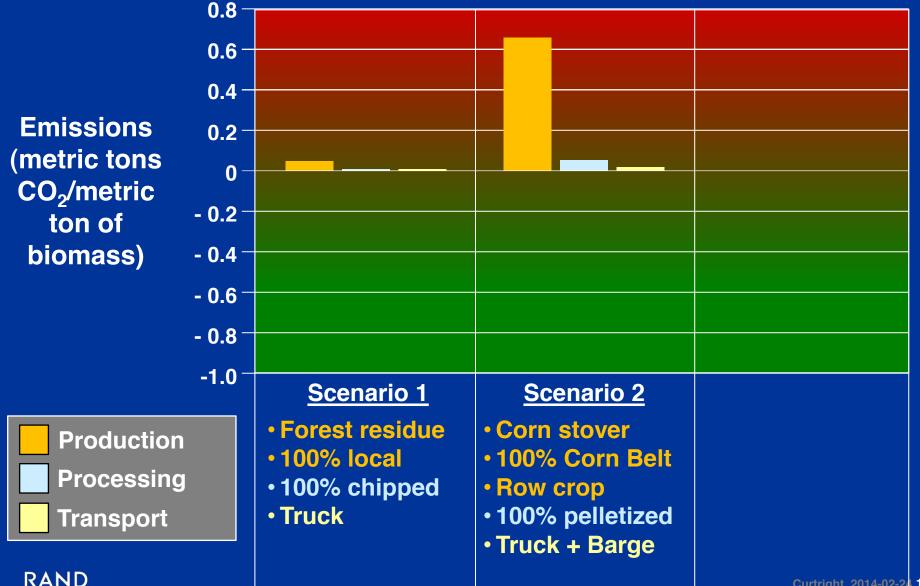
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Key choices Which type of biomass? Where will it be grown? How will it be processed? How will it be transported?

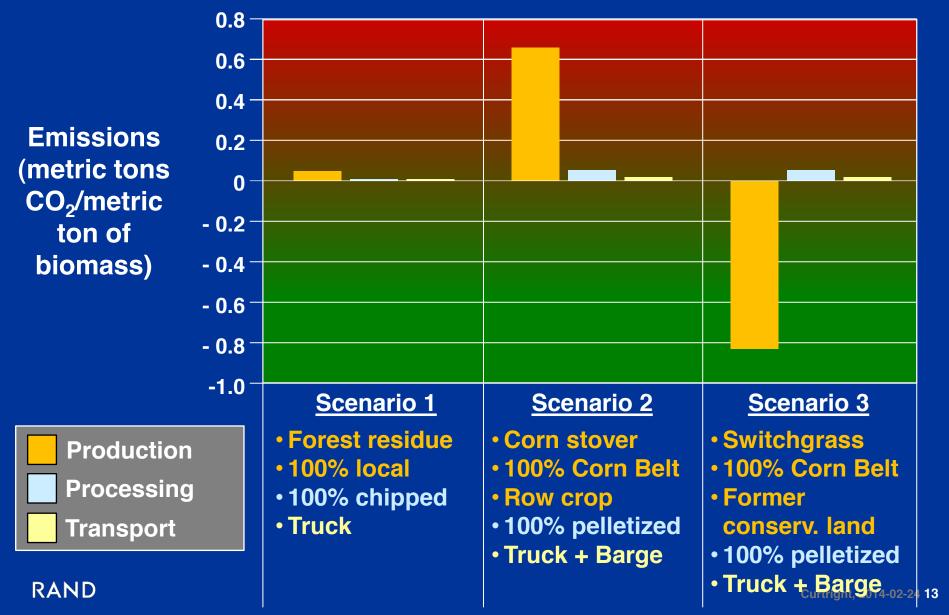
Each Scenario Represents Different Biomass Choices



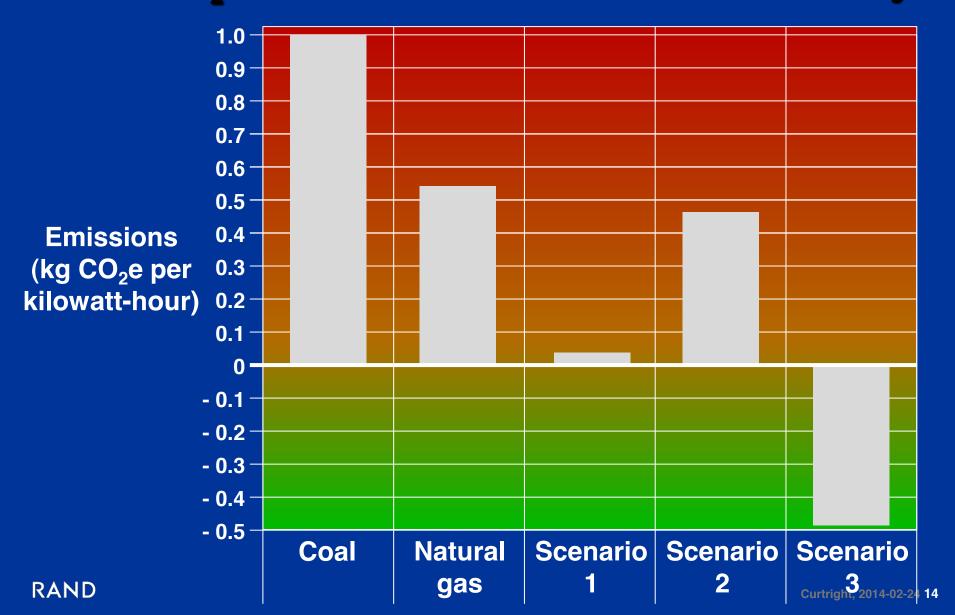
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Each Scenario Represents Different Biomass Choices



Despite Scenario Choices, Biomass Still Emits Less CO₂ than Coal When Used for Electricity

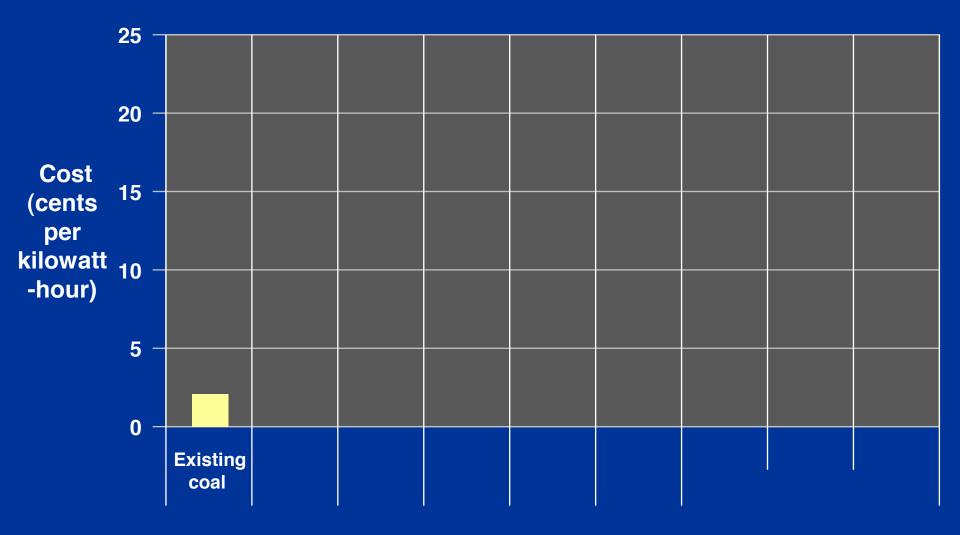


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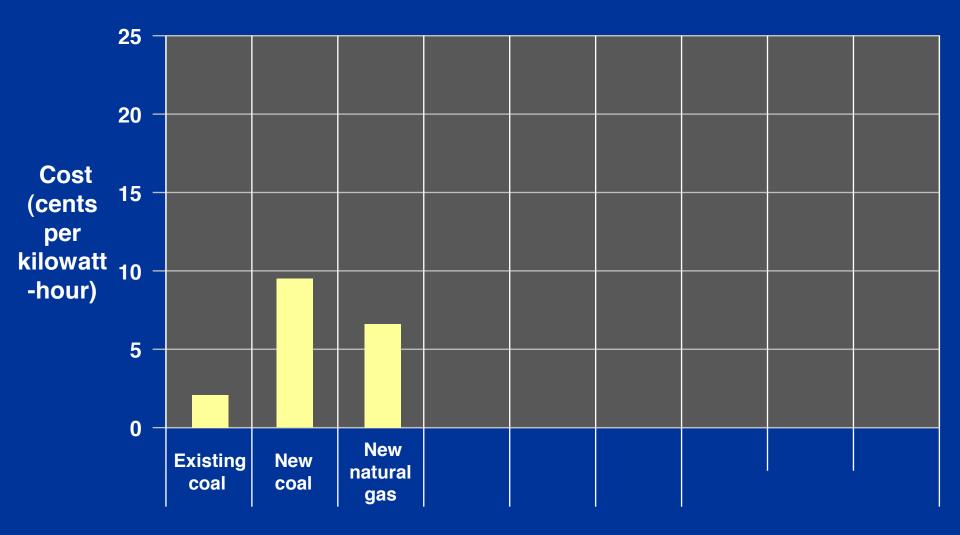
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Biomass can reduce CO₂ relative to coalbased electricity

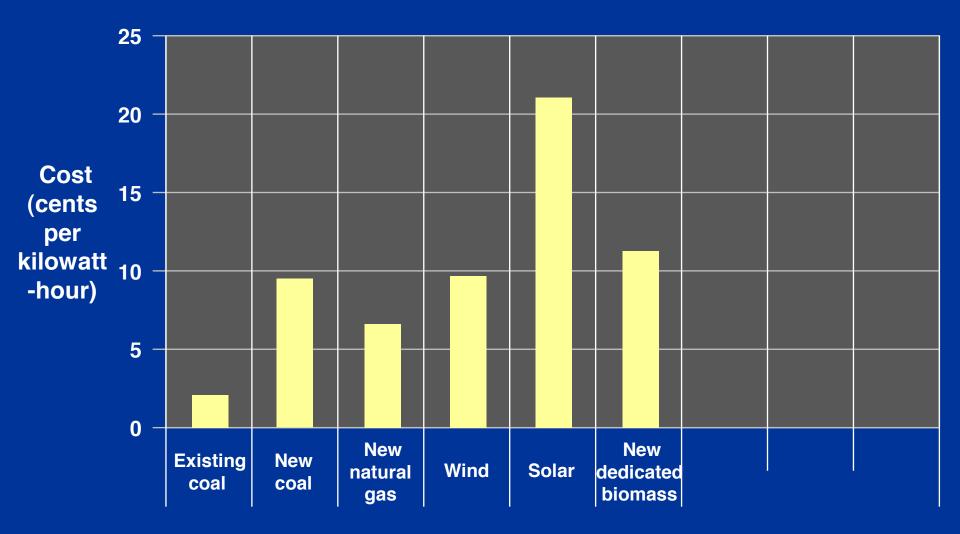
Burning Coal in Existing Power Plants Is a Very Inexpensive Way to Make Electricity



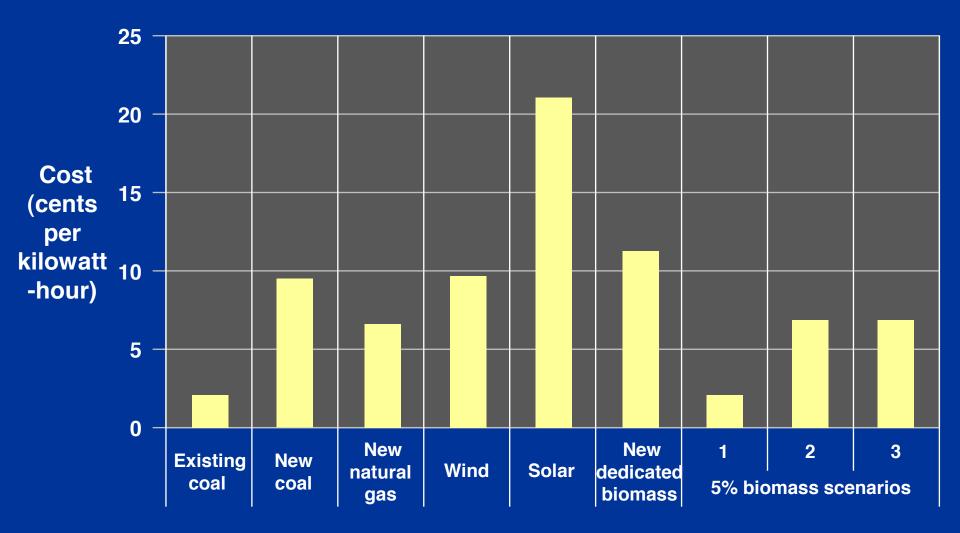
New Fossil Fuel-Based Electricity Would Be More Expensive



Many Renewable Sources of Electricity Are Significantly More Expensive As Well



Burning Biomass in Existing Coal-Fired Electricity Facilities is Relatively Inexpensive



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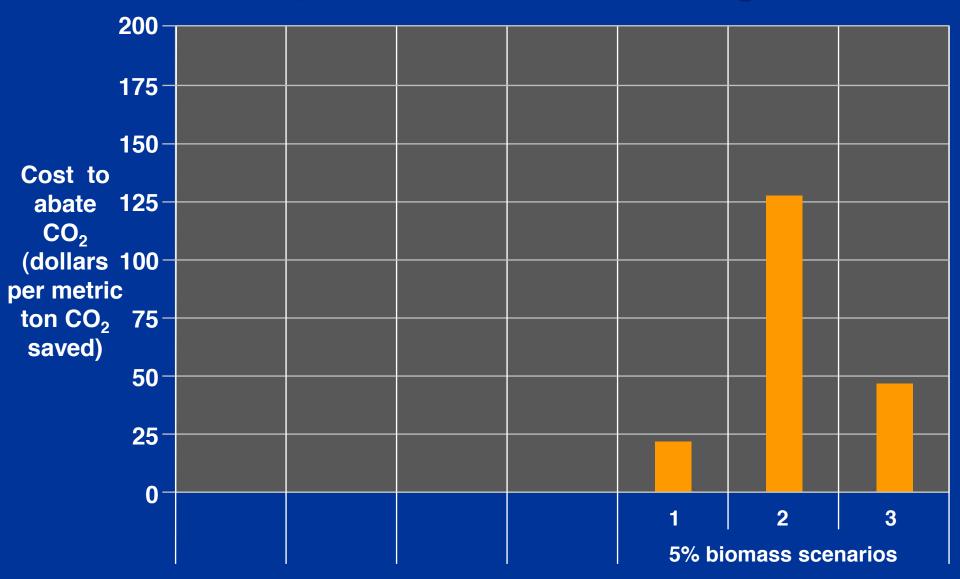
 Can biomass reduce the CO₂ emissions generated by producing electricity?

 How much does it cost to use biomass for electricity? Biomass can reduce CO₂ relative to coalbased electricity

Biomass can be competitive with new fossil generation and other renewables

 How cost-effective is biomass at reducing CO₂ relative to other low-CO₂ technologies?

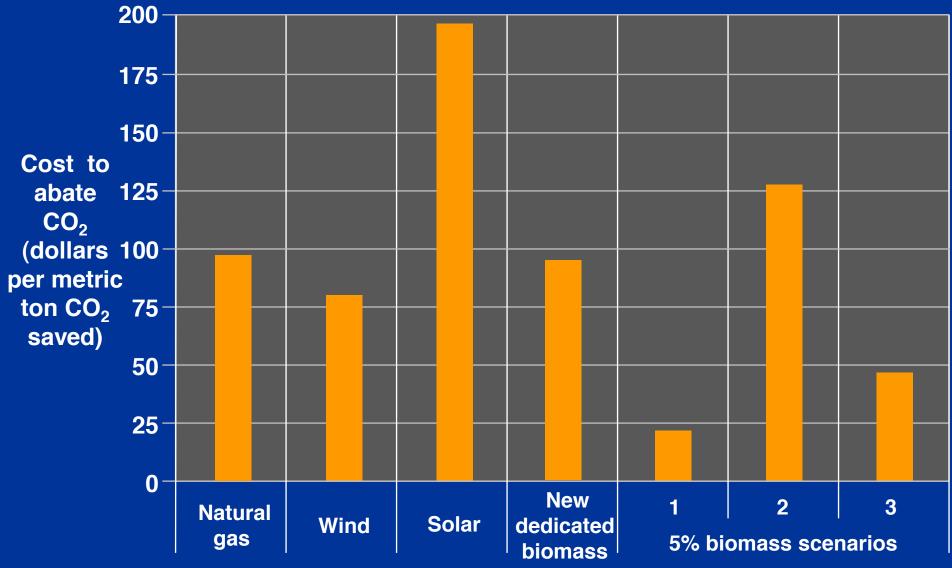
We Calculate the Cost-Effectiveness of Using Biomass to Reduce CO₂



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These Findings Allow Us to Compare Biomass to Other Low-CO₂ Technologies



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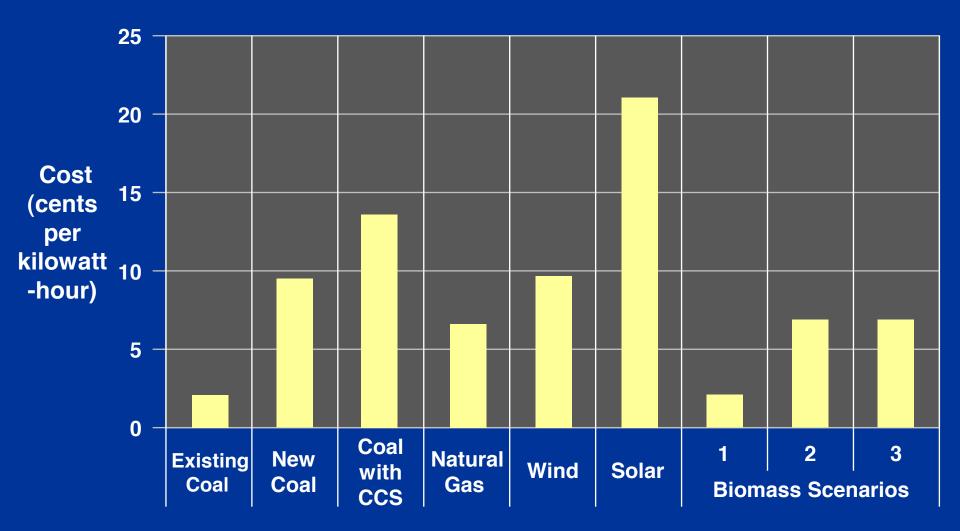
Biomass may be costeffective for CO₂ reduction but must be assessed on a case-by-case basis

Acknowledgments and Sources

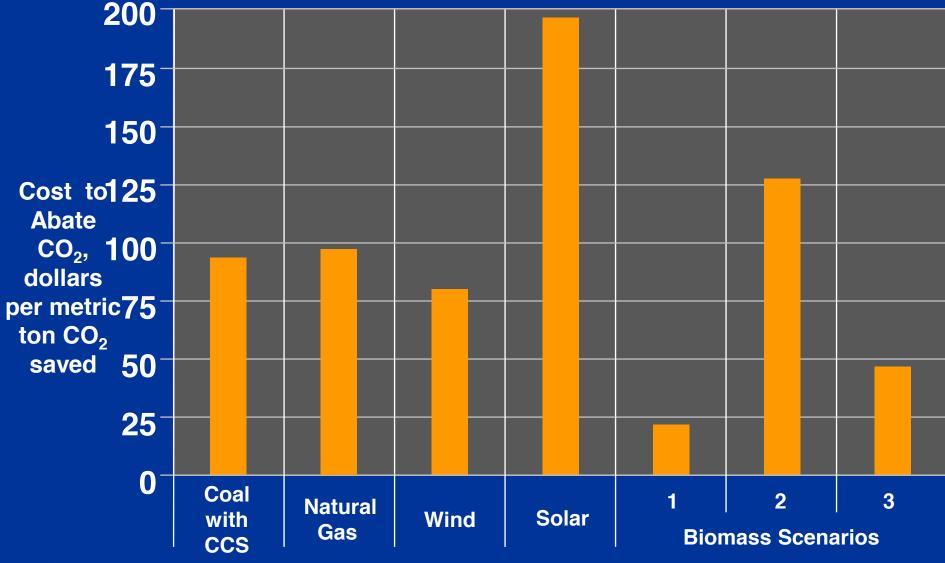
- Funding and helpful substantive feedback provided by Department of Energy (DOE)'s NETL
- We also thank more than a dozen individuals at companies for sharing their experiences with biomass co-firing and for providing feedback on the final report
- Sources:
 - Ortiz *et al* "Near-Term Opportunities for Integrating Biomass into the U.S. Electricity Supply: Technical Considerations"
 - Johnson *et al* "Identifying Key Drivers of Greenhouse Gas Emissions from Biomass Feedstocks for Energy Production"



Burning Biomass in Existing Coal-Fired Electricity Facilities is Relatively Inexpensive



These Findings Allow Us to Compare Biomass to Other Low-CO₂ Technologies



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The Relative Cost of Capital versus Operations and Maintenance (O&M) Vary By Technology

