Outline

• About EPRI and Renewables
• Pathways to Biopower
• Utility Biopower Interest and Needs
• EPRI’s R&D agenda for Biopower
• Moving Forward
About The Electric Power Research Institute

The Electric Power Research Institute (EPRI), with major locations in Palo Alto, California; Charlotte, North Carolina; and Knoxville, Tennessee, was established in 1973 as an independent, nonprofit center for public interest energy and environmental research.

EPRI brings together members, participants, the Institute’s scientists and engineers, and other leading experts to work collaboratively on solutions to the challenges of electric power.

These solutions span nearly every area of electricity generation, delivery, and use, including health, safety, and environment.

EPRI’s members represent over 90% of the electricity generated in the United States. International participation represents nearly 15% of EPRI’s total research, development, and demonstration program.
EPRI’s 2010 Renewable Energy Research Portfolio
Leveraging Cross-Sector Expertise

Core Research
• Waterpower
• Renewable Generation
• Enabling Transmission for Large-Scale Renewable Integration
• Enabling Integration of Distributed Renewables

Enabling Research
• Energy Storage
• IntelliGrid℠

Key Elements
• Resources Evaluations
• Conversion Technologies
• Grid Integration
• Data and Information

Advantages
• Broader Technical Base
• Cross-Sector Advisory

RENEWABLE ENERGY
Working to develop large-scale and distributed generation technology, and to expand and equip the grid to operate efficiently and reliably with diverse renewable sources.
Expanding EPRI’s Portfolio

Renewables

Water Power

Large Renewable Integration

Distributed Integration

Economics and Technology Status

Biomass

Solar

Wind

Geothermal

Water Power

2008

2009

2010
What is Biomass?

Historical context - Fuel

Biomass is...

A. Waste
B. 2nd Generation solar
C. An environmental solution
D. An environmental problem
E. An energy crop
F. Carbon neutral
G. Carbon positive
H. Carbon negative
I. As Justice Stewart said, “…pornography…I know it when I see it.”
J. All of the above

Biomass Resources

- High moisture
- Geographically disseminated
- Can have undesirable and favorable constituents and components
- Typically fibrous
- Cost varies considerably
- Amenable to upgrading
- Energy density is low
Pathways to Electric Power

• Microorganism action
  – Digestion – typically manure or landfill
  – Fermentation – ethanol
  – Algae

• Combustion
  – Direct combustion
  – Co-combustion – typically with coal

• Gasification, Pyrolysis, Feedstock Upgrading

• Other – biodiesel
Combustion Based Electric Power

• Direct Combustion
  – Fluid Bed
  – Stoker
  – Pneumatic Injection
  – Repowered units

Awirs, Belgium

• Co-Combustion (Cofiring)
  – Typically in coal-fired units
  – Some investigation into co-firing with gas
    • Liquid fuels in CT
    • Solid fuels in boiler

Gadsden, Alabama
Biomass Gasification / Pyrolysis

- Gasification – produces low to medium quality gas
- Multiple utility-scale technologies
  - Fixed Bed Updraft
  - Fixed Bed Downdraft
  - Fixed Bed Co-current
  - Fluid Bed
- Gas for CT/IC, repowering, upgrading, or cofiring
- Not quite ready for prime time?

- Pyrolysis typically focuses on liquid products
- Similar to No. 2/6 oil or diesel, only acidic
- Not widely deployed, even at pilot scale, for electricity
- Potential for carbon recycling
- Partial pyrolysis is the basis for torrefaction processes
General Conclusions

Strategic Objectives for Biomass

• Sustainability
  – Resource availability
  – Fuel-type
  – Energy supply chain
• Power generation
  – Repowering
  – Co-firing
  – Gasification
  – Others
• Minimize impact on operation and environment
EPRI Biomass 2009 Activities Summary

• Cofiring Guideline
• SCR Issues Report
• Gasification Commercial Deployment Issues
• Torrefied Wood Chips Test Burn
• Vista Software Application Study
• FBC Applications
• Biomass to Electricity Workshop, BIG meeting
• European Experiences Webcast

• SE US Resource Assessment
• Mitchell Repowering study
• Scholz Repowering Study
• Sweatt Repowering Study
• Pulverized wood transport
• Alabama Power Repowering Assessment
• Accurate Biomass Fraction in Cofiring
• Torrefied Wood Technology Review
• Torrefied Wood Plant Development
EPRI Biomass 2010 Activities

- Biomass Sustainability White Paper
- Building a Robust Supply Chain
- Biomass Properties Database
- Test Burn of Torrefied Biomass Pellets
- Gasification Technology: Cost, Performance, Deployment Data for Project Planners
- Tests of Biomass Cofiring Impact on Catalyst Life
- Transport Gasifier Tests
- Pressurized Gasifier Tests
- Reference Plant Development
- Biomass crops studies
- Bio Oil Test Burns
- Environmental Permitting Issues
- Biomass Milling Tests
- Trees to Transport Analysis
- CFD Modeling of Biomass Combustion Systems
- Novel Approaches to Biomass Power
- Biomass Handling Best Practices
Biomass to Electricity Drivers

• Renewable Portfolio Standards
  – Existing and future state standards (26?)
  – Big, medium, and small blocks of biopower required
  – Future federal regulations
• Generation in a carbon constrained world
  – Sustainable supply
  – Reliable life cycle analysis
• Favorable economics, local conditions

Biomass based power is dispatchable, reliable, and generally requires no investment beyond the generating asset.
Technology Spotlight: Big Blocks of Renewable Energy with Biomass

• Three primary ways to “Big Blocks” New units, High-Rate Cofiring, Repowering
• Numerous Projects Completed/Announced
  – Awirs, Avedøre, Hasselby, Schiller, Snowflake, Mitchell, Atikoken, Bay Front, Burger, Thunder Bay, Scholz, Nanticoke, Stoneman, others
• Advantages of Repowering with Biomass
  – Significantly cheaper than new capacity (1/3 or better?)
  – GHG/RPS Implications
  – Environmentally simpler (?)
  – Use of existing assets, and all associated implications
  – Many options for moving off coal
• Disadvantages of Repowering with Biomass
  – No capacity addition (frequently a capacity loss)
  – Biomass supply, cost have a highly uncertain future
Large Scale Deployment Options Abound

<table>
<thead>
<tr>
<th>Approach</th>
<th>Industry Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenfield New Boiler</td>
<td>Oglethorpe Power Cooperative announcements</td>
</tr>
<tr>
<td>Modify Existing Boiler to Stoker or Fluid Bed</td>
<td>Georgia Power Plant Mitchell</td>
</tr>
<tr>
<td>Direct Firing in Existing Boiler</td>
<td>FirstEnergy R. E. Burger or Ontario Power coal fleet</td>
</tr>
<tr>
<td>Externally Gasify Biomass</td>
<td>Xcel Energy Bay Front</td>
</tr>
<tr>
<td>Replace Boiler with Turbine-Sized FBC/Stoker</td>
<td>Northern Wood Power Plant Schiller</td>
</tr>
<tr>
<td>Modify Gas Steam Unit</td>
<td>Mississippi Power Plant Sweatt</td>
</tr>
</tbody>
</table>

Many other options, combinations, and permutations are possible
# Large Scale Biomass Deployment: Cost Issues

<table>
<thead>
<tr>
<th>Approach</th>
<th>Expected Capital Cost</th>
<th>Expected O&amp;M Cost, incl. Fuel</th>
</tr>
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<tbody>
<tr>
<td>Greenfield/Brownfield New Boiler</td>
<td></td>
<td>✅</td>
</tr>
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<td></td>
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<td>✅</td>
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<td>✅ ()/</td>
<td>✅</td>
</tr>
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<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>Modify Gas Steam Unit</td>
<td>✅</td>
<td></td>
</tr>
</tbody>
</table>

- **Relative Advantage**
- **Relative Disadvantage**
## Large Scale Biomass: Deployment Issues

<table>
<thead>
<tr>
<th>Approach</th>
<th>Capacity Implications</th>
<th>Schedule Issues</th>
<th>Technical Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenfield New Boiler</td>
<td>✓</td>
<td>✗</td>
<td>✓</td>
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<td>✓</td>
</tr>
<tr>
<td>Modify Gas Steam Unit</td>
<td>✓/✗</td>
<td>✗</td>
<td>✓</td>
</tr>
</tbody>
</table>

- ✓ Relative Advantage
- ✗ Relative Disadvantage
Multiple host sites are envisioned to capture the wide variety of technology solutions

• Wood (in various forms) is dominant fuel

• Major technology types:
  ✓ • Direct Firing in Existing Boiler
  ✓ • Modify Existing Boiler to Stoker or Fluid Bed
  ✓ • Externally Gasify Biomass
  ✓ • High Rate Cofiring
    • Modify Gas Steam Unit
    • Replace Boiler with Turbine-Sized FBC/Stoker

✓ likely to be considered in Demo
Proposed Industry Technology Demonstration for Biomass Power

**Benefits:** Accelerate deployment of renewable energy by supporting the demonstration of biomass repowering technologies that leverage existing assets, help meet renewable targets, and dramatically reduce CO₂ emissions

**EPRI Role:**

- Potentially work with 2 or more host projects that are powering existing fossil-fired stations with biomass
- Support testing and data analysis during start-up and operation
- Perform independent evaluation of plant performance and operations
- Assess best practices and lessons learned regarding planning, design, fuel supply, construction, O&M, performance, economics, etc.
- Develop guidelines, reports, workshops, etc. and disseminate knowledge to those with interests in biomass power
Moving Forward—Current Needs and Future Prospects

• Regulatory certainty
  – Supply, sustainability
  – Environmental treatment

• Resolve supply issues

• Provide repowering analysis, demonstrations
  – One size fits all—not likely

• Develop high percentage cofiring technology

• Resolve environmental equipment performance

• Develop, demonstrate gasification for power production

• Demonstrate commercial viability of upgrading technologies

• As appropriate, integration with biorefinery concepts
Together…Shaping the Future of Electricity
Biomass R&D Needs/Opportunities

Progress needed for repowering and co-firing

- Resource availability / fuel cycle
- Fuel processing & handling
- O&M
- Combustion and environmental control
- Environmental impact
- Performance and demonstration
Biomass Resource Availability / Fuel Cycle

• Supply Security
  – ‘Trees to transport’
  – Initial studies show electric route offers efficiency, GHG advantages over cellulosic ethanol

• Energy supply chain
  – Promote/encourage energy crops
  – Harvesting issues
  – Seasonal issues / storage
  – Plant delivery systems
  – Forestry management

• Economics of competing feedstocks
  – RPS
  – Exports
Biomass Fuel Processing / Handling

• Torrefied fuel
  – Various feedstocks
    • Wood, grasses, reeds
    – Performance in utility service
    – Economics
• Fuel drying to improve efficiency
• Ag waste or seasonal storage
• Best practices
Biomass Operations & Maintenance

• Supply-side optimization
• Varying co-firing fractions and feedstock
  – Operating strategies
  – Reliability centered maintenance
  – Slagging and fouling
• Predictive tools for minimizing impact of biomass
• Emission control equipment
Biomass Combustion & Environmental Control

• Impact on SCR systems
  – Catalyst de-activation
  – Catalyst poisoning
• Feasibility of biomass with CCS
• Impact of various biomass feedstocks
  – Corrosion
  – Deposition
  – Ash characterization
  – Emissions
Biomass Environmental Impact

- Life-cycle assessment -- Is biomass carbon neutral?
- Sustainability concerns
  - Soil quality/stand productivity
  - Water quality
  - Biological diversity/habitat
- Changes in forestry management
  - Maintain water quality
  - Reduce environmental impact
- Fugitive emissions air quality studies
  - Increase in dust at site boundary
  - Emissions from truck unloading mechanisms
- Emissions benefits (credits, etc) – a moving target
Biomass Performance / Demonstration

• Evaluate co-firing technologies
  – Co-milling
  – Direct injection
  – Multi-waste
• Design tools
  – Modular design/construction
  – Optimum size
  – Co-location study of torrefaction facility
• Permitting guidance and data
• Small (2-10 MW) distributed generation
• Large-scale demonstration