Biomass and the RPS

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Commissioner

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Outline

- Introduction
- Biomass Policy Context
- California’s Electricity Supply
- California’s Biomass Wastes
- Status of Bioenergy Development in California
- Biomass RD&D Activities & Projects
- Concluding Remarks
Key Renewable Energy Policy Impacting California

2010

- Accelerated RPS (from SB 107/IEPR/EAP/Governor’s Response)
- SB-1 and California Solar Initiative
- State Bioenergy Goal (Executive Order S-06-06)
- AB-32

2016

- Renewables 20% of Generation (~54,000 GWh)
- New Roof-top Solar PV 3,000 MW (~5,000 GWh)
- 20% of RPS from biopower (~11,000 GWh)
- 20% biofuels produced in California

2020

- Renewables 33% of Generation (~98,000 GWh)
- 20% of RPS from biopower (~20,000 GWh)
- 40% biofuels produced in California
- Global Warming Solutions Act of 2006; aggressive GHG Reduction goals for 2020

1. Assumed capacity factors are 20% for residential and commercial solar PV and 90% for biopower.
California’s Electricity Supply in 2008

In-State Generation and Estimated Energy Imports by Fuel Type
(Total: 306,577 GWh)

- Natural Gas: 45.7%
- Nuclear: 14.4%
- Large Hydro: 11.0%
- Renewables: 10.6%
- Coal: 18.2%
- Geothermal: 4.4%
- Biomass: 2.1%
- Small Hydro: 1.4%
- Wind: 2.4%
- Solar: 0.2%

(Includes Energy Imports)

http://www.energy.ca.gov/2010publications/CEC-500-2010-007/CEC-500-2010-007.PDF
Biomass to Electricity

Electricity generated by 1 kJ of solar energy

<table>
<thead>
<tr>
<th>Capture technology/fuel</th>
<th>Efficiencies</th>
<th>Storage time (yrs)</th>
<th>J generated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Energy</td>
<td>Fuel</td>
<td>Electricity</td>
</tr>
<tr>
<td></td>
<td>capture</td>
<td>synthesis</td>
<td>generation</td>
</tr>
<tr>
<td>Solar b</td>
<td>0.15</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Photosynthesis/biomass</td>
<td>0.024</td>
<td>1</td>
<td>0.21</td>
</tr>
<tr>
<td>Photosynthesis/coal</td>
<td>0.024</td>
<td>0.089</td>
<td>0.38</td>
</tr>
<tr>
<td>Photosynthesis/gas</td>
<td>0.024</td>
<td>84 x 10^{-6}</td>
<td>0.42</td>
</tr>
<tr>
<td>Photosynthesis/oil</td>
<td>0.024</td>
<td>93 x 10^{-6}</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Biomass Wastes = Viewed as a Disposal Problem

- Reducing Landfill Capacity
  - Over 40 million tons of biomass goes into landfills every year
- Contributing to Air Pollution and Fire Risk
  - Open field burning of crop residues emits more than 100,000 tons of air pollutants annually
  - Wildfires contribute over 1.1 million tons per year at a cost of >$900 million/year
- Local Concerns
  - California’s 1.67 million dairy cows generate odor and health concerns
California Biomass Resources

Agriculture, 128 TBtu, 22%

Forestry, 242 TBtu, 41%

Urban, 128 TBtu, 11%

Landfill Gas, 61 TBtu, 2%

Waste-water Treatment, 10 TBtu, 2%

Agriculture, 137 TBtu, 24%

Potential Feedstock Energy in Biomass
507 Trillion Btu/year

+ 137 BCF/year landfill and digester gas

California Energy Commission
Biomass Feedstock
- Agricultural Residues
- Forestry Residues
- Municipal Solid Waste
- Energy Crops

Conversion Processes
- Thermochemical (Combustion, Gasification, Pyrolysis)
- Biochemical (Anaerobic Digestion, Fermentation, Aerobic, Direct Hydrogen))
- Physicochemical (Oil Extraction, Hydrocarbon Extraction)
- Manufacturing (may employ Physical & chemical Processing)

Utilization
Biofuels:
- Ethanol
- Biodiesel
- Methanol
- Hydrogen
- Others
Power:
- Electricity
- Heat
Bioproducts & Chemicals
- Plastics
- Solvents
- Chemical Intermediates
- Phenolics
- Adhesives
- Furfural
- Fatty acids
- Acetic Acid
- Carbon black
- Paints
- Dyes, Pigments, and Ink
- Detergents
- Lubricants
- Etc.

Food and Feed and Fiber
### Current Biomass Power Capacity in California

#### California Biomass Facilities

<table>
<thead>
<tr>
<th>Technology/Fuel Source</th>
<th>Number of Facilities</th>
<th>Gross Capacity (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid Fuel Combustion (includes 3 MSW facilities)</td>
<td>30</td>
<td>640</td>
</tr>
<tr>
<td>Landfill gas-to-energy</td>
<td>60</td>
<td>275</td>
</tr>
<tr>
<td>Wastewater treatment *</td>
<td>20</td>
<td>64</td>
</tr>
<tr>
<td>Animal and food waste digester</td>
<td>22</td>
<td>5.7</td>
</tr>
<tr>
<td>Totals</td>
<td>132</td>
<td>985</td>
</tr>
</tbody>
</table>

* Suspect - Probably higher

Source: Williams, 2007

- **Solid Combustion Fuel Sources**
  - Forest: 50%
  - Urban Wood: 40%
  - Ag./Food Processing: 15%
  - MSW: 5%

- **Over 5 million bone dry tons being used**
California’s Biopower Mix in 2008

Figure 1. California’s Biopower Mix (943 MW), 2008
Data source: California Biomass Collaborative
Biomass RD&D Activities & Projects

- Technology Development
  - Direct Combustion/Co-Firing/Hybrid Systems
  - Biogas
  - Thermal Gasification and Pyrolysis
  - Biofuels and Biorefineries

- Analysis and Planning
  - California Biomass Collaborative Support
    - Biomass Roadmap for biomass development
    - Biomass Resource Assessments
    - Biomass Performance Reporting System
  - Strategic Value Analysis
    - Linking cost competitive biomass resources to electricity system needs while addressing public benefits

- Natural Gas Replacement by Biomass
  - Implement Natural Gas RD&D Program Plan
  - PIER Transportation RD&D
  - AB118 Bio-methane solicitation
Recommendations for Bioenergy Development in California

- Expand the use of in-state biomass for bio-energy
- Develop policy changes to address regulatory hurdles and price uncertainty
- Develop viable solutions for existing barriers
- Create long term programs to help financing biopower and biofuel projects
- Validate and track critical research results and data achieved to date, encourage research on integrated system design and operation, and support bioenergy education, research, and training programs
Concluding Remarks

- California has abundant biomass resources for bioenergy development. California generates about 80 million BDT biomass annually which presents numerous opportunities and challenges.

- The development of bio-power using biomass is slow and unlikely to meet the bio-energy target by 2010. Currently 5 million bone dry tons are being used for energy.

- **Electricity Generation Gaps**
  - Costs still need to come down to more competitive levels
  - Air emission profiles (esp. NOx) need to meet or exceed regulations (e.g., CARB guidelines)
  - At utility-scale sizes, need development of super clean, super-efficient systems with high degree of responsiveness
  - At DG levels - small modular-scale, need to develop a track record
Thank You

Additional information can be found at:

The Energy Commission’s web site has extensive information on the ongoing bioenergy work in California at:

http://www.energy.ca.gov/bioenergy_action_plan
Extra Slides
California’s Renewable Energy Goals

Projected Renewables to Meet California Policy Goals

- Total: 29,000 GWh (11% Renewables)
- 2010 Total: ~59,000 GWh (20% RPS)
- 2020 Total: ~99,000 GWh (33% RPS*, CSI*)

Data Sources: 2004, CEC Electricity Report which includes all renewables in the State, not just IOUs; 2010 and 2020, PIER Renewables Projections.

*RPS: Renewable Portfolio Standard
*CSI: California Solar Initiative
California’s Electricity Supply in 2007

In-State Generation and Estimated Energy Imports by Fuel Type
(Total: 209,856 GWh)

- Natural Gas: 45.2%
- Nuclear: 14.8%
- Renewables: 11.8%
- Wind: 2.3%
- Large Hydro: 11.7%
- Renewable Hydro: 2.8%
- Solar: 0.2%
- Coal: 16.6%
- Geothermal: 4.5%
- Biomass: 2.1%

(Includes Energy Imports)


Totals may not sum due to rounding.
## Biomass Solid Fuel Biopower Plants Developed in California

<table>
<thead>
<tr>
<th>Year of Construction</th>
<th># of Total Facilities Constructed</th>
<th># of Facilities Currently Operating</th>
<th>MW Capacity of the Total Facilities Constructed</th>
<th>MW Capacity of Facilities Currently Operating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980s or before</td>
<td>53</td>
<td>22</td>
<td>759</td>
<td>474</td>
</tr>
<tr>
<td>1990s</td>
<td>13</td>
<td>7</td>
<td>199</td>
<td>179</td>
</tr>
<tr>
<td>2000s</td>
<td>1</td>
<td>1</td>
<td>36</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>67</td>
<td>30</td>
<td>994</td>
<td>667</td>
</tr>
</tbody>
</table>

Data source: Dr. Gregory Morris, Future Resources Associates, Berkeley, CA
### MSW Incineration Power Plants Developed in California

<table>
<thead>
<tr>
<th>Year of Construction</th>
<th># of Total Facilities Constructed</th>
<th># of Facilities Currently Operating</th>
<th>MW Capacity of the Total Facilities Constructed</th>
<th>MW Capacity of Facilities Currently Operating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980s or before</td>
<td>3</td>
<td>3</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>1990s</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2000s</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>3</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>

Data Source: California Energy Commission
Landfill Gas to Electricity Biopower Plants Developed in California

<table>
<thead>
<tr>
<th>Year of Construction</th>
<th># of Total Facilities Constructed</th>
<th># of Facilities Currently Operating</th>
<th>MW Capacity of the Total Facilities Constructed</th>
<th>MW Capacity of Facilities Currently Operating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980s or before</td>
<td>43</td>
<td>24</td>
<td>170</td>
<td>127</td>
</tr>
<tr>
<td>1990s</td>
<td>24</td>
<td>19</td>
<td>84</td>
<td>72</td>
</tr>
<tr>
<td>2000s</td>
<td>51</td>
<td>47</td>
<td>126</td>
<td>110</td>
</tr>
<tr>
<td>Total</td>
<td>118</td>
<td>90</td>
<td>380</td>
<td>309</td>
</tr>
</tbody>
</table>

Data Source: US EPA Landfill Methane Outreach Program.
### Technologies Used for Landfill Gas to Electricity Developed in California Since 2000

<table>
<thead>
<tr>
<th>Technologies</th>
<th># of Facilities</th>
<th>MW Power Generation</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC Engine</td>
<td>25</td>
<td>78</td>
</tr>
<tr>
<td>Gas Turbine</td>
<td>3</td>
<td>20</td>
</tr>
<tr>
<td>Microturbine</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Co-generation</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Alternative fuel or direct thermal</td>
<td>3</td>
<td>NA</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>110</td>
</tr>
</tbody>
</table>

**Data Source:** US EPA Landfill Methane Outreach Program.
Livestock Manure Biogas Power Plants Developed in California

<table>
<thead>
<tr>
<th>Year of Construction</th>
<th># of Total Facilities Constructed</th>
<th># of Facilities Currently Operating</th>
<th>MW Capacity of the Total Facilities Constructed</th>
<th>MW Capacity of Facilities Currently Operating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980s or before</td>
<td>18</td>
<td>1</td>
<td>NA</td>
<td>0.03</td>
</tr>
<tr>
<td>1990s</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>2000s</td>
<td>18</td>
<td>4/5</td>
<td>3.8</td>
<td>0.90</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
<td>10</td>
<td>3.8</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Data Source: California Energy Commission
Barriers for Biopower Development in California

- Air Quality Permitting
- Financial Situation for Biomass Facilities
- Project Financing
- Injection of Landfill Gas into the Natural Gas Pipelines
- Municipal Solid Waste Gasification Conversion
- Coal Co-Firing or Fuel Switching to Biomass