Building the CA Circular Economy: Bio-based Strategies to Convert Wastes to Carbon-Neutral-to-Negative Fuels and Products

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February 3, 2020
Building California’s Circular Economy

- The US bioeconomy is currently ~$1T
- CA is at the forefront of building a circular economy within the US
- Result of growing awareness of environmental impacts of current practices
- Important policy initiatives underway to bolster the CA and national bioeconomy
- National Labs and Universities in CA have unique capabilities that are a force multiplier for the state
CA Carbon Resources are Distributed

- Gross resource – ~85 million bone dry tons per year (BDT/y)
- Biomass considered to be available on a technically sustainable basis – ~35 million BDT/y
- Need efficient harvesting, conversion, and reuse of all carbon inputs and outputs
- Diversified portfolio of bio-related options at all steps of the process
- Better crops, conversion technologies, and products
Biomanufacturing Enables the Circular Economy

- Sugars
- Lignin
- Amino acids
Transitioning Organic Waste from GHG Source to Sink

SB 1383 and improved forest management will
• Increase quantity of biomass that requires management/conversion
• Increase generation of byproducts: digestate, compost, and biochar

Applying biochar and digestate to soils accumulates stable soil carbon, removes $\text{N}_2\text{O}$ from the air, and increases carbon stock in plants

Source: Breunig et al. 2019 Environmental Science & Technology

Funding: CEC EPIC 14-030
Role of Biochar and Digestate in a Net Carbon Negative Circular Economy

- Bioenergy growth could offset 50–400 MMTCO$_2$e and sequester an additional 80–300 MMTC to soils
- This corresponds to net GHG mitigation over 100 years equivalent to 340–1500 MMTCO$_2$e (0.8–3.50X California’s annual GHG emissions)

Source: Breunig et al. 2019 Environmental Science & Technology

Funding: CEC EPIC 14-030
MSW as a Bioenergy Feedstock

The MSW stream did not inhibit the conversion process significantly compared to the regular lignocellulosic feedstocks.

Valorizing Organic Waste Streams

Major chemical composition of the sorted MSW samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture (%)</th>
<th>Glucan (%)</th>
<th>Xylan (%)</th>
<th>Lignin (%)</th>
<th>Ash (%)</th>
<th>Starch (%)</th>
<th>Others* (%)</th>
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<tbody>
<tr>
<td>Paper-rich MSW</td>
<td>22.8</td>
<td>41.2</td>
<td>5.2</td>
<td>7.2</td>
<td>8.6</td>
<td>2.6</td>
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<td>Food-rich MSW</td>
<td>63.2</td>
<td>7.8</td>
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<td>5.5</td>
<td>6.8</td>
<td>4.1</td>
<td>10.4</td>
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Conversion of CA Woody Biomass

- $3M, 2-year project awarded by the State of California/CEC to JBEI as cost share to JBEI’s $125M DOE/BER investment
- Partnership with Aemetis
- Deployment and demonstration of an IL-based process for production of an advanced biofuel
- Using California wild type woody waste streams (almond, walnut, pine, poplar)
- Generating 600kg of hydrolysate that will be converted into biofuels at Aemetis facility
- Funding: CEC FRD-17-004
CA Mobile Biomass Harvester and Conversion Unit (CARIBOUU)

- Converts woody biomass waste into biopower, biofuels and bioproducts
- Minimizes GHG emissions by ~90%, significantly improves air quality by eliminating PM2.5 emissions, and boosts local economies
- Process 500 lbs/hr of biomass cleared as a result of forest thinning/clearing operations
- Funded January 2020 by California Climate Investment/GGRF
Enable a biorefinery to achieve a positive return on investment through a 50% reduction in time-to-scale up compared to the average of ~10 years.

Public infrastructure investment that increases U.S. industrial competitiveness and enables new opportunities for private sector growth and jobs.
Advanced Biofuels and Bioproducts Process Demonstration Unit

- Unique 15,000 sq. ft scale-up facility funded by DOE/ARRA and operated by LBNL

- Specializes in all of the unit operations needed for the conversion of biomass into biofuels and bioproducts

- Open collaboration facility w/a focus on helping industry launch new bioproducts
ABPDU has worked with 40+ industrial collaborators

<table>
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<th>Biofuels &amp; biomass</th>
<th>Materials &amp; Chemicals</th>
<th>Food &amp; health</th>
<th>Environment &amp; Ag</th>
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Ongoing projects
Summary

- Establishing a Circular Economy in CA requires the conversion of multiple inputs into multiple outputs that are fit for purpose.
- Includes urban and rural feedstocks.
- Distributed conversion and production facilities can boost economic growth and improved human health in urban and rural areas.
- Significant opportunities with wildfire risk mitigation efforts.
- Carbon negative systems are key to meeting overall GHG reduction targets.
- CA needs a balanced, integrated and inclusive renewable energy strategy enabled by science-based policies that benefit the environment, the economy and improve human health.
Thank You

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