



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

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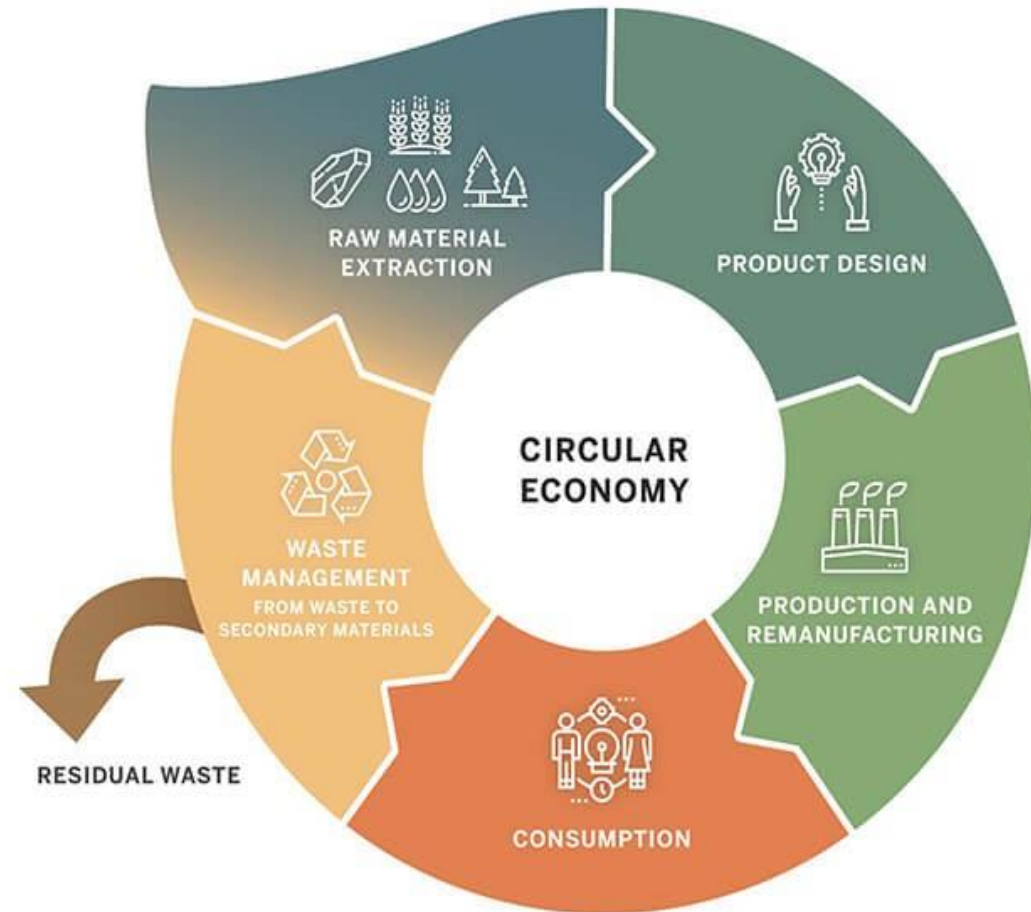
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# Building California's Circular Economy

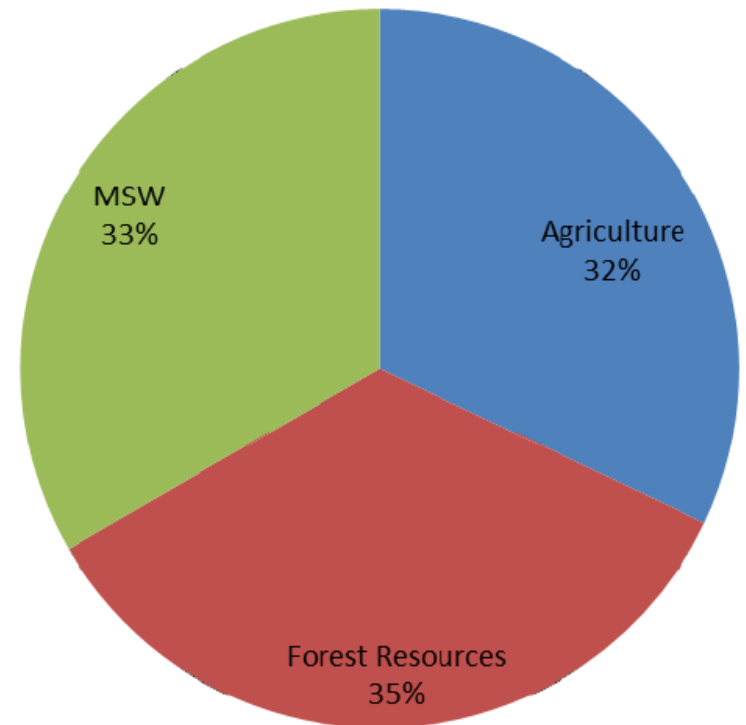
- The US bioeconomy is currently ~\$1T
- CA is at the forefront of building a circular economy within the US
- Result of growing awareness of environmental impacts of current practices
- Important policy initiatives underway to bolster the CA and national bioeconomy
- National Labs and Universities in 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**

**Biomass Resources by Type**



# Biomanufacturing Enables the Circular Economy



Sugars



Lignin



Amino acids

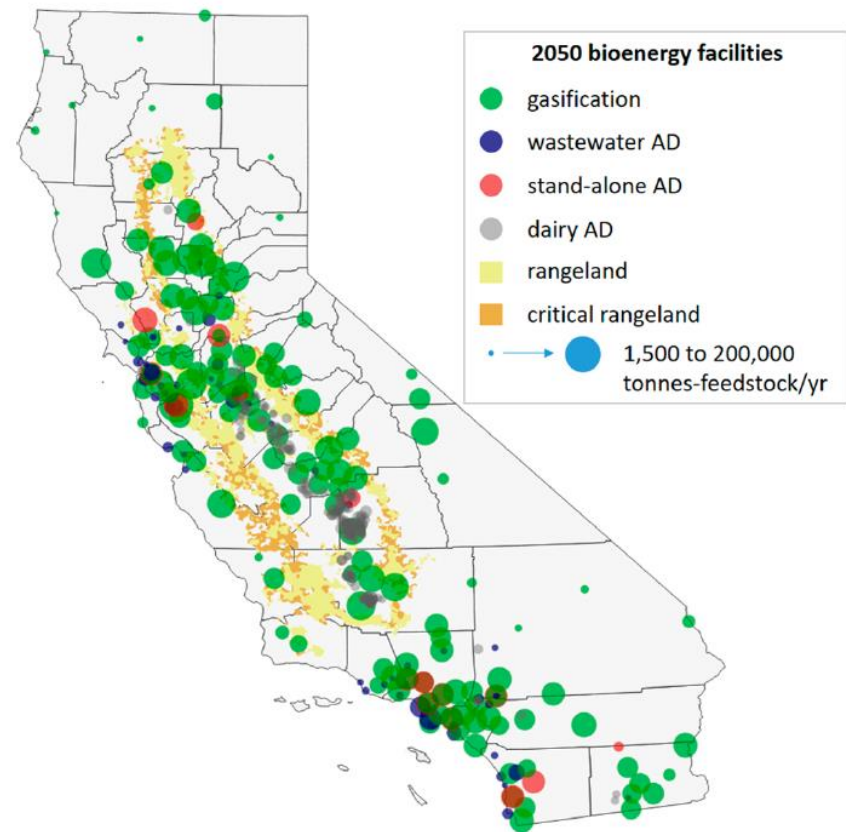
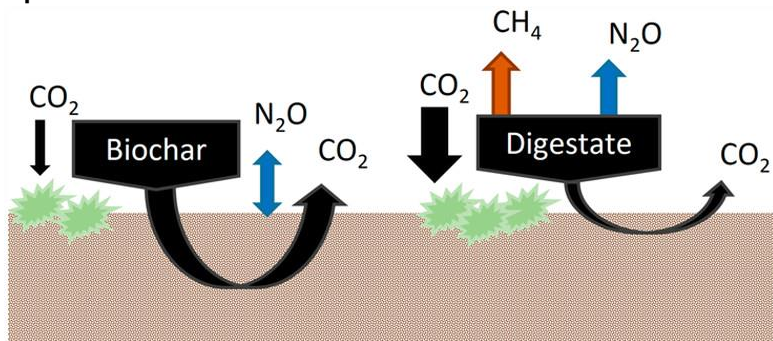


# Transitioning Organic Waste from GHG Source to Sink

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

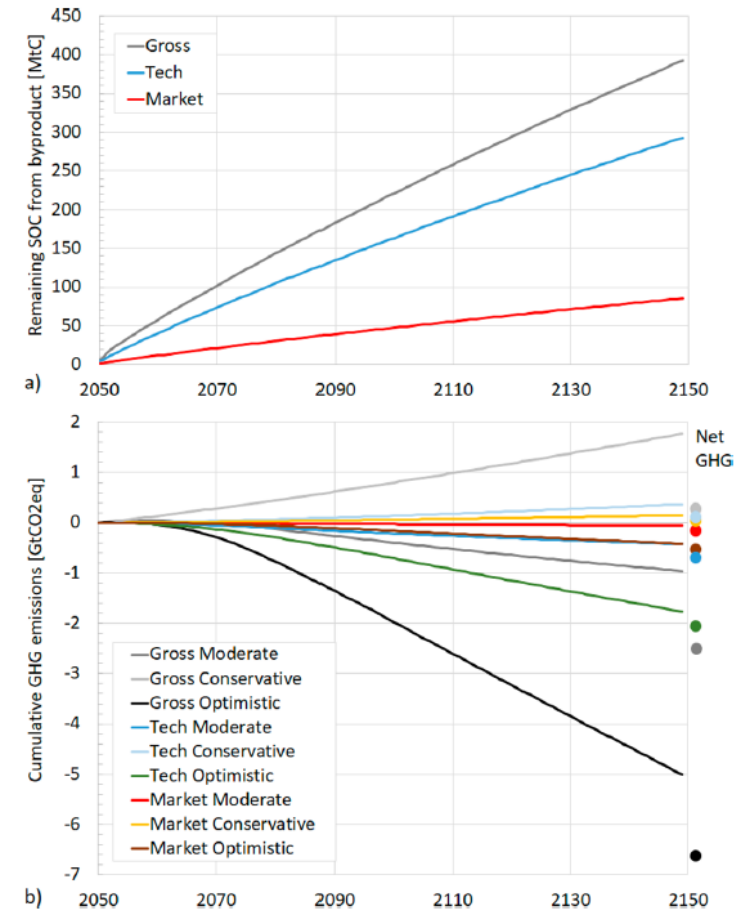
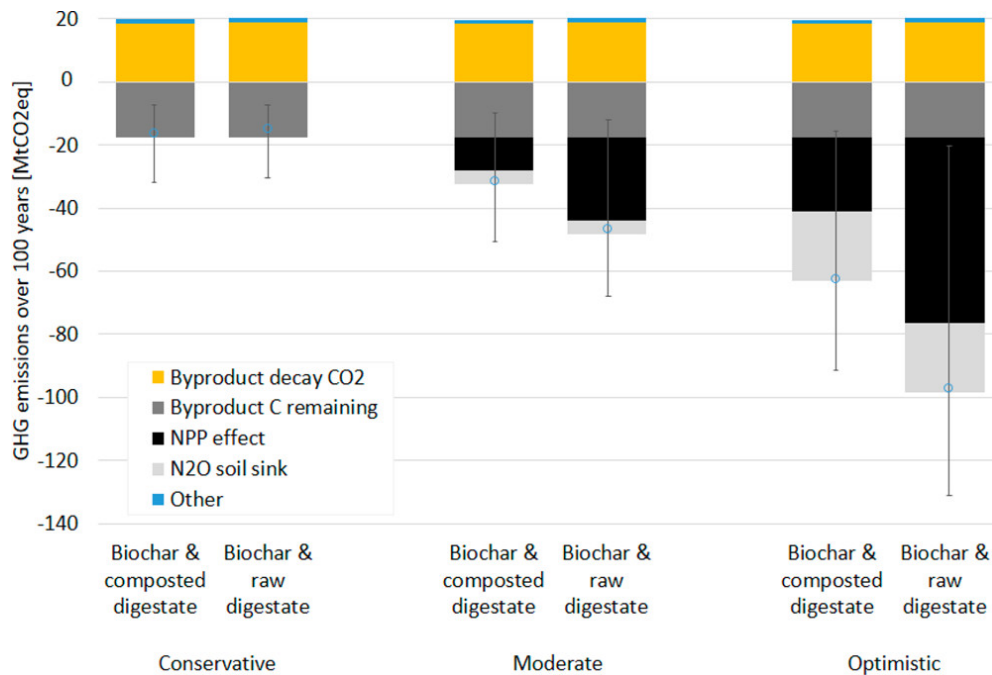


Source: Breunig et al. 2019 *Environmental Science & Technology*

Funding: CEC EPIC 14-030

# Role of Biochar and Digestate in a Net Carbon Negative Circular Economy

- Bioenergy growth could offset 50–400 MMTCO<sub>2e</sub> and sequester an additional 80–300 MMTC to soils
- This corresponds to net GHG mitigation over 100 years equivalent to 340–1500 MMTCO<sub>2e</sub> (0.8–3.50X California's annual GHG emissions)

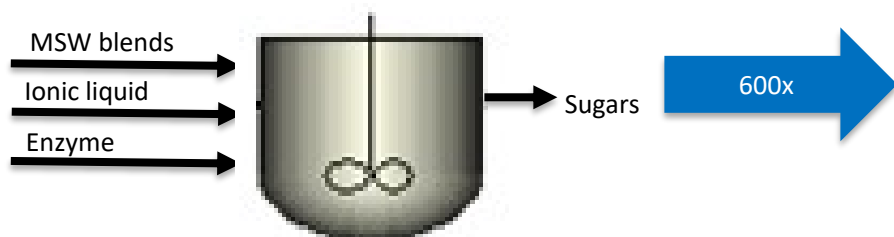


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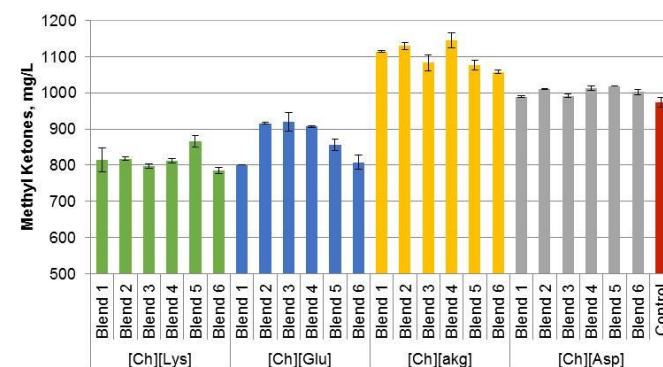
# MSW as a Bioenergy Feedstock

## MSW blends



## Deconstruction

## Deconstruction scale-up & Fermentation



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

# Valorizing Organic Waste Streams

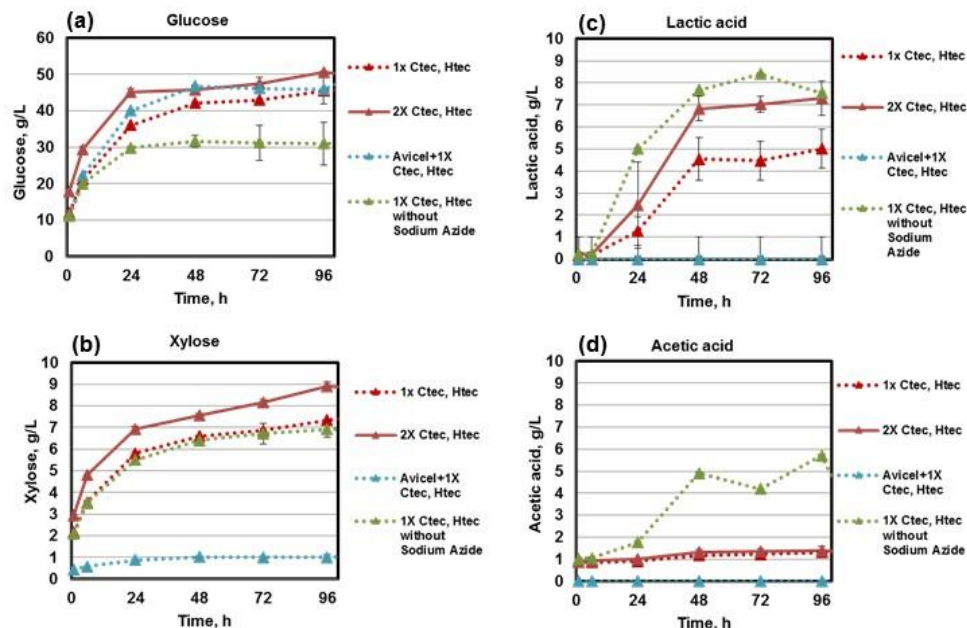


Food Waste (FW)



Paper Waste (PW)

biocatalyst



Major chemical composition of the sorted MSW samples

Sample	Moisture (%)	Glucan (%)	Xylan (%)	Lignin (%)	Ash (%)	Starch (%)	Others* (%)
Paper-rich MSW	22.8	41.2	5.2	7.2	8.6	2.6	12.2
Food-rich MSW	63.2	7.8	0	5.5	6.8	4.1	10.4

# 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



AEMETIS

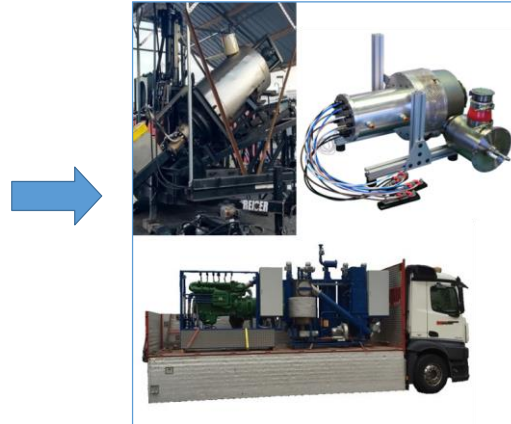


# CA Mobile Biomass Harvester and Conversion Unit (CARIBOU)

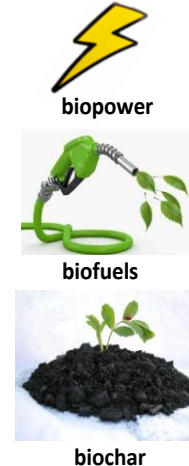
Forestry thinnings/residues



CARIBOU Platform

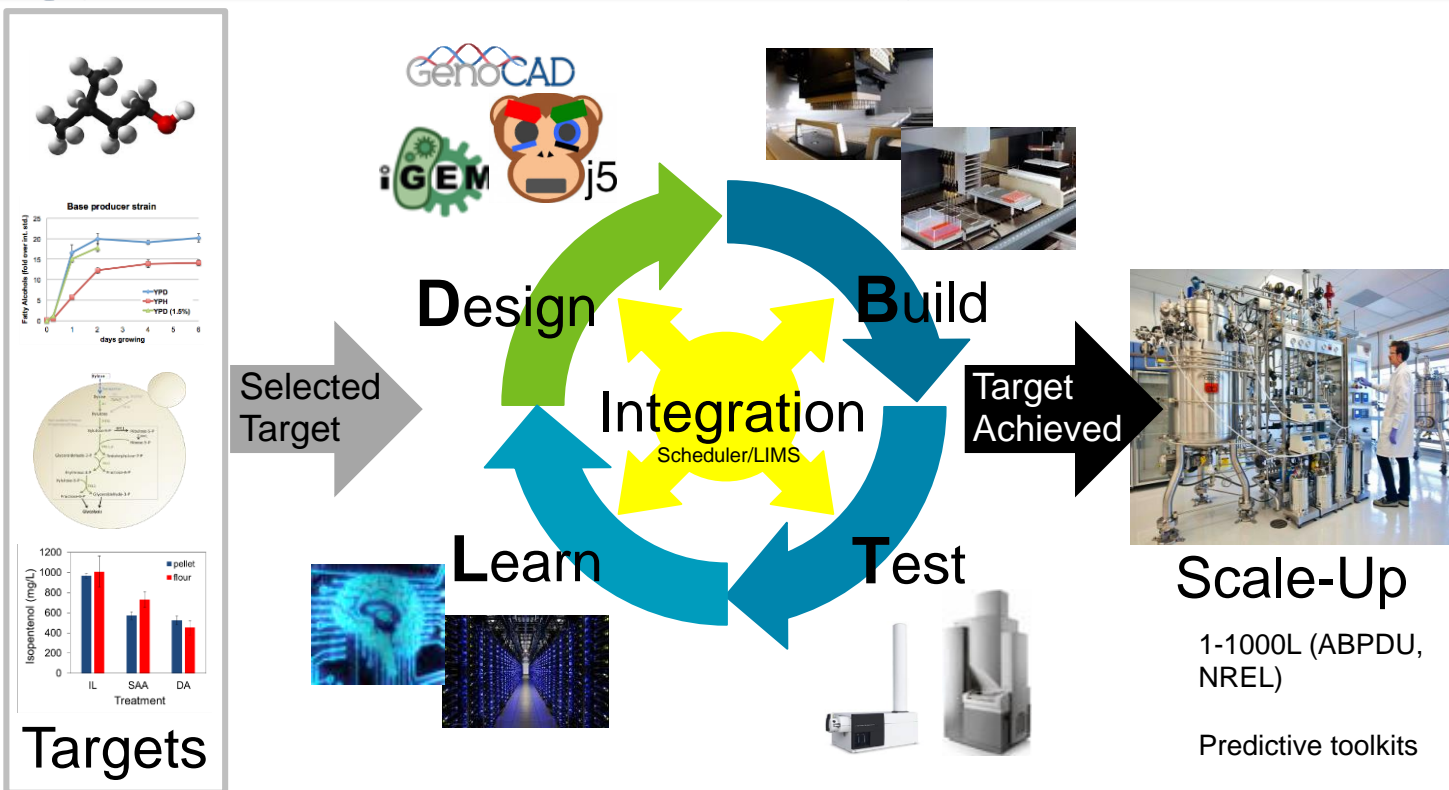


Products



- **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**

# Agile BioFoundry – Engineering Biology for the Bioeconomy



- 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



## Biofuels & biomass



## Materials & Chemicals



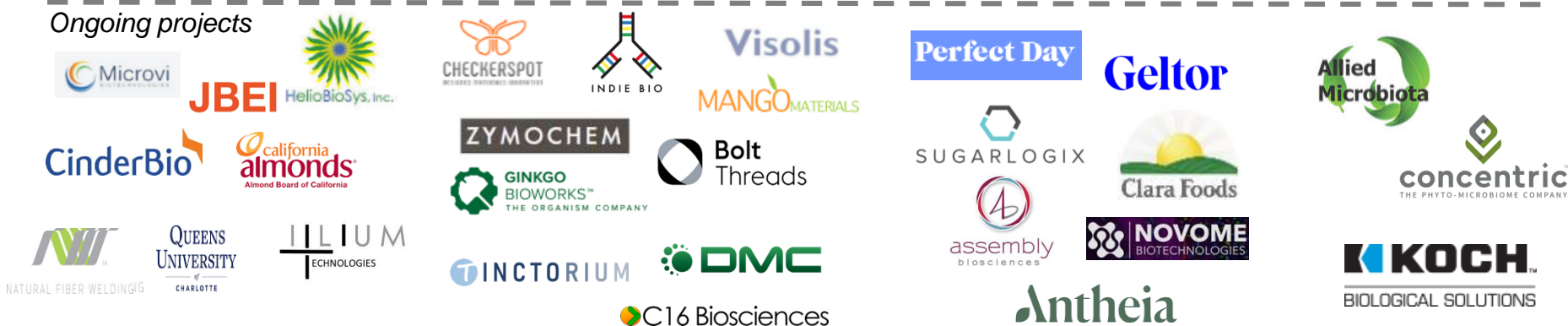
## Food & health



## Environment & Ag



## 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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