

 **Clean Energy
Systems, Inc.**
Power Without Pollution™



Carbon-Negative Biomass Power: An Opportunity for California

November 8, 2017

Keith Pronske • President & CEO • CES • 3035 Prospect Park Dr., Suite 150 • Rancho Cordova, California 95670 • +1 916-638-7967

Biomass Challenges in the State

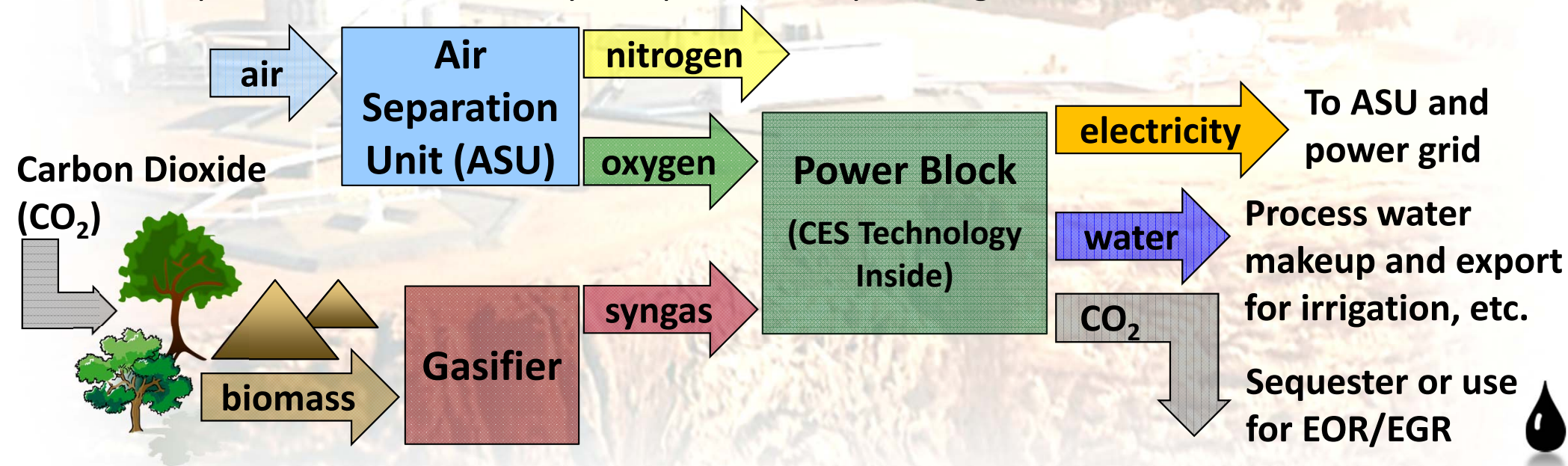
Limited Use and Disposal Options

- Direct-combustion biomass plants previously utilized much of the valley's biomass as a fuel source
 - ⇒ Expiration of preferred PPAs and poor emissions led to decommissioning of many facilities
 - ⇒ Decent solution for biomass disposal, yet elevated PM levels and criteria emissions = we can do better
- Farmers currently grinding into soil, piling onsite, or sending to landfills
 - ⇒ Amount that can be ground into soil is limited
 - ⇒ Open burning permits are severely detrimental to air quality

CES Solution

Carbon Negative BioCCS Plant for Baseload Power

- Clean Energy System' BioCCS plants convert waste biomass fuels into clean, renewable electricity with net-negative carbon emissions
- The plants effectively pull the harmful greenhouse gas carbon dioxide (CO₂) from the atmosphere and store it safely and permanently underground



CES Solution

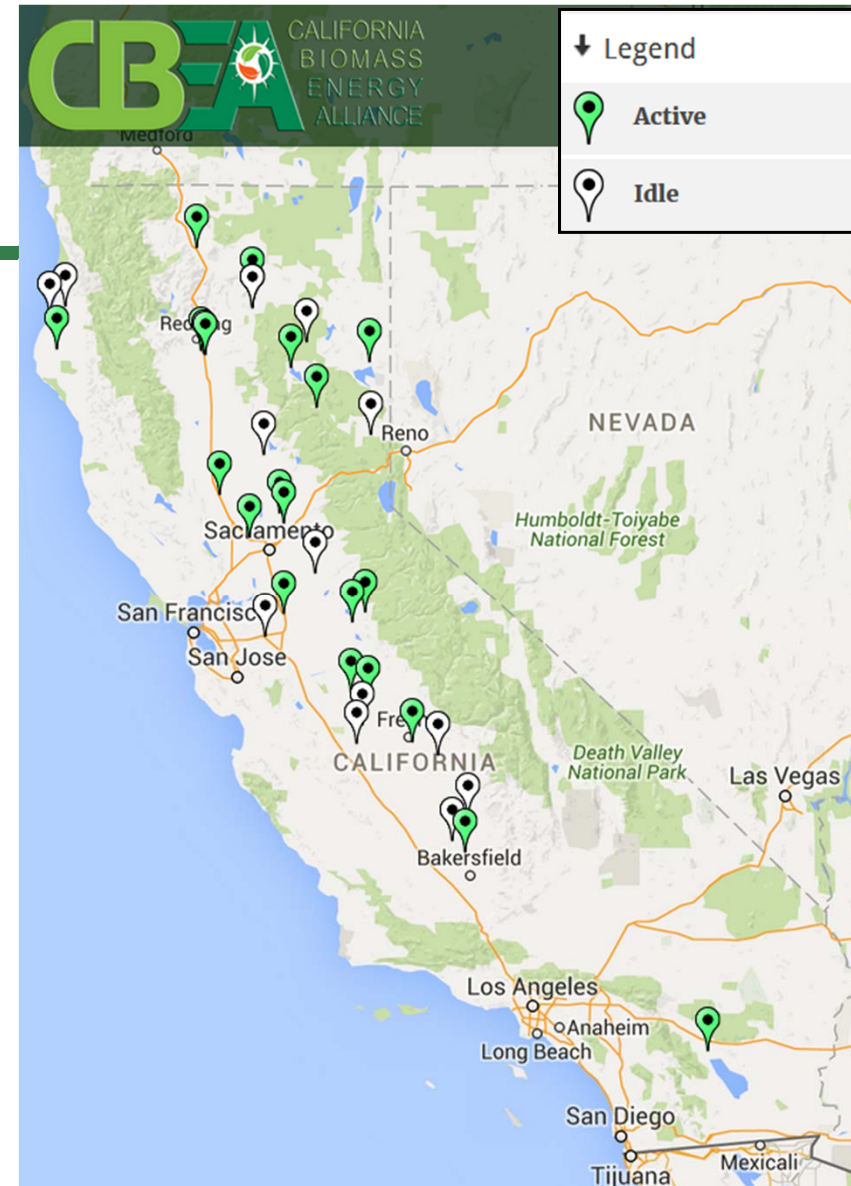
Deployment Strategy

- Plan a two-phase strategy to deploy a new fleet of bioCCS plants across California, with capability to remove significant CO₂ from the atmosphere:
 - ⇒ Phase 1: Small-scale commercial demonstration CES' Kimberlina facility
 - Taking advantage of existing infrastructure and a favorable power contract tariff (bioMAT)
 - Though modest in size (up to 3 MWe net), the plant will effectively remove up to 2 million tons of CO₂ from the atmosphere over a 20 year operating life if CCS is added in this phase
 - ⇒ Phase 2: Retrofit or new build of 100 - 300 MW of bioCCS power across California
 - Each plant ranging from ~15 to 50 MW will be competitive at power price of ~\$0.04-0.06/kWh, depending on value of CO₂ (Tax credit vs. LCFS credit)
 - Can remove 3-10 million tons of CO₂ from the atmosphere over a 20 year operating life
- Commercial deployment can make use of idle biomass facilities
 - ⇒ Reduces plant capex and deployment schedule while revitalizing valuable resources
 - ⇒ Helps solve California's problems of excess agricultural waste and forestry management while cleaning air of GHGs and reducing particulate pollution

Bioenergy in California

Numerous Idle Facilities Available

- 260 MW of commercial biomass power plants have shutdown in California (>30% state's facilities); with an estimated 207 MW (>25%) more closed in 2016
 - ⇒ Many citing low cost renewables (solar) as reason PPA not extended
- In the central valley, ~145 MW sit idle today
 - ⇒ Area is rich with agriculture and unfortunately known for poor air quality
 - ⇒ Without another viable options, farmers will be forced to burn ag waste in their fields, emitting harmful GHGs and other criteria pollutants into the atmosphere



Reference: www.calbiomass.org/facilities-map/

BioCCS in California's Central Valley

First Project Planned for CES' Kimberlina Power Plant

- CES' Kimberlina Power Plant (KPP) facility is ideal for pilot program
 - ⇒ Large CO₂ sequestration potential in the Southern San Joaquin Valley
 - Lawrence Berkeley National Lab (LBNL) completed simulation of 250k tons of CO₂ injected annually (total of 1 million tons over 4 years);
 - Awarded proposal to continue work under DOE's Carbon SAFE program in 2017
 - ⇒ Former biomass power plant and current oxy-fuel test facility
 - Significant infrastructure may be reused such as biomass handling and storage, electrical interconnect, O-F combustion systems, etc.
 - ⇒ Located near significant agricultural (fuel source) and skilled labor



Waste-to-Energy

Primary Elements

Power Production
Unit



RNG Filling Station



Location: KPP

Gasifier & Fuel
Upgrading Package



Feedstock Unloading,
Handling & Processing



Feedstock



Waste-to-Energy

Next Steps to Complete Project




- Completing requirements to release facility bond financing (January 2018)
- Install modular 100 TPD gasifier/fuel upgrading package
 - ⇒ Fabrication in-process; staged delivery and assembly, with construction linked to issuance of key permits (air permit and CUP)
 - ⇒ RNG and/or power production (under BioMAT Feed-In tariff)
- Install 2 ea. additional modular 100 TPD gasification/fuel upgrading packages
- Commission 300 TPD system and begin commercial operations
 - ⇒ Initial 100 TPD operations in slated for Q3 2018, with 300 TPD expected Q2 2019
- Repeat at other sites

BioCCS in California

Opportunities for CCS in California

- A comparison of existing biomass power plants to California's sedimentary basins shows excellent potential for CCS and possible use in enhanced oil or gas recovery (EOR/EGR)

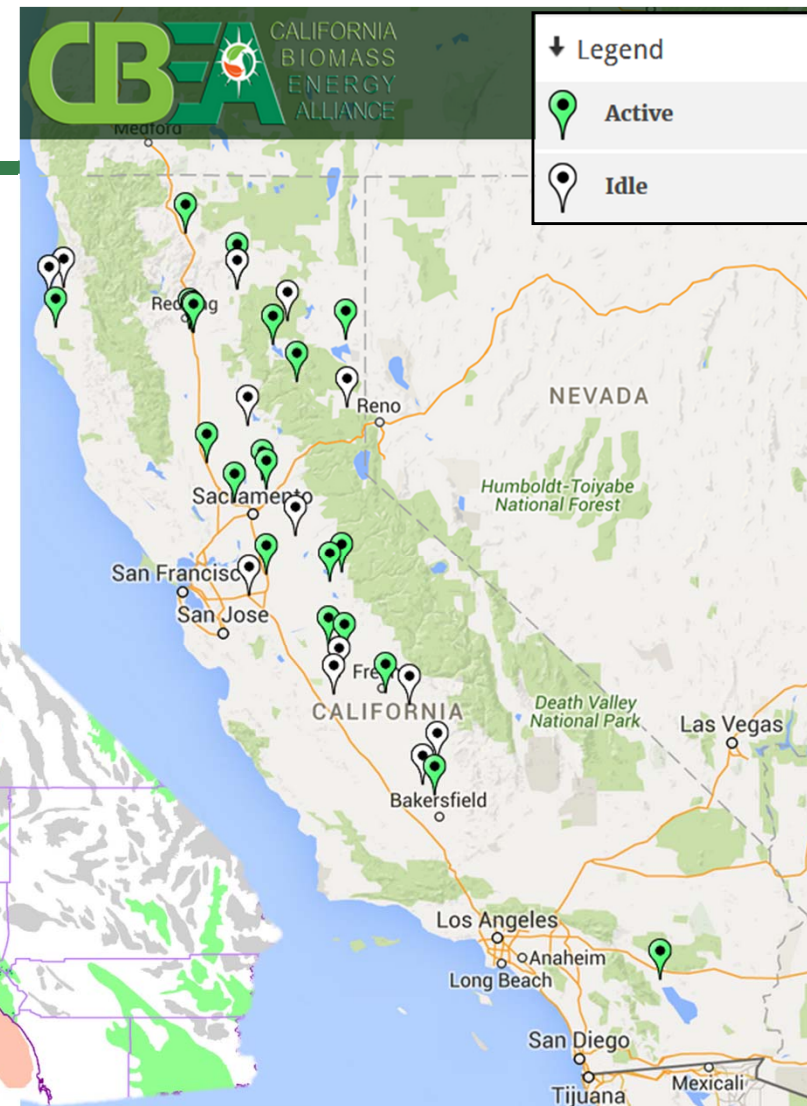
Sedimentary Basin Status:

-  Basins with Carbon Sequestration Potential
-  Basins Lacking Carbon Sequestration Potential
-  Offshore Basins with Unknown Carbon Sequestration Potential

Other Layers:

-  Natural Gas Field
-  Oil Field
-  County Boundary

Map Courtesy of WESTCARB



Reference: www.calbiomass.org/facilities-map/



Thank You!

For more information contact:

Keith Pronske
President & CEO
klpronske@CleanEnergySystems.com
+1 916-638-7967



*Clean Energy
Systems, Inc.*
Power Without Pollution™