ARLINGTON, TEXAS

AAPL 2021 ANNUAL MEETING

PROFESSIONAL DEVELOPMENT AND LAND CONFERENCE

AAPL
Powering The Profession

Rebecca Hollis

AAPL 2021 **ANNUAL MEETING**

AAPL
Powering The Profession

California Carbon Negative Energy

Rebecca Hollis
Director of Business Development - CNE
Clean Energy Systems, Inc.

25-June-2021

AAPL 2021 **ANNUAL MEETING**

AGENDA

- **Company Overview**
- **What is** Carbon Negative Energy and BECCS
- Why Now and Why California
- Deployment Strategy
- Summary & Conclusions

CES | COMPANY OVERVIEW

- Founded in 1993 by former Aerojet (a GenCorp company) aerospace engineers; incorporated in 1996, Clean Energy Systems, Inc.
- Focused on the development and deployment of carbon reducing energy systems
- 30 patents issued (36 pending) on zero-emissions oxy-combustion technology and power cycles
- Products include enabling technologies for advanced clean energy solutions - based on proven aerospace technology transferred to energy production:
  - Pressurized Oxy-Fuel Combustors (direct and indirect steam gas generators);
  - Compact Diffusion Bonded Heat Exchangers; and
  - Oxy-Fuel Turbines (OFTs) with development partners
- Small business, headquartered in Rancho Cordova, California (Sacramento area)
  - Multiple facilities in California

CES | CALIFORNIA FACILITIES

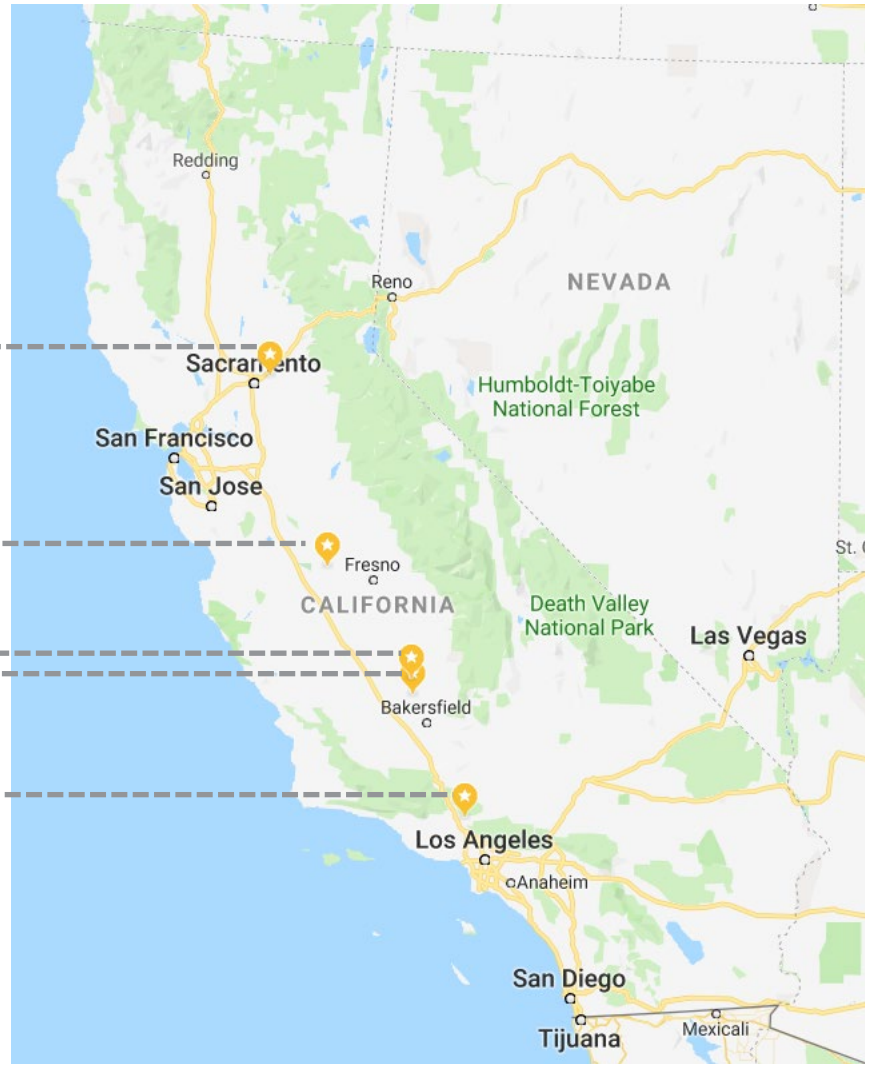
CES Corp. Headquarters

Mendota; Idled 600 TPD Biomass Power Plant

Delano; Idled 1200 TPD Biomass Power Plant

Kimberlina; Oxy-Combustion R&D Test Facility

Placerita; Idled Combined Heat & Power Plant



WHAT IS CARBON CAPTURE AND SEQUESTRATION (CCS)?

- **Carbon Capture and Sequestration (CCS)** is the process of capturing carbon dioxide (CO_2) either to prevent it from entering the atmosphere or to directly remove it from the atmosphere and storing that CO_2 underground for an extended period of time
- **Carbon Capture** can be deployed in Power or Industrial applications, or as Direct Air Capture;
- **Carbon capture technologies** in the power and industrial sectors include:
  - Pre-combustion capture
  - Post-combustion capture
  - Oxy-Combustion
- **Carbon Sequestration** stores CO_2 in deep geologic formations; is a proven process; operating in U.S. for decades
  - CO2 can be stored underground in saline aquifers or used for Enhanced Oil Recovery (EOR)
  - Today, pipelines transport CO_2 across states such as TX, NM, MS, CO, ND

HOW CAN LANDMEN SUPPORT CCS PROJECTS?

Landmen are needed throughout the process of siting, developing, and operating CCS projects.

CCS experience similar challenges landmen find when prospecting for oil and gas.

- Initial Due Diligence:
  - Preliminary title work involving surface ownership and possible mineral severances being identified
  - Identifying utilities and rights of way which may conflict with CCS's operations, determining permitting requirements tied to rights of way
  - Mineral and surface ownership reports identifying all parties having an interest in the project area, including buffer zones
  - If the area of land involves an abandoned oil and gas field, or previously drilled dry holes, knowing how to research the states' well records which may affect triggering Dormant Mineral Rights for the state a project is being planned
  - Understanding the concept of pore space rights and ownership in the state a CCS project is located

LANDMEN SUPPORT OF CCS PROJECTS (cont.)

- Project Development:
  - Obtaining rights of entry permits for surface testing such as seismic permitting or other purposes
  - Preparing approved acquisition documents for the acquisition phase
    - Consider if storage space lease be part of the project or outright purchase of all subsurface interest
  - Coordinating relocation of surface utilities [dry or wet] when necessary
  - Coordinating acquisitions with qualified mineral appraiser for purchasing of mineral rights or an appraiser who expertise is valuating storage rights
- Operations:
  - Land administrative skills processing the rights acquired and when the project is fully operational
    - Rights or permits for additional testing or monitoring activities such as seismic permitting
  - Future 3rd parties requiring easements, temporary rights of entry affecting the project site

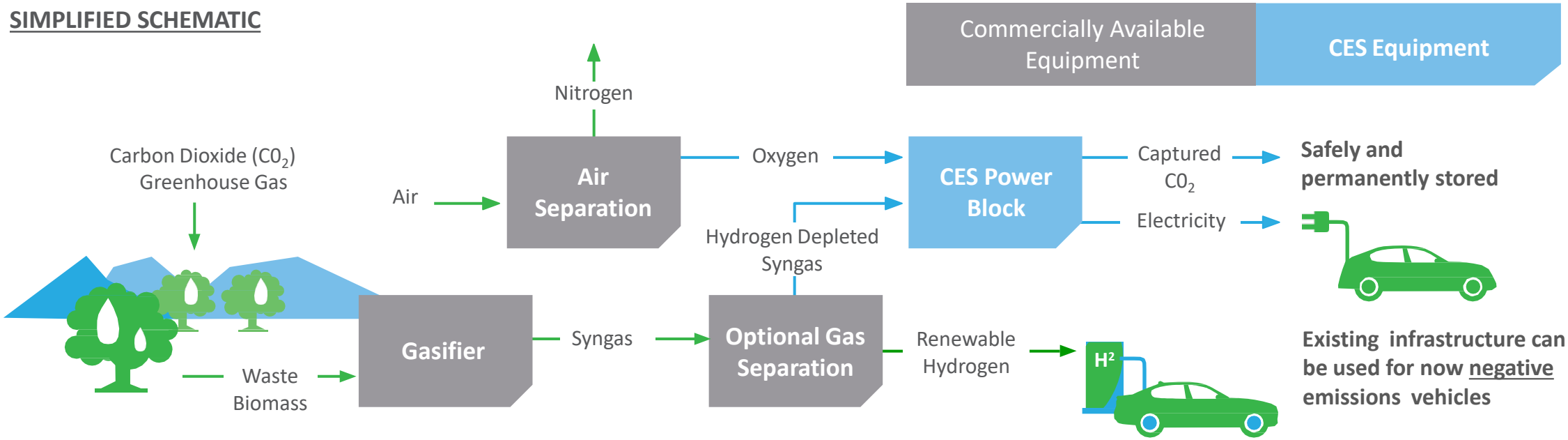
CARBON NEGATIVE ENERGY | WHAT IS BECCS?

- **Carbon removal** refers to any process or system capable of removing and sequestering carbon from the air over its life cycle; enables clean up of emissions that have accumulated in the atmosphere
- **BECCS** refers to any bioenergy process that captures and permanently stores carbon safely underground through carbon capture and storage (CCS); also known as BioCCS (bioenergy with carbon capture and storage)
- Potential to remove carbon dioxide (greenhouse gas) from the atmosphere while producing electricity and/or clean, renewable fuels
- Receiving growing attention in recent years as key to meet ambitious emissions reduction and climate goals

CNE | HOW IT WORKS

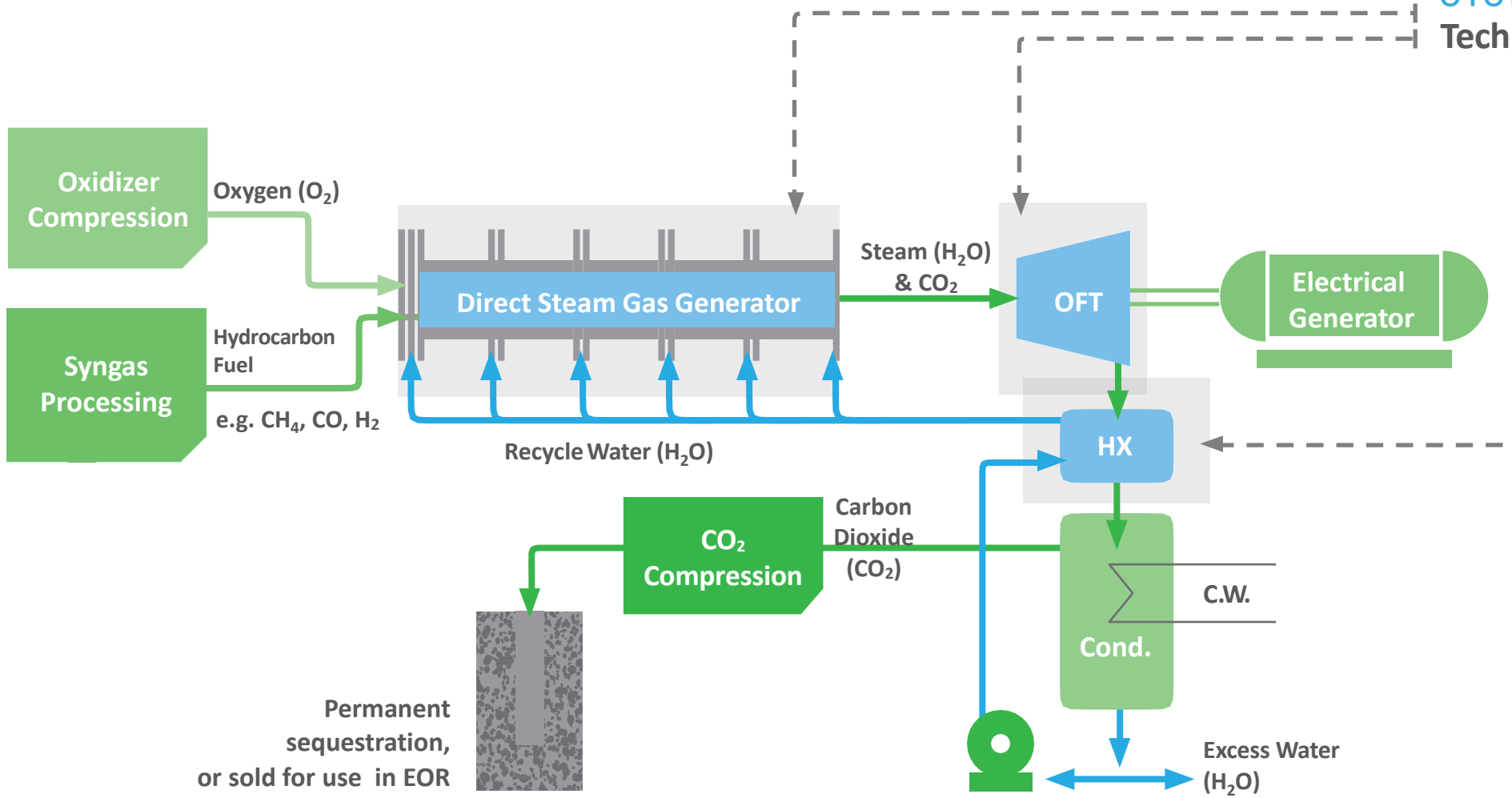
CES Carbon Negative Energy (CNE) plants use waste biomass fuels that are gasified to produce a synthesis gas. This “syngas” can then be separated to produce renewable hydrogen (RH_2) or directly fed to the power block. Nearly pure oxygen is generated by an air separation system and used by CES‘ proprietary technology with the bio-syngas to produce electricity to power the plant and electric vehicles. Greater than 99% of the carbon from the process is captured for permanent storage. By using fuel that consumes carbon dioxide (CO_2) over its lifetime and safely and permanently storing captured CO_2, the process results in net-negative carbon emissions, effectively removing the greenhouse gas from the atmosphere.

SIMPLIFIED SCHEMATIC



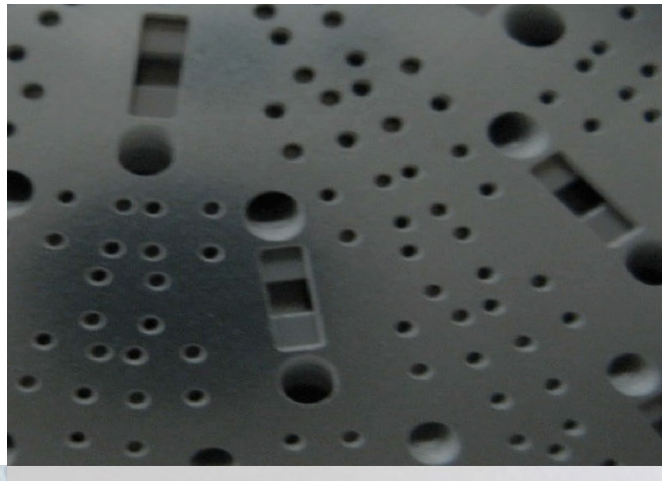
CES | OXY-FUEL POWER BLOCK

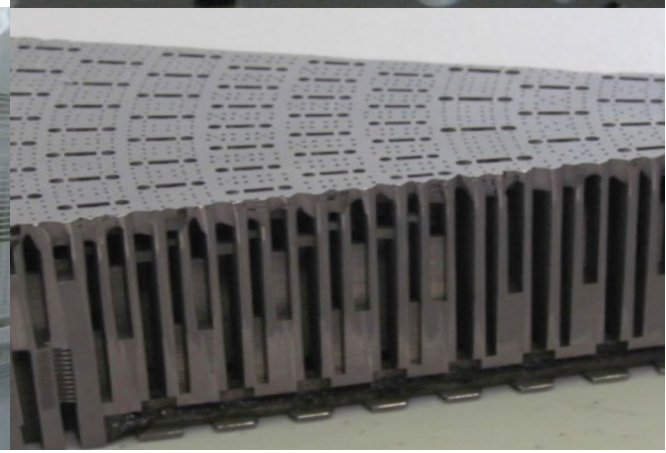
CLEAN ENERGY SYSTEMS Technologies



CES | ENABLING PLATELET TECHNOLOGY

- **Precise, stoichiometric combustion** enabled by proven, reliable, platelet injectors
- **Hundreds of individual platelets** are designed and photo-etched to created unique, intricate patterns
- **Platelets are stacked** in a set pattern to form 3D internal flow passages not possible via any other process
- **Platelet stack is then bonded into a single monolithic structure** that can then be machined and assembled
- **The resultant intricate Individual pathways** channel fuel, oxygen, and water to hundreds of combustion elements where intimate, stoichiometric mixing occurs, resulting in complete combustion

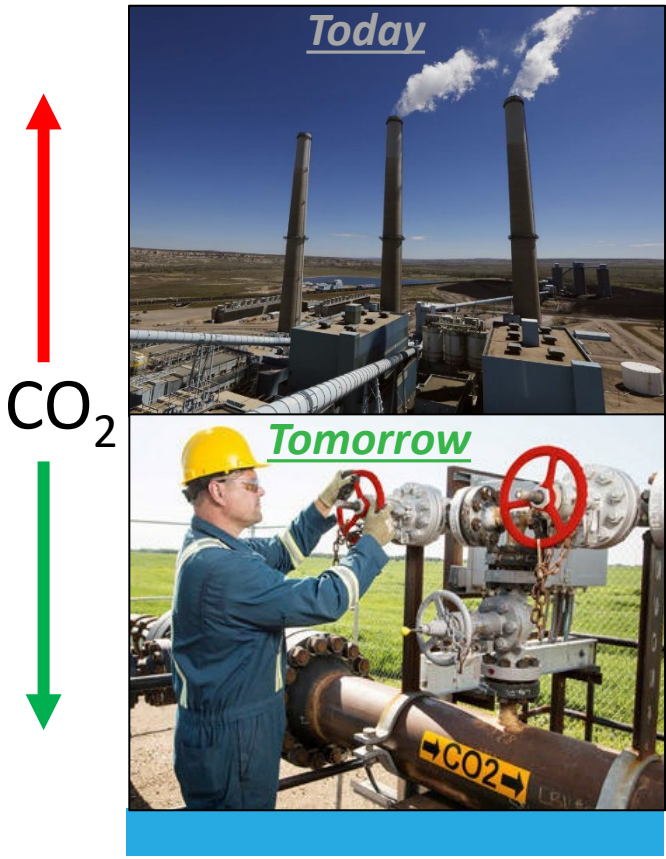




CCS | WHY NOW?

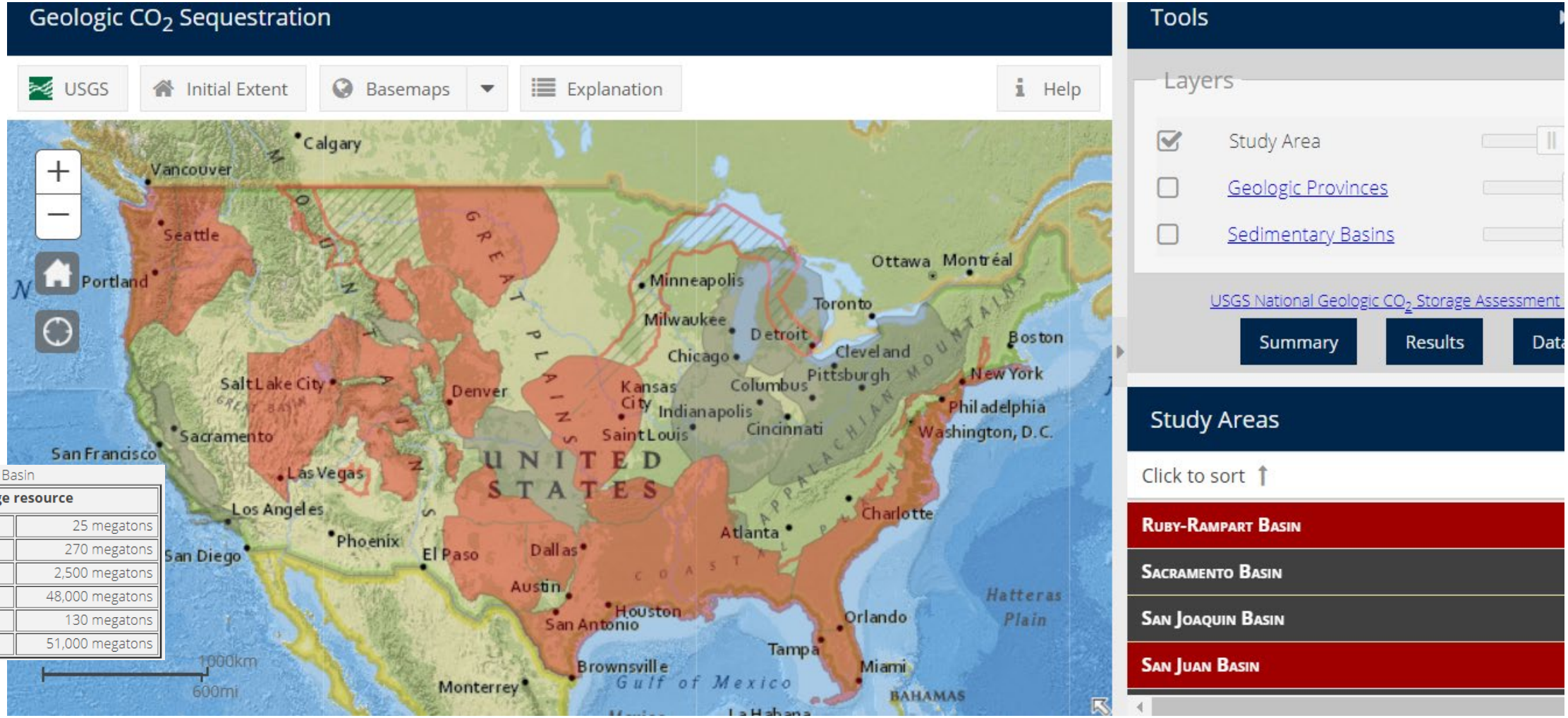
Builds upon decades of work to make CCS projects technically and economically feasible

- Government and private funded research into both capture and storage technologies to advance readiness and reduce risks
  - DOE NETL's Regional Carbon Partnerships, CarbSAFE, NRAP tools, etc.
- Economic incentives, e.g. Cap & Trade
  - Federal Tax Credit increased from \$20/tonne CO_2 to \$50/tonne CO_2
- Business and private investments into clean energy and sustainability funds
  - Commitments to "Net Zero" emissions
- Advancement in government policies and legislation to reduce "unknowns"
- Education and outreach on global climate trends
  - According to the UN's IPCC, we will fail to meet the 2 deg. C limit on global temperature rise without greater than 100% emissions reduction*



*Intergovernmental Panel on Climate Change, AR5 Climate Change, 2014

CCS | U.S. GEOLOGIC SEQUESTRATION MAP



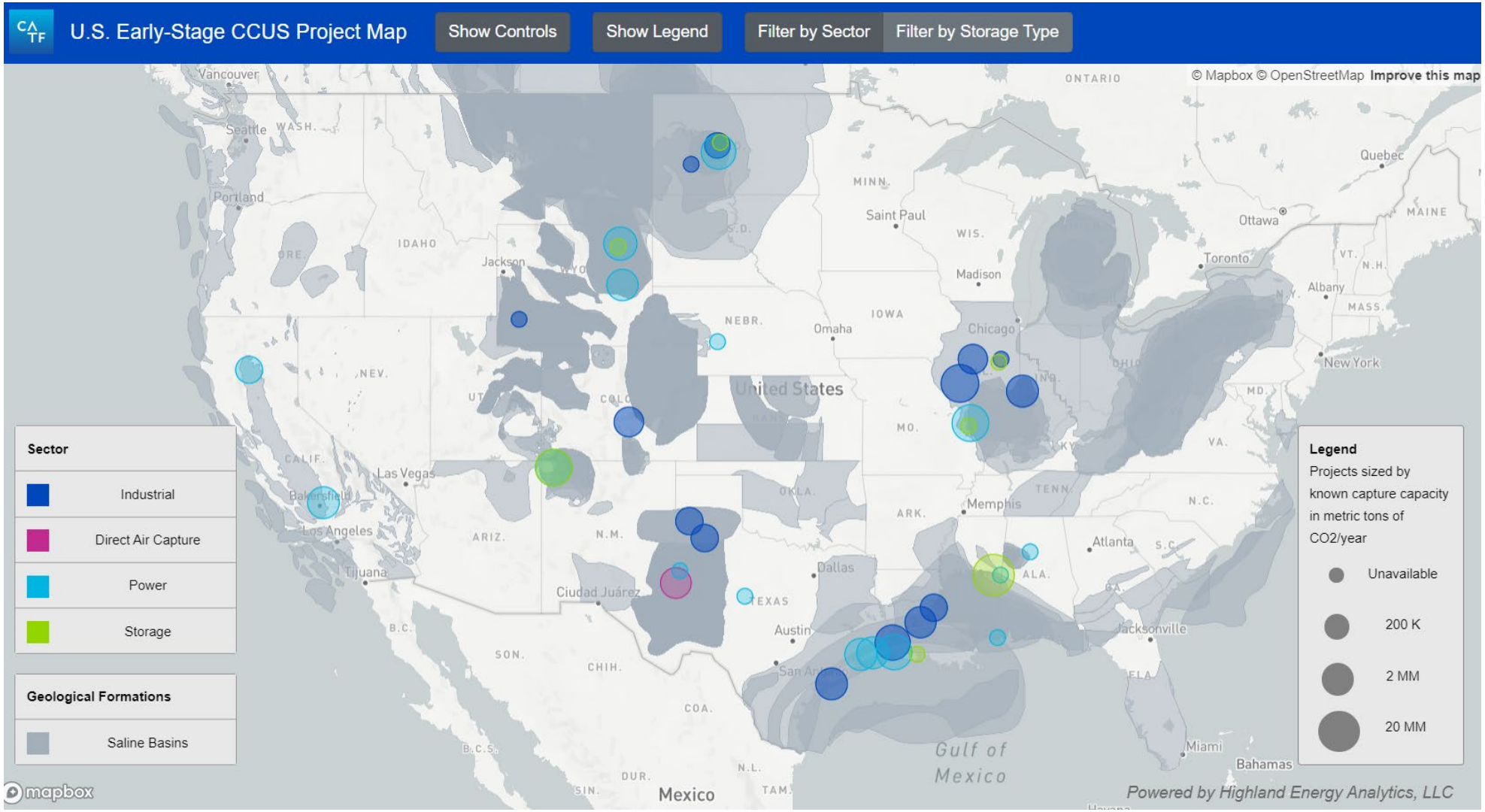
San Joaquin Basin

Mean CO_2 storage resource	
Known recovery replacement	25 megatons
Buoyant trapping	270 megatons
Residual trapping class 1	2,500 megatons
Residual trapping class 2	48,000 megatons
Residual trapping class 3	130 megatons
Technically accessible	51,000 megatons

https://co2public.er.usgs.gov/viewer/

CCS | U.S. PROJECT MAP

Clean Air Task Force (CATF);
Interactive Map of CCUS Projects
in Development in the U.S.



https://www.catf.us/2020/07/ccus-interactive-map/

https://ww3.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm

CNE | WHY CALIFORNIA?

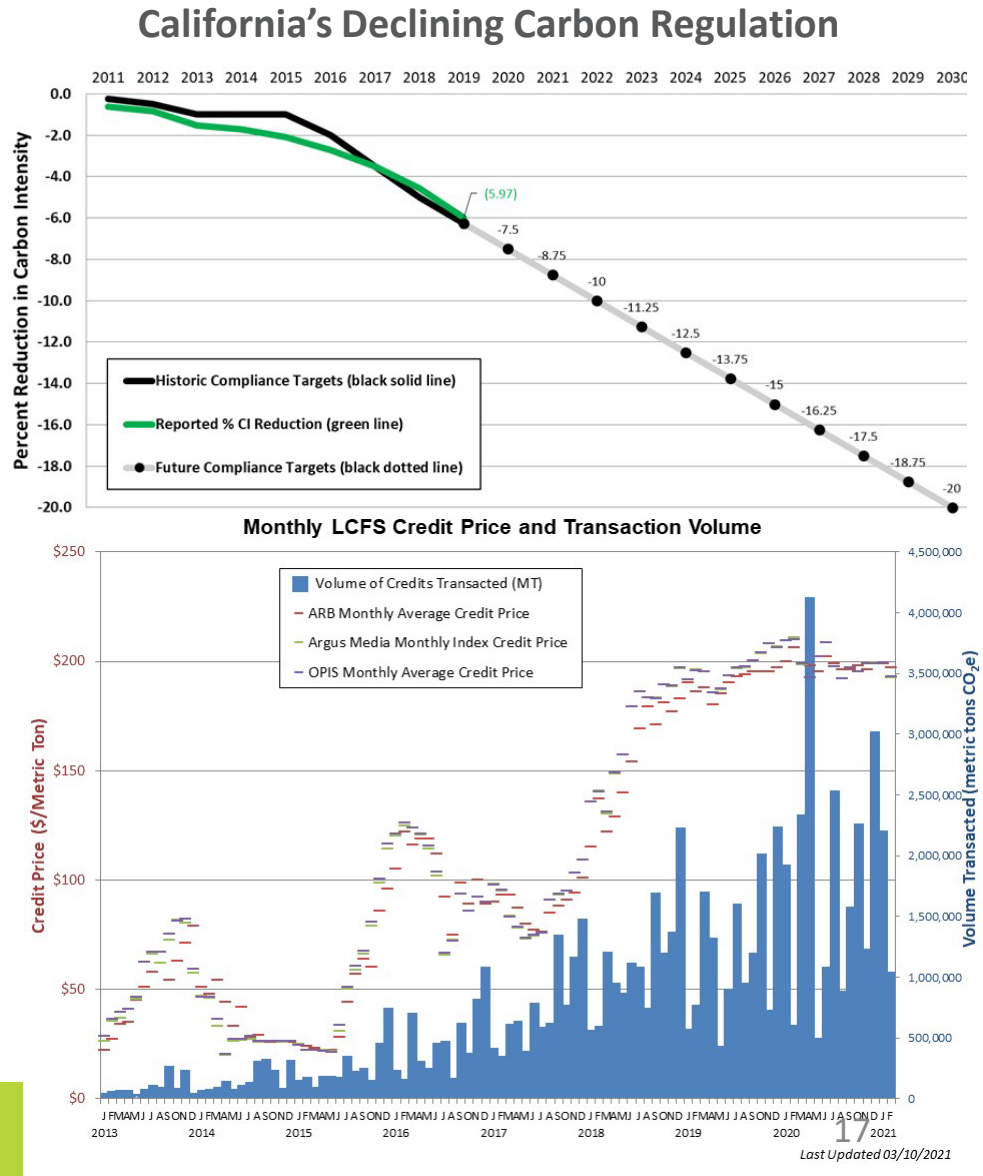
California's unique attributes support successful deployment:

- Enormous potential for onshore carbon storage
- Excess of biomass wastes and idled resources
- Strong government support and commitment to low carbon future
- Robust carbon pricing and trading network

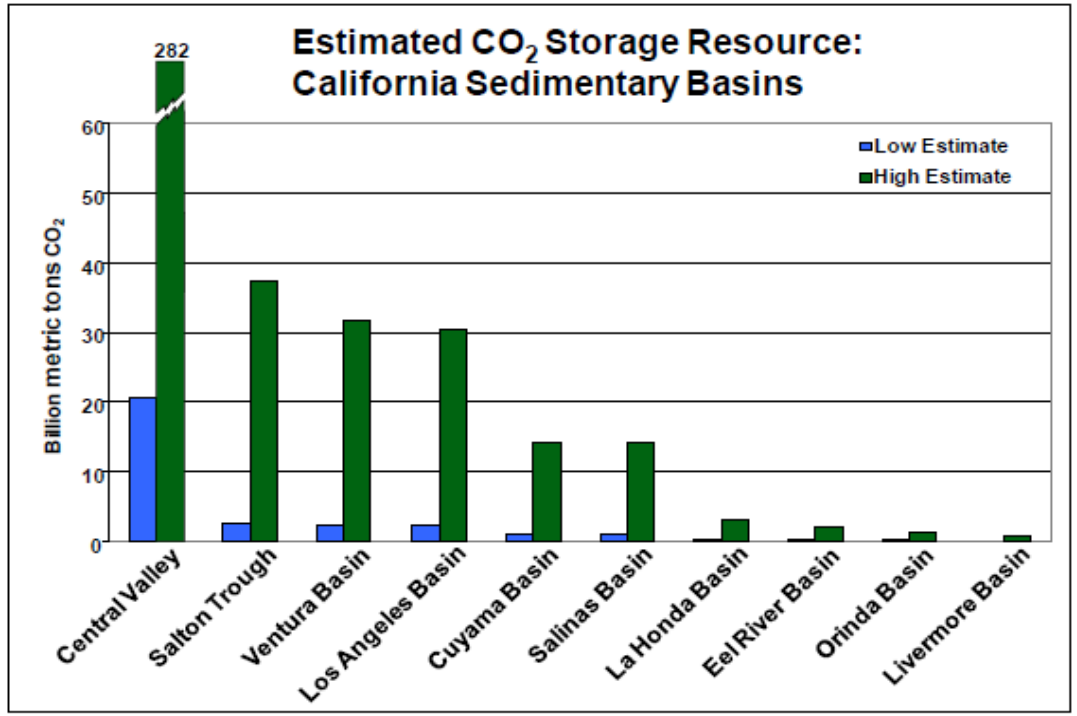
Multiple factors aligned to make deployment profitable

- Revenues for CCS projects up to $250/tonne in select markets
  - Federal Tax Credit increased from $20/tonne CO_2 to $50/tonne CO_2
  - California's Low Carbon Fuel Standard (LCFS) program credit prices consistently average near $200/tonne cap*
- Biomass power industry collapsing in California
  - Resulting in stranded assets and infrastructure
  - Biomass waste disposal now a significant challenge for farmers, municipalities, and state wildfire abatement

*$200/tonne cap set in 2016 (later years adjusted for inflation)



OPPORTUNITIES FOR CCS IN CALIFORNIA



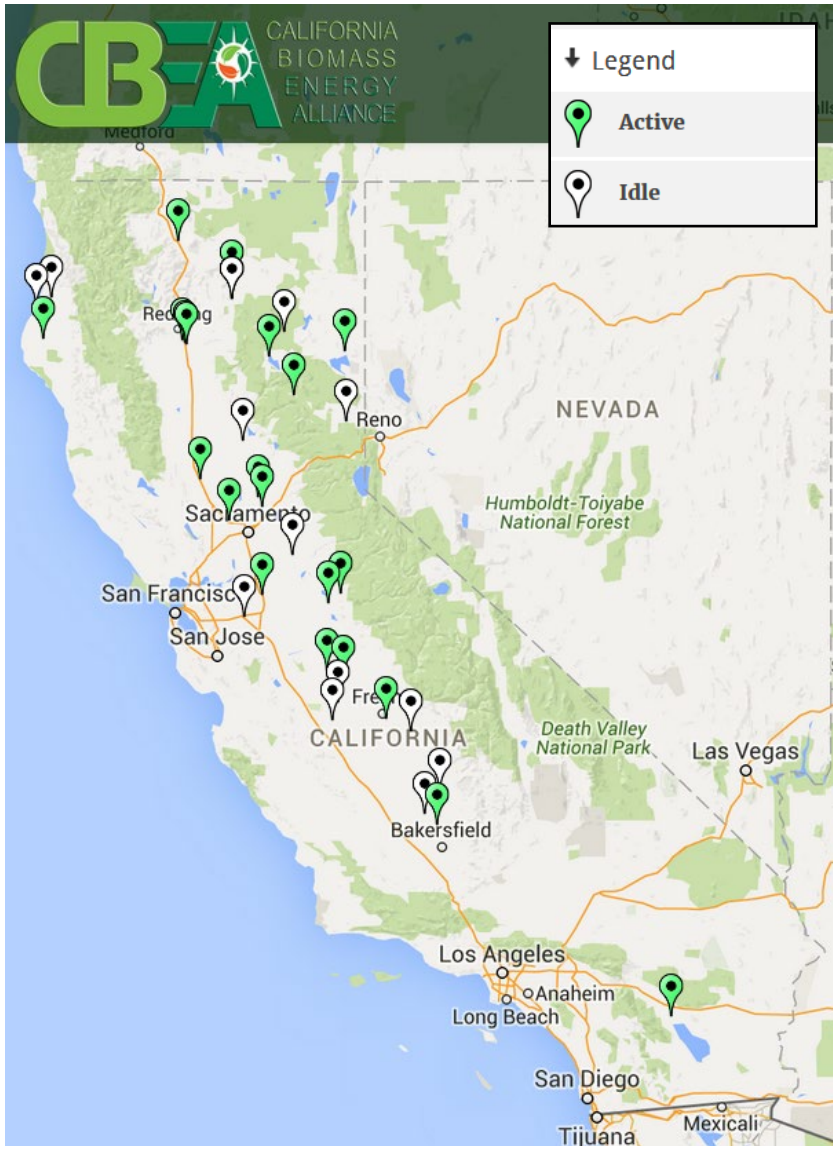
30–460 Gt onshore saline formation capacity
3.3–5.7 Gt natural gas reservoir capacity
1.4–3.7 Gt oil reservoir capacity

California Offers Very Large CO_2 Storage Capacity:

- California's on-shore sedimentary basins conducive to storage; represent capacity for roughly 1,000 years of current CO_2 emissions (point source)
- The Central Valley's basins have the largest capacity
- Opportunities for CO_2 storage also exist in the state's oil and natural gas fields – many have potential for CO_2-enhanced oil recovery
- Off-shore basins identified and partially characterized (potential for coastal plants)

BIOENERGY IN CALIFORNIA | THE SITUATION

- Today, more than 375 MW of commercial biomass power plants sit idle in California with more anticipated to close in the coming years
  - Many citing competition from low cost renewables (e.g. solar, wind) as reason for not extending operations
- Many of these idled facilities are located in the Central Valley
  - Area is rich with agriculture but unfortunately known for poor air quality
  - Without another viable disposal option, farmers are forced to burn agricultural wastes in their fields, emitting harmful greenhouse gases and other pollutants into the atmosphere



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

CALIFORNIA AIR QUALITY | TROUBLE IN THE CENTRAL VALLEY

- Several factors contribute to California having the worst air quality in the nation, including the state's industrial and transportation sectors, population, and geography
- This is further complicated by severe drought and extreme wildfires (impacted by climate change) and recently, the closure of numerous bioenergy plants previously used to dispose of agricultural and forestry residues

CALIFORNIA AIR QUALITY | TROUBLE IN THE CENTRAL VALLEY

American Lung Association "State of the Air" 2021 Report

www.lung.org/research/sota

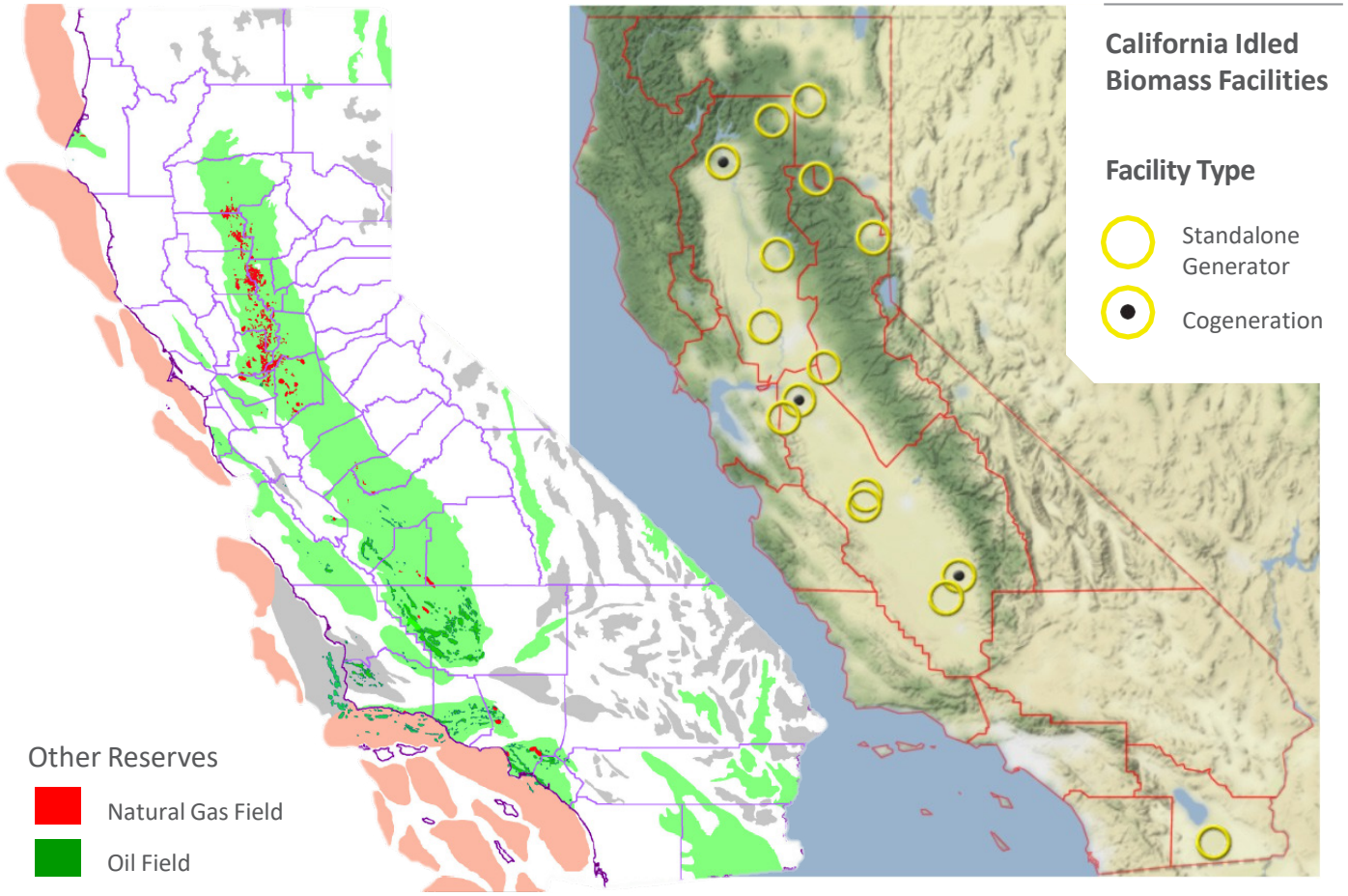
Most Polluted U.S. Cities:

www.lung.org/research/sota/city-rankings/most-polluted-cities

Ozone	Year-Round Particle Pollution (Annual $PM_{2.5}$)	Short-Term Particle Pollution (24-hour $PM_{2.5}$)
1 Los Angeles-Long Beach, CA	**1 Bakersfield, CA**	1 Fairbanks, AK
2 Bakersfield, CA	**2 Fresno-Madera-Hanford, CA**	**2 Fresno-Madera-Hanford, CA**
3 Visalia, CA	**3 Visalia, CA**	**3 Bakersfield, CA**
4 Fresno-Madera-Hanford, CA	**4 Los Angeles-Long Beach, CA**	**4 San Jose-San Francisco-Oakland, CA**
5 Phoenix-Mesa, AZ	5 Medford-Grants Pass, OR	5 Yakima, WA
6 Sacramento-Roseville, CA	6 Fairbanks, AK	**6 Los Angeles-Long Beach, CA**
7 San Diego-Chula Vista-Carlsbad, CA	**7 San Jose-San Francisco-Oakland, CA**	7 Logan, UT-ID
8 Denver-Aurora, CO	8 Phoenix-Mesa, AZ	**8 Redding-Red Bluff, CA**
9 Salt Lake City-Provo-Orem, UT	9 Pittsburgh-New Castle-Weirton, PA-OH-WV	9 Missoula, MT
10 San Jose-San Francisco-Oakland, CA	**10 El Centro, CA**	**10 Sacramento-Roseville, CA**
11 Houston-The Woodlands, TX	11 Cincinnati-Wilmington-Maysville, OH-KY-IN	**11 Visalia, CA**

CNE I OPPORTUNITES FOR BECCS IN CALIFORNIA

- At least 15 idle biomass power plants in California today (>375 MW), with more anticipated to close in the coming years
- A comparison of idle biomass facilities to California's sedimentary basins shows excellent potential for carbon capture and storage and possible use in enhanced oil or gas recovery (EOR/EGR)
- Several benefits of retrofit deployment strategy



Map Courtesy of WESTCARB https://www.westcarb.org/geocharacter.html

https://ucanr.edu/sites/WoodyBiomass/California_Biomass_Power_Plants/

CNE I COMMUNITY BENEFITS

- Revitalization of existing, idle biomass facilities, supporting economic growth and jobs
- Elimination of criteria pollutant and CO_2 greenhouse gas emissions – improving local air quality
- Reduction and possible elimination of open field burning of agricultural wastes – solving waste management issues
    - Supports the California Air Resources Control Board plan to begin phasing out almost all agricultural burning in the Valley by 2025
- Helps address tree mortality and wildfire crisis in the state
- Supports California's low-carbon energy and transportation goals
    - Recent State mandate requires 100% carbon-free electricity by 2045
- Necessary to meet the world's goals to limit global temperature rise per the Paris Agreement

CES CNE | DEPLOYMENT STRATEGY

- CES plans a two-phase strategy to deploy a new fleet of CNE plants across California, with the capability to remove significant amounts of CO_2 from the atmosphere:
  - Phase 1: Initial commercial plant in the Central Valley at existing facility
    - Retrofit existing 600 TPD biomass power plant with CES oxy-fuel technology; This first CNE plant will be capable of removing more than 6 million tons of CO_2 from the atmosphere over a 20-year operating life
  - Phase 2: Retrofit 3 to 5 more biomass power plants across California
    - Each new CNE plant will use 300 TPD to 1,200 TPD waste biomass input and be capable of removing 3-14 million tons of CO_2 from the atmosphere over its lifetime, while producing enough electricity or RH_2 to fuel thousands of electric vehicles
- Commercial deployment can make use of existing, idle biomass facilities
  - Reduces deployment schedule and costs while revitalizing valuable resources

CNE | PROJECT SITE #1

Mendota BECCS

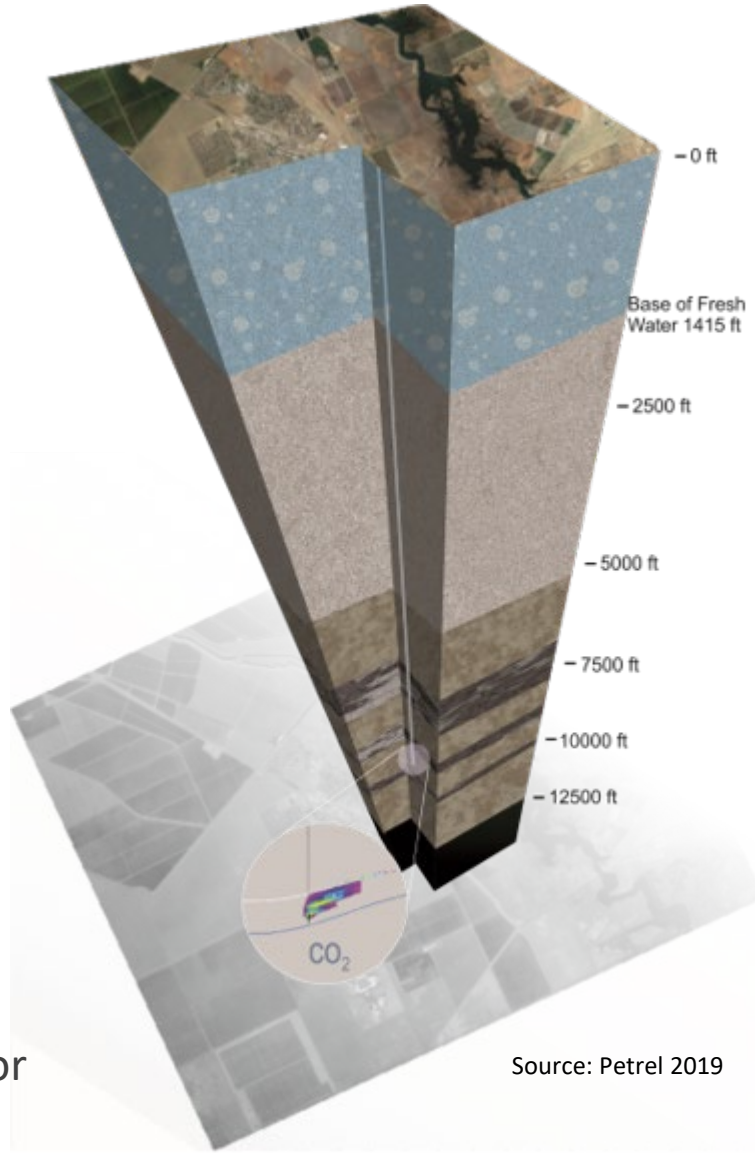
- Located in the heart of California's Central Valley, on the west side of Fresno County; Surrounded by agricultural fields and sitting ontop a WESTCARB identified storage basin
- Revitalizes an idle biomass power (operational through 2015)
  - Site has existing biomass infrastructure, electrical interconnect, and other useful BOP
  - Requires new biomass gasification, oxygen supply, and carbon sequestration systems, and CES power block
- Use approx. 200,000 tons of agricultural waste per year
- Produce up to 5 MWe for use in EVs and other transportation needs
- Store approx. 300,000 tons of CO2 per year
  - Equivalent to the emissions emitted from electricity usage by more than 65,000 U.S. homes*

* Based on average electricity use
https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

CNE | PROJECT SITE #1

Mendota BECCS (continued)

- Captured CO_2 to be permanently sequestered on-site; nearly 10,000 ft below the surface, beneath multiple confining layers
  - Working with Schlumberger to model and develop the storage facility; EPA Class VI UIC Permit application submitted in 2020
- Geologic storage of CO_2 is permitted by the US Environmental Protection Agency (EPA) after:
  - Extensive environmental and efficacy review of proposed site, construction, operation, testing, monitoring, and closure plans,
  - Analysis of 3D subsurface data in area,
  - Analysis of data from test well boring, and
  - Identification and verification of confining geology
- In addition, EPA and California ARB review to certify permanent storage of CO_2 for the lifetime of the project, including long after operations have ceased



Source: Petrel 2019

Learn more at: https://www.epa.gov/uic, and https://www.netl.doe.gov/coal/carbon-storage/faqs/carbon-storage-faqs

MENDOTA BECCS | PROJECT PARTNERS

https://www.businesswire.com/news/home/20210304005631/en/Schlumberger-New-Energy-Chevron-and-Microsoft-Collaborate-on-Carbon-Negative-Bioenergy

Clean Energy Systems technology to remove the equivalent of CO2 emissions from 65,000 homes

Houston, TX, March 4, 2021—Schlumberger New Energy, Chevron Corporation, Microsoft and Clean Energy Systems today announced plans to develop a ground-breaking bioenergy with carbon capture

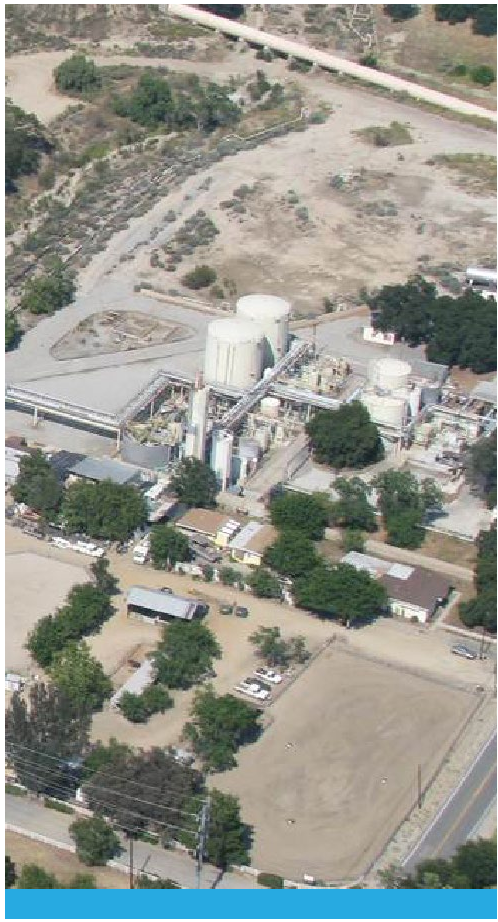
CNE | REPLICATE AND SCALE

Phase 2 Deployment builds upon lessons learned

- CES CNE plants are replicable and scalable
- Retrofit 3 to 5 more biomass power plants across California taking advantage of knowledge gained and lessons learned from first project
- Classic project development opportunity with a phased approach
- First projects focus on electricity sales into California's transportation sector
- Future projects can add renewable hydrogen production using commercially available gas separation technologies
- Then, expand beyond California; potential projects in the Pacific Northwest, Canada, and Europe

SUMMARY & CONCLUSIONS

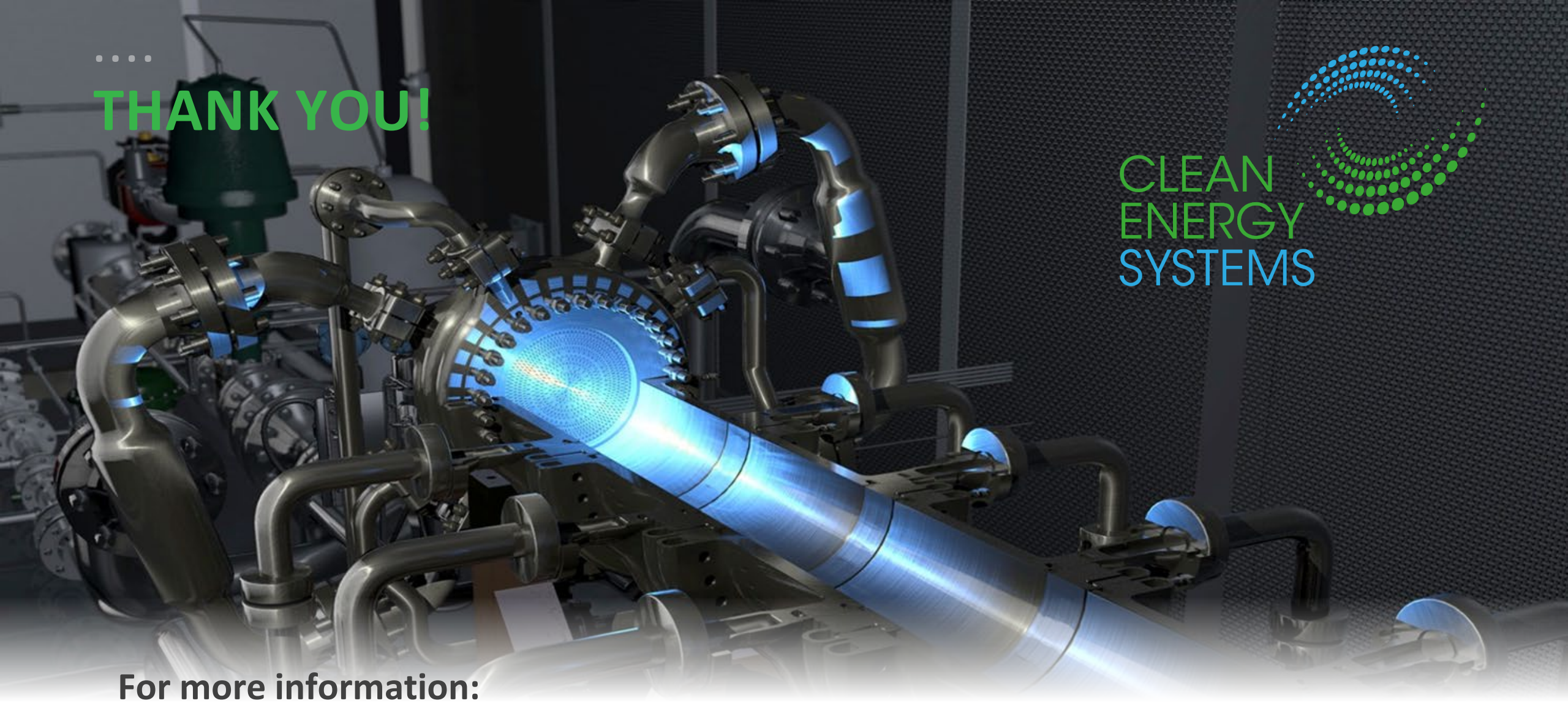
- CES plans to deploy a fleet of CNE plants across California to help solve multiple problems and take advantage of the state's unique features, including:
  1. Excess of biomass wastes and idled resources
  2. Strong government support and commitment to a low carbon future
  3. Enormous potential for onshore carbon storage
  4. Robust carbon pricing and trading network
- Deployment builds upon decade of work to advance CCS in the United States
  - Government and private funding into RD&D in both carbon capture and storage
  - CES' oxy-combustion technology developed over the past 25 years
- Two phase deployment approach retrofits existing, idled biomass facility; then scales and replicates at multiple other sites across the state
  - First project, Mendota BECCS in Fresno County, California
  - Strong partners supporting project development



KEY TAKEAWAYS

- **CCS Projects are Coming!**
- **CCS Projects Need Landmen!**
- Some tools and considerations for CCS projects presented here

THANK YOU!



CLEAN ENERGY SYSTEMS

For more information:

Visit: www.CleanEnergySystems.com/CNE, or
www.CleanEnergySystems.com/MendotaBECCS

Email: MendotaBECCS@cleanenergysystems.com

Continued Education Component Code

ARTX-6