CLEAN ENERGY SYSTEMS

Carbon-Negative Energy Renewable Hydrogen Project An Opportunity for California

December 2019

CARBON NEGATIVE ENERGY
WHAT IS CNE?

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- **Carbon removal** refers to any process or system capable of removing and sequestering carbon from the air over its life cycle
- **CNE (or BioCCS)** refers to any bioenergy process that captures and permanently stores carbon safely underground through carbon capture and storage (CCS) – Indirect Air Capture
- CNE can remove the harmful greenhouse gas carbon dioxide (CO_2) from the atmosphere while producing electricity and **clean, renewable hydrogen**

CNE | HOW IT WORKS

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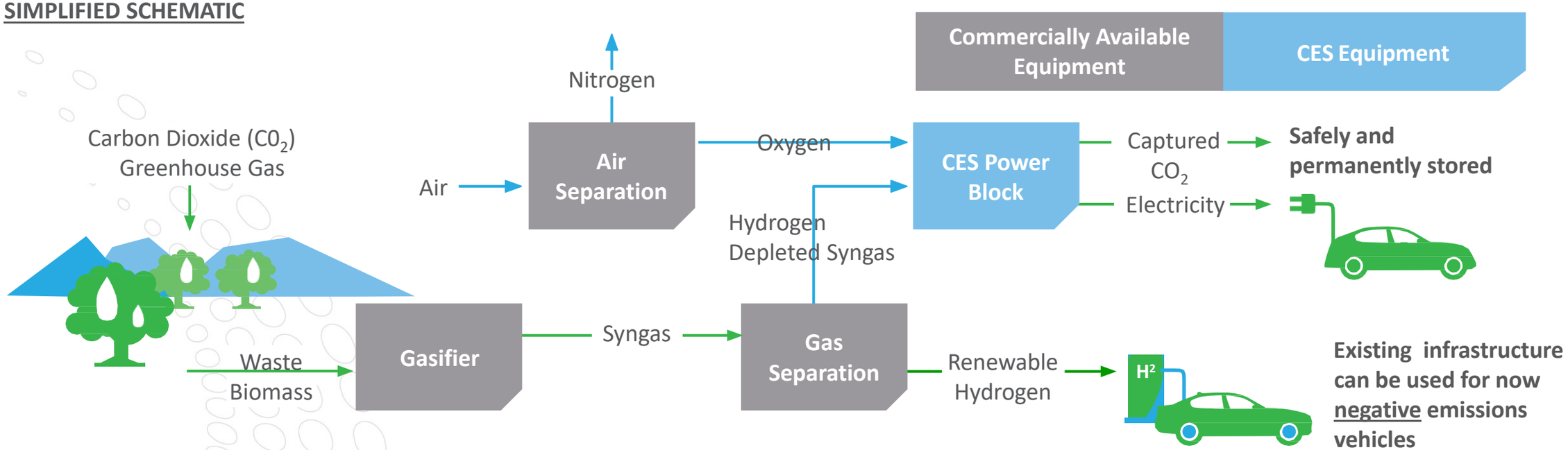
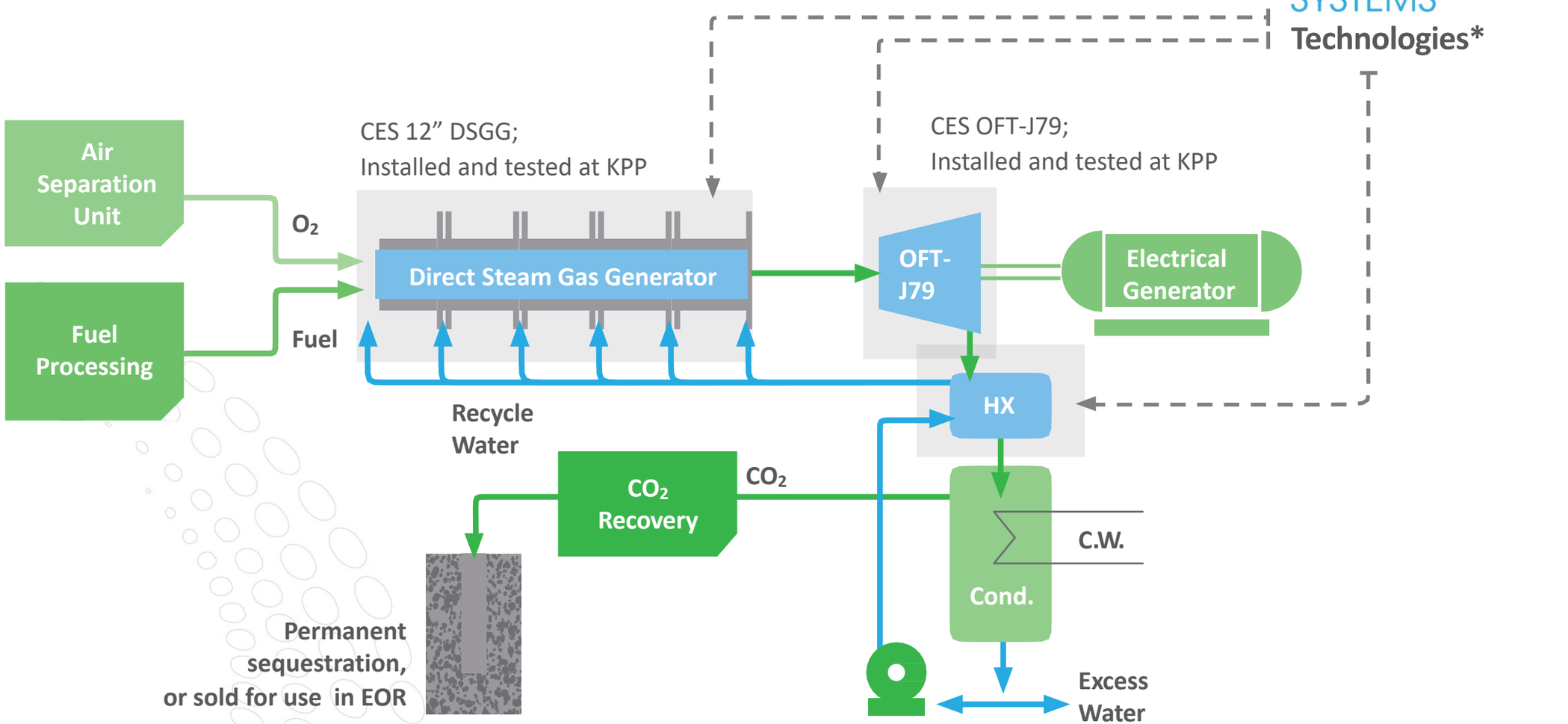
CES Carbon Negative Energy (CNE) plants use waste biomass fuels that are gasified to produce a synthesis gas. This “syngas” is then used to produce renewable hydrogen (RH_2), and/or electricity with full carbon capture using proprietary oxy-combustion technology

SIMPLIFIED SCHEMATIC



CNE | CES POWER BLOCK

CLEAN ENERGY SYSTEMS Technologies*



*See www.CleanEnergySystems.com for info on CES technologies

CNE: WHY NOW?
ECONOMICS

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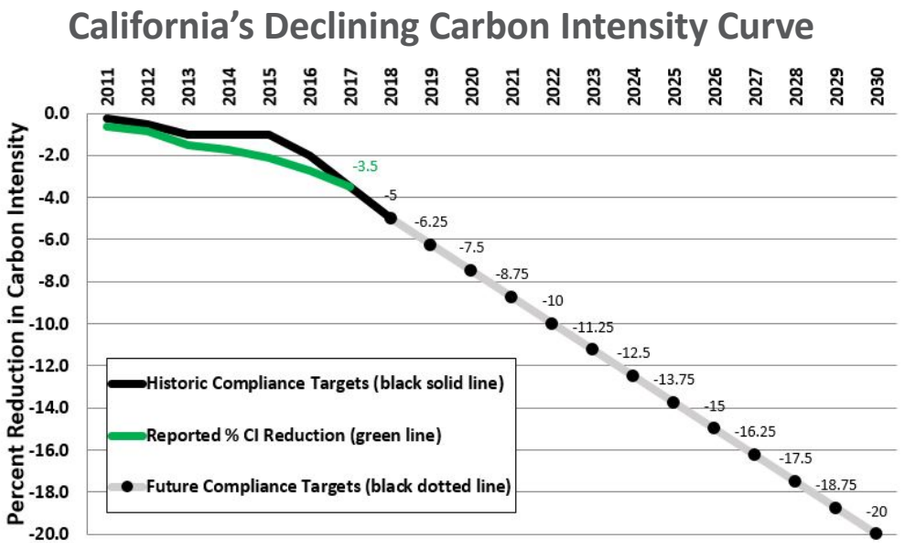
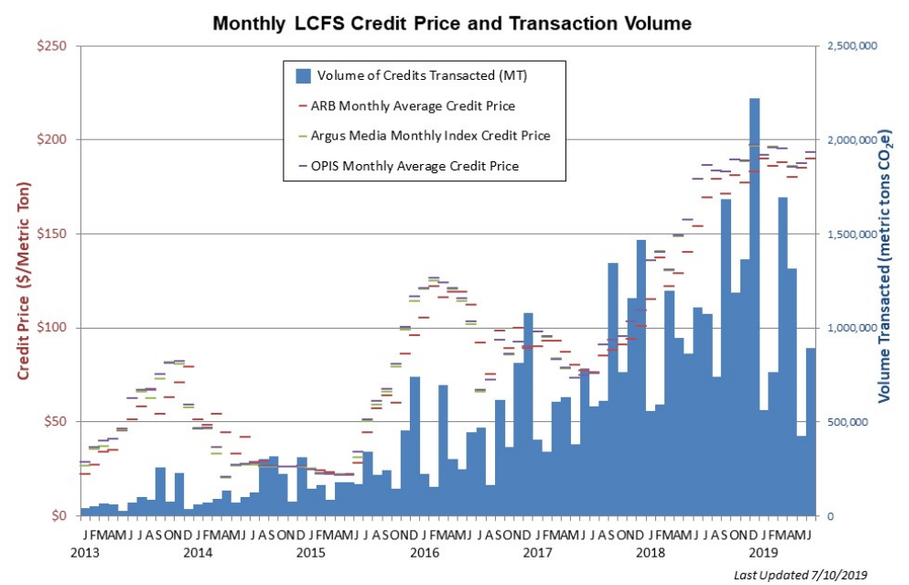
Revenues have increased from $20 to $250/tonne for Carbon Capture in select markets

- Value Proposition for CCS projects today:
  - Renewable Hydrogen sales at avoided cost
  - Federal Tax Credit (45Q); increased from $20 to $50/tonne CO_2 in 2018
  - California's Low Carbon Fuel Standard (LCFS); credit prices exceeding $190/tonne
- Concurrently, the Biomass Power industry in California has collapsed due to competition from wind and solar
  - Stranded assets may be used for alternative purposes
  - Feedstock pricing collapse; long-term contracts available
- Required CES capture tech. ready for commercial deployment
  - More than 25 years and $135 million invested





CNE I OPPORTUNITES FOR CALIFORNIA

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TODAY	→	TOMORROW
• Half the state's biomass plants shuttered	→	All biomass plants repurposed and life extended
• Criteria pollutants from biomass plants	→	Near-zero atmospheric emissions
• Open field burning of agricultural waste	→	Ag. waste used to produce renewable hydrogen
• Natural gas is used to make hydrogen	→	Renewable hydrogen from ag. and green waste
• Tree mortality and wild fire crisis	→	Beneficial use of cleared forestry waste
• Current biomass plants consume water	→	CNE plants are net producers of water
• Water shortages in the Central Valley	→	Brackish water can be processed with waste heat

CNE | POTENTIAL FOR CCS IN CALIFORNIA

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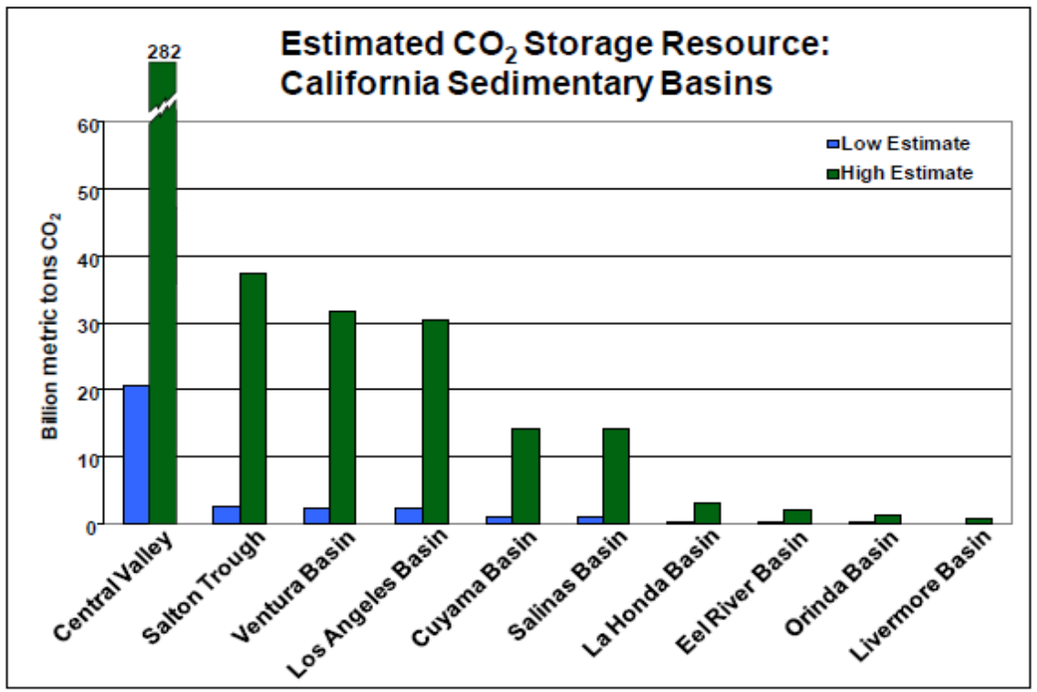

30–460 Gt onshore saline formation capacity
3.3–5.7 Gt natural gas reservoir capacity
1.4–3.7 Gt oil reservoir capacity

California Offers Very Large CO_2 Storage Capacity:

- California's on-shore sedimentary have capacity for roughly 1,000 years of current CO_2 emissions (point source)
- The largest storage capacity identified in the state's Central Valley basin

Courtesy of the California Energy Commission

CNE I POTENTIAL FOR BioCCS IN CALIFORNIA

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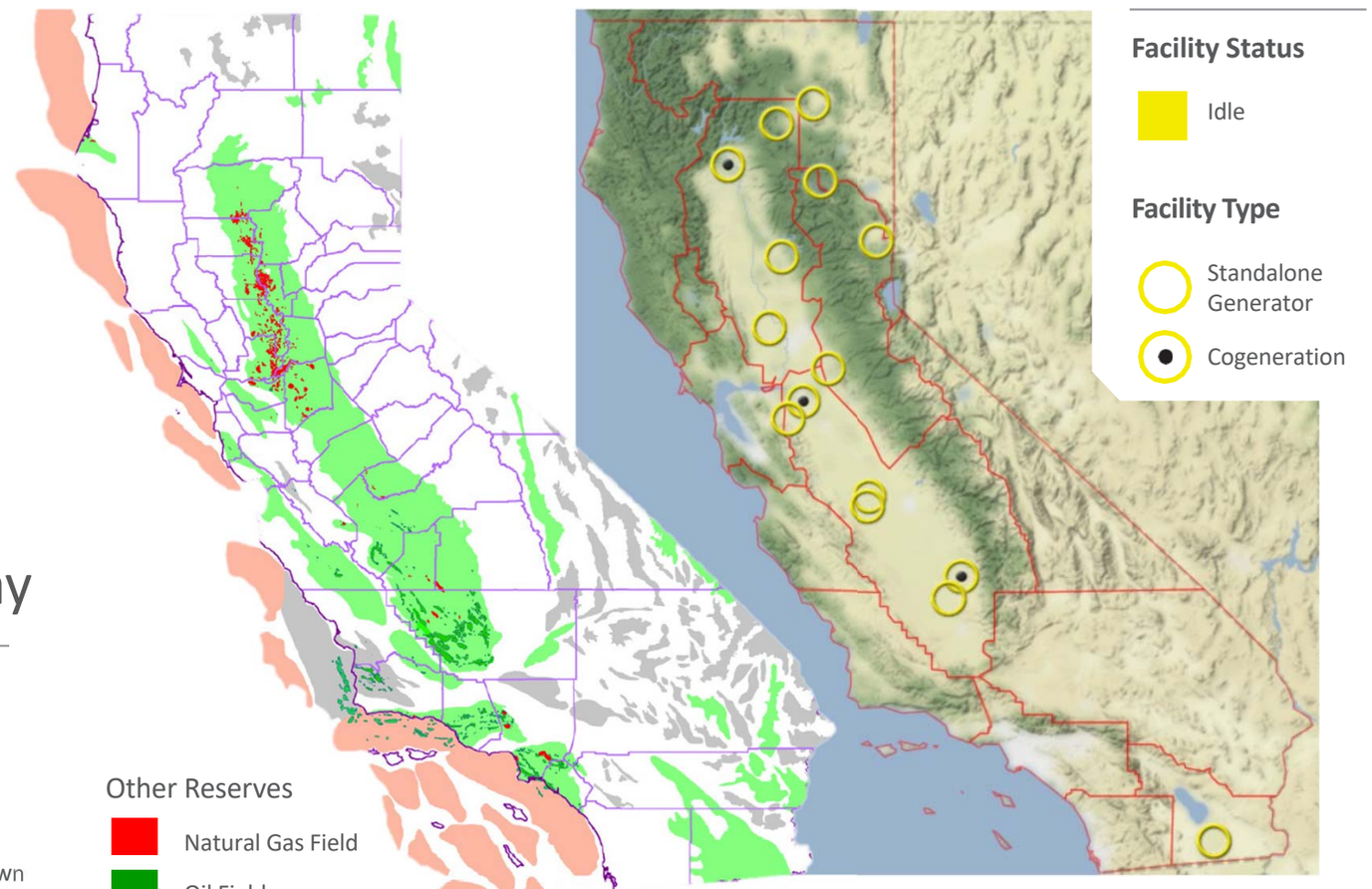
- More than 15 idle biomass power plants in California today (>375 MW), with more anticipated to close in the coming years
- Excellent overlay of plant locations with CCS storage sites
- Suitable for delivery to state refineries or the Hydrogen Highway



Courtesy of WESTCARB

CNE DEPLOYMENT | HOW TO ACCELERATE?

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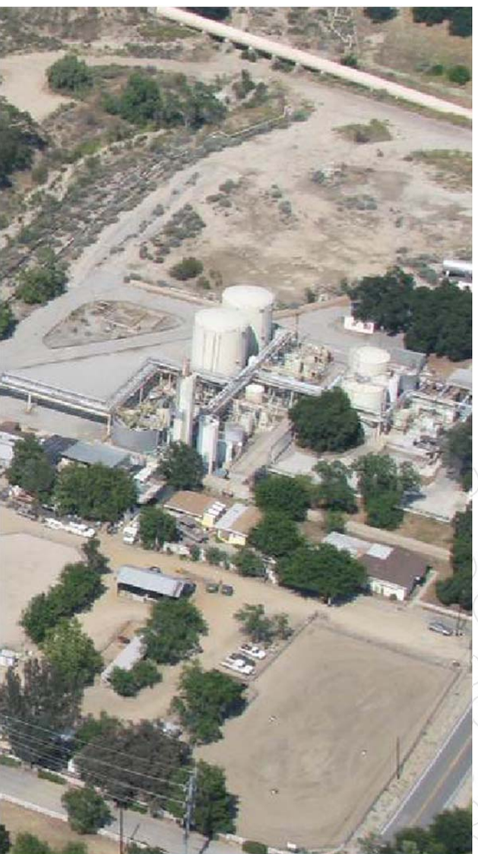

1. Fast-track approval of CCS projects
    - Resolution of permanence storage protocol
    - Coordination between state agencies and US EPA
2. Greater flexibility in LCFS pathway calculations/monetization/eligibility
    - Currently results in a fixed CI, whereas CNE projects may have variable CI attributes
    - Increased trading/monetization opportunities
    - More favorable interpretation of the regulations
3. Predictability of LCFS pricing to support project financing
    - A floor price is optimal, but highly problematic
    - Opportunities through the Pollution Control Tax-Exempt Bond Financing Program

CES DEPLOYMENT | ENVIRONMENTAL IMPACT

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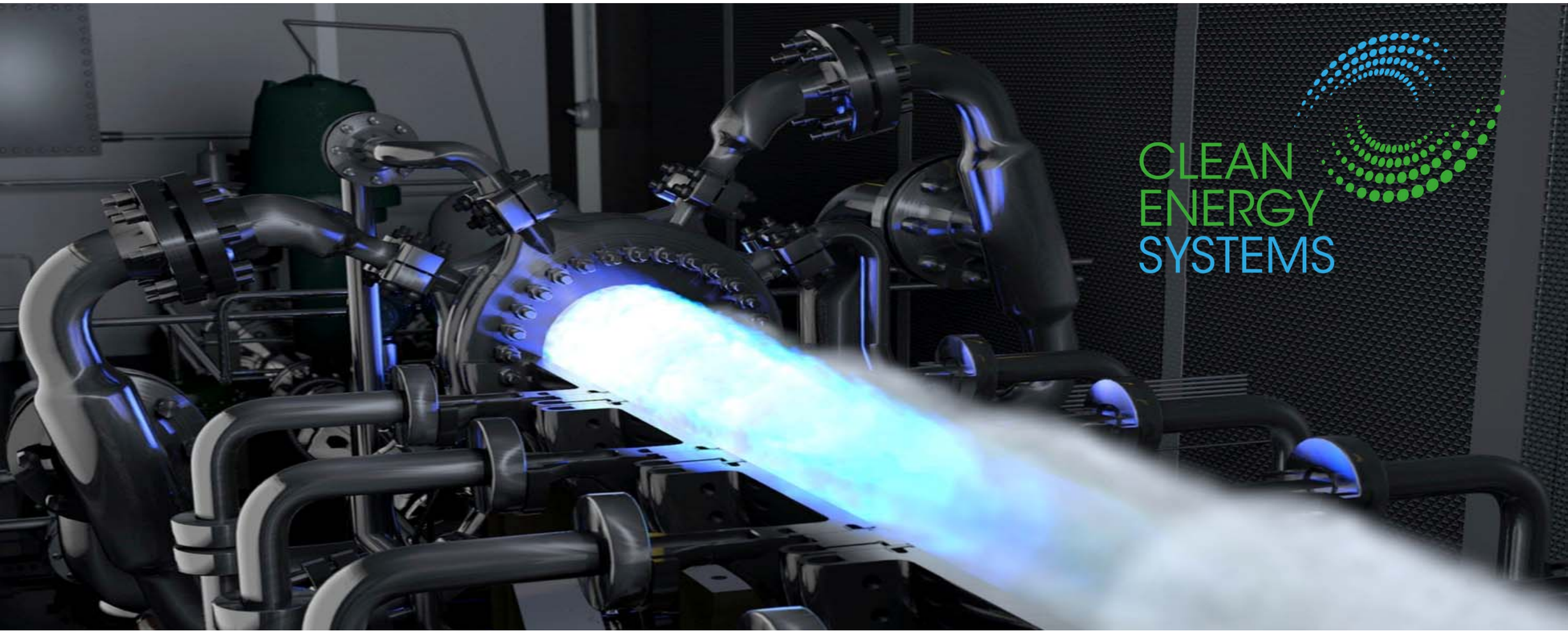
- CES plans to deploy a fleet of CNE plants across California by retrofitting existing, idled biomass facilities
- First plants will be deployed in the Central Valley; CES has site control for the first four plants to be deployed by 2025
- Significant fuel production and environmental benefits for the state by replicating and scaling CNE plants

	First Four CNE Plants 2022-2025	Future Potential 2025+
Fuel Production (tonne/day)		
RH_2 Produced	33	425
Emissions Avoided (tonne/yr)		
CO_2 Captured & Avoided	1,300,000	16,200,000
NOx Avoided	2,400	29,900
Particulates Avoided	5,100	64,100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