

ELEVENTH CLIMATE
SMART AGRICULTURE
WEBINAR

CALIFORNIA – DENMARK



CALIFORNIA DEPARTMENT OF
FOOD AND AGRICULTURE



ENVIRONMENTAL AND ECONOMIC IMPORTANCE OF ANAEROBIC DIGESTION AND RENEWABLE NATURAL GAS

A CALIFORNIA CLIMATE SMART AGRICULTURE
WEBINAR IN COLLABORATION WITH DENMARK



**MINISTRY OF FOREIGN AFFAIRS
OF DENMARK**
The Trade Council



PURPOSE

INFORMATION SHARING
BETWEEN DENMARK AND
CALIFORNIA
ON DAIRY METHANE
CAPTURE AND
RENEWABLE ENERGY USE



TODAY'S AGENDA

1. Welcome and Introductions

Troels Mandel Vensild, Minister Counselor, Food & Agriculture, Embassy of Denmark
Jenny Lester Moffitt, Undersecretary, California Department of Food and Agriculture

2. Digesters, Biogas and RNG - Meeting California and Denmark's energy and environment goals

- Discussion of Danish policy and incentive drivers for biogas growth
Louise Hansen, Commercial Advisor, Trade Council of North America
- Discussion of current CDFA incentive programs for methane capture
Geetika Joshi – Dairy Digester Research and Development Program
- Current and Future regulations designed to capture and utilize methane in California
Mary Jane Coombs, Chief of the Projects Assessment Branch, California Air Resources Board

3. Farm-Based Biogas Plant Examples from California and Denmark

- Danish Dairy Biogas Plant Developer and Operator
Trine Dalsgaard, Nature Energy
- California Dairy Operators and Developers
Joey Airoso (dairy producer)
Daryl Maas (Maas Energy - developer)
Neil Black (CalBio – developer)

4. Q &A

WELCOME & OPENING REMARKS

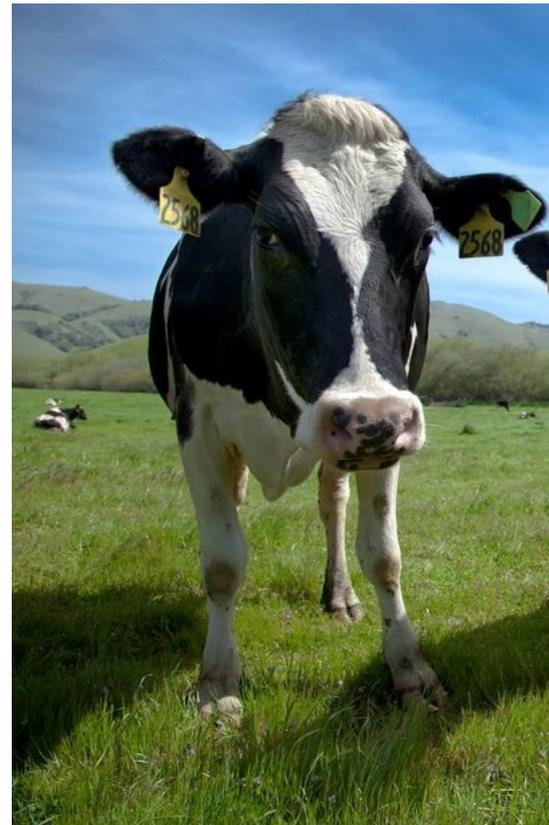


Troels Mandel Vensild
Minister Counselor, Food &
Agriculture, Embassy of Denmark



Jenny Lester Moffitt
Undersecretary, California Department
of Food and Agriculture

DIGESTERS,
BIOGAS AND
RNG:
MEETING
CALIFORNIA
AND
DENMARK'S
ENERGY AND
ENVIRONMENT
GOALS



Discussion of Danish policy and incentive drivers for biogas growth



Louise Hansen
Commercial Advisor,
Trade Council of North America

Louise Hansen is a Business Consultant at the Danish Trade Council in North America where her job is to assist Danish biogas companies enter into or expand current operations in the U.S. Louise holds comprehensive knowledge of the Danish biogas market, including policy drivers and technological advancements and is regularly invited to speak at industry forums and conferences in the U.S. She holds a Master of Science in International Business and Politics from Copenhagen Business School.



policy drivers incentives for biogas growth

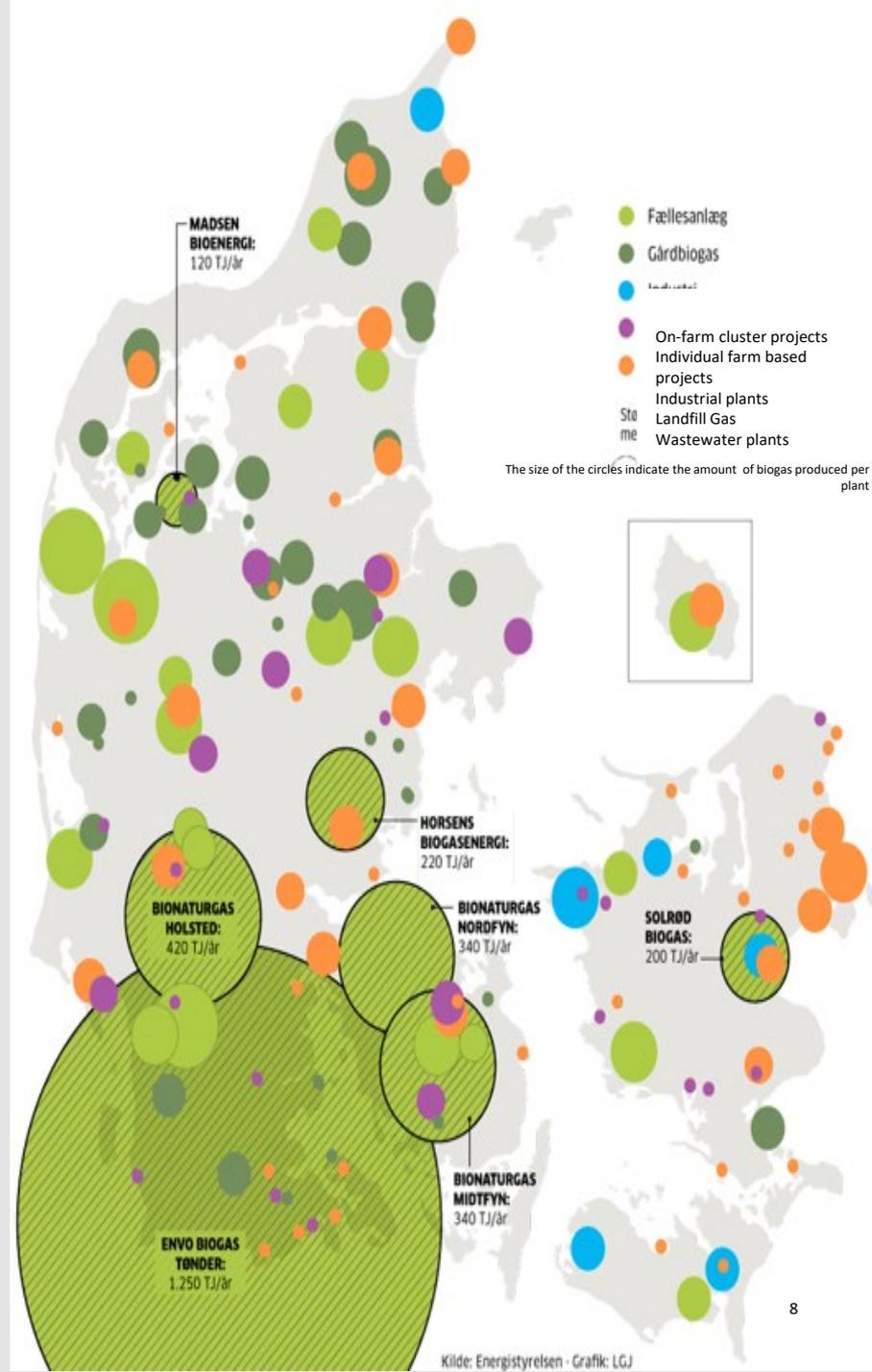
Experiences from Denmark

Louise Hansen – Commercial Advisor (Waste, Recycling and Biogas), Trade Council of North America

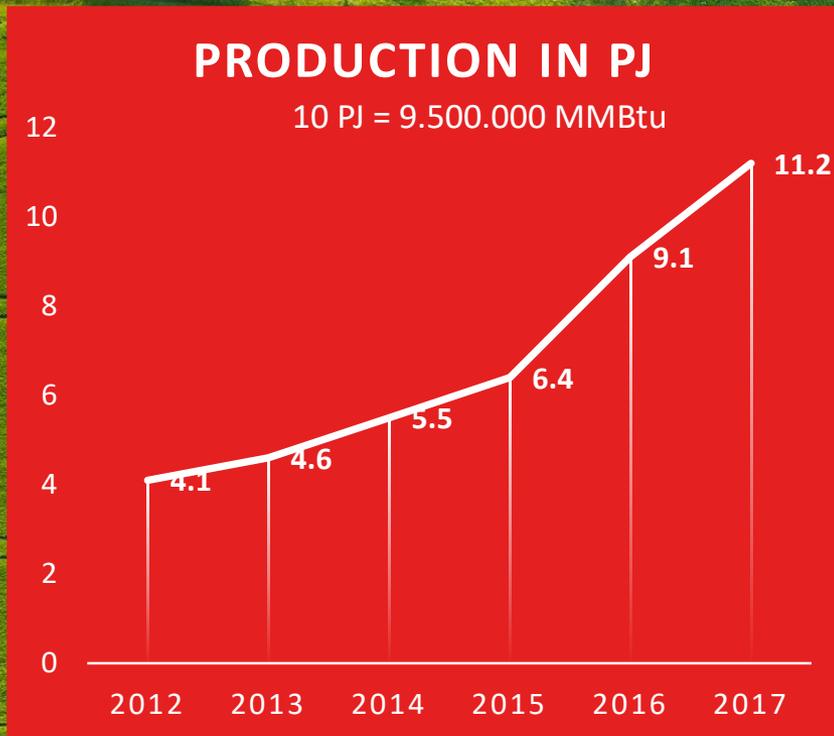
+1 202-797-5322 / +1 202-704-8727 / lohans@um.dk

the lay of the land

- Denmark's population: 5.6 mil.
- 38,800 farmers
- 1,560,000 cows
- 575,000 **dairy** cows
- 62% of land area is cultivated (43,000 km²)
- ~50 on-farm biogas plants
- ~30 centralized biogas plant (largest plant processing up to 1 mil t/y)
- 12% of manure is used for biogas production
- **13 % industrial waste → 53 % share of biogas**



Biogas is booming in Denmark



8% biogas
in the grid
in 2018

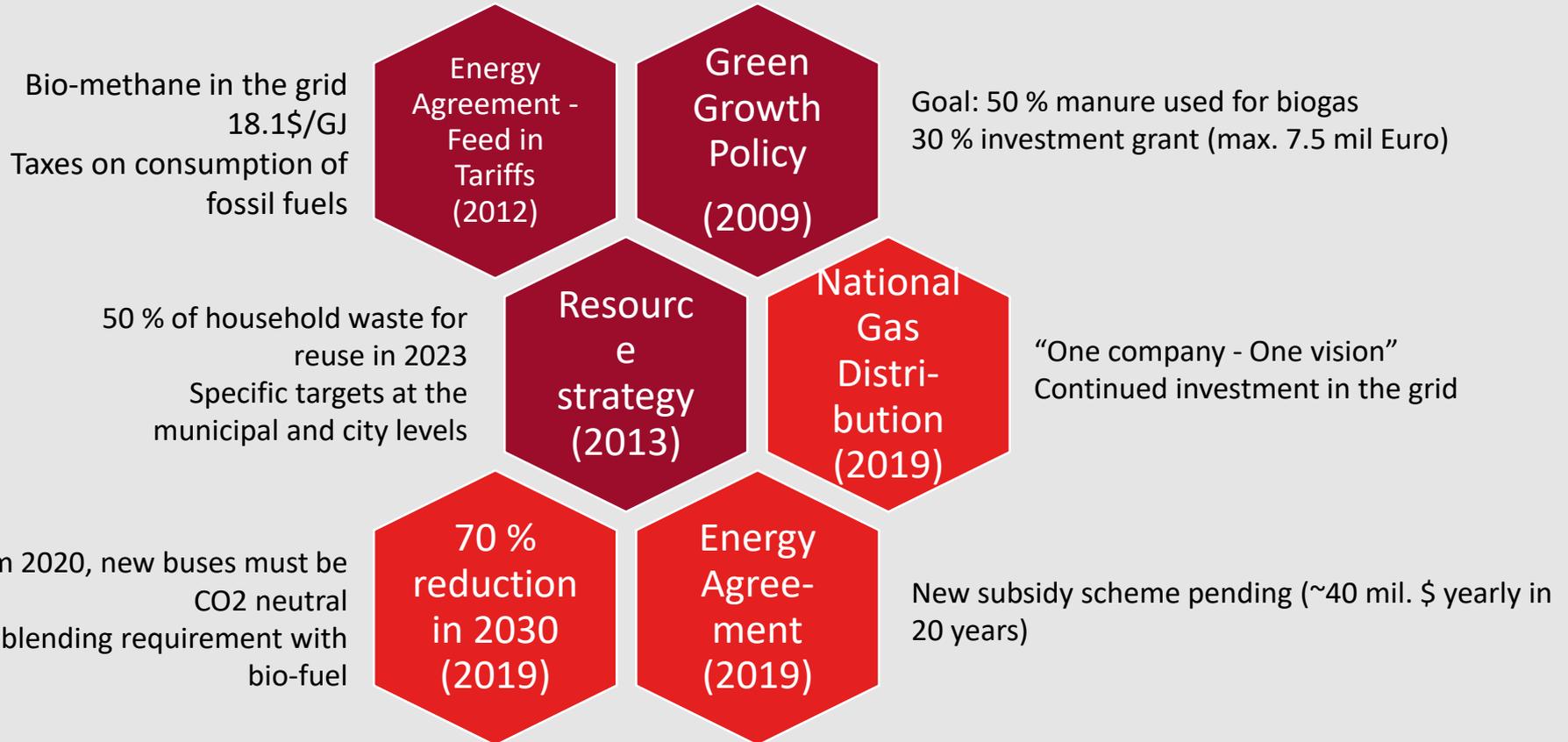
30%
biogas in 2023
is projected

100%
biogas in the grid in 2035 is
technically feasible

why a Danish farmer wants biogas

- He can reduce his environmental impact of animal production
- He wants to have a good relationship with his neighbours (reduced odours)
- He can produce more with less
- He saves money on synthetic fertiliser
- He can better control the in and output of nutrients
- There are restrictions on the use of mineral fertilisers → higher utilisation of nutrients for the crops
- He gets access to the nutrients in industrial waste

A patchwork of policy drivers and incentives



Looking into the future

- Biogas will continue to play in Denmark to foster:
 - Green Transportation particularly in heavy duty vehicles
 - Sustainable agricultural production and a healthy rural economy
 - A flexible and reliable energy supply
 - Innovation and export of technologies... but there is still work to do!



Biogas go global- project team and roles



AGRO
BUSINESS
PARK



Facilitating knowledge sharing between research environments in Denmark and the U.S., orchestrating project development workshops with U.S. innovation clusters and identify financing to fund innovation projects in the U.S.

Government2Government knowledge exchange of policy frameworks focused on addressing regulatory barriers and positive externalities of biogas production and identify opportunities in third countries

Facilitating and promoting a **U.S. Biogas Alliance** that represents complementary competencies and works collaborately with an aim to unlock commercial opportunities in the U.S.



Discussion of current CDFA incentive programs for methane capture



Geetika Joshi

Dairy Digester Research and Development Program, CDFA

Geetika Joshi is a Senior Environmental Scientist in the Office of Environmental Farming and Innovation at CDFA, overseeing the Dairy Digester Research and Development Program (DDRDP), Alternative Manure Management Program (AMMP) and the Healthy Soils Program. Geetika has been involved with the development of DDRDP since its inception in 2014. Previously, she was a post-doctoral researcher at the Center for Regional Change at the University of California, Davis. She holds a Ph.D. in Soils and Biogeochemistry from UC Davis and Master of Science in Microbiology from University of Delhi, India.

DAIRY DIGESTER RESEARCH AND DEVELOPMENT PROGRAM (DDRD)

Geetika Joshi, Ph.D.

Office of Environmental Farming and
Innovation

Geetika.Joshi@cdfa.ca.gov

October 24, 2019

Environmental and Economic Importance of Anaerobic Digestion and
Renewable Natural Gas

A California Climate Smart Agriculture Webinar in Collaboration with
Denmark



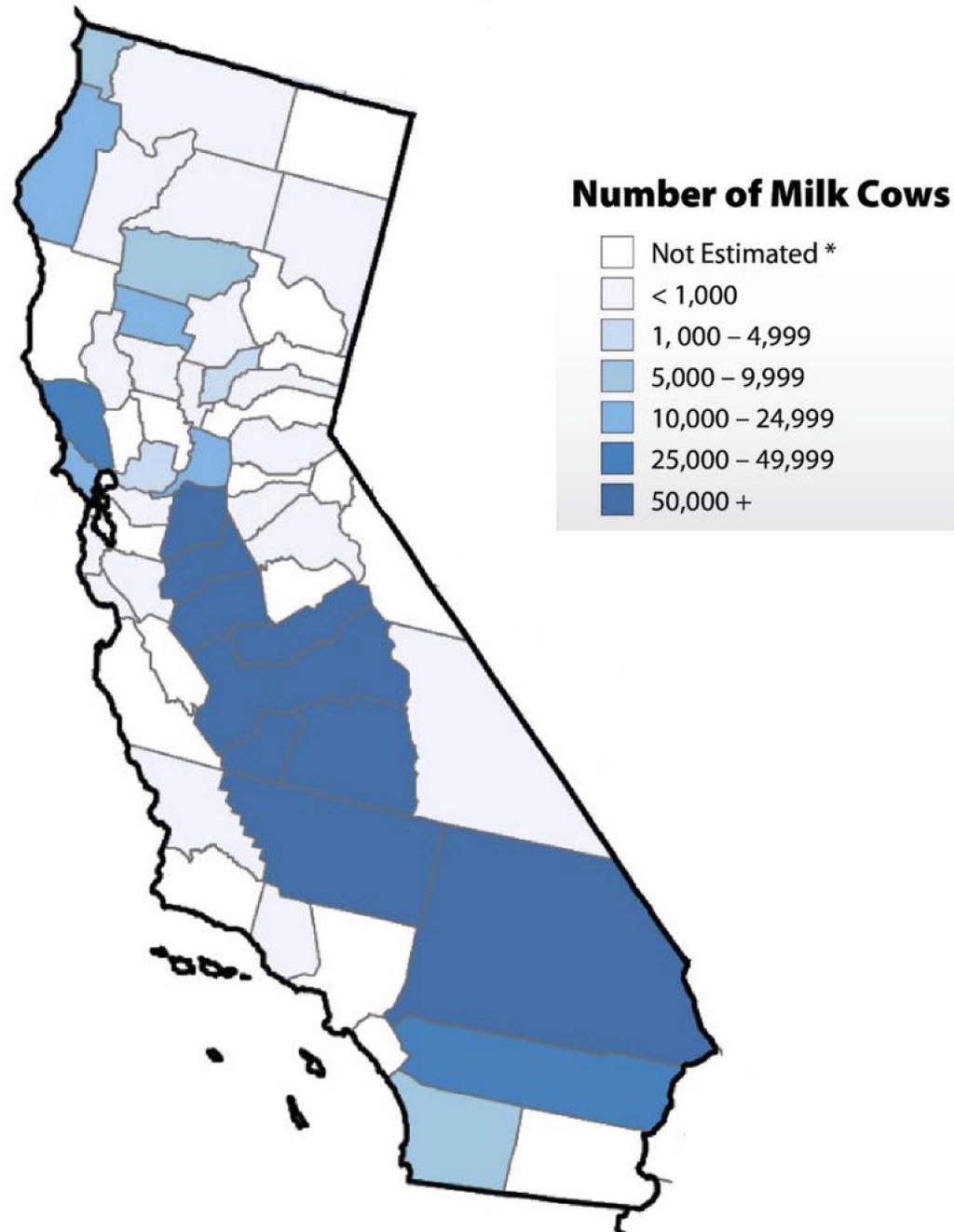
CALIFORNIA'S DAIRY REGIONS

VARY BY OVERALL POPULATION, DAIRYING STYLE, CLIMATE, AND ENVIRONMENTAL CONDITIONS.

Approximately 91 percent of state's dairy cows and more than 80 percent of dairies are in the Central Valley.

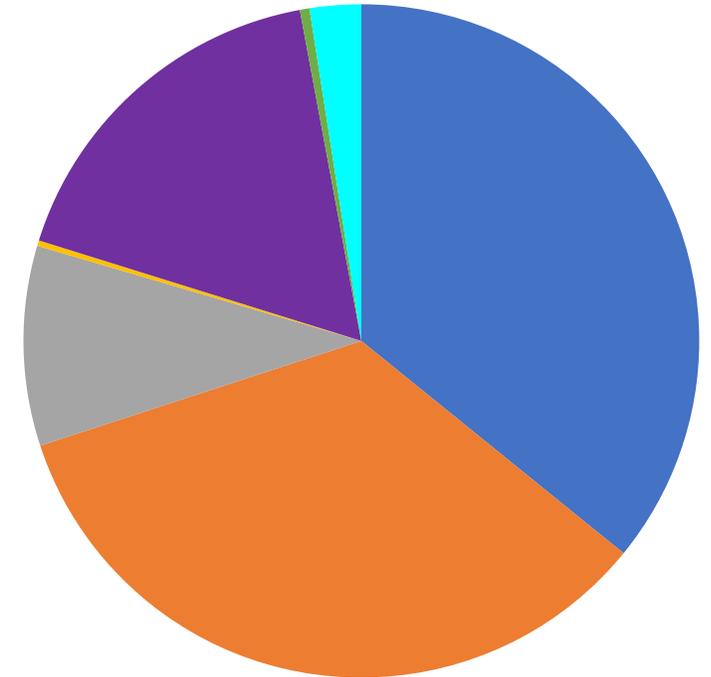
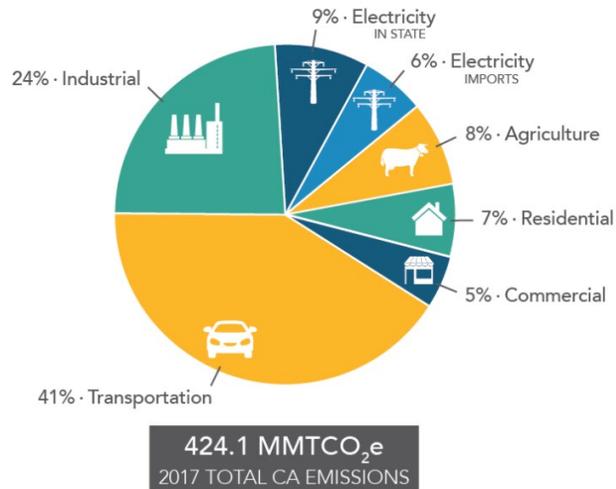
3 percent of state's dairy cows are in North Coast region, such as Humboldt, Marin and Del Norte counties, primarily on pasture.

5.6 percent of dairy cows are in Southern California, including Riverside, Imperial, and San Diego counties, primarily on drylots



GHG EMISSIONS FROM AGRICULTURE IN CALIFORNIA

Agriculture contributes to approx. 8% of the State's total GHG emissions.



All values in million metric tonnes (MMT) of CO₂e

GHG Emissions from Agriculture - 2017
Total: 32.4 million metric tonnes of CO₂e (MMTCO₂e)

Approaches for Methane Reduction

- Legislation:

LEGISLATION • SB 1383 (Lara, 2016): Dairy and livestock methane emissions 40% below 2013 levels by 2030.

• SB 1383 (Lara, 2016): Dairy and livestock methane emissions 40% below 2013 levels by 2030. • Incentive programs administered by CDFA

- Voluntary Reduction:

emissions 40% below 2013 levels by 2030. • Incentive programs administered by CDFA:

- Dairy Digesters.

- Non-digester manure management practices.

• Regulation of methane emissions on or after 2024. • Enteric fermentation

- Enteric fermentation

emissions on or after 2024.

- Research to determine cost-effective and feasible approaches.

cost-effective and feasible approaches. .



DAIRY DIGESTER RESEARCH AND DEVELOPMENT PROGRAM

Grant Size

- A maximum of 50% of total project cost, up to \$3 million
- 2 year project term

Eligibility

- Existing milk producers, dairy digester developers.
- Cluster projects.
- Eligible biomethane uses: on-site use or into electrical grid/pipeline (i.e. RCNG), transportation fuel, utilization of thermal energy on site or at neighboring facility.

Environmental Quality Requirements

- *Water Quality Protection:*

Double-lined ponds consistent with Tier-1 specification of the Dairy General Order (Central Valley Regional Water Quality Control Board), or above ground tank, or below-ground concrete lined tank.

- *Air Quality Protection:*

Total NOx emissions no greater than 0.50 lb/MWh

Demonstration Projects

- New technologies and practices not currently incentivized by DDRDP.
- Grants up to \$2 million.

DAIRY DIGESTER RESEARCH AND DEVELOPMENT PROGRAM

2014-19 - \$183 million awarded to projects

- Financial incentives to implement dairy digesters to reduce methane emissions from livestock agriculture (manure management)
- Contributes to GHG mitigation, renewable energy generation, climate change adaptation and agricultural sustainability

108

Digesters on
California Dairy
Operations

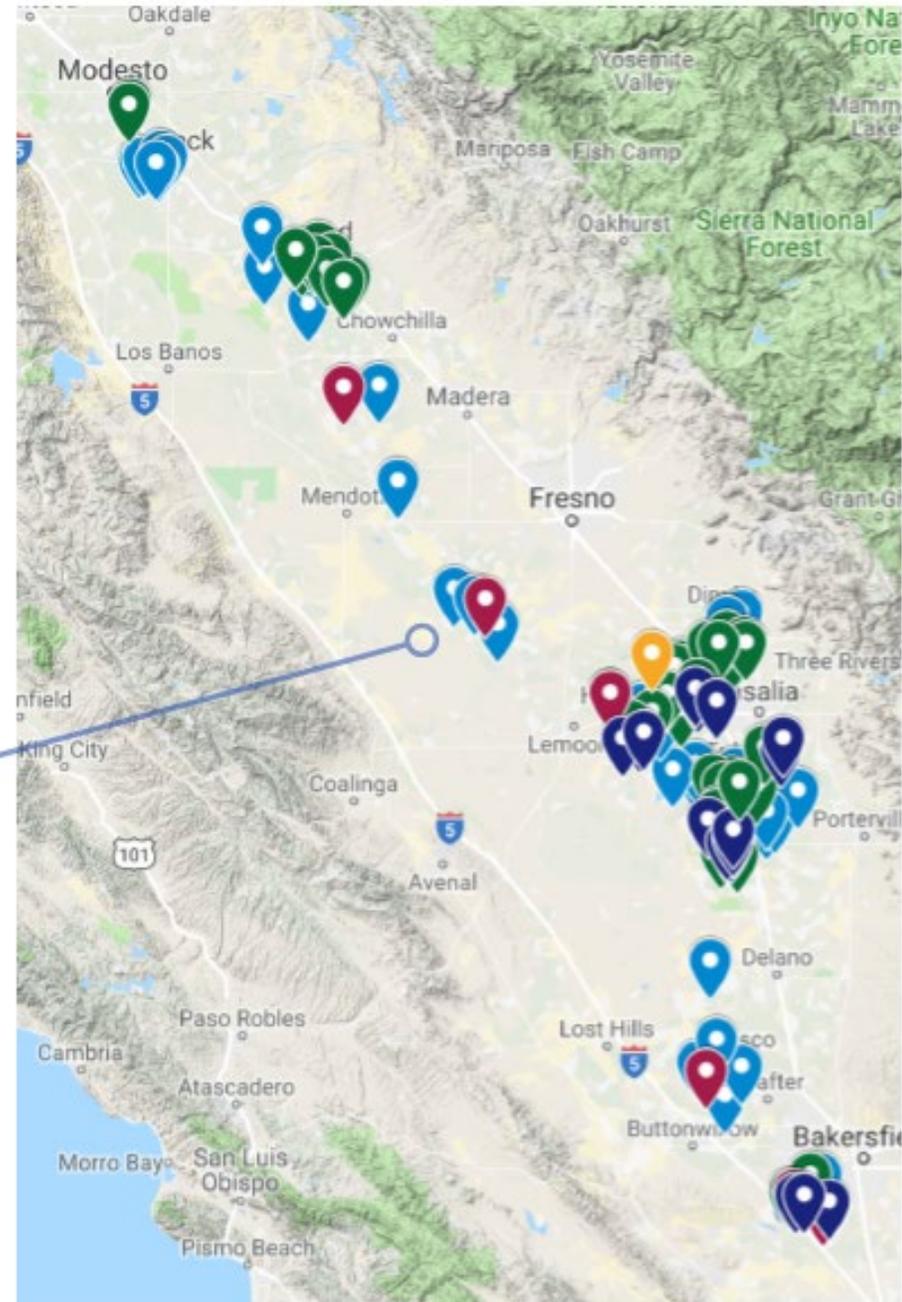
**\$369
million**
In matching
funds

CO₂
**1.9
million**
Tons CO₂
reduced/year



DDRDP FUNDED PROJECTS

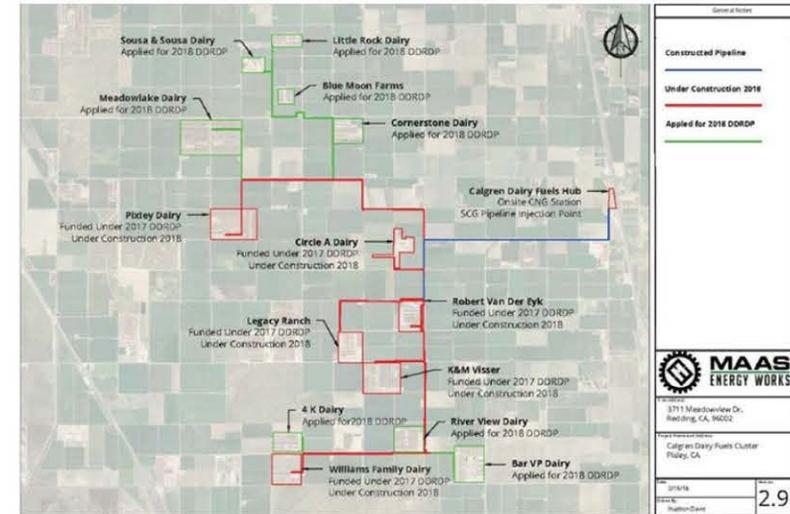
Total estimated GHG reductions
19.9 million metric tons CO₂
equivalent (over 10 years)





CALGREN DAIRY: MAAS ENERGY WORKS- TULARE CO.

Private pipeline to Pixley Ethanol plant where fuel will be cleaned up and used to lower carbon intensity of ethanol production.



ALTERNATIVE MANURE MANAGEMENT PROGRAM

2016-19 - \$63.1 million

- Financial incentives to reduce manure management methane emissions on dairy and livestock operations
- Non-digester practices
- Contributes to GHG mitigation and agricultural sustainability

108

Projects on
California Dairy
Operations



211,759

Tons CO₂
reduced/year

Top Practices include:

- Conversion from flush to scrape
- Solids separation
- Compost bedded pack barns

Demonstration Projects

- New technologies and practices not currently incentivized by AMMP.
 - Grants up to \$1 million
- Advancing farmer-to-farmer education and outreach.
 - Grants up to \$250,000



2019-20: FUNDING OPPORTUNITIES

- CDFA was appropriated \$34 million from the Greenhouse Gas Reduction Fund for DDRDP and AMMP.
- Public comment period:
 - September-October, 2019
 - Upcoming – November, 2019
- Anticipated application period: Late January/Early February, 2020 through March 2020.

THANK YOU!

CDFA-DEF Dairy and Livestock Methane Team

Casey Walsh Cady, M.Sc., Sr. Environmental Scientist

Roberta Franco, Ph.D., Sr. Environmental Scientist

Nolan Watmore, M.Sc., Environmental Scientist

Ravneet Behla, Ph.D., Sr. Environmental Scientist

Geetika Joshi, Ph.D., Sr. Environmental Scientist (Supervisory)

Armith Gunasekara, Ph.D., Manager, Office of Environmental Farming and Innovation and Science Advisor to CDFA Secretary Karen Ross

CDFA.CA.GOV/OEFI



California policy efforts to reduce dairy methane emissions



Mary Jane Coombs

Chief of the Projects Assessment Branch,
California Air Resources Board

Mary Jane Coombs oversees implementation of the California Air Resources Board's methane emissions reduction programs for California dairies and landfills as well as electricity-related greenhouse gas emissions reduction programs. She previously oversaw allowance allocation, emissions leakage prevention and electricity policy for California's Cap-and-Trade Program. She holds a Bachelor of Arts in Geology & Environmental Studies and a Master of Science in Marine Science (research in paleoclimatology).



California Policy Efforts to Reduce Dairy Methane Emissions

Danish Delegation

Mary Jane Coombs, California Air Resources Board

October 24, 2019

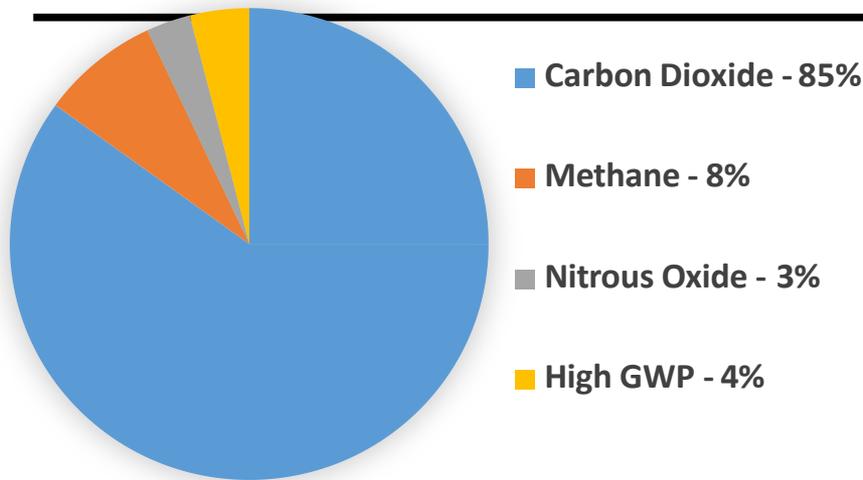
Short-Lived Climate Pollutants (SLCPs)

- High global warming potential
- Methane, fluorocarbons (including HFCs), and black carbon
- SLCPs account for over 1/3 of targeted GHG emissions reductions from 2021 to 2030
- Senate Bill 1383 (Lara, 2016) directed approval and implementation of an SLCP reduction strategy to:
 - Develop State policies to encourage renewable gas
 - Achieve emissions reductions targets for methane, HFCs, and anthropogenic black carbon by 2030
 - Encourage voluntary methane reduction projects from dairy/livestock operations
 - Divert organics from landfills and recover edible food

https://www.arb.ca.gov/cc/shortlived/meetings/03142017/final_slcp_report.pdf

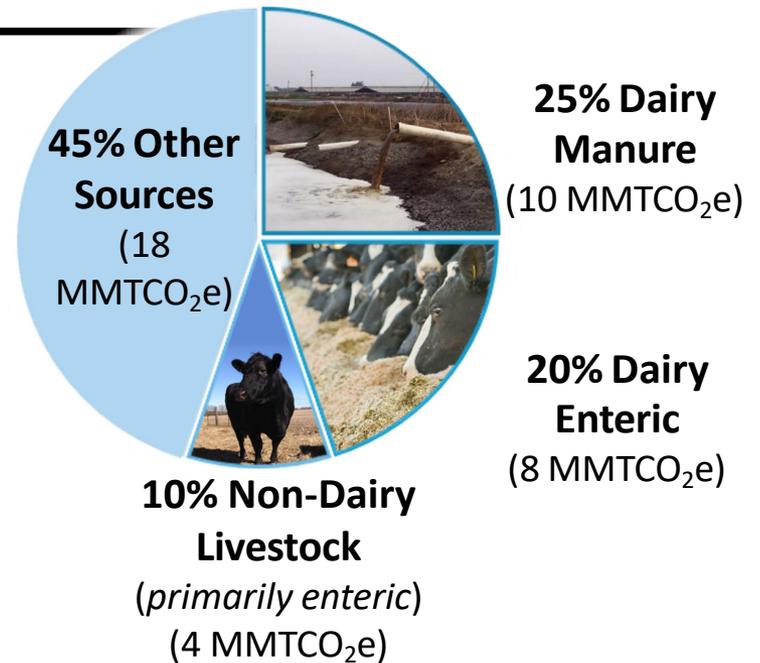
California 2013 Greenhouse Gas (GHG) and Methane Emissions

Emissions by Greenhouse Gas



2013 Total GHG Emissions*: ~448 million metric tons carbon dioxide equivalent (MMT CO_2e)

*100-yr global warming potential



State Programs Incentivizing Dairy Methane Emissions Reductions

California Air Resources Board Programs

- Cap-and-Trade Program (in particular the Livestock Projects Compliance Offset Protocol)
- Low Carbon Fuel Standard Program

California Department of Food and Agriculture Programs

- Dairy Digester Research and Development Program
- Alternative Manure Management Program

California Public Utilities Commission Programs

- Senate Bill 1122 Bioenergy Market Adjusting Tariff (biogas to electricity)
- Dairy biomethane pilot project (connecting dairy biogas to pipeline system)
- Assembly Bill 2313 pipeline infrastructure funds
- Senate Bill 1440 renewable gas procurement standard

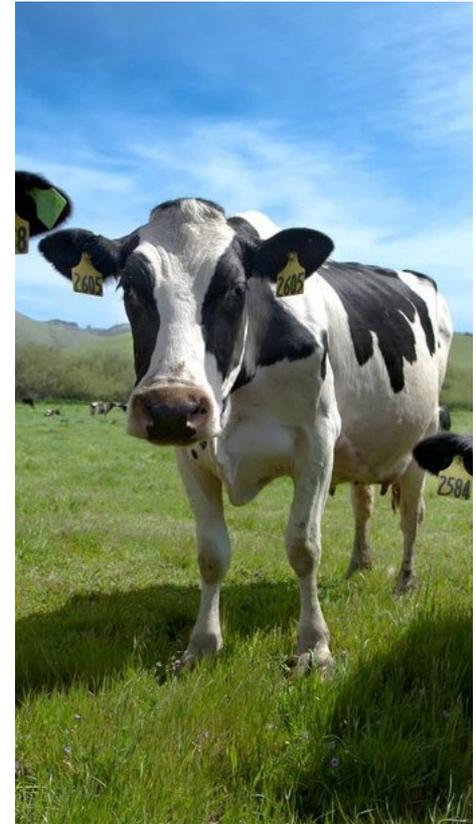
Dairy and Livestock GHG Working Group (2017-18)

- SB 1383 requires State to consult with stakeholders to identify and resolve barriers to achieving dairy and livestock methane emissions reductions
- Notable barriers:
 - Interconnecting to utility pipelines and electricity grids
 - Securing project funding
 - Implementing projects with limited available funds due to economic hardship in the dairy industry
- Notable recommendations to the Working Group:
 - Continue project incentives
 - Foster market development and improve market certainty
 - Evaluate mitigation strategies for enteric fermentation
 - Develop measurement and monitoring program & improve GHG emissions inventory
 - Identify and address environmental impacts to nearby communities

CARB Next Steps on Dairy GHG Emissions

- 2020 analysis required by SB 1383
 - Evaluate progress toward meeting 2030 target
 - Assess technical and market barriers to emissions reductions
 - Analyze sector trends and emissions leakage potential
 - Identify areas for improvement through continued dialogue
- Implement Dairy and Livestock Working Group recommendations where appropriate
- Continue research on dairy and livestock emissions reductions

FARM-BASED
BIOGAS PLANT
EXAMPLES
FROM
CALIFORNIA
AND
DENMARK



Danish dairy biogas plant developer and operator



Trine Dalsgaard

Business Development Director, Nature Energy

Trine Dalsgaard has been working in renewable energy for the past 10 years. At Nature Energy, she is responsible for building and executing the global development strategy, with a focus to drive the agenda of circular economy forward by identifying new markets, locations and partners. Trine has experience in the aviation, wind and telecom industries, and works as mentor for foreign students at the Technical University of Denmark. She holds Master's Degrees in Export Engineering and Engineering Business Administration.



nature
energy

From grey to green - Nature Energy

24 October 2019

From Naturgas Fyn to Nature Energy

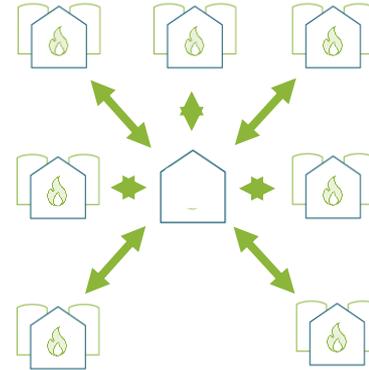
Since 2012 Nature Energy has been pursuing our vision to transform a fossil based gas distributor and retailer, to a leading biogas company.





Nature Energy in numbers

- 250 employees (DK & F)
- operating 10 plants
- National Competence Centers



- 1 plant under construction
- 2 plants pending appeal

Fully integrated renewable natural gas (RNG) company

Biomass sourcing

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graph TD; A[Biomass sourcing] --> B[Plant Development, Design & Construction]; B --> C[Biogas production]; C --> D[Gas certification and sales];
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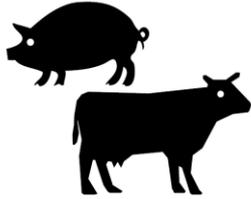
Plant Development, Design & Construction

Biogas production

Gas certification and sales

Contributing to a more circular future

Environmentally harmful methane and dinitrogen oxide evaporation is removed from the farmland



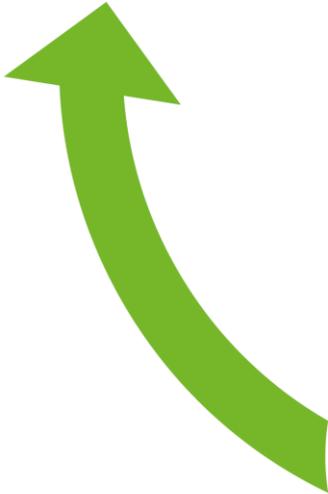
The Biogas plant is converting the carbons from waste to methane for green energy purposes



The biogas is displacing fossil fuels in the industry, CHP's, house heating and transport



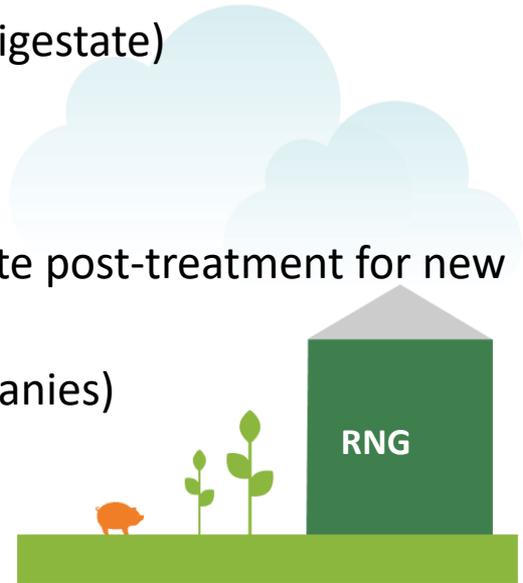
Nutrients are sent back to the soil. Less smell and more efficient



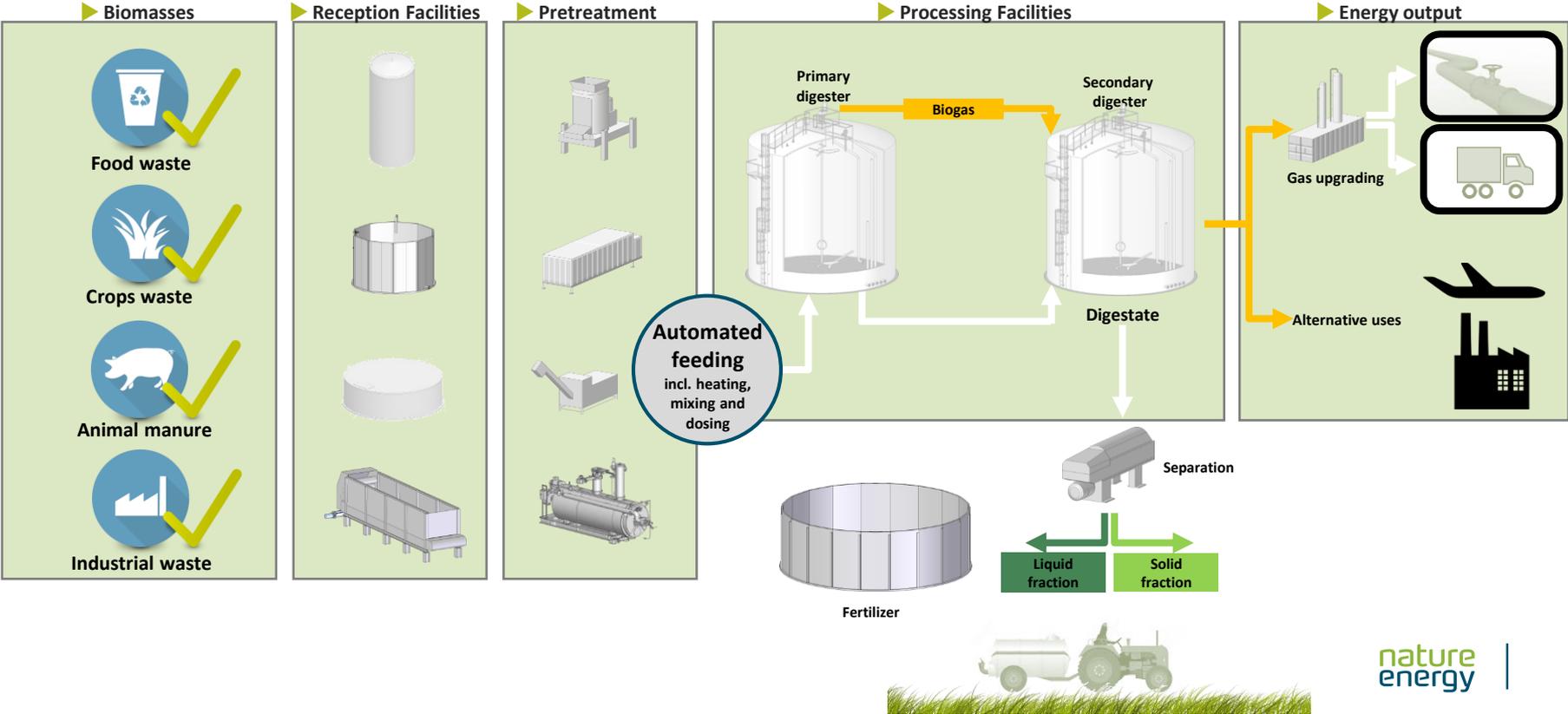
Dedicated to Circular Economy

Creating synergies, maturing the industry, and reducing cost

- Economy of scale with large plants
- Co-digestion to increase gas yield (and manage N P K in digestate)
- Standardisation/modularisation to reduce CAPEX
- OPEX reduction by automation and use of big data
- Biomass optimization – pre-treatment, recipe and digestate post-treatment for new business streams
- Partnerships (farmers, industrial players and energy companies)



Plant concept



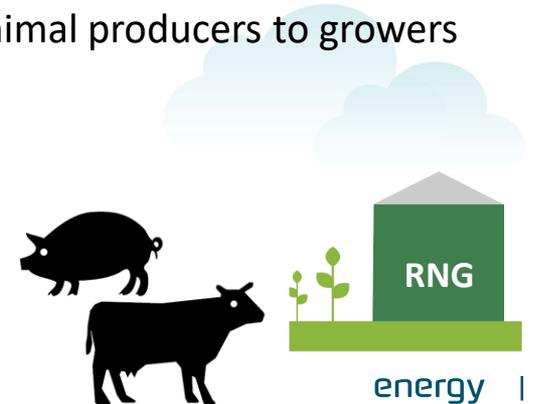
Nature Energy – international market leader



AD advantages

Benefits for farmers

- Improved fertilizer with improved nutrient uptake
- Improved nutrient balance and distribution between different farm-types (NPK)
- Thermophilic AD process operates at 50 -52 °C which kills many pathogens
- Reduced odor (during storage and spreading)
- Fertilizer transport and logistics is outsourced to the biogas plant
- Facilitates spreading and distribution of organic fertilizer from animal producers to growers
- Social acceptance/AG image:
 - CO2 emissions
 - Reduced leaching of nutrients



Nature Energy – Slurry from agriculture can be used in the production of biogas



Link: <https://www.youtube.com/watch?v=BfQf6Eilq4s>

PENGE

Gylleboblere i øl og sodavand

CO₂ fra verdens største biogasanlæg skal genbruges i fødevarerindustrien, hvor den udskældte drivhusgas er en mangelvare. Men bare rolig: du slipper for lugten.



Danish CO₂ from agriculture becomes bubbles in your soda

Nature Energy and Strandmøllen A/S have entered into a partnership under which excess CO₂ from one of the world's largest biogas plants in Esbjerg will be recycled as, for example, bubbles in your soda. Under the partnership, Strandmøllen will have easy access to necessary CO₂, which is otherwise in short supply throughout Europe, and, in addition, CO₂ emissions from the biogas plant will be reduced by 70% compared with an ordinary biogas plant.

Extra slides

Investing in Future Technology and Knowledge

- Similar to wind – scale and technology improvements are expected to substantially reduce the production cost
- The capacity of new plants can grow significantly as CAPEX is not proportionally higher
- Lower operating costs as plant size increases
- Scale advantages in logistics –Technology is still at an early stage. Nature Energy is investing in efficiency improvements by:
 - ✓ Optimising feedstock input
 - ✓ Better route planning and higher input flexibility
 - ✓ Optimising production through control of operating parameters
 - ✓ Turning digestate into high-value products (fertilisers)



The growth of Nature Energy



Holsted

Production: 12,5 (20,7) million m³ pr. year
Biomass capacity: 400.000 (600.000) tonnes
Biomasses: Agricultural and industrial
Gas to grid





Korskro

Production: 22 million m³ Biomethane pr. year

Biomass capacity: 700.000 tonnes

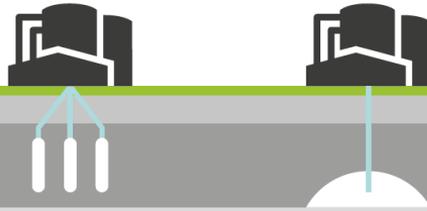
Biomasses: Agricultural and industrial

Gas to grid

Månsson



Denmark has two gas storages that are 85.000 times larger than the Tesla battery in South Australia



1/3 Of Denmark's yearly electricity consumption

California dairy operators and developers



Joey Airoso
Dairy Producer

Joey Airoso is a fourth generation dairyman whose family started their first dairy in 1912. He grew up working on his father's dairy, learned the business, and then started his own Circle A Dairy in 2006. The Airoso family is one of the earliest dairy settlers in the Pixley area. Joey is a leader in the Tulare County agricultural community and involved in multiple non-profits. He advises the Pixley Water Irrigation Commission, serves on the board of Farm Credit West and founded the Central Valley Water Coalition.

California dairy operators and developers



Daryl Maas

Owner/Operator, Maas Energy

Daryl grew up as one of the non-farming kids in a school full of farmers. After attending the Air Force Academy and various overseas deployments, he came back home and found a new kind of career in renewable agriculture. Now with eleven years of constant expansion and 24-7 operations, Daryl possesses more direct experience as a digester developer and owner/operator than anyone in the US biogas industry. He has served as the start-to-finish developer of 21 successful digester projects, and continues to oversee continuous operations at 19 facilities while retaining ownership in seven.



DAIRY DIGESTER DEVELOPER CASE STUDY

Daryl Maas, CEO of Maas Energy Works

October 24, 2019

Overview

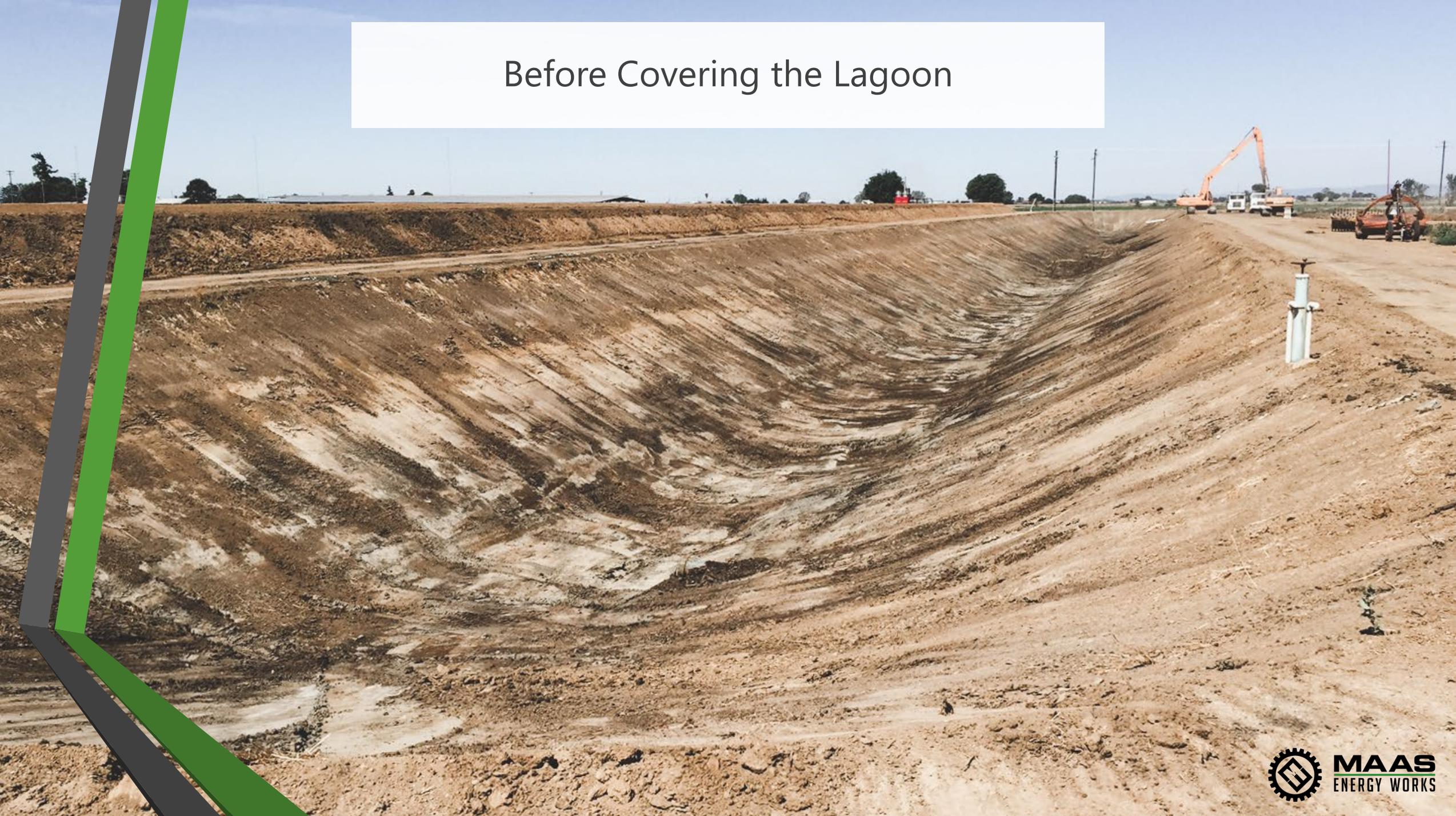
- Digester Technology
- Business Models
- Major Obstacles



Freestalls

Covered Lagoon Manure Digester

Before Covering the Lagoon



During Covering the Lagoon

After Covering the Lagoon



Our Resource

1

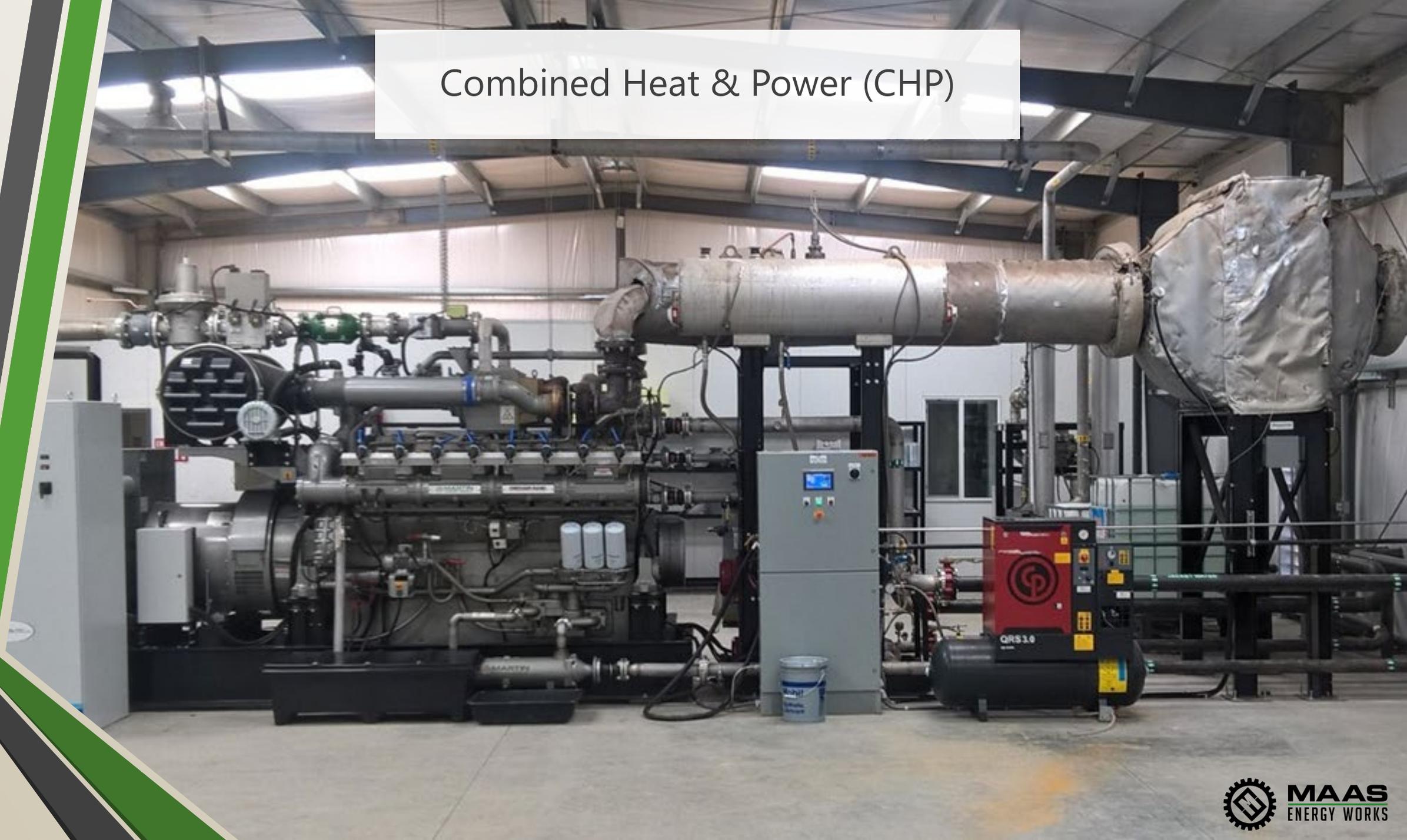


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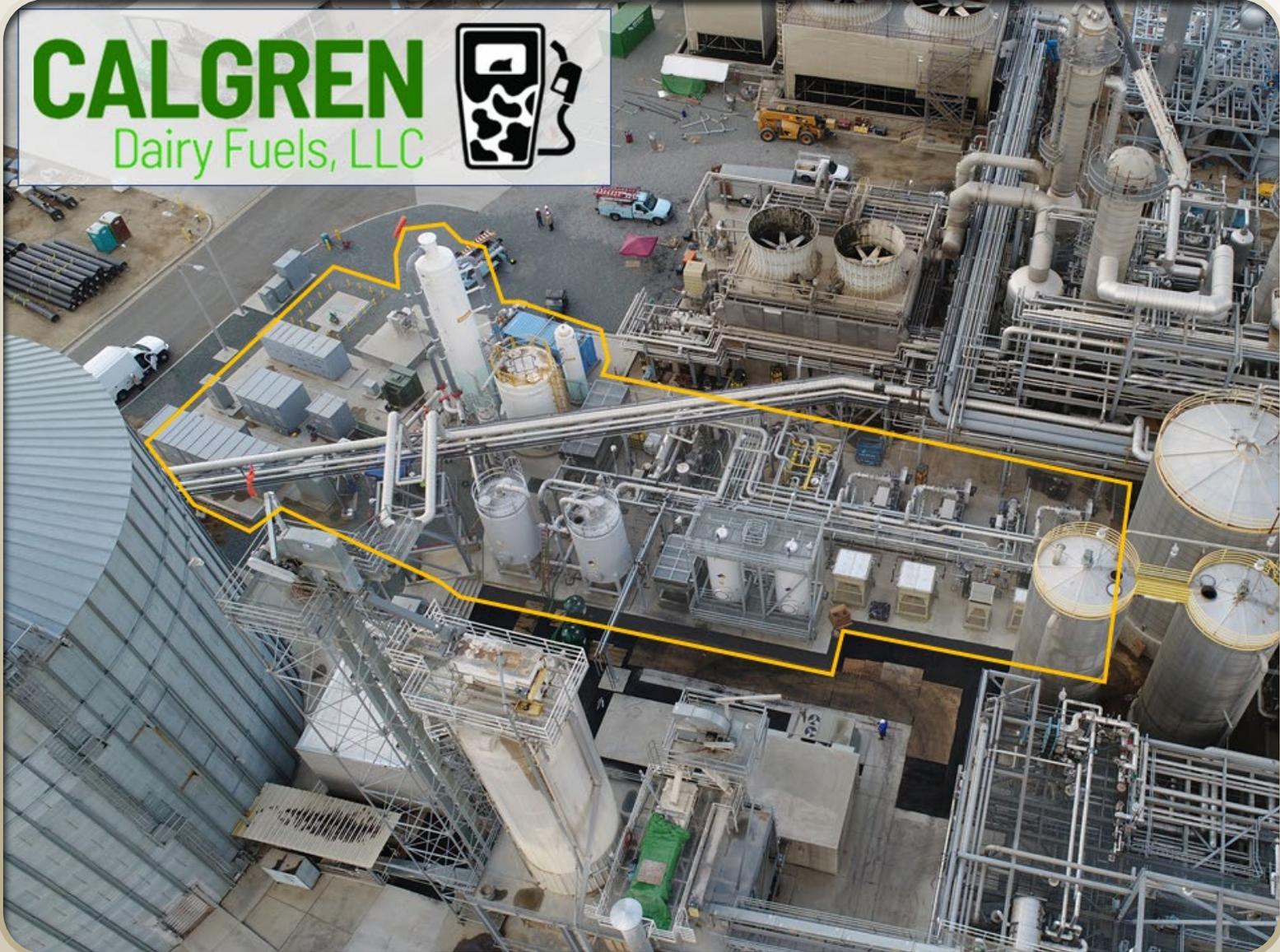


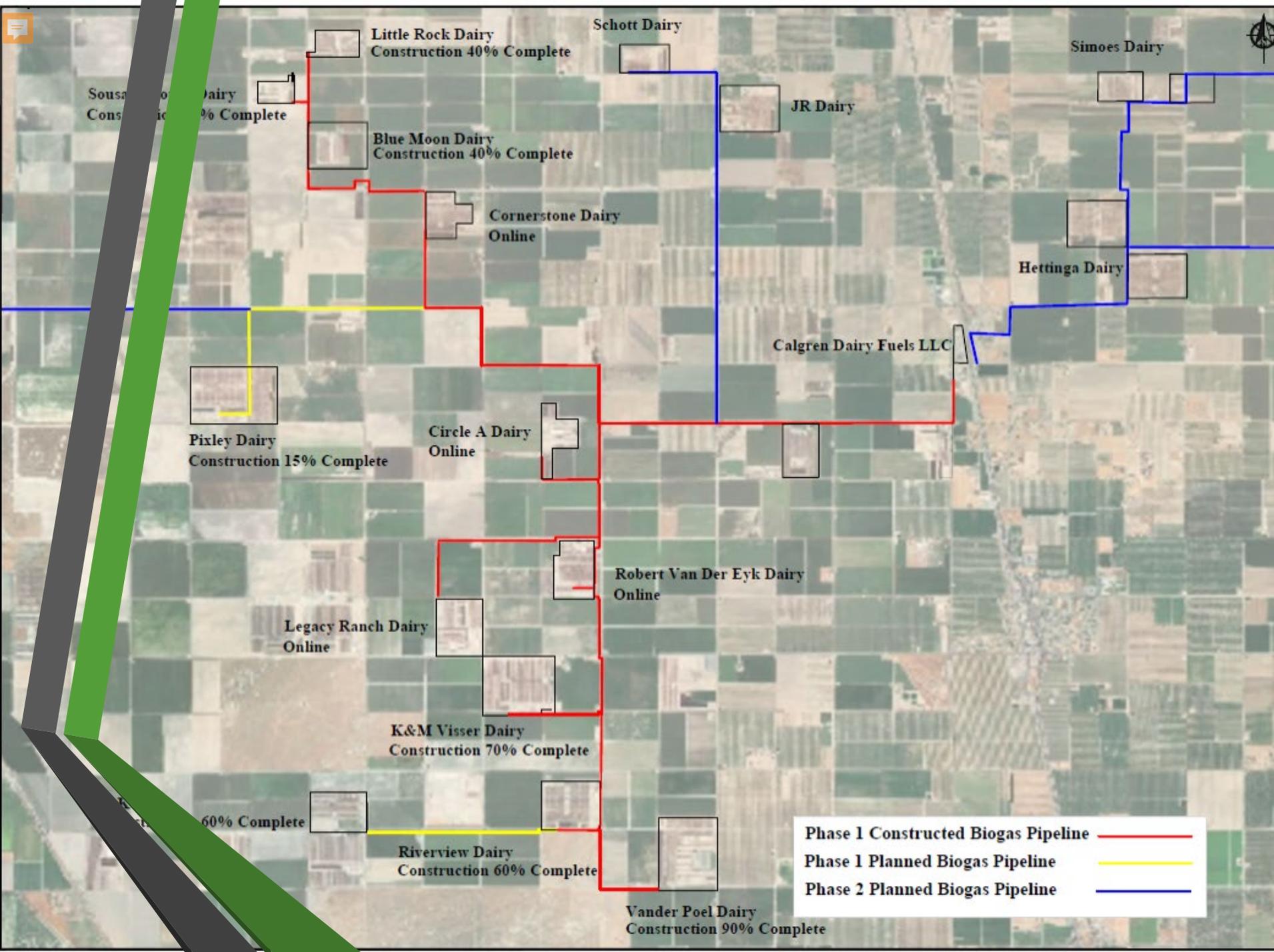
And - 1 () CO2-e

Combined Heat & Power (CHP)



Pipeline





Calgren Dairy Fuels Cluster

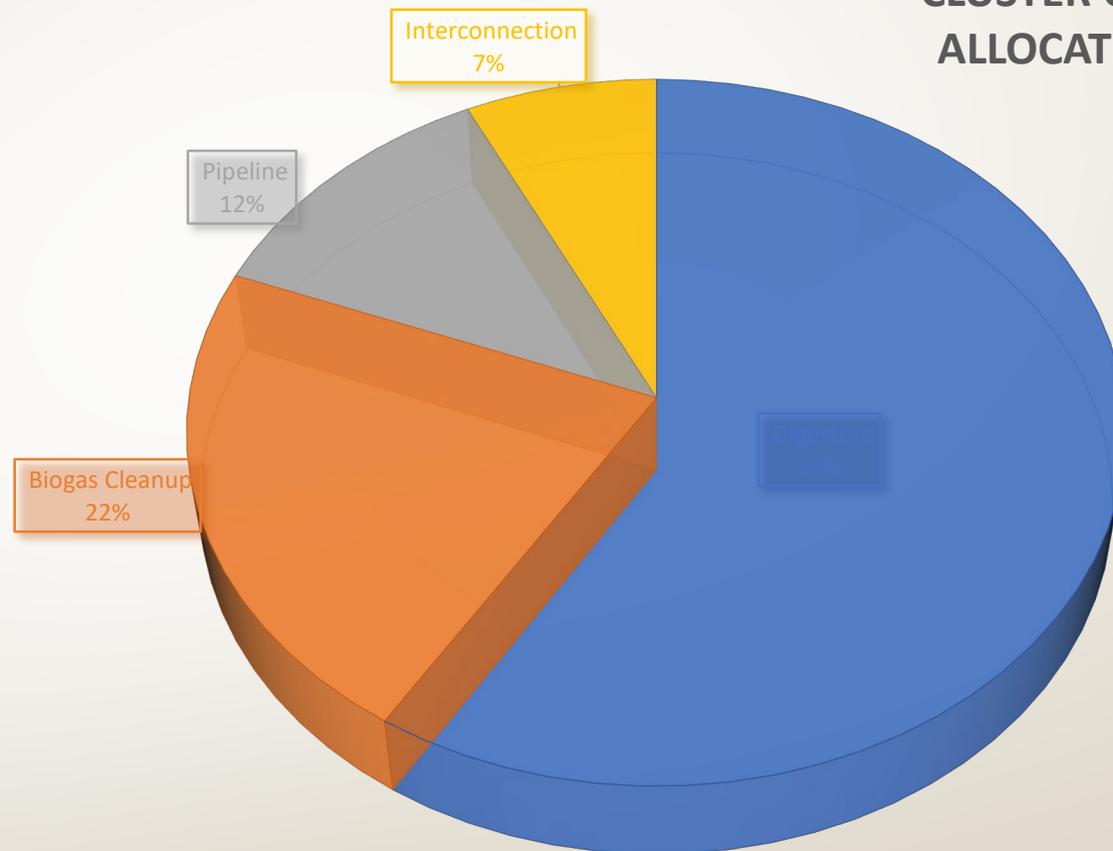
- Maas Energy Works – Lead Developer
- 9 Digesters online injecting RNG to SoCalGas Pipeline
- Expanding to 20+ total dairies
- ~4M GGE/year CNG

Virtual Pipeline Online!



CLUSTER COST ALLOCATION

Digesters	\$	30,075,000
Biogas Cleanup	\$	11,200,000
Pipeline	\$	6,050,000
Interconnection	\$	3,700,000
Total	\$	51,025,000



Major Obstacles

- Very small expertise base
- Utility interconnect timelines
- Environmental permitting



California dairy operators and developers



Neil Black

President, Co-Founder, California Bioenergy (“CalBio”)

Neil Black has over twenty-five years of senior management experience. Prior to joining CalBio, Neil was managing principal at GreenOrder, a strategic consulting firm which worked with GE, GM and other large corporations, helping them profit from environmental leadership. He was also the CEO of two technology start-ups and president of The Nation magazine. Neil has an undergraduate degree from Yale University and an MBA from Harvard Business School.



CDFA Office of Environmental Farming and
Innovation

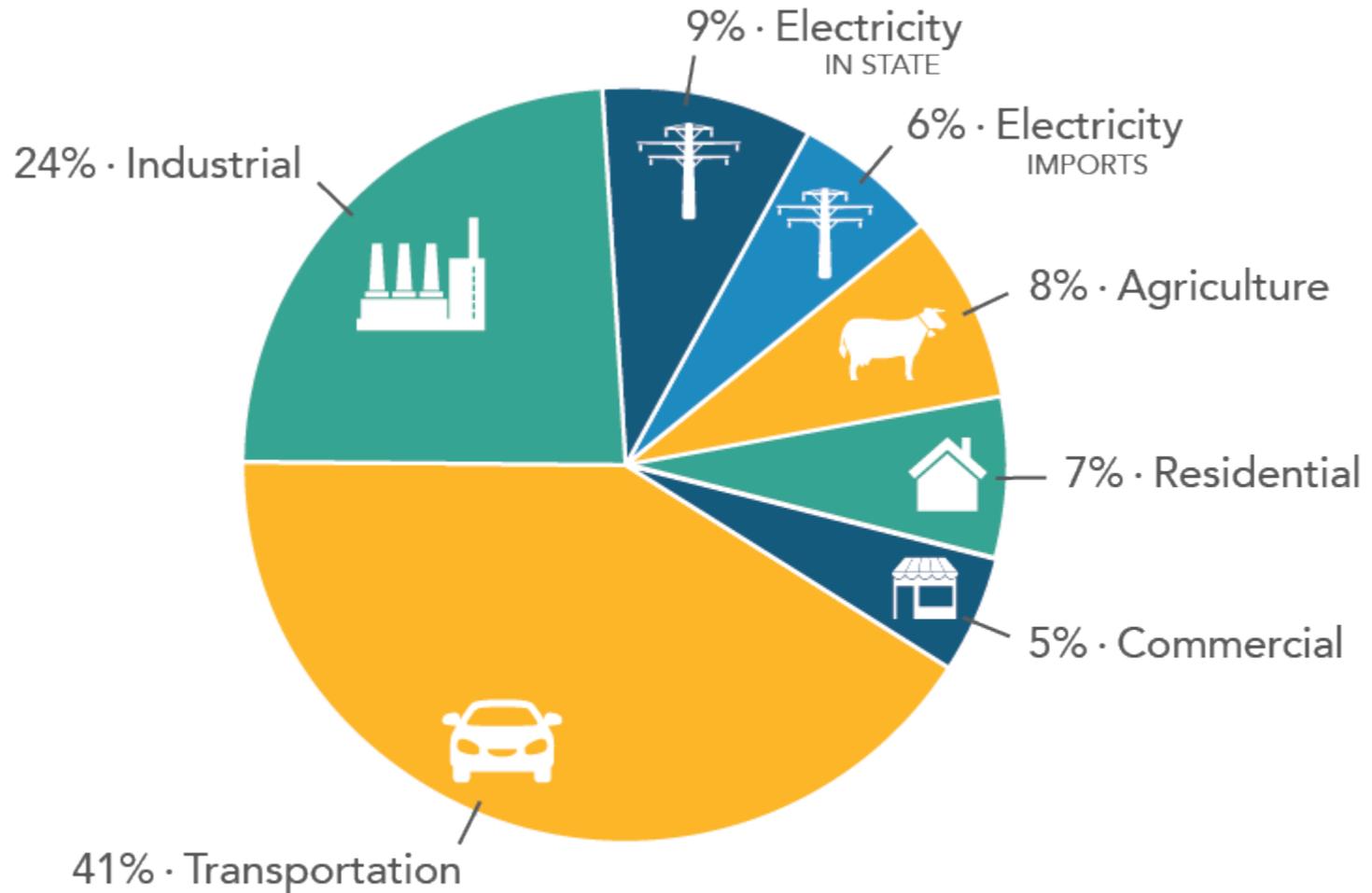
California and Denmark Webinar on Anaerobic Digestion

October 24, 2019





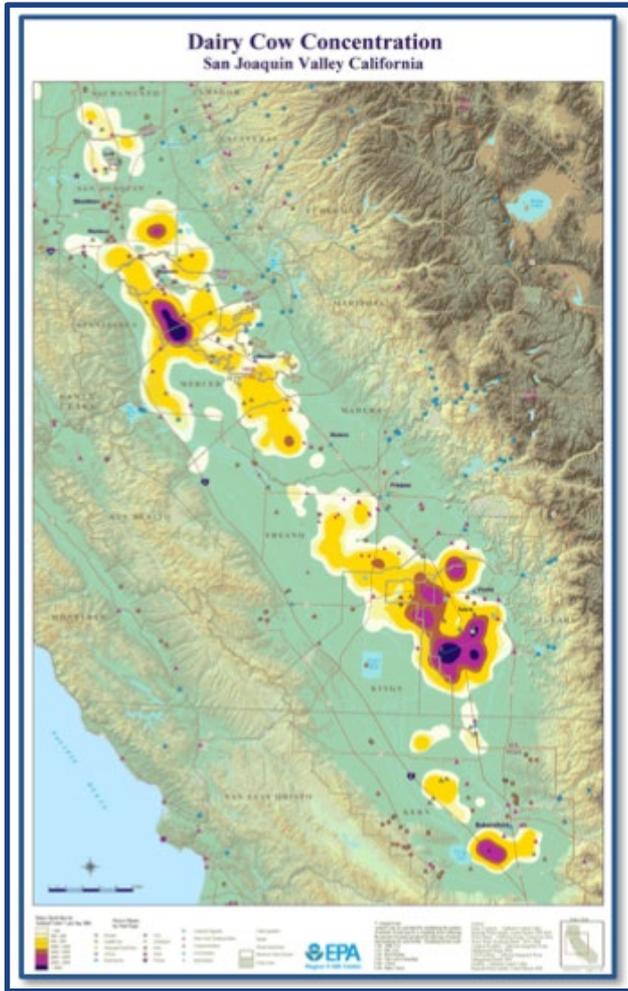
California's GHG Emissions



424.1 MMTCO₂e
2017 TOTAL CA EMISSIONS



California Dairy Industry – Key Statistics



- Dairy is California's #1 ag product
 - \$7+ billion per year in farm sales. \$98B of economic value.
 - 20% of the nation's milk
 - 1.74 million milk cows
 - 1,300 dairies, family owned
- San Joaquin Valley – center of California's dairying
 - Over 90% of California milk production
- Dairy productivity
 - 63 lbs of milk/cow/day; 23,000 lbs/yr
 - 120 pounds of manure/cow/day
 - 100 DGS/cow; drive a car across USA



Dairies: A Key to California's GHG Law



- California is a world leader in climate policy and program development
- CA to reduce GHG* by 40% by 2030
 - All GHG by 40% versus 1990 baseline
 - Dairy CH₄ by 40% versus 2013 baseline
- Methane is a significant GHG source
 - 9% of total: 100 year GWP*
 - 22.4% of total: 20 year GWP
- Dairies: a primary source of CA CH₄
 - 55% of CA methane emissions
 - 26% of CA total from manure lagoon

Source: CARB. *GHG: Greenhouse Gases.
GWP: Global Warming Potential



California Incentive Programs

Construction incentives

1. CDFA grants (GGRF funding). 2017: \$35M. 2018: \$70M. 2019: \$70M.
2. Pipeline incentives: AB 2313 (50%); SB 1383 (100%)

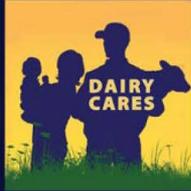
Revenue incentives

1. Electricity: California's BioMAT
2. Vehicle Fuel (R-CNG):
 - California's Low Carbon Fuel Standard (LCFS)
 - U.S. Renewable Fuel Standard RINs (D-3 status)



Dairy Digesters are Cost Effective*

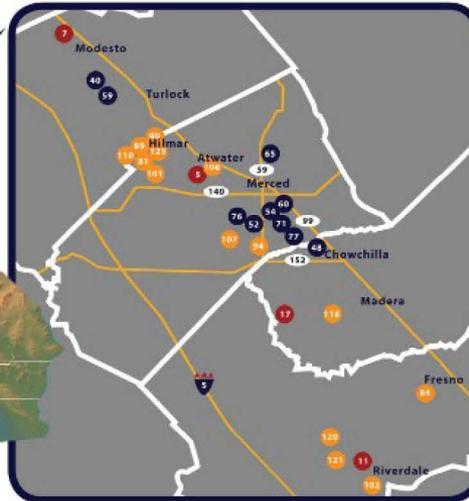
Program	Cost Per Ton ^a
Organics and recycling loans	\$4
Forest health	4
Dairy digester research and development program	8
Organics composting/digestion grants	9
Forest legacy	10
Recycling manufacturing	15
Delta and coastal wetlands restoration	30
State water and efficiency and enhancement program	33
Clean vehicle rebates	46
Sustainable agricultural lands conservation	59
Mountain meadow ecosystems restoration	113
Urban and community forestry	116
Water-energy grant program	141
Affordable housing and sustainable communities	191
Single-family solar photovoltaics ^b	209
Transit and intercity rail capital	259
Single-family energy efficiency and solar water heating ^b	282
Large multifamily energy efficiency and renewables ^b	343
Enhanced fleet modernization program "plus-up"	414
Truck and bus voucher incentives	452
Incentives for public fleets pilot project for DACs	725
Overall Average	\$57



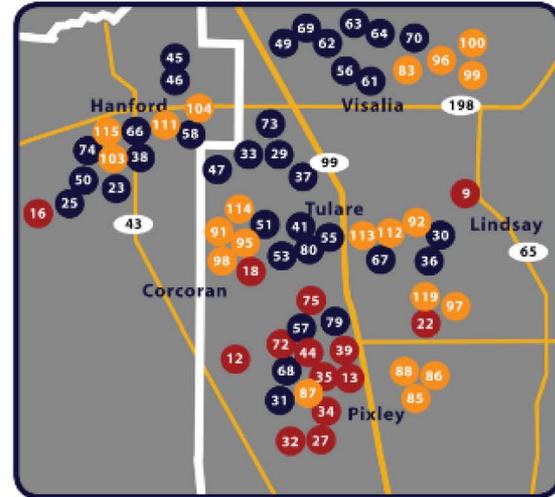
California Dairy Digester Development



Stanislaus County (3), Merced County (17),
Madera County (3), & Fresno County (5)



Kings County (14) & Tulare County (55)



Kern County (19)



- Operating 30
- In Development 50
- 2019 Grant Recipient 43



Cap and Trade
Dollars at Work

Learn more at DairyCares.com/dairy-digesters





About California Bioenergy LLC (“CalBio”)

- Founded 2006. Focus on dairy biogas in California.
- Construct, operate, finance projects and sell fuel-energy
- Operating 5 projects, developing 60+, 7 clusters
- Work with regulatory and state agencies
- Supported by grants & investors
- Partner with the dairy farmer
- Goals
 - (1) Protect global-local environment
 - (2) Create a new revenue for dairy
 - (3) Enhance dairy operations
 - (4) Support the community





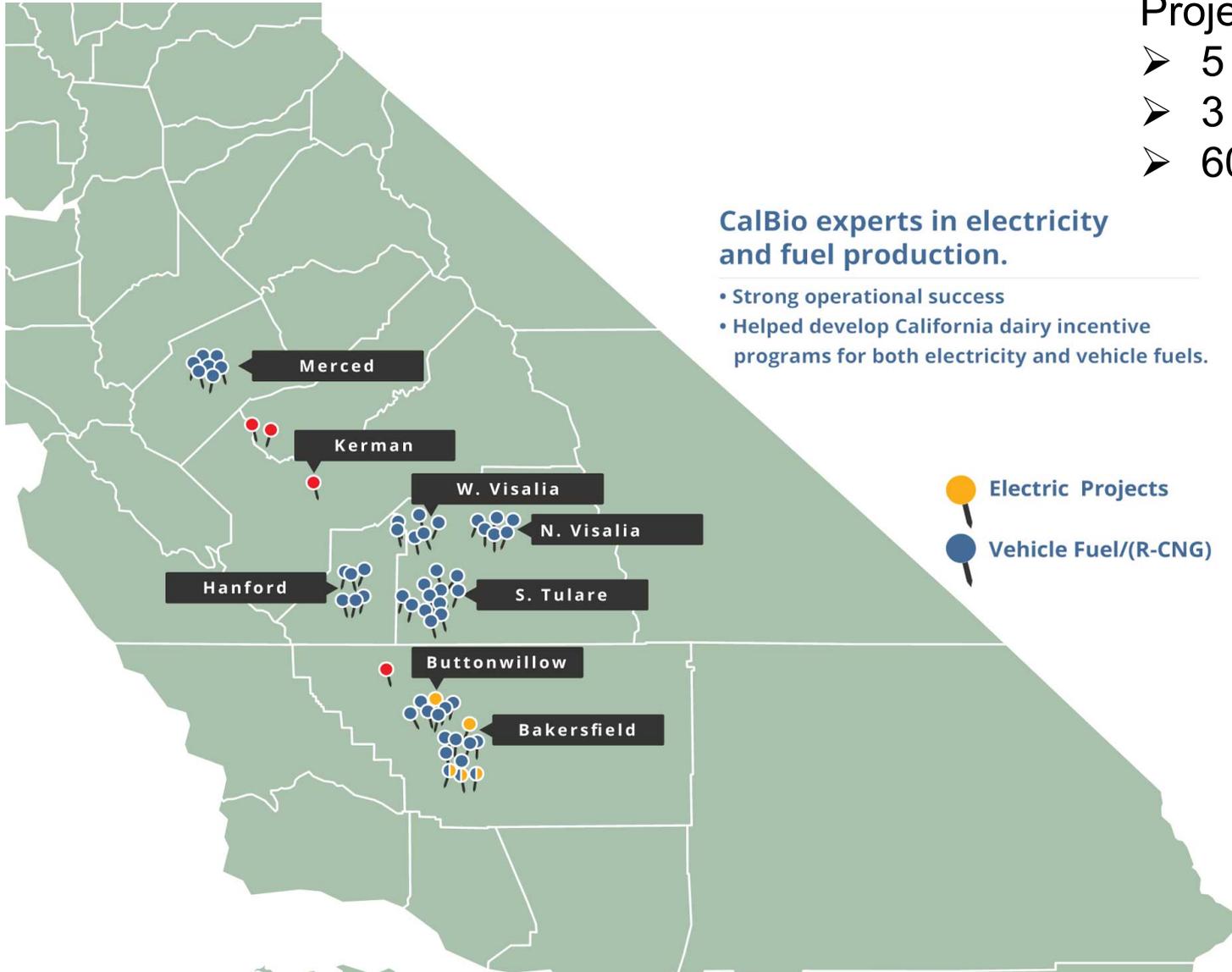
CalBio Projects – San Joaquin Valley

Projects:

- 5 CAT engines
- 3 fuel cells
- 60 CNG projects

CalBio experts in electricity and fuel production.

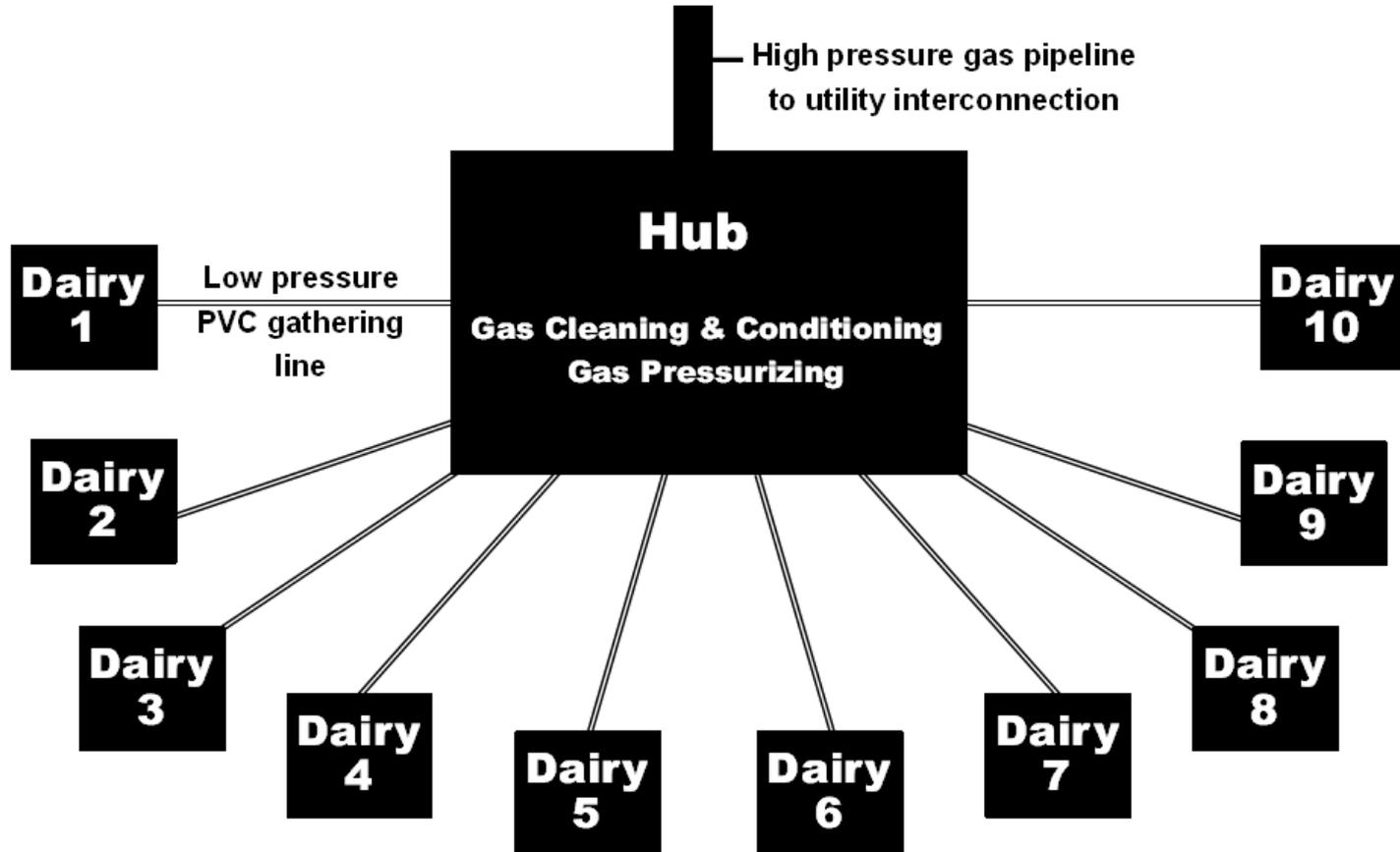
- Strong operational success
- Helped develop California dairy incentive programs for both electricity and vehicle fuels.





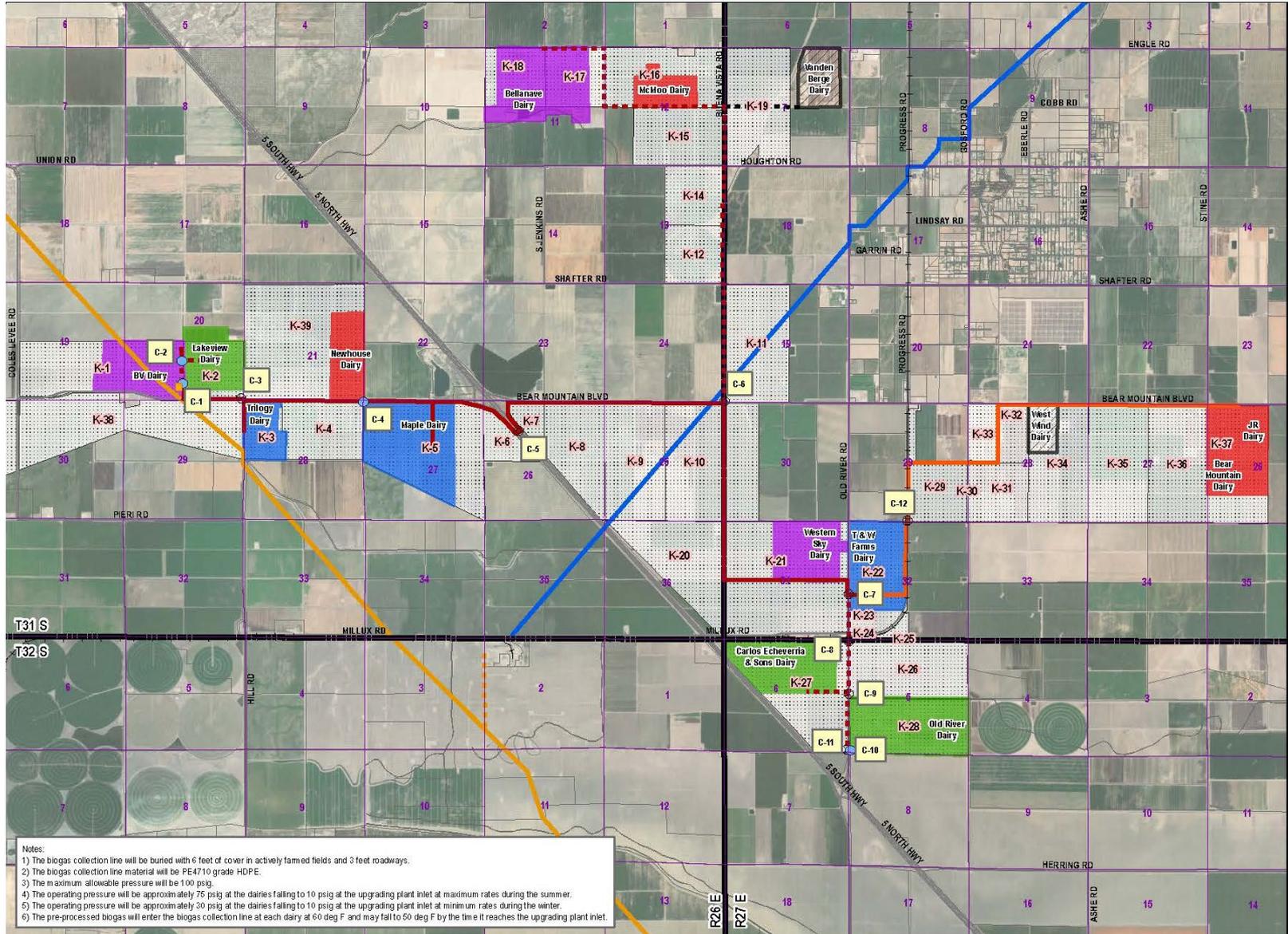
Hub (gas cleanup) & Spoke (dairy digester)

Hub & Spoke Model





Kern Cluster



- Notes:
- 1) The biogas collection line will be buried with 6 feet of cover in actively farmed fields and 3 feet roadways.
 - 2) The biogas collection line material will be PE4710 grade HDPE.
 - 3) The maximum allowable pressure will be 100 psig.
 - 4) The operating pressure will be approximately 75 psig at the dairies falling to 10 psig at the upgrading plant inlet at maximum rates during the summer.
 - 5) The operating pressure will be approximately 30 psig at the dairies falling to 10 psig at the upgrading plant inlet at minimum rates during the winter.
 - 6) The pre-processed biogas will enter the biogas collection line at each dairy at 60 deg F and may fall to 50 deg F by the time it reaches the upgrading plant inlet.



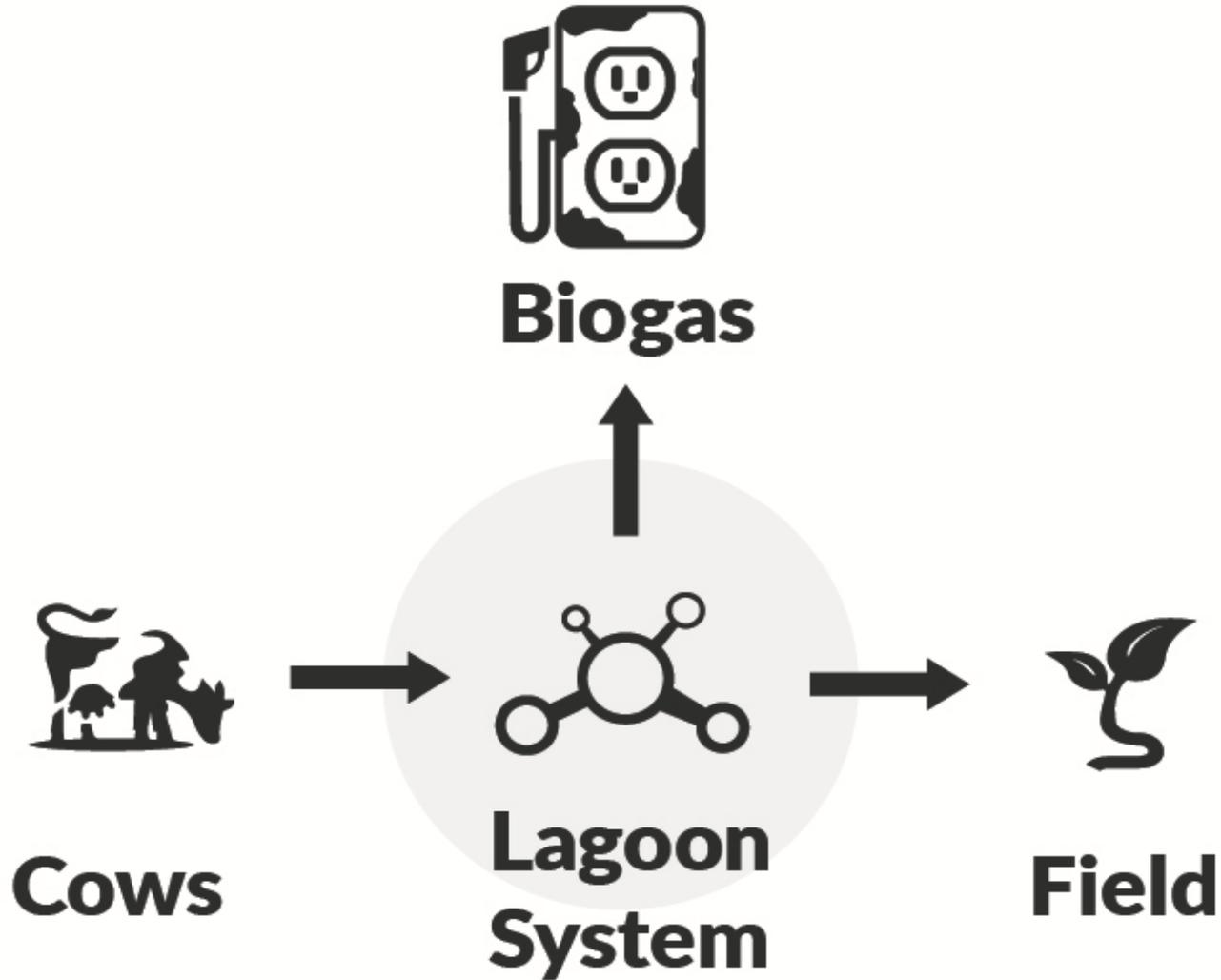
CalBioGas™ Stations & Partner Progress



*CalBioGas™
biogas, biomethane, R-CNG
and electric fuels*



How a digester works to produce biogas





How a Digester Project Works

Manure in water (an Oxygen free environment) is broken down by naturally occurring bacteria, releasing methane. There is also CO₂, H₂S and other gases.

We capture the gas. Clean it up.

And inject the methane into the pipeline.



1. Manure water is flushed in California

Approximately 1% manure





2. It goes over a separator and sand lane





3. Flows into a Covered Lagoon - Digester





3a. The Lagoon Digester is Double-Lined for groundwater protection





3b. The Lagoon Cover is Strong & Expands for Storage





4. On-site Dairy Gas Cleanup

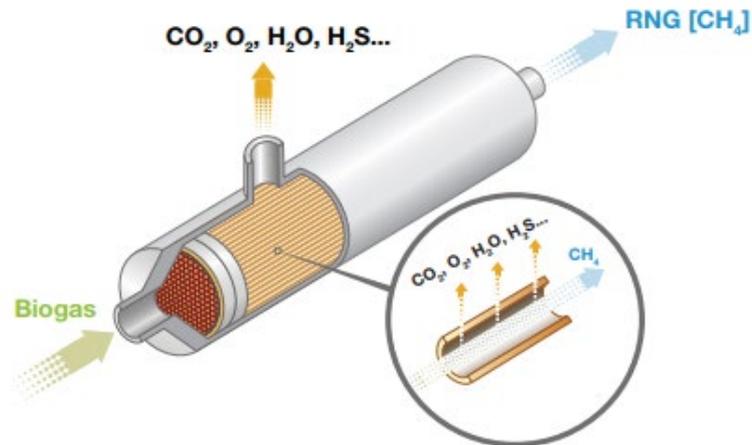
- **First, H₂S removal (important area for collaboration)**
 - Very corrosive to metal, so vital to remove for continued performance
 - Gives dairies the rotten egg smell, which is drastically reduced after cleanup
- **Second, Dehydration and compression**
 - Removal of water important when transporting gas, or water will build up
 - Compression needed for transport and injection into pipeline





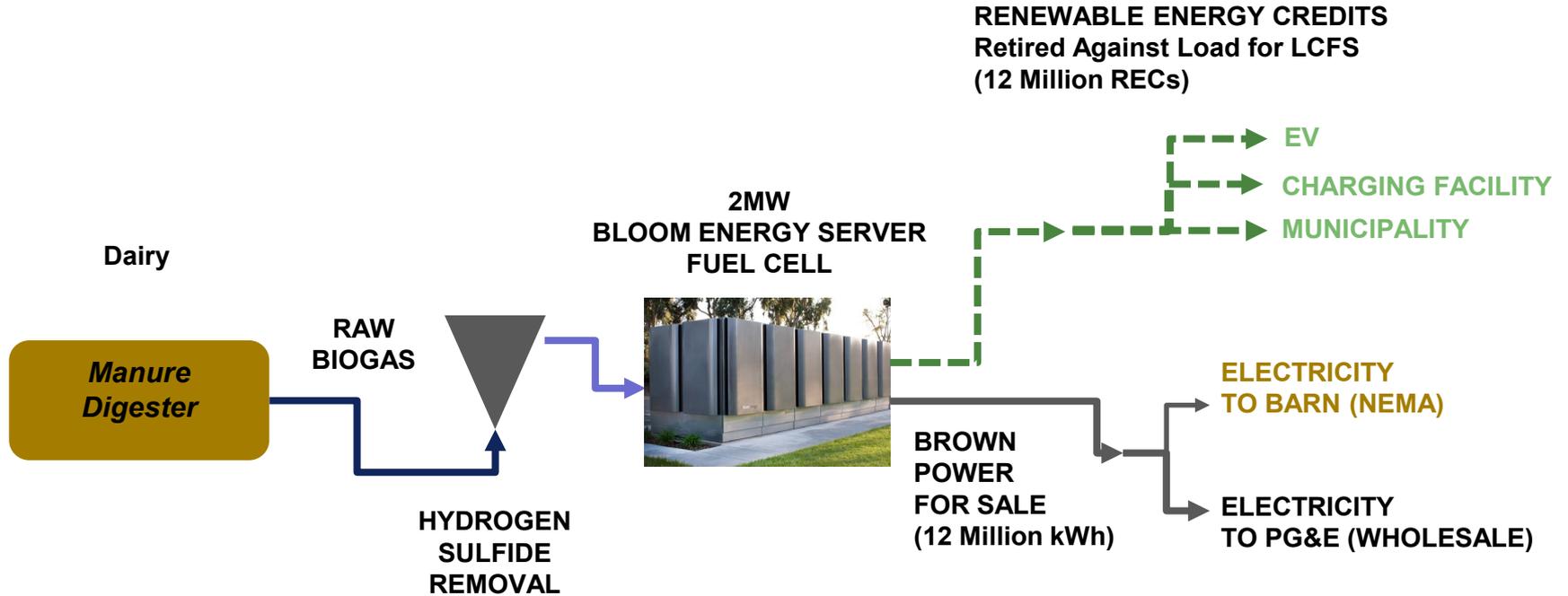
5. Upgrading to CNG

- Multiple solutions. Pressure swing, membranes, water wash. CalBio - Air Liquide System
- SoCalGas has high standards for quality of gas to be accepted
 - Greater than 97% methane at very high pressures
 - Nearly non-existent levels of H_2S , H_2O , and CO_2
 - If requirements are not met, gas is rejected and vented into the atmosphere
- A very precise membrane that only allows CH_4 to flow





5b. Dairy Fuel Cell Alternative



Two Cows

=

One EV



Renewable Compressed Natural Gas (R-CNG) Economics



R-CNG has three revenue sources

1. California's Low Carbon Fuel Standard Program (LCFS).
 - Created by the California Air Resources Board to reduce GHG emissions from transportation (41% of emissions)
 - Sister program to "cap and trade"
2. U.S. Renewable Fuel Standard
 - Created by EPA originally for ethanol
 - More valuable for dairy projects, since greater benefits
3. Sale of natural gas



Dairy Biogas -> Fuel Options



R-CNG Fuel

1. \$75/MMBTU (Gas, LCFS, RIN)
2. 90% less NOx Emissions
3. LCFS & RIN Market Price Risk



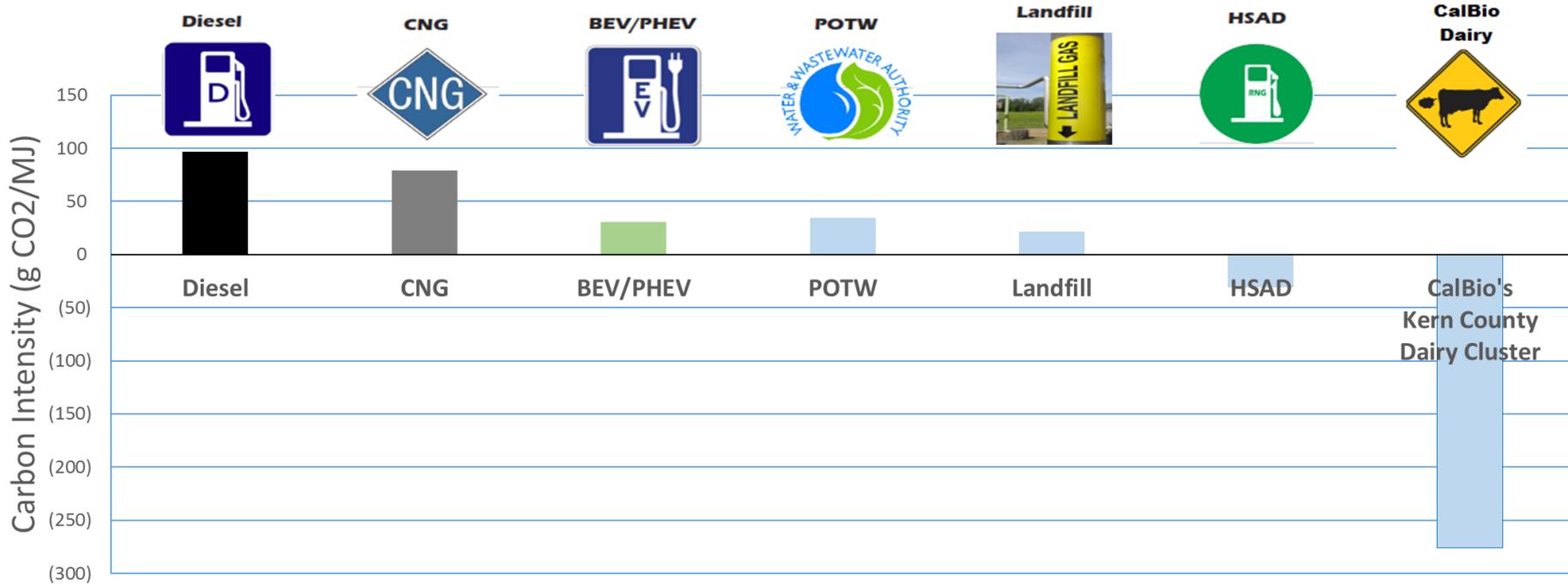
Electric Fuel

1. \$64/MMBTU (kWh, LCFS, ~~RIN~~)
2. 90+% less NOx Emissions
3. LCFS Market Price Risk
(Floor = BioMAT \$25/MMBTU)



The LCFS Values Relative Carbon Intensity

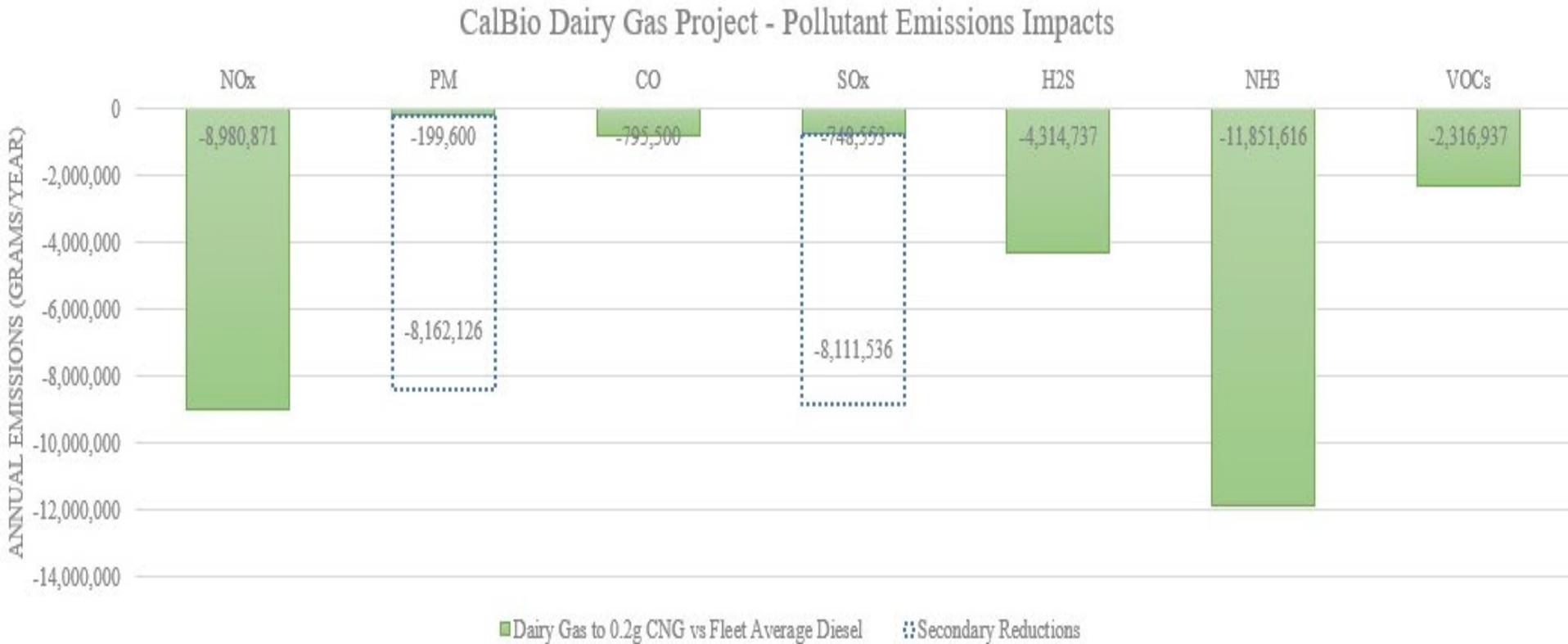
Carbon Intensity for Diesel & Substitute Fuels
(g CO₂/MJ)



* California Bioenergy LLC: California Dairy Digester Biogas to CNG GREET 2.0, LCFS FP: CNG056, CI: -276.24



Air Quality Benefits Graph: Impact from Use in CNG fleets



* California Bioenergy LLC: California Dairy Digester Biogas to CNG GREET 2.0, LCFS FP: CNG056, CI: -276.24



San Joaquin Valley Air Quality Improvements

- One digester at a dairy of approximately 3000 cows reduces NOx emissions equivalent to taking 89 cars off the road. The displacement of diesel by CNG trucking fleets further reduces NOx by the equivalent of 5,971 cars
- A cluster of digesters (of approximately 24,000 cows) reduces NOx emissions equivalent to taking 40,837 cars off the road





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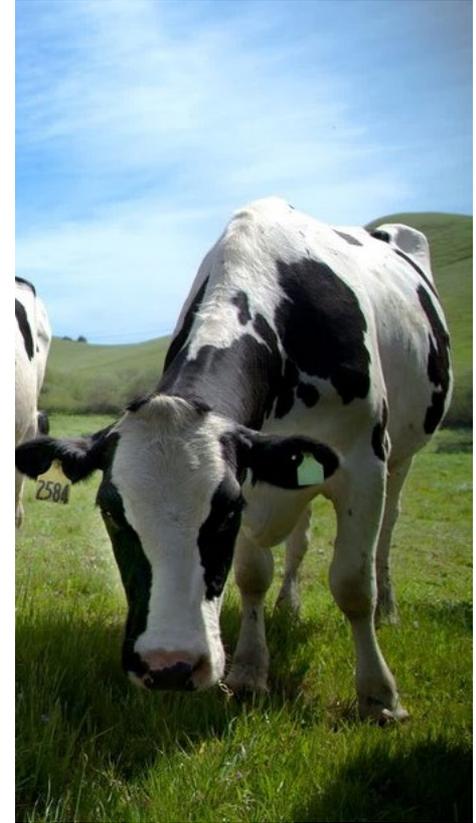
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QUESTIONS?



Thank you for joining us today!



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