

| DOCKETED | |
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RNG Market

Sources, Potential, and Costs

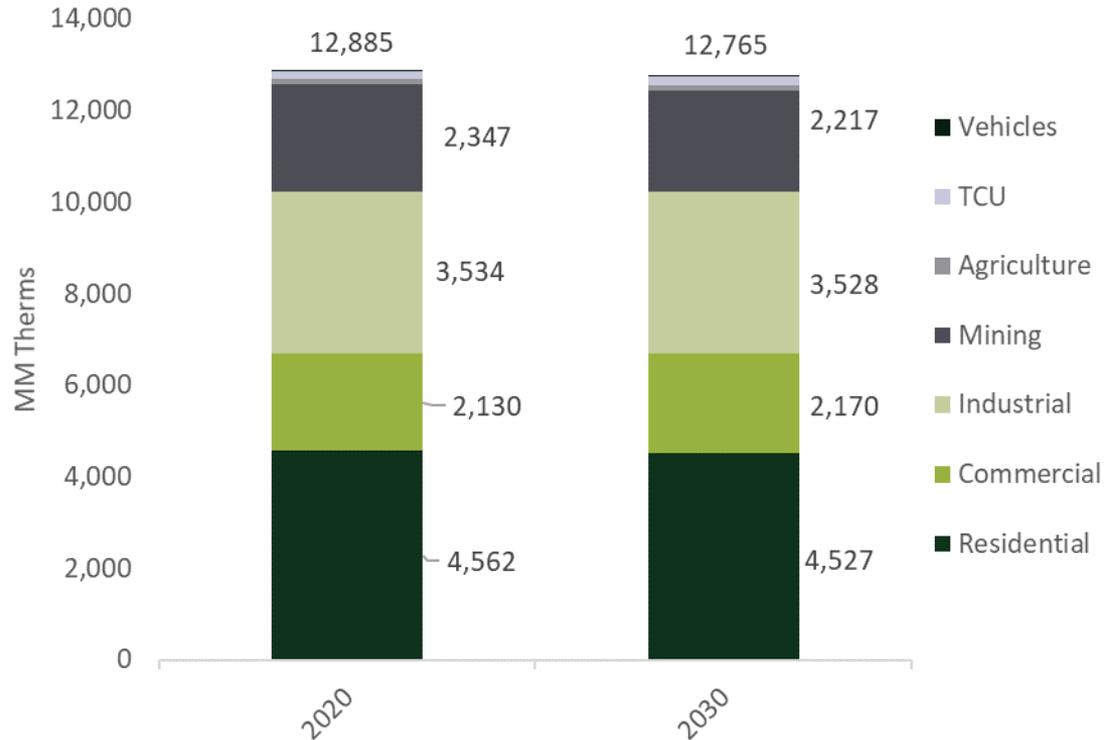
TERMS

- » Biogas – methane from renewable sources but not necessarily pipeline quality
- » Biomethane– biogas that has been further processed to pipeline quality
- » RNG – Biomethane that has been compressed and injected into a pipeline for use to replace natural gas
- » Formed anaerobically (no oxygen) from renewable sources such as:
 - Animal manure
 - Wastewater Treatment Plants (WWTP)
 - Landfill Gas (LFG)
 - Forestry & Crop waste
 - Can also be through gasification or pyrolysis
- Potentially from crops; but such isn't usually classified as renewable by California

NATURAL GAS USE

» Source:

- California Energy Demand 2020 - 2030 Baseline Forecast - Mid Demand Case

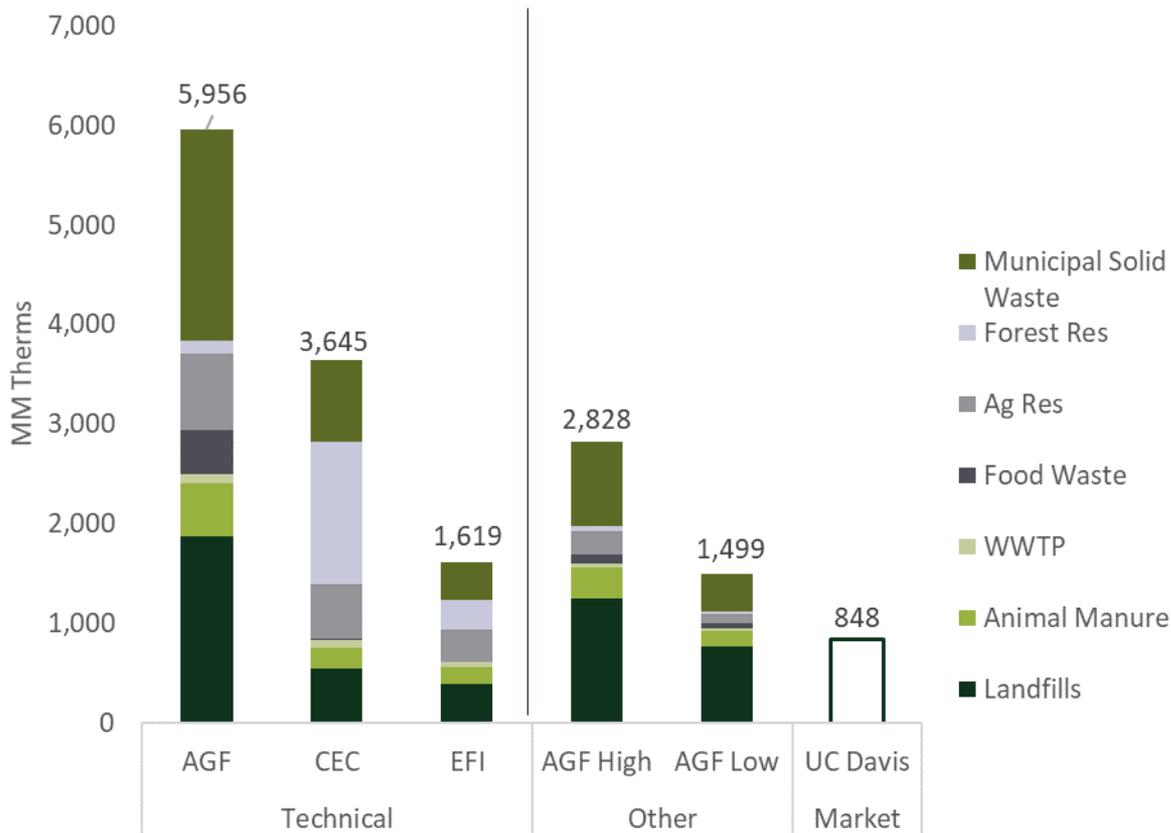


RANGE OF ANNUAL RNG POTENTIAL ESTIMATES

- » Usage is 12,000 MM Therms
 - A little over half by buildings; will electrification reduce?
 - Transportation could consume more

- » Technical potential is capturing every feasible methane molecule

- » See Slide in appendix for sources

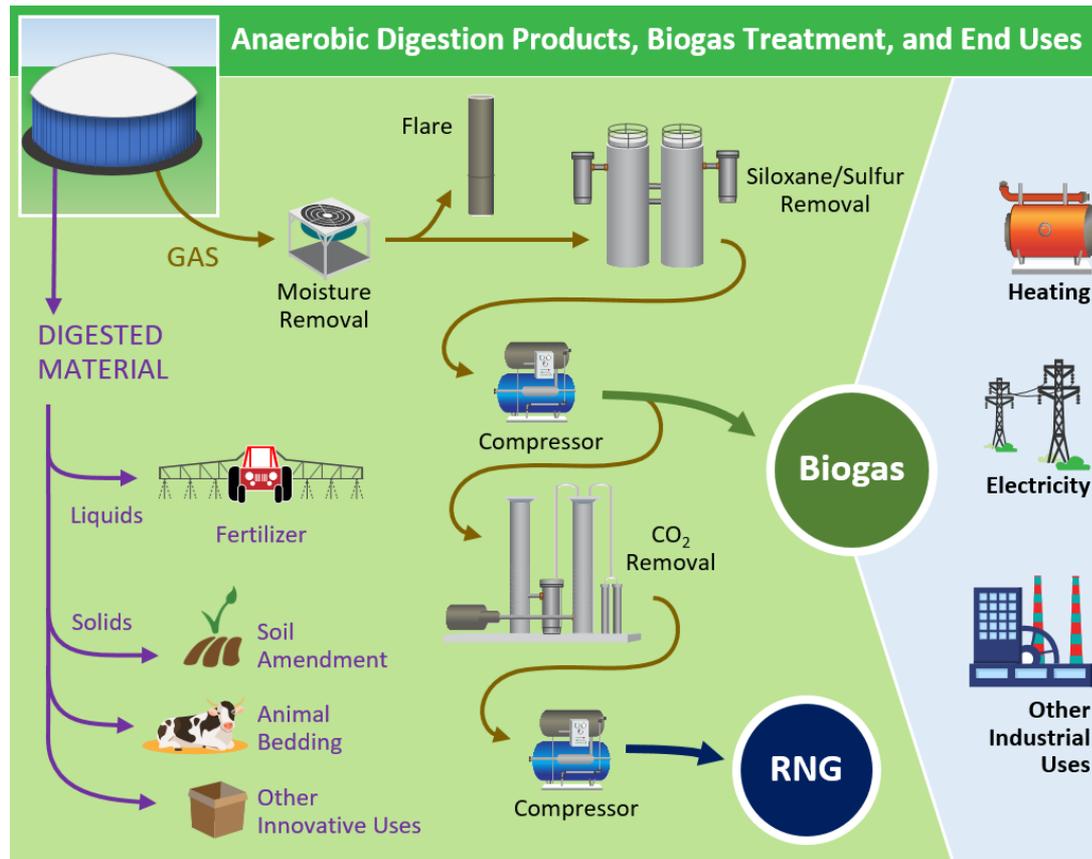


RNG AND BIOGAS FROM ANAEROBIC DIGESTERS

» Anaerobic digesters are used to process and sterilize waste from:

- Manure from dairies and swine farms
- Wastewater Treatment Plants (WWTP)
- Municipal Organic Waste (e.g., food scraps and lawn clippings)

» Heating content of biogas often much lower than RNG



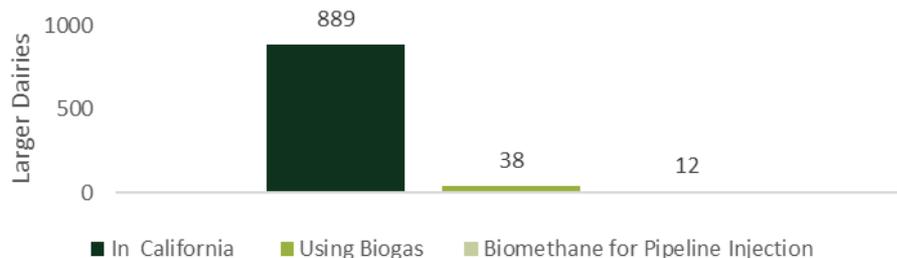
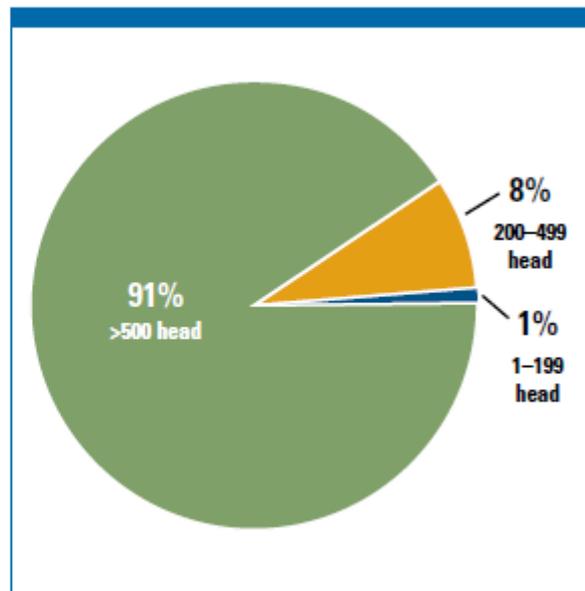
DAIRIES

- » Source: EPA and LCFS
- » 889 Dairies with Over 500 Cows
- » Some in industry think minimum herd size is more like 1,500-2,000
 - Current average is over 5,000 cows for digester sites
- » ~100 more in construction

| Market Opportunities to Generate Electricity with Anaerobic Digestion (2007) | |
|--|-------|
| Total number of dairy operations | 2,165 |
| Total number of mature dairy cows (000 head) | 1,841 |
| Number of feasible dairy cow operations ¹ | 889 |
| Number of mature dairy cows at feasible operations (000 head) | 1,352 |
| Methane emission reduction potential (000 tons/year) | 341 |
| Methane production potential (billion ft ³ /year) | 27.9 |
| Electricity generation potential (000 MWh/yr) | 2,375 |

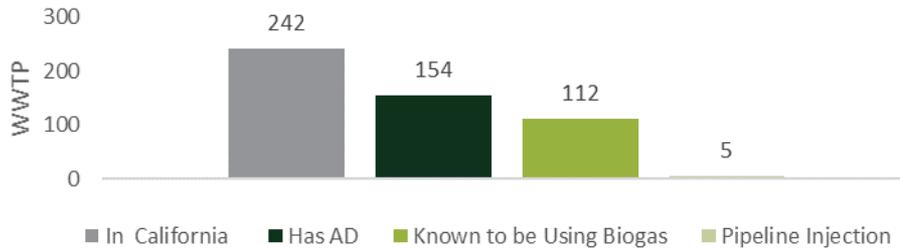
¹ Anaerobic digestion was considered feasible at all existing operations with flushed or scraped freestall barns and drylots with at least 500 dairy cows.

Dairy Farm Size

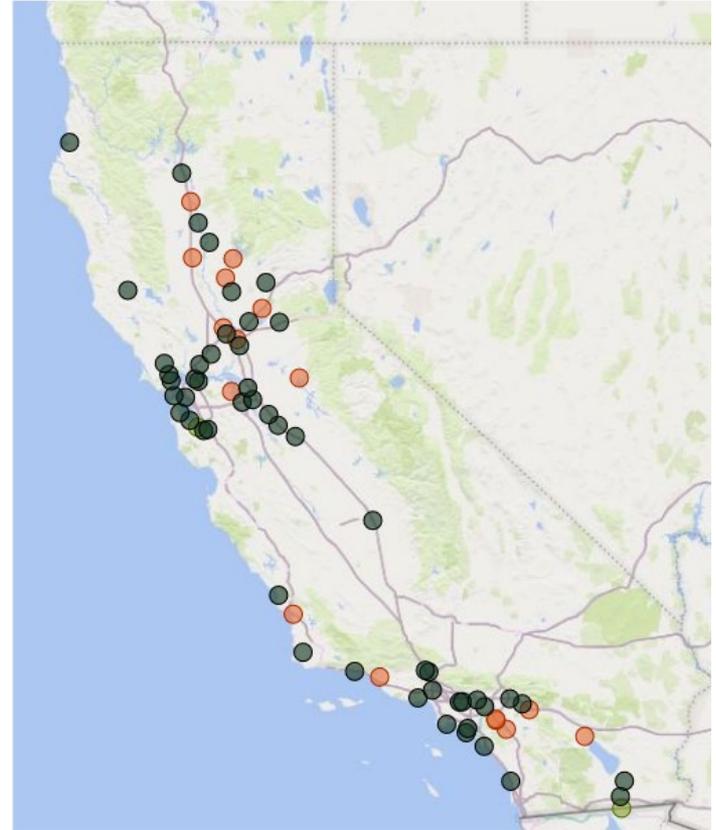


WASTEWATER TREATMENT PLANTS

- » Required to flare
- » Facilities with an Anaerobic Digester (AD) have 10x the average design flow as those without
- » Known uses of biogas are largely generation
- » Difference 'Has AD' vs 'Known to be Using Biogas' is largely due to unknown uses

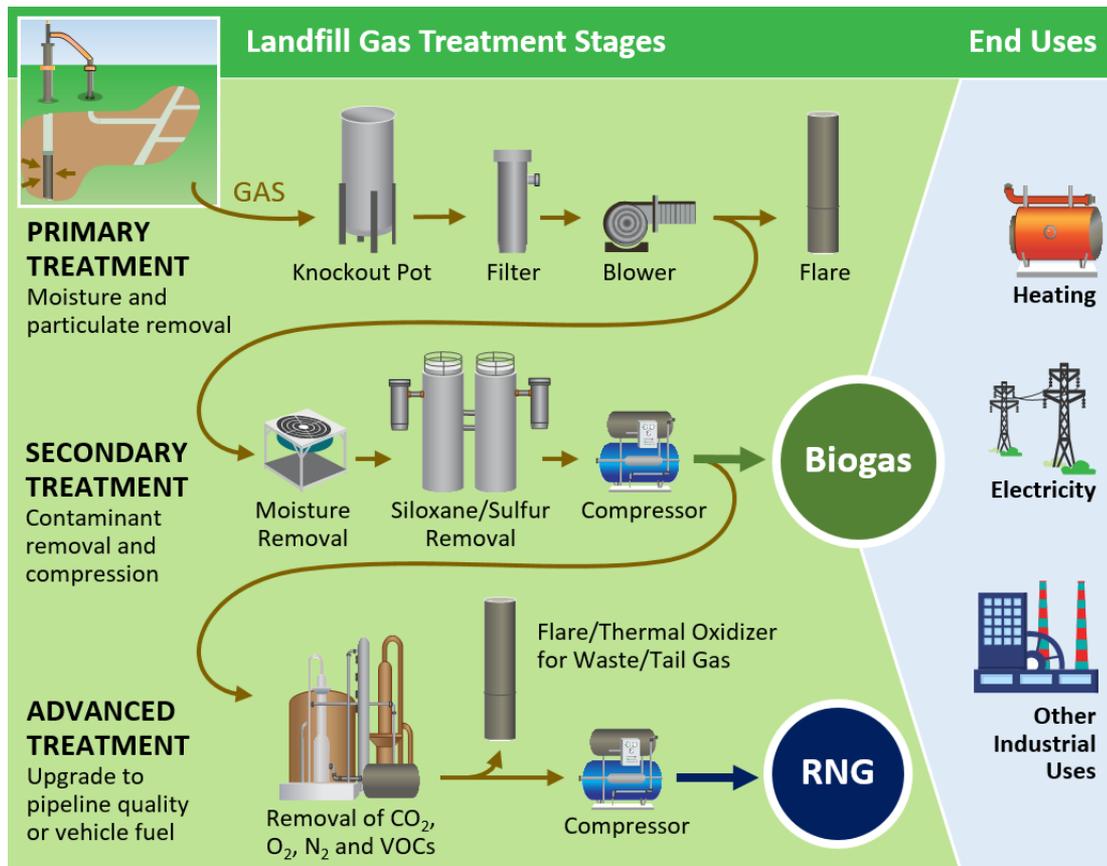


Anaerobic Digester? ● N ● UNKNOWN ● Y



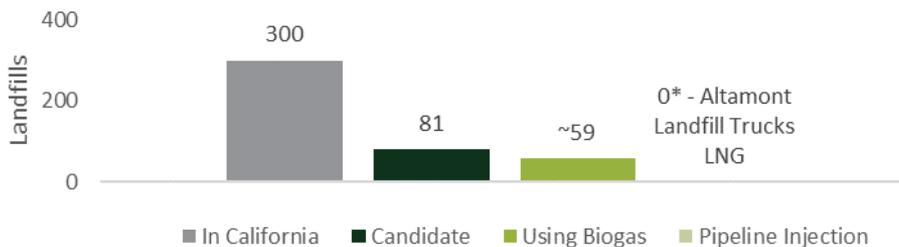
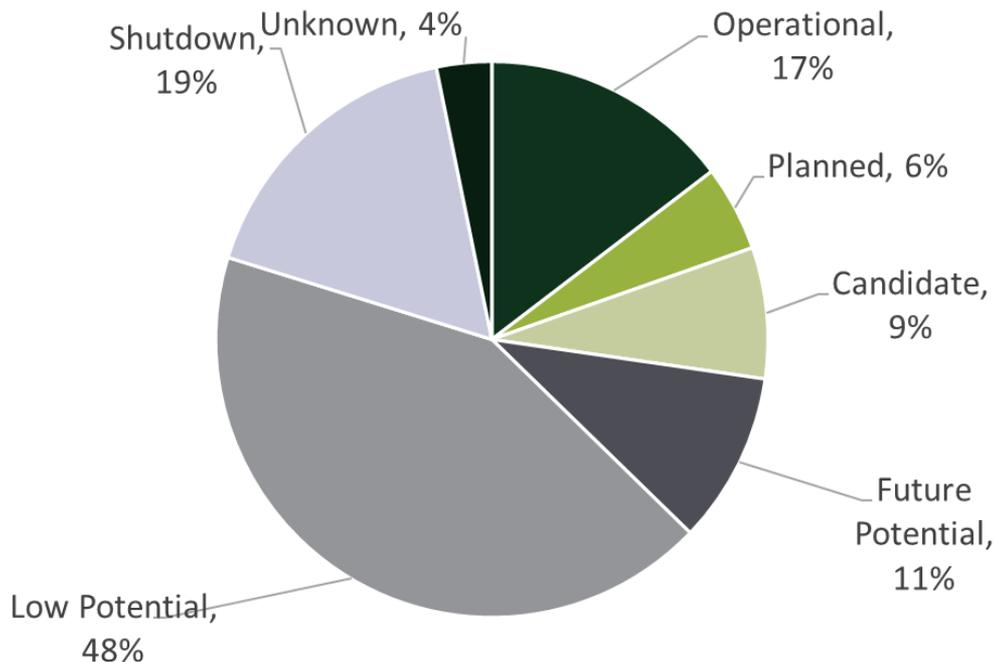
LANDFILL GAS TO BIOGAS OR RNG

- » Larger Landfills (>450k tons) are Required to Collect Methane and destroy it
- » Siloxanes (compounds from breakdown of plastics) need to be removed
- » Sulfides (particularly H_2S) also need removals



LANDFILLS

- » Source: EPA LMOP (Landfill Methane Outreach Program) and LCFS
- » Candidate:
 - Accepting waste or closed five years or less
 - At least one million tons of waste (note >450k tons require gas collection)
- » Future Potential:
 - Landfill is open but does not meet criteria for Candidate status yet
- » Low Potential:
 - Landfill is closed and
 - Does not meet criteria for Candidate status;
 - or other site-specific information.



BIOMASS

» Source: University of California **Woody Biomass Utilization Group**

» Most used for generation

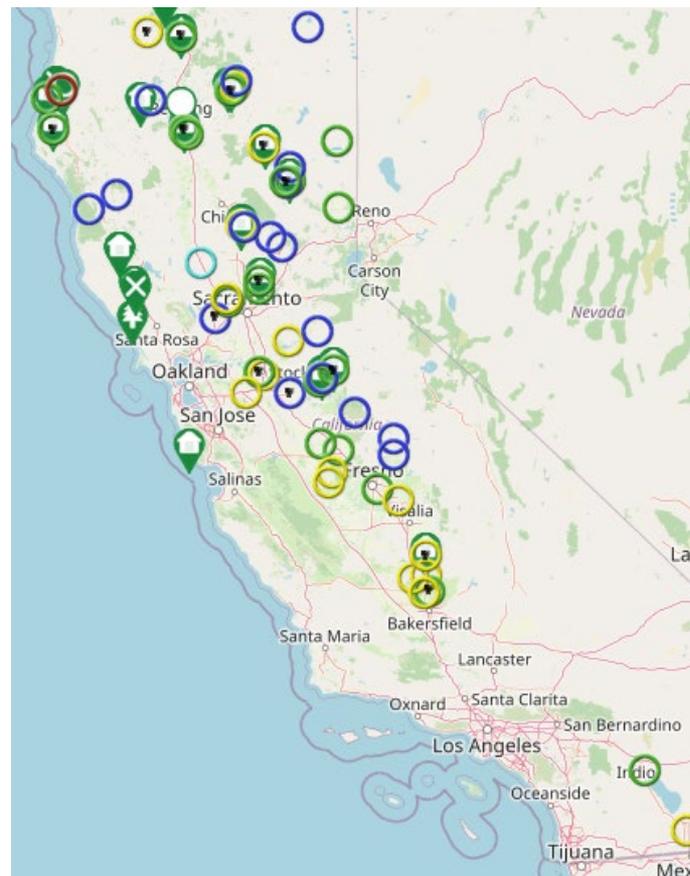
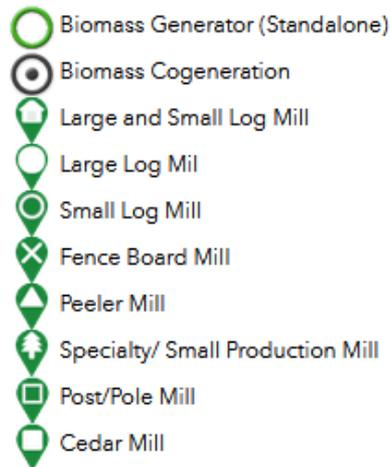
» Current driver likely the BioMat Feed-In-Tariff generation program (more this afternoon)

» SB 1440 (Biomethane) may drive more towards pipeline injection

Status

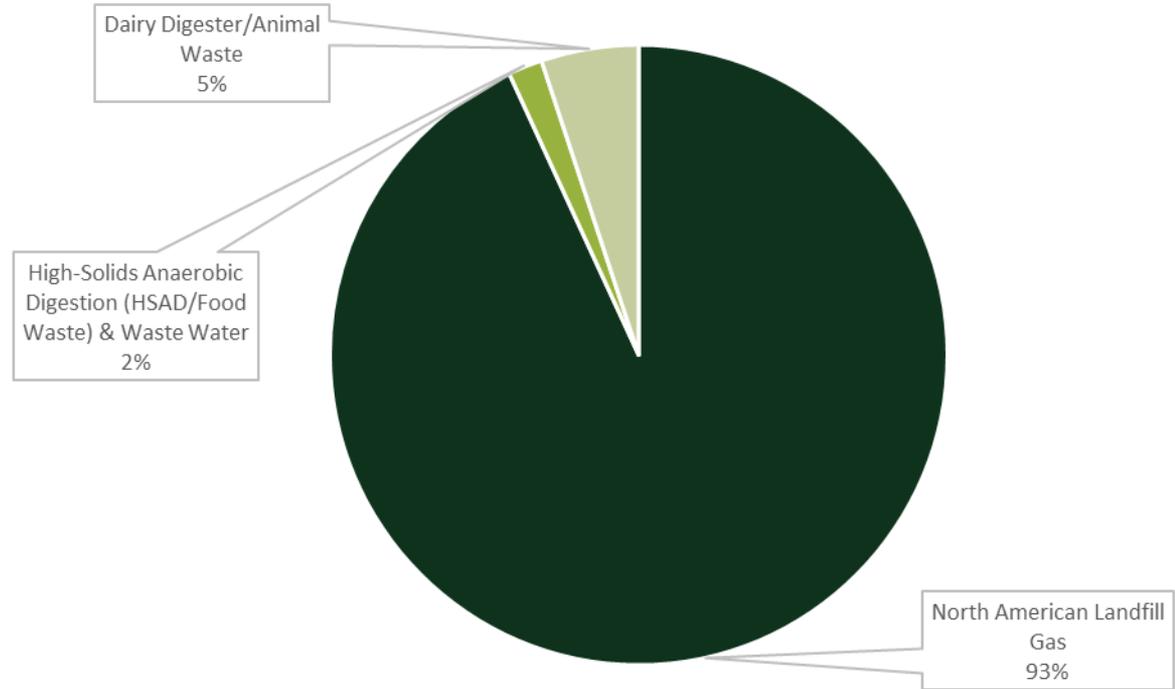


Facility Type



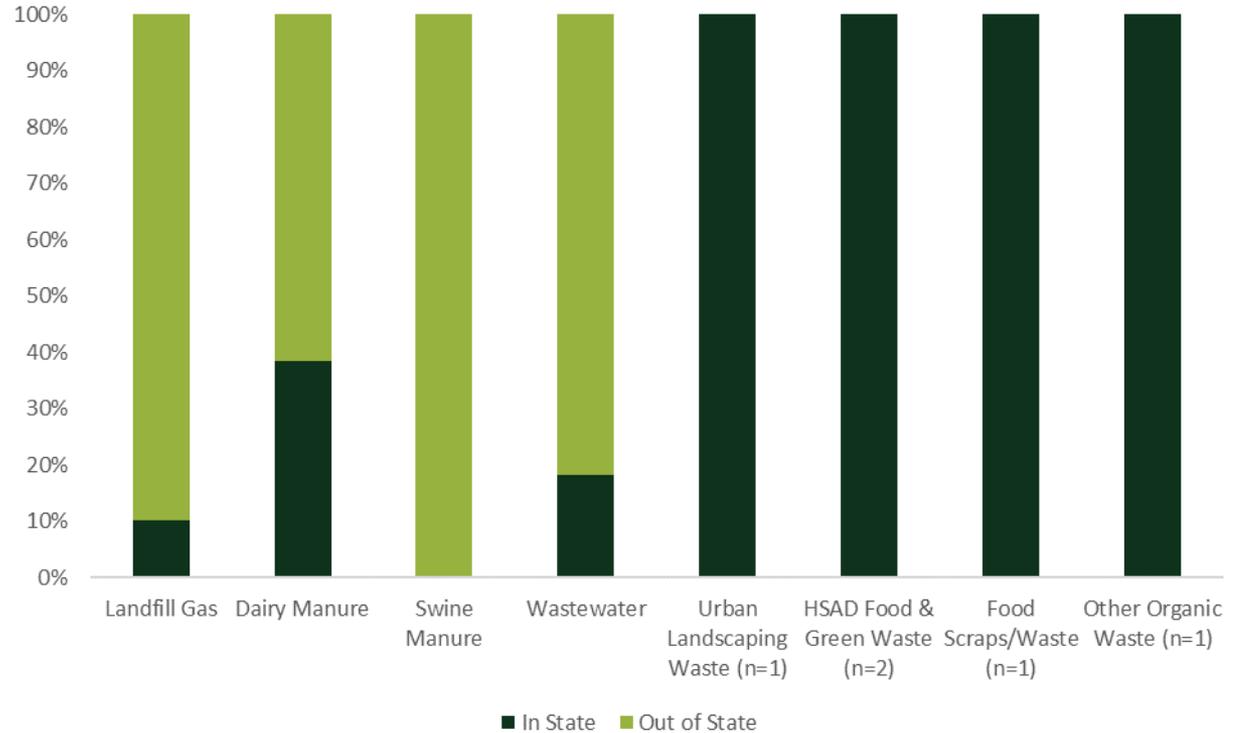
CURRENT SOURCES

» Using LCFS historical data as a proxy



IN VS OUT OF STATE SOURCES

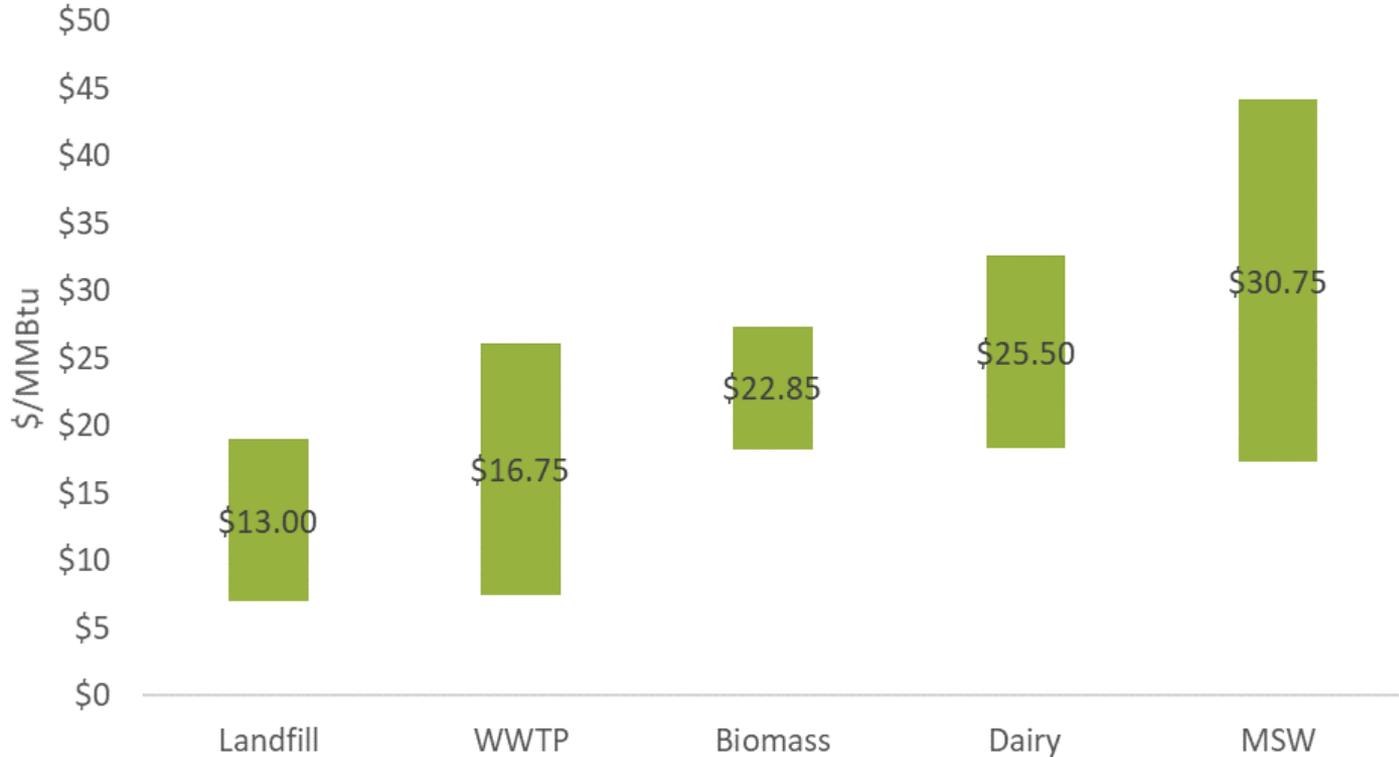
- » Based on CARB LCFS Pathways
- Proxy for RNG Supply



EXPECTED COMMODITY COSTS

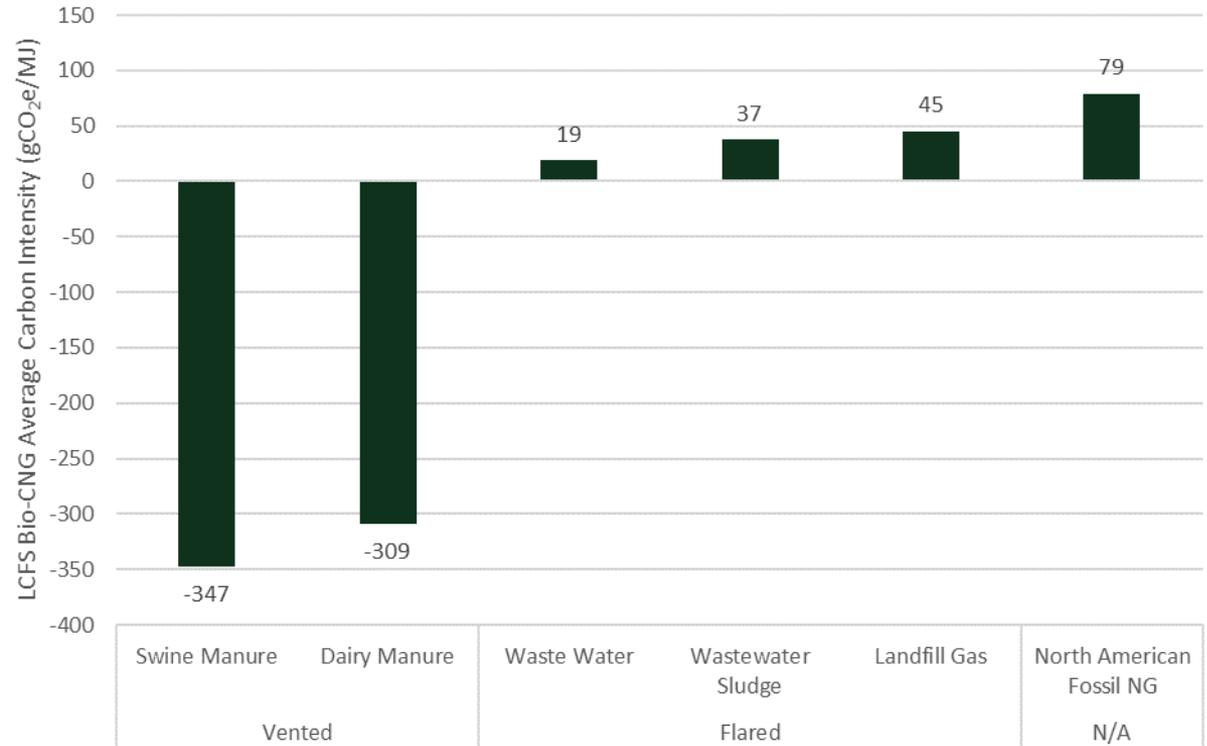
From 2019 AGF Report

- » Nationwide estimates
- » Based on bottom-up estimates
- » Only commodity, not transportation
- » Actual contract pricing likely to vary with source and term



THE SOURCE MATTERS FOR CARBON

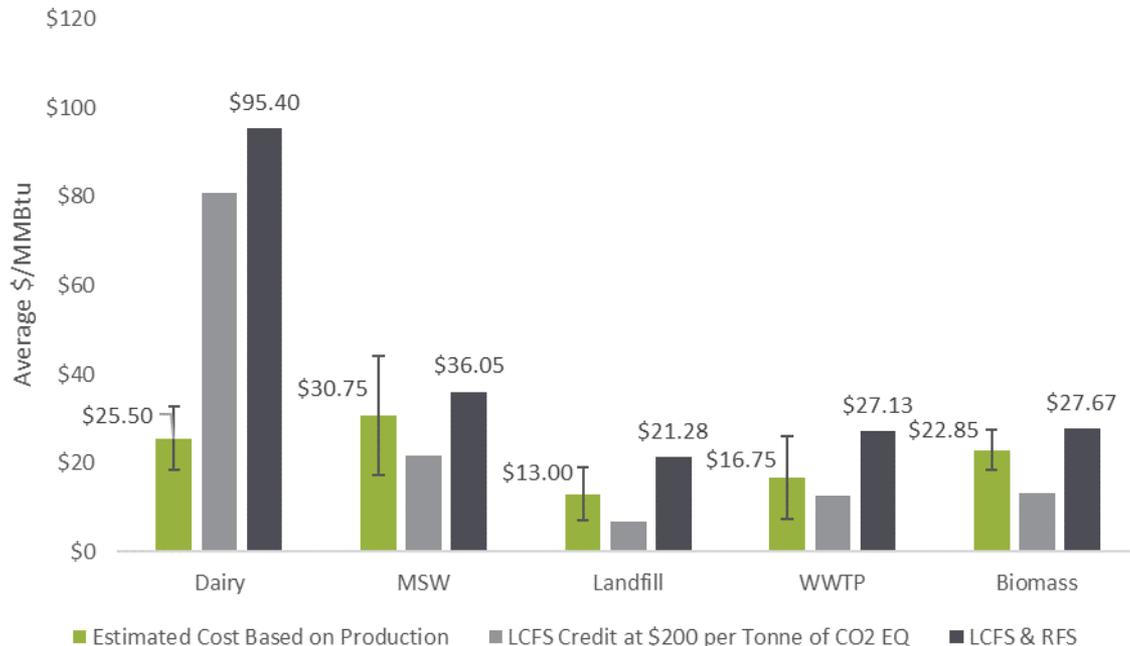
- » What would have been done in the absence of a program (the counterfactual)?
- Venting – methane released to the atmosphere
 - Flared – methane destroyed by burning



BOTTOM-UP COSTS VS LCFS & RFS CREDITS

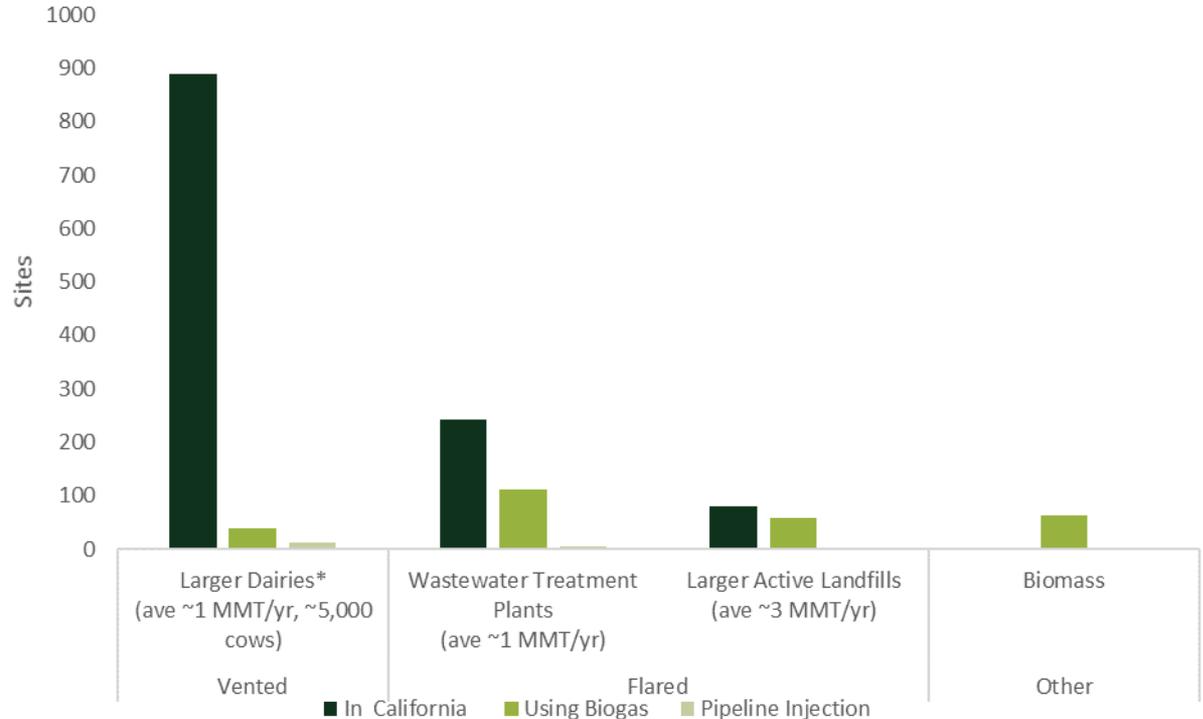
Primary Market for RNG (?)

- » Both LCFS and RFS are variable->risk
- » Dairy has significant differences
- » One long-term RNG contract price estimate is \$18/MMBtu
 - Actual pricing will vary based on term, location, source, etc.



SUMMING IT UP

- » Dairies have significant potential in both production and carbon reduction
- » Landfills and Wastewater plants provide lots of volume
 - SB 1383 could drive this up
- » Biomass could be another large source
- » Policies can influence

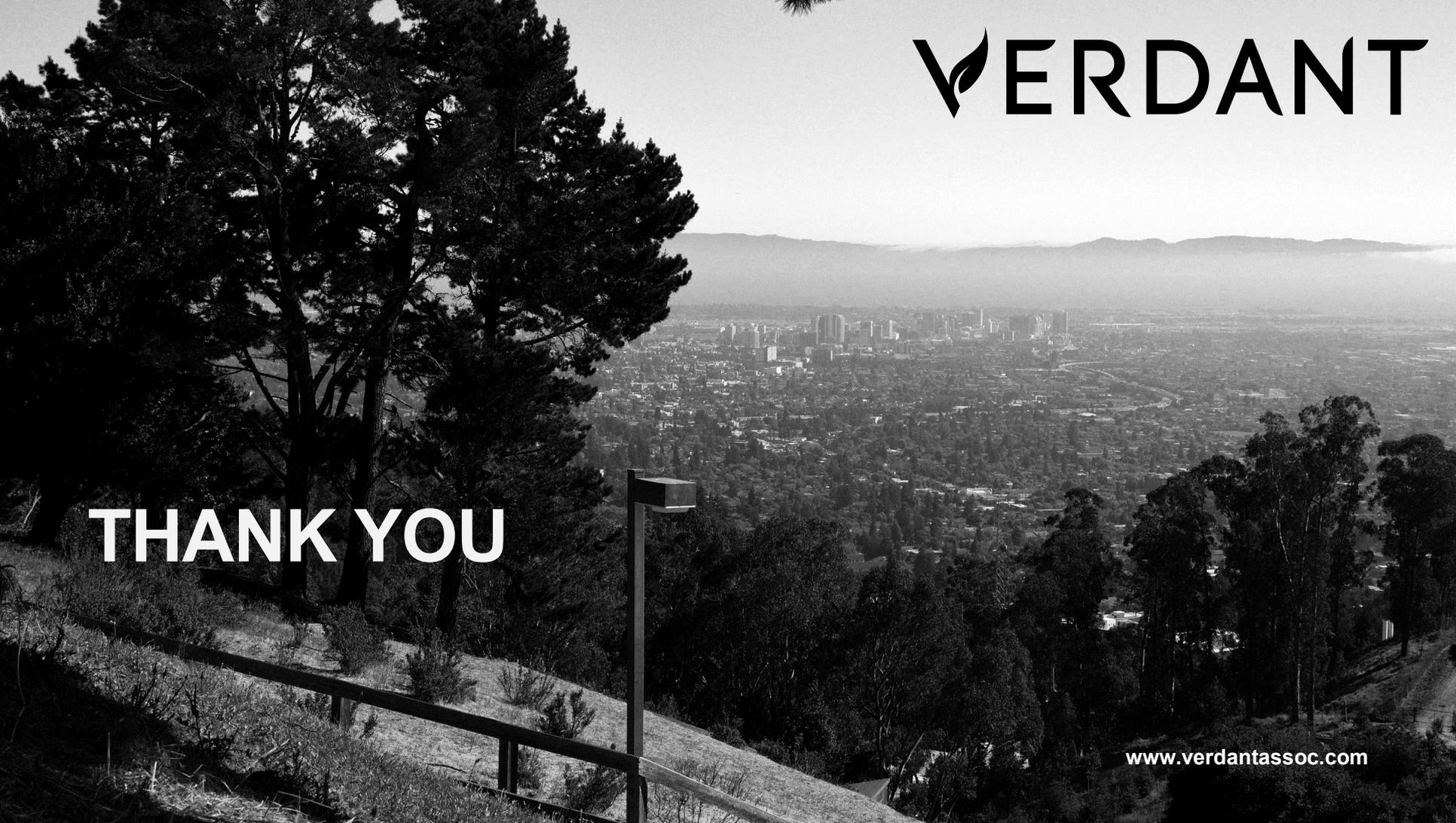


QUESTIONS?

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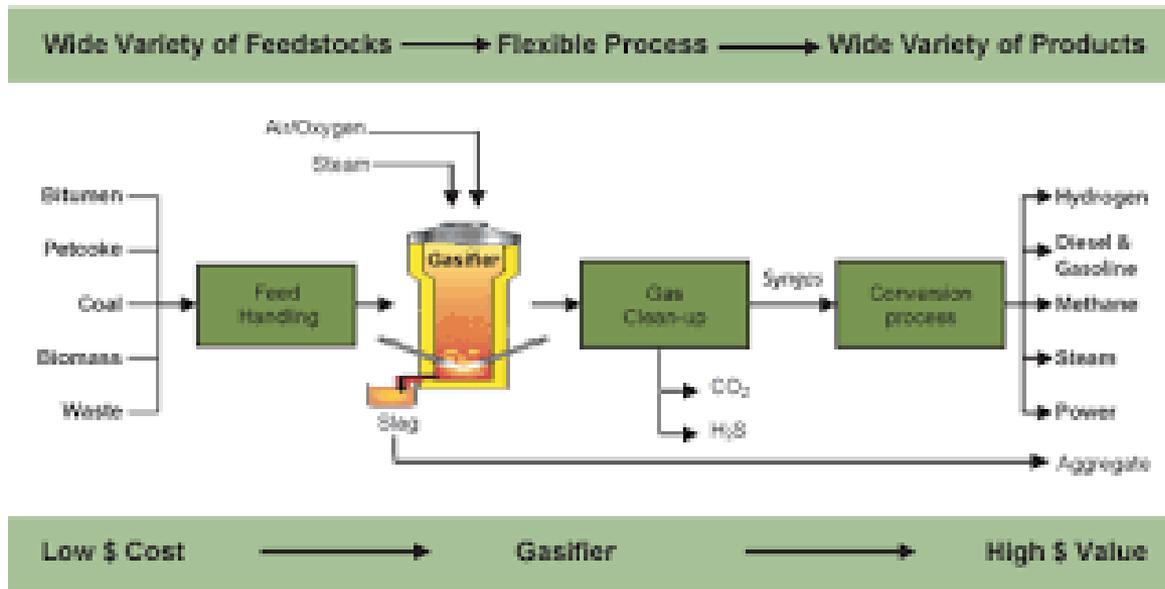
THANK YOU

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BIOMASS PROCESSING

» Collection can be significant barrier

Gasification:



» Can also process through digestion

SOURCES

- » Potential:
 - UC Davis: Jaffe et al, June 2016
 - EFI: Energy Futures Initiative; Pathways for Deep Decarbonization, May 2019
 - AGF: American Gas Foundation, Renewable Sources of Natural Gas, December 2019
Also costs
 - CEC Tech: Rob Williams and Stephen Kaffka, UC Davis, presentation to the CEC on January 30, 2017
- » \$18/MMBtu RNG: Supporting letter by ENERGY VISION 138 East 13th Street New York, NY 10003 for Reply Comments of Southern California Gas Company (U904g) to Assigned Commissioner's Ruling Seeking Comments on Implementation of Senate Bill 700 and Other Program Modifications in CPUC Rulemaking 12-11-005 (Filed November 8, 2012)