| DOCKETED | |
|---|---|
| **Docket Number:** | 21-IEPR-05 |
| **Project Title:** | Natural Gas Outlook and Assessments |
| **TN #:** | 239520 |
| **Document Title:** | Presentation - Renewable Natural Gas Research & Development |
| **Description:** | Previously docketed to 21-IEPR-06<br>S1.3A Rizaldo Aldas, CEC |
| **Filer:** | Raquel Kravitz |
| **Organization:** | California Energy Commission |
| **Submitter Role:** | Commission Staff |
| **Submission Date:** | 8/30/2021 10:59:31 AM |
| **Docketed Date:** | 8/30/2021 |

# California Energy Commission

Title: Staff Perspective on Renewable Natural Gas Research and Development

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Date: August 31, 2021

# Overview

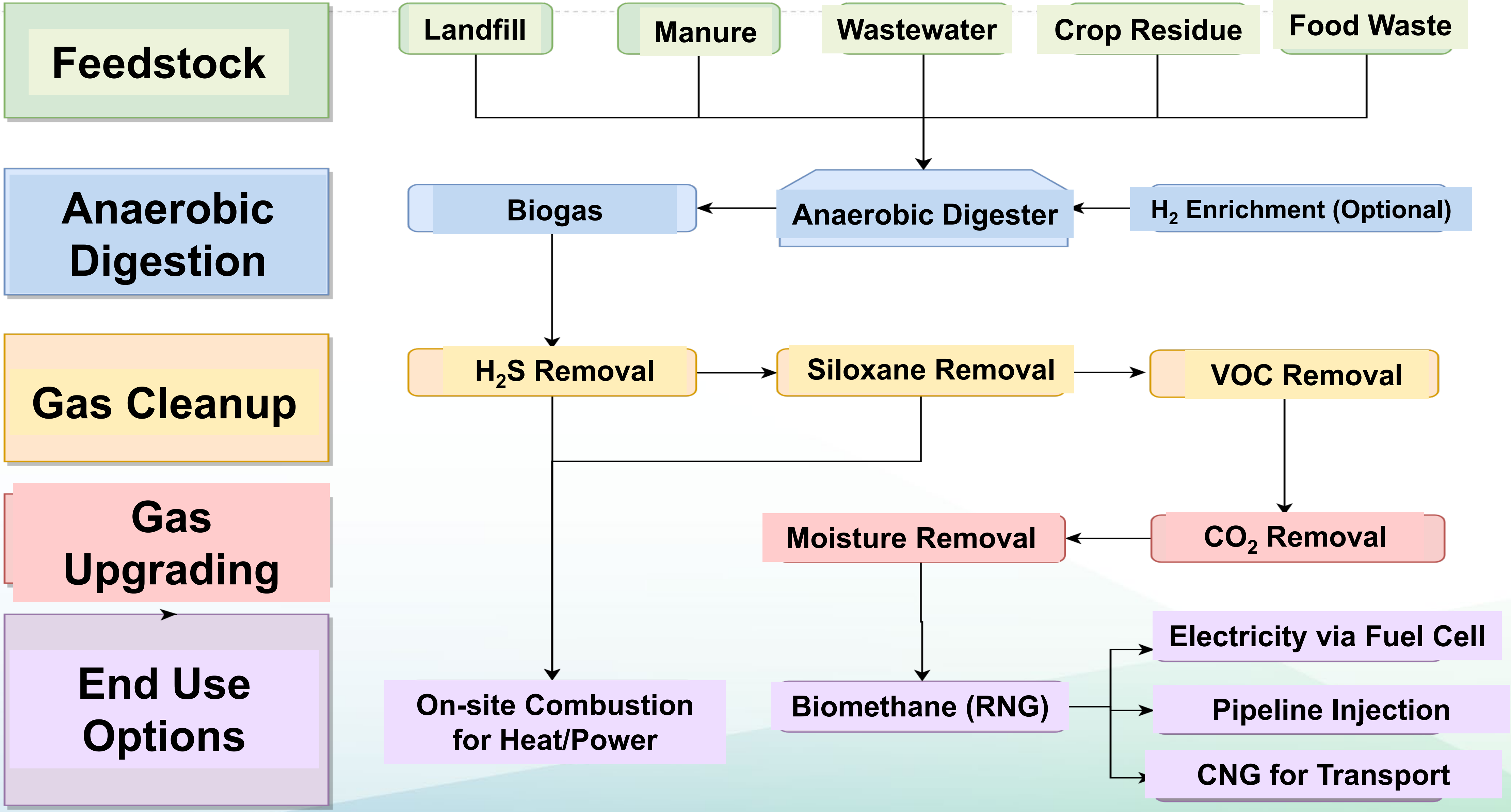
- Renewable natural gas definition
- “Most common” feedstock and conversion pathway
- Three examples of different facilities and applications
- Emerging renewable gas production
- RNG in decarbonized future
  - ➢ Resource estimates and projections
  - ➢ Select takeaways from an E3 study
  - ➢ Revisiting challenges and technological development needs

# Defining Renewable Natural Gas

- Renewable natural gas (RNG) could be any of several low-GHG substitute fuels to fossil natural gas. For today's purposes, RNG will refer to biomethane which is a purified form of biogas.

- AB 3163 (Salas, Chapter 358, Statutes of 2020) expanded the definition of biomethane to include:
  - Methane produced from an organic waste feedstock that meets the standards for injection into a common carrier pipeline.
  - Methane produced from the anaerobic decomposition of organic material, including codigestion.
  - Methane produced from the noncombustion thermal conversion of any of the following materials, when separated from other waste: agricultural crop residues; bark, lawn, yard, and garden clippings; leaves, silvicultural residue, and tree and brush prunings; wood, wood chips, and wood waste; nonrecyclable pulp or nonrecyclable paper materials; livestock waste; and municipal sewage sludge or biosolids.

# Anaerobic Digestion Pathway to Renewable Natural Gas



# Example 1: Food Wastes and Green Wastes Biogas-to-Electricity

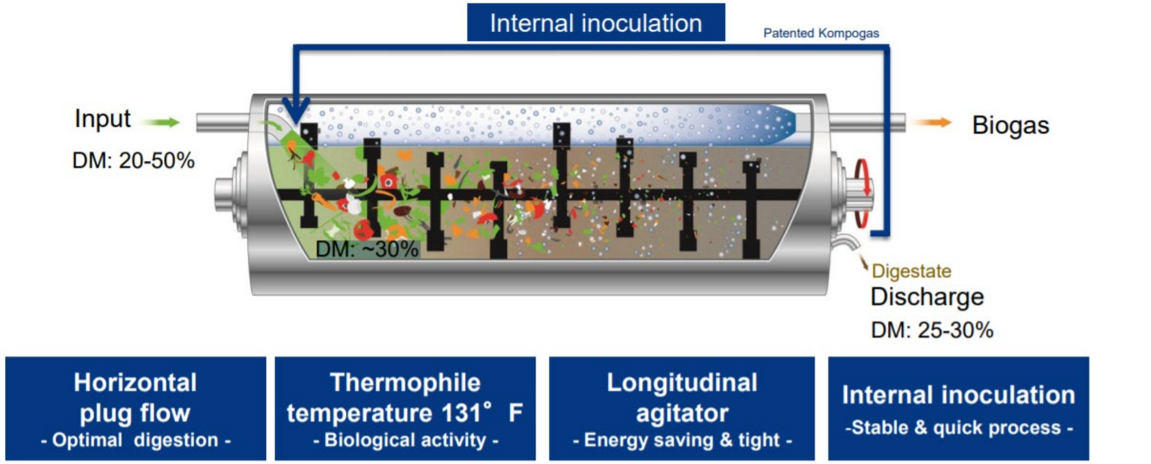



Diagram of horizontal plug-flow digester (Credit: HZIU Kompogas)

Example of green waste feedstock (left) and digestate (right). (Credit: HZIU Kompogas)

- > Uses local food wastes and green wastes
  - Ave. of 100 tons per day; 36,500 tons per year (TPY)
- > Produce renewable electricity for power purchase agreement
  - Average 733kW, 85% capacity factor
- > Create value-added fertilizer by-products
  - 13,000 TPY of solid fertilizer
  - 1.6 million gallons of liquid fertilizer

# Example 1: Food Wastes and Green Wastes Biogas-to-Electricity

**Results by the End of Project Term:**

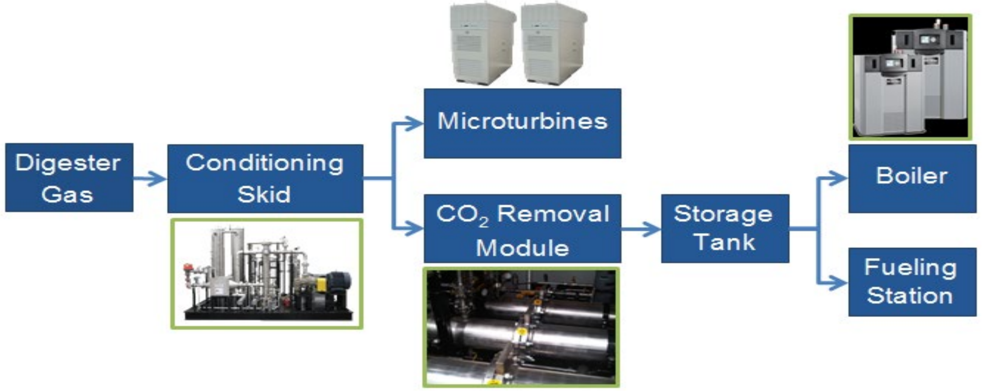
- Fast construction and first generator for BioMAT
- Exported 2,058,698 kWh of renewable electricity
- Processed 31,261 tons of organic feedstock
- Reduced GHG emission by 5151 MTCO2e
- Produced 7,679 tons of solid fertilizer/compost and 1.5 million gallons of liquid fertilizer

**Sample Lessons Learned:**

- Need for education to support diversion
- Feedstock contamination impacts wear of equipment
- Lower food waste percentages in feedstock stream lowers biogas yields

High-solids anaerobic digestion system designed to meet the organics diversion goals of San Luis Obispo County.
(Credit: HZIU Kompogas)

# Example 2: Wastewater Biogas-to-Energy System




Simplified schematic of the biogas energy recovery system

Photograph of microturbines, gas cleanup system and digester

- Pre-commercial biogas energy recovery system at a small wastewater treatment plant
- Biogas provide renewable electricity, heat, and transportation fuel
- Utilizes a biogas cleanup skid, microturbines, hydronic boiler, and CNG refueling station
- New system replaces aging internal combustion engine and diesel-fueled vehicles with cleaner, more efficient technologies.

(Credit: Las Gallinas Valley Sanitary District)

# Example 2: Wastewater Biogas-to-Energy System

**Results from the First 12 Months of Operation:**

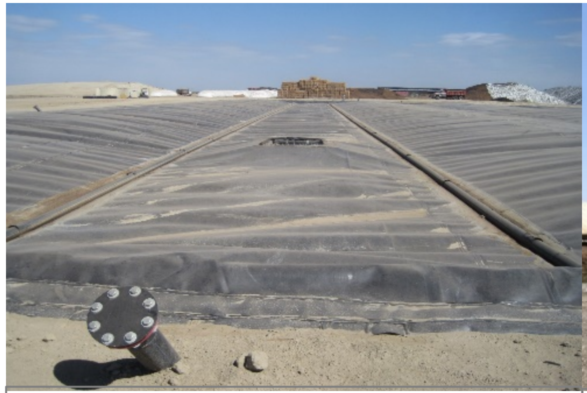
- Average of 33 scfm of biogas production
- Produced 7,700 MMBtu of conditioned digester gas
- Produced 520 DGE of RNG
- Generated ~ 438,265 KWh of renewable electricity
- Overall system efficiency of 60%

**Some Lessons and Opportunities:**

- Need for accurate biogas use study
- Verify quantity and quality of digester gas
- Unique engineering and construction challenges
- Knowledge of equipment functionality and selection
- Demonstrated a wide range of possibilities for larger size facilities

Time-fill RNG Station (*top picture*) and Fast-fill CNG station (*bottom picture*). (Credit: Las Gallinas Valley Sanitary District)

# Example 3: Dairy Manure Biogas-to-Energy System



Digester Cover Installation (Hub-and-Spoke Project)

H2S Sponge scrubber (Biogas Storage Project)


Location of Digester Projects

CHP Cooling Tower & Chiller (CHP Project)

Three different strategies :

**Biogas Storage Project**: Two cell digester for producing and storing biogas and generating electricity at times of peak demand

**Hub-and-Spoke Project**: 1 central hub dairy; 11 nearby spoke dairies transport biogas to hub to process, clean, and generate electricity

**CHP Project**: Improved energy efficiency by capturing waste heat from power generation system and using for absorption chiller to chill milk

Credit: CalBio / ABEC #2 LLC, ABEC #3 LLC, and ABEC #4 LLC

# Example 3: Dairy Manure Biogas-to-Energy System

**Estimated Impacts of Each Dairy Digester Project:**

- 7 - 8 million kWh of electricity exported over 12 months
- 10k - 21k metric tons of $CO_2$ equivalent reduced per year
- Reduce hydrogen sulfide prolongs engine-generator life
- 20 full time jobs during construction, and 125 at hub-and-spoke cluster
- $120,000/month net income, with 7- to 8-year payback period

**Key Lessons and Opportunities:**

- Business model breakthrough in dairy bioenergy operation
- Technology improvements resulted to Increased biogas production and electricity generation
- 20-year utility contract and incentives is key to bioenergy economics
- Use and optimization of the air injection system
- Explore improved solids separation methods
- Expanding on-farm use of waste heat from generators

Credit: CalBio / ABEC #2 LLC, ABEC #3 LLC, and ABEC #4 LLC

# Emerging Method for Upgrading Biogas to RNG

## ❑ Efficient Biogas Upgrading Technology Based on Metal-Organic Frameworks (MOF)

Sample of composite MOF pellets for exposure testing (top); tableted MOF adsorbent (bottom-left); Slipstream testing apparatus at the biogas site (bottom-right)

- A solid-state amine scrubbing technology for biogas upgrading
- Sorbent material (called metal organic framework or MOF) tested over long-term repeated cycling.
- Removed $CO_2$ down to ≤2% for 1000+ cycles without capacity loss
- 38% reduction in OpEx, 14% reduction in CapEx vs. standard chemical scrubbing system
- New technology will enhance biomethane with increased efficiency and reduced the cost

Credit: Mosaic Materials, Inc. (Grant Recipient)

# Exploring the Potentials of Woody Biomass to RNG

## Production of Renewable Natural Gas and Value-Added Chemicals from Forest Biomass Residues

- Catalytic upgrading of syngas to RNG.
- Lower wholesale cost of RNG with low carbon intensity of less than 15 grams CO2eq per MJ.

West Biofuels Catalytic Synthesis Reactor System
Source: West Biofuels, LLC

## Renewable Syngas Methanation

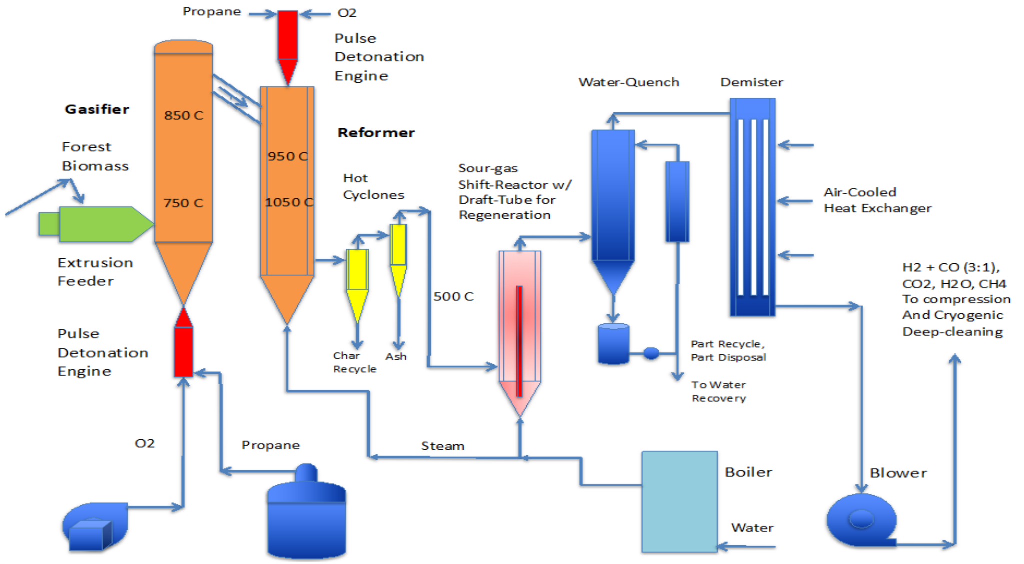



Diagram of Gasifier and Syngas Methanation System. Source: Taylor Energy

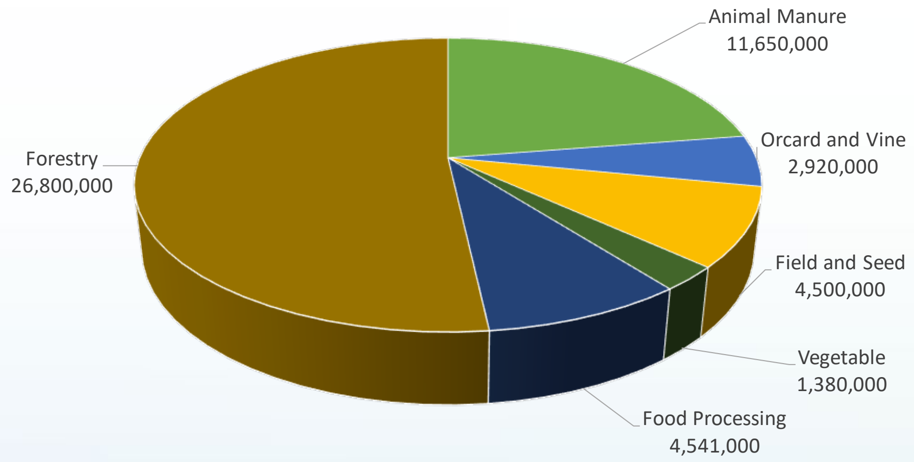
- An autothermal-gasification process designed to convert forest-biomass into renewable natural gas.
- Gas shift methods, cryogenic deep-cleaning and methanation while producing RNG with 990-1150 BTU/scf and with low sulfur content.

# RNG in a Decarbonized Future

## ❑ Different Estimates of Biomass Resource Potentials

- Biogas potential from manures, landfills, food wastes, green wastes, and wastewater = 93 billion cubic ft/year
- Gross – 78 million bone dry tons per year (BDT/y)
- Technically sustainable – 35 million BDT/y

**California Gross Biomass Resource Potential (BDT/yr), 2013 data**




Source: California Biomass Collaborative, UC Davis. https://biomass.ucdavis.edu/wp-content/uploads/CA_Biomass_Resource_2013Data_CBC_Task3_DRAFT.pdf

**Table A-1: California Biomass Availability for Different Data Sources (Millions of Dry Tons per Year)**

| Biomass Type | CEC/UC Davis*: 2013 resource | CCST[5]: 2050 resource, baseline scenario | CCST: 2050 resource, high-biomass scenario | E3 assumptions: 2040 resource |
|---|---|---|---|---|
| Wastes & Residues | 31.0 | 36.1 | 77.1 | 28.0 |
| *Energy crops* | *Not included* | *4.5* | *45.7* | *Not included* |
| Total Excluding Energy Crops | 31.0 | 36.1 | 77.1 | 28.0 |
| Total including assumptions about imported biomass from rest of U.S. | *Not included* | *Not included* | *Not included* | 43.3 |

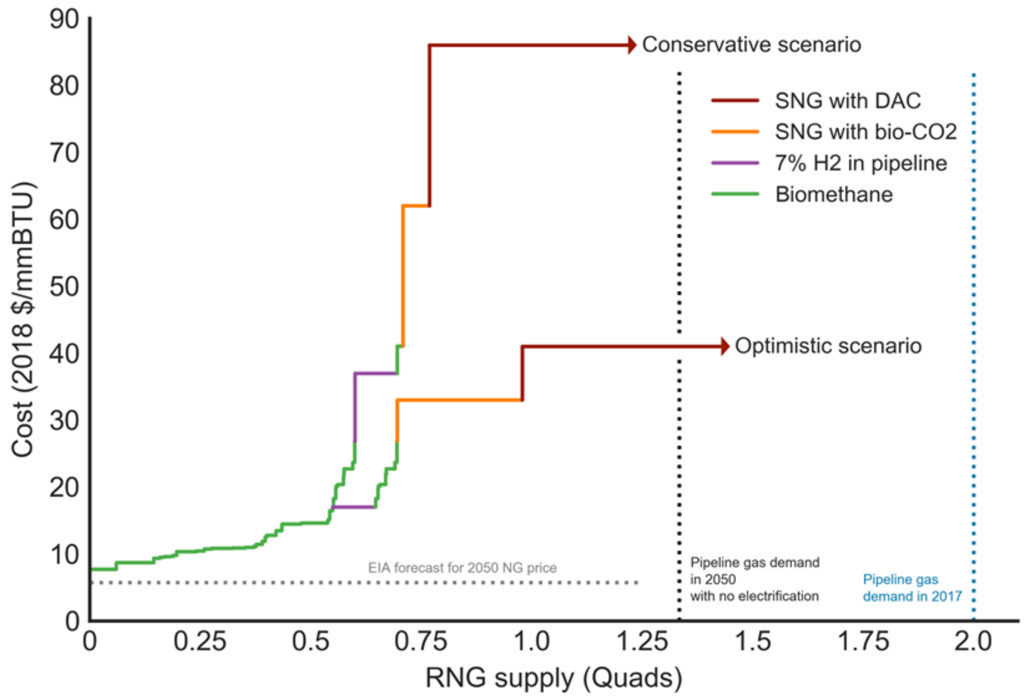
*Does not count landfill or wastewater treatment gas, which are not listed in dry tons. As with the previous table, numbers from the Bioenergy Association of California (BAC) document prepared by Rob Williams of UC Davis are used, which are based on prior CEC work. However, the numbers in the BAC document for agricultural waste biomass availability are slightly lower than what is listed in the CEC reports (8.7 million vs 12.1 million dry tons).

Source: E3, 2019. California Energy Commission. Publication Number: CEC-500-2019-055-F. https://www.ethree.com/wp-content/uploads/2021/06/CEC-500-2019-055-AP-G.pdf

# RNG in a Decarbonized Future

❑ Select Takeaways from the E3 2019 Study

- Use of fossil fuels like natural gas will need to decrease by 80 percent or more by 2050.
- Any scenario that meets California's climate policy goals uses some amount of renewable natural gas
- Biomethane is limited in availability based on sustainable sources of biomass feedstock.
- Reserve the inexpensive portions of biomethane for energy-intensive sectors of economy that do not have efficient, electrified substitutes readily available.




California RNG Technical Potential Supply Curve in 2050, Assuming All Biomass Is Directed to RNG.

The biomethane supply curve segments (green) are based on allocating California's population-weighted share of United States waste and residue biomass entirely to biomethane.

Source: E3, 2019. CEC Publication Number CEC-500-2019-055-F)

# RNG in a Decarbonized Future

## ❑ Revisiting Select Lessons Learned and Development Needs

- Feedstock supply quality, availability, and cost, including process and management scale and logistics
- Improving efficiency of biogas clean-up and upgrading technologies
- Improving processes for managing wastes and co-products, e.g. solids separation
- Performance validation for emerging RNG production technologies, e.g. woody feedstock to RNG
- Cost and efficiency improvements for RNG downstream equipment

Other considerations:

- High capital cost of process equipment (e.g., digester, clean-up and upgrading)
- Relatively low RNG yields vs high availability and low cost of fossil natural gas
- Gas quality requirements for pipeline and onsite use
- Training and education

# Thank You!