How to Unlock Savings & Revenues with Biogas Utilization

WEF eShowcase Webcast

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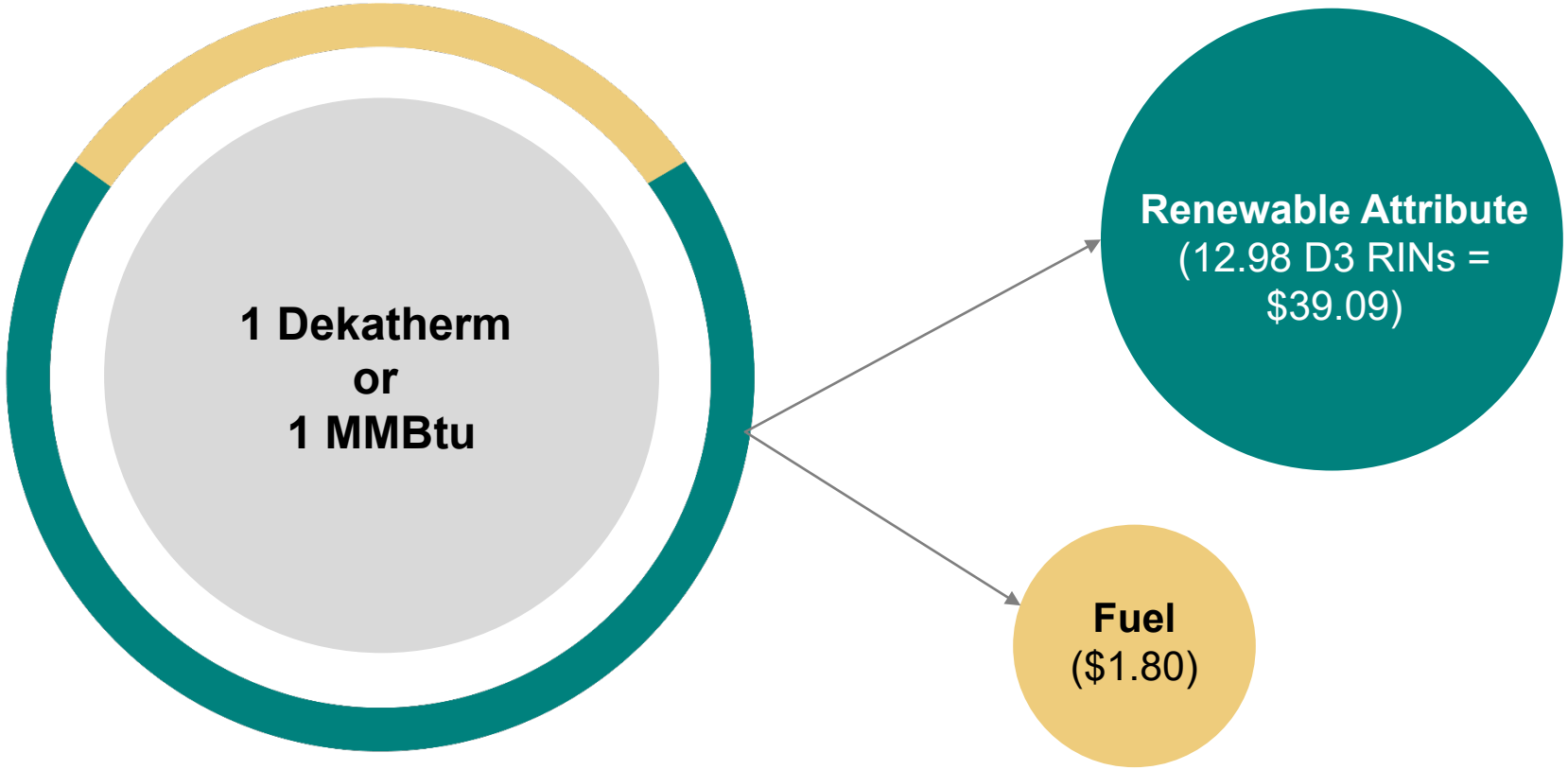
Opportunity for Better Biogas Utilization

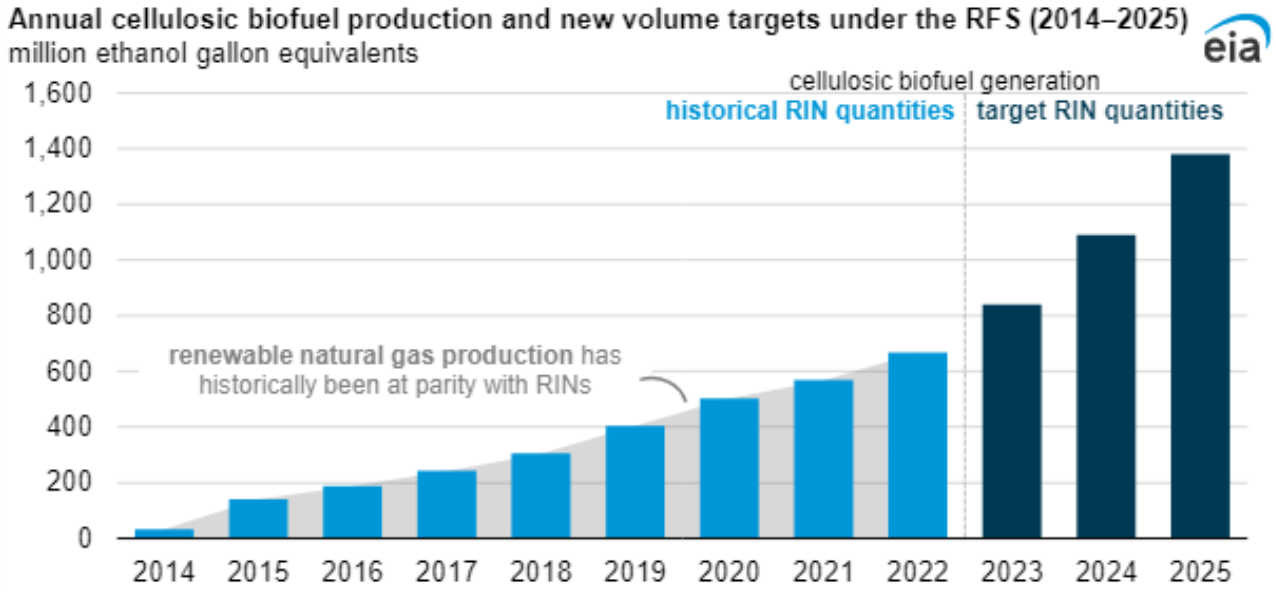
Understanding the Value of Biogas as RNG



1 Dekatherm = 1 MMBtu
1 Ethanol Gallon Equivalent = 77,000 Mbtus = 1 RIN

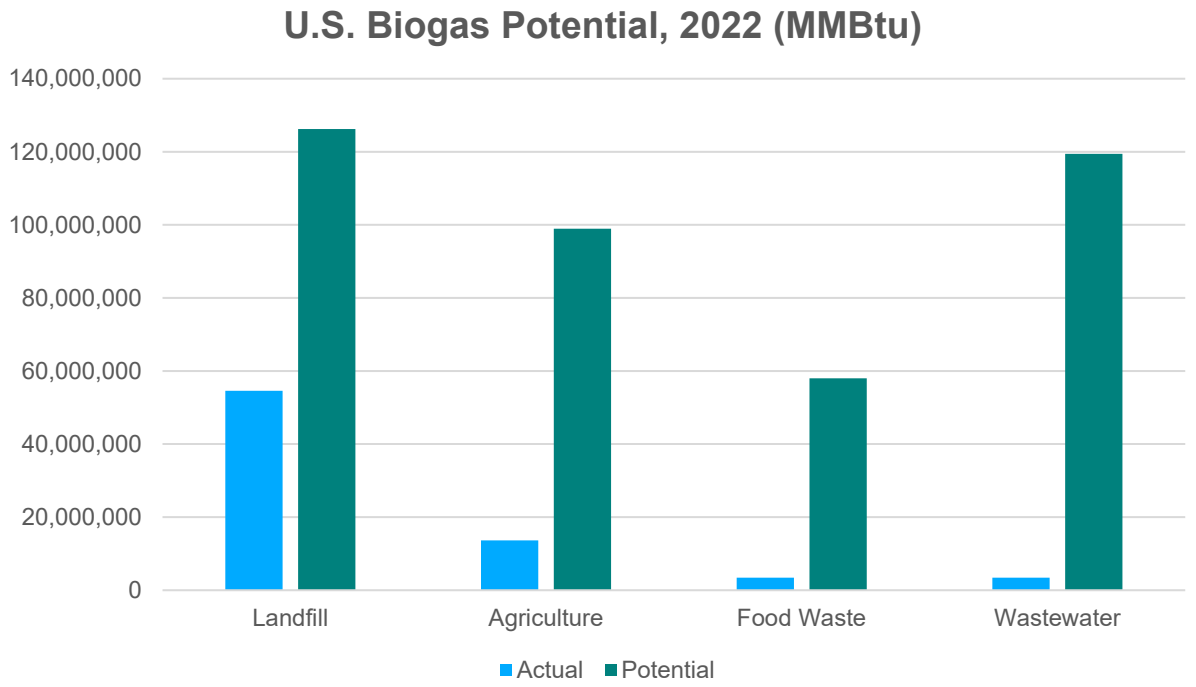
Growth of the Biogas Market

- Origins of a biogas ecosystem started with electricity production and landfill feedstock – mainly to comply with new anti-pollution regulations
- Federal and local programs started by targeting pollution from transportation:
  - Federal – Renewable Identification Numbers (RINs) under the Renewable Fuel Standard Program
  - California – Low Carbon Fuel Standard (LCFS)
- Both LCFS and RINs were game changers and incentivized the development of a biogas ecosystem
- These programs have market exposure: potentially high returns (short payback) but with higher risk



The U.S. Biogas Market

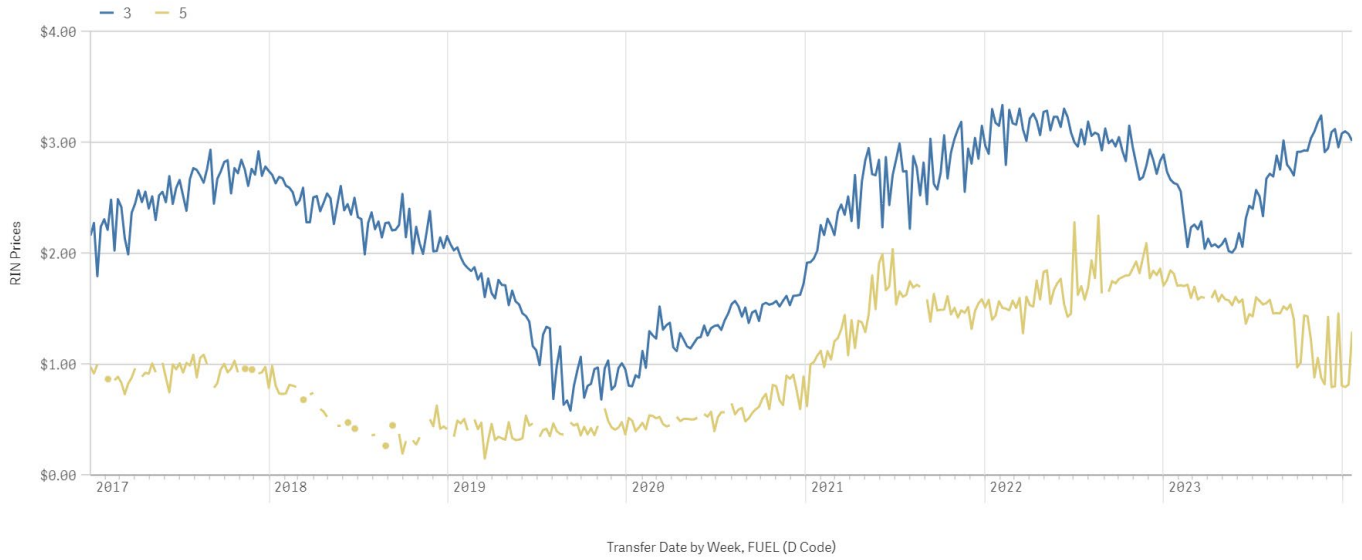
- Biogas production:
  - 75 Million MMBtu in the U.S. Vs. 133 Million MMBtu in Europe (2022)
- Only a small portion of the feedstock has been exploited
- There is room for growth
  - Low-hanging fruit is still available
  - Challenges reside in grid connection, and feedstock collection
- The **current natural gas demand in the U.S. is around 31 Billion MMBtu** (Source: EIA, 2023)



RINs: Flagship Federal Biomethane Program for Transportation

Renewable Identification Numbers (RINs) Under the Renewable Fuel Standard Program:

- The Environmental Protection Agency (EPA) sets the required Renewable Fuel Standard (RFS) volumes and percentage standards for the following years
  - On Dec. 1, 2022, it announced standards for 2023, 2024, and 2025
- Current and past administrations have influenced the rules, impacting the market prices of RINs
- ExxonMobil, Chevron, and BP are the primary buyers of RINs

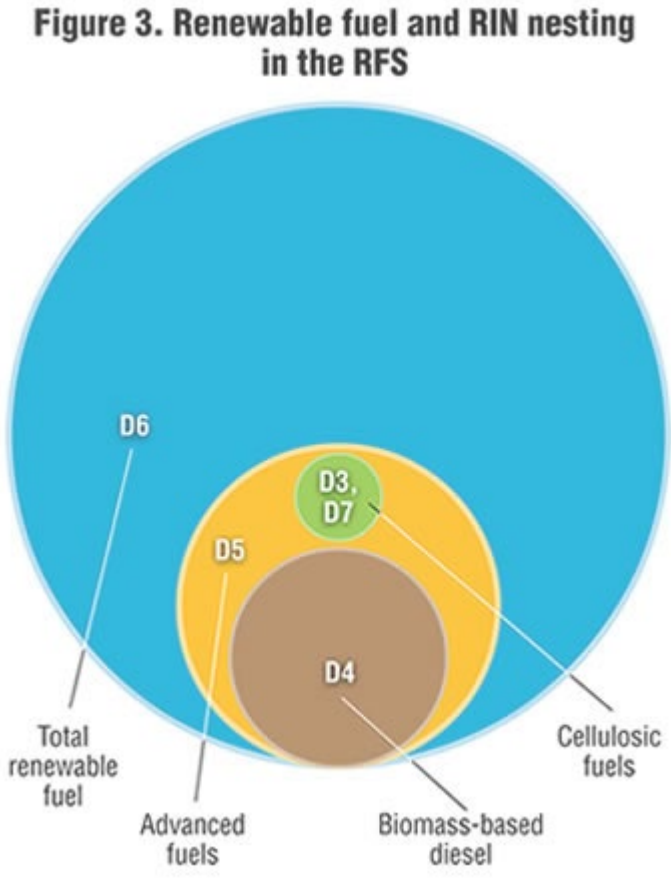


RIN Classifications

Fuel type	Feedstock	D-Code
Renewable compressed natural gas, renewable liquefied natural gas, renewable electricity	Biogas from landfills, municipal wastewater treatment facility digesters, agricultural digesters, and separated MSW digesters; and biogas from the cellulosic components of biomass processed in other waste digesters	3 (cellulosic biofuel)
Renewable compressed natural gas, renewable liquefied natural gas, renewable electricity	Biogas from waste digesters	5 (advanced)

How to use RINs – An example with D3

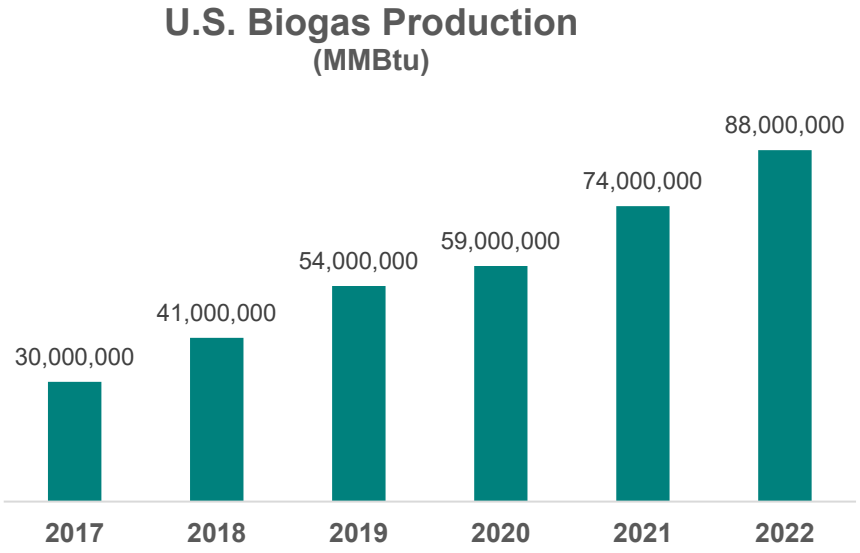
- D3 RINs Nominal Prices, USD / gal = $3.01 (Q1 2024)
- D3 RINs Nominal Prices, USD / MMBTU = $39.09
- Buyers usually buy at ≈ 25% discount
- After the buyer's discount, D3 RINs sell price USD / MMBTU ≈ $29.30

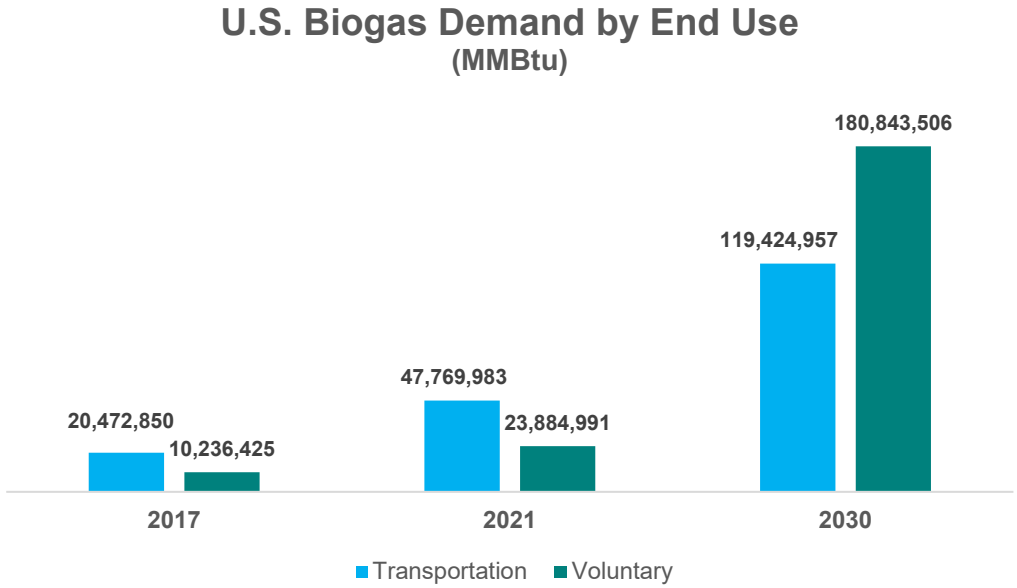


Biogas in Figures

Market Insights

- With investments attracted to landfills, dairy farm feedstock, and now wastewater and food waste, RNG production is expected to continue growing
- It is expected that voluntary buyers' demand will be significantly higher than transportation by 2040
  - More sources of feedstock will be developed in the United States to meet the demand



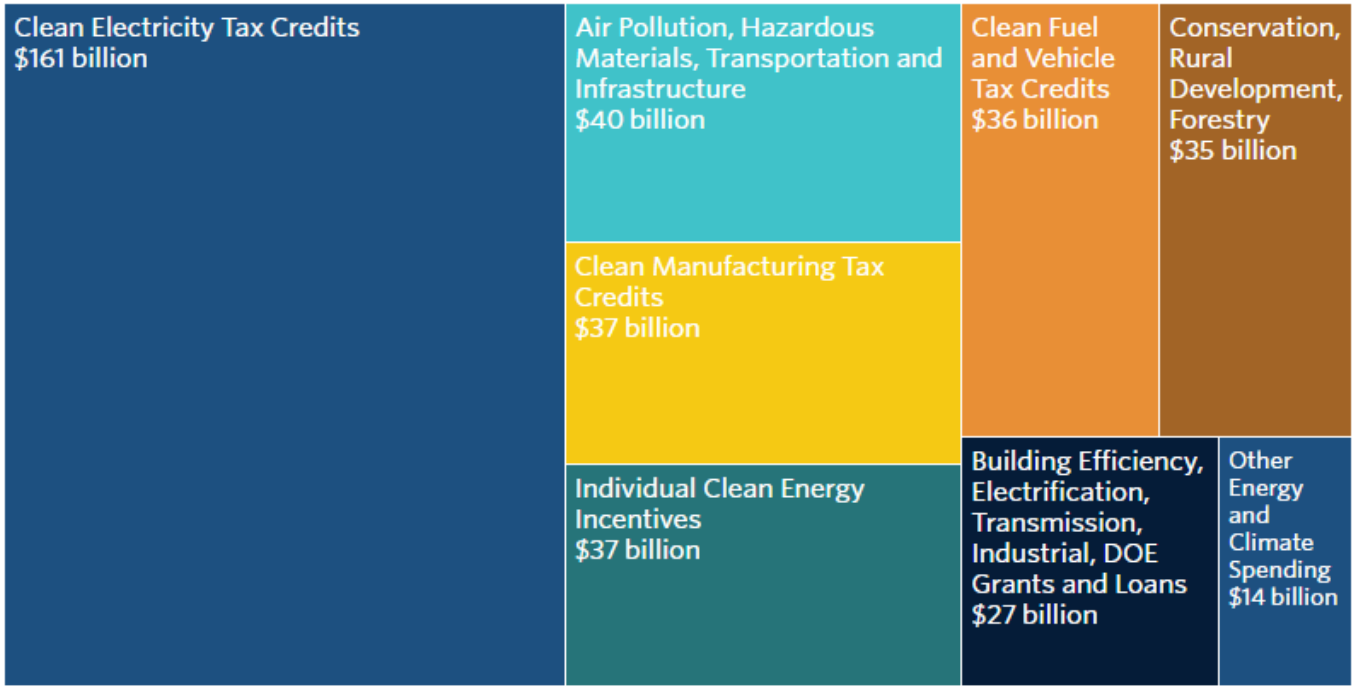


Inflation Reduction Act (IRA)
Historic Climate and Energy Legislation

Key energy and climate elements of the IRA:

- Over 10 years
  - $369B climate and energy spending
    - Tax incentives
    - Grant funding
  - Reduces cost of clean, renewable energy
  - Puts the U.S. on path of 40% GHG reduction by 2030
  - Supports environmental justice and domestic content preferences

The Inflation Reduction Act includes **$360B+** in climate investment, tax credits, and loans

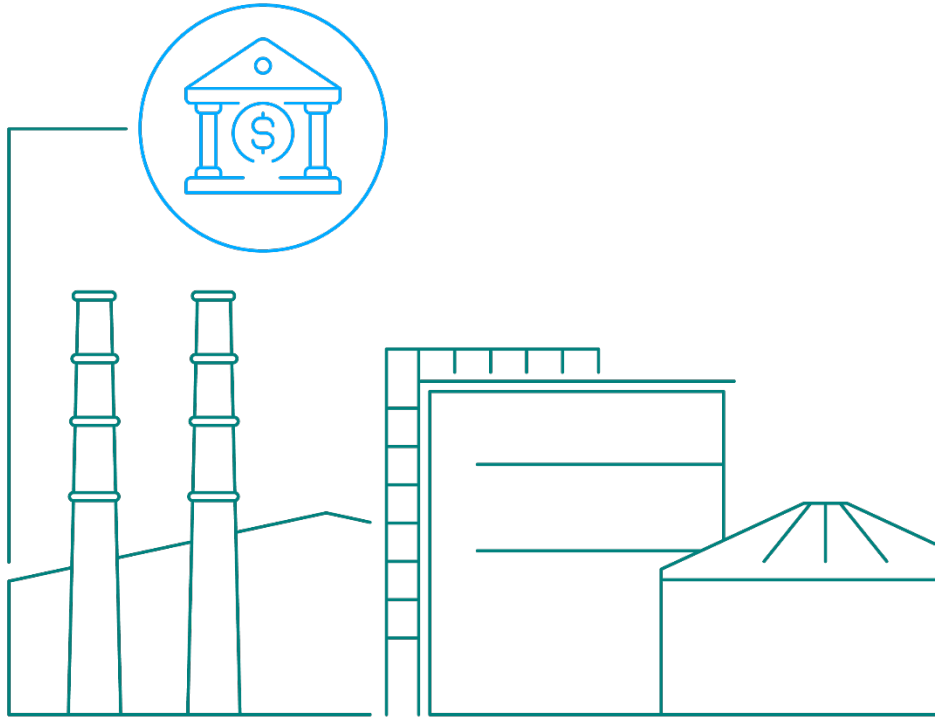


Source: Committee for a Responsible Federal Budget
Note: Senate Democrats estimate that the bill will provide $369 billion in climate and energy investment. CFRB estimates the figure at $386 billion.

Inflation Reduction Act (IRA)
Historic Climate and Energy Legislation

IRA as it relates to Biogas and RNG:

- Investment tax credits are set to expire on December 31, 2024
- They will transition to production tax credits
- Energy Production Tax Credit (PTC)
  - 1.25 cents per-kilowatt hour (adjusted each year for inflation) for the first ten years of operation. This tax credit is based on the electricity produced using biogas generated from the anaerobic digestion process.
- Clean Fuel Production Tax Credit (45Z)
  - Production of transportation fuel from anaerobic digesters could qualify for up to $1.00 per gallon (or equivalent) of fuel, provided certain emissions standards are met.
  - This credit applies only to transportation fuel produced during the years 2025 through 2027.
  - That's equivalent to an additional $13 per MMBtu.



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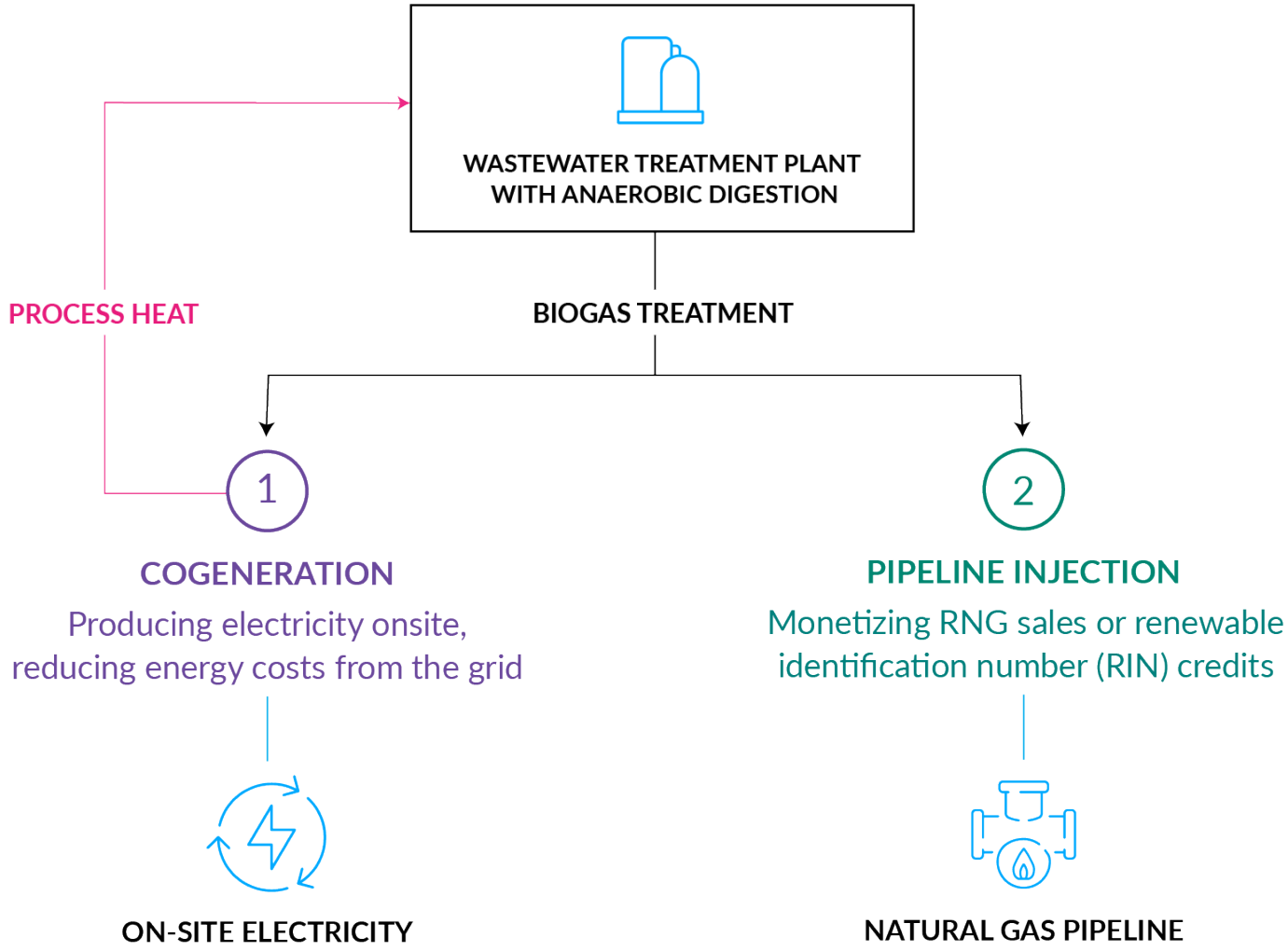
Two Primary Ways to Utilize Biogas

Harnessing Biogas as an Asset



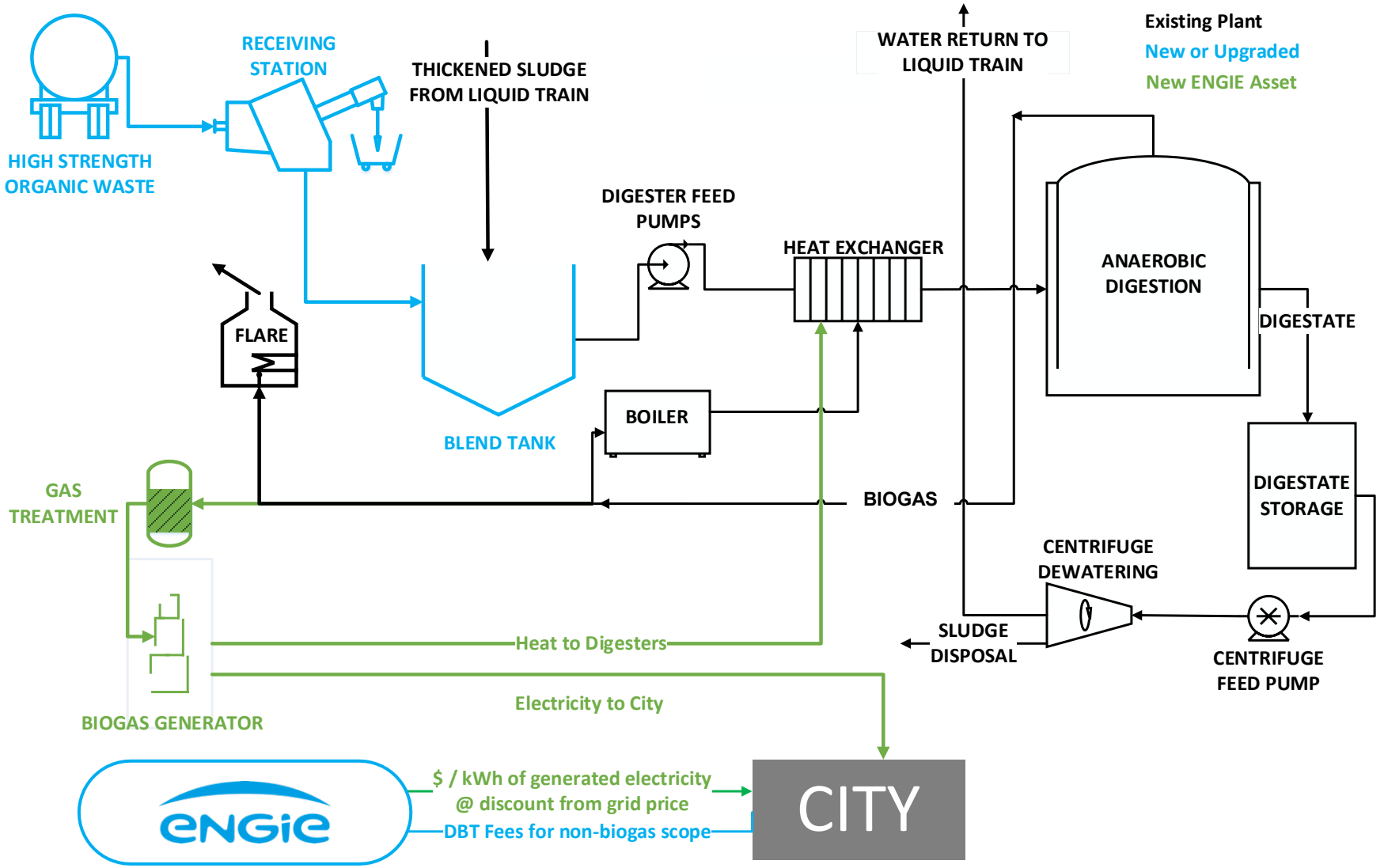
Advantages and Disadvantages of Cogeneration

- Power generated can be used internally without utility company involvement
- The most common method of biogas utilization for wastewater plants <50 mgd
- Gas cleaning required to remove hydrogen sulfide, siloxanes, and moisture
  - Hydrogen sulfide oxidizes to sulfuric acid when burned which corrodes internal combustion engines
  - Siloxanes burn to form silicon dioxide (silica) which causes deposits in engine cylinders
  - Adequate preventive maintenance can cost $0.06 to $0.09/kWh generated.

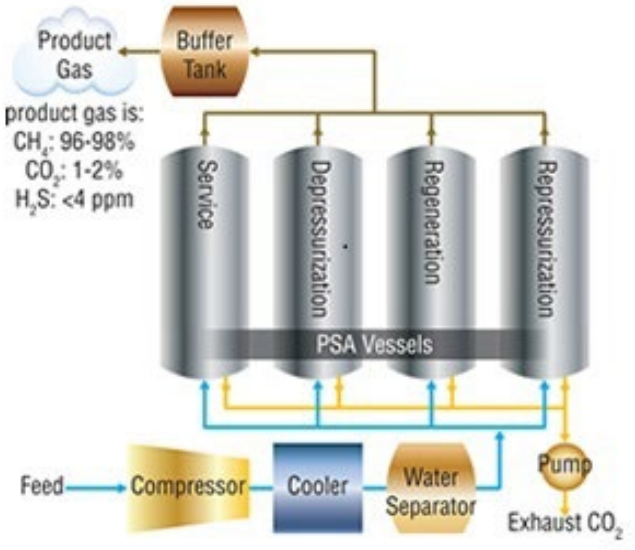
Cogeneration with Biogas

- Biogas is either burned or oxidized to generate thermal energy which is used to generate electricity. There are three main technologies:
  - Reciprocating engines and turbines
  - Fuel cells
  - Linear expansion engines (Mainspring Linear Generator)
- The first two are heavily dependent on gas quality
  - Removal of hydrogen sulfide
  - Removal of siloxanes
  - Removal of moisture
- Energy content typically between 500 – 650 BTU/cubic foot (by comparison natural gas has a heating value around 1000 BTU/cubic foot)

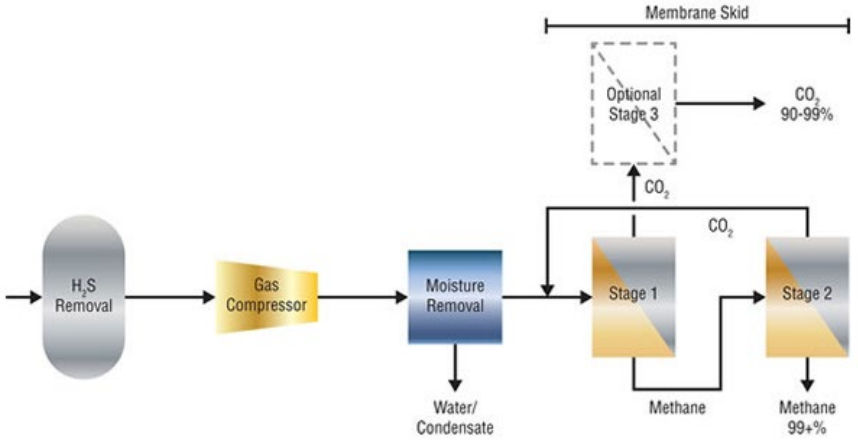
Biogas Treatment with On-Site Cogeneration



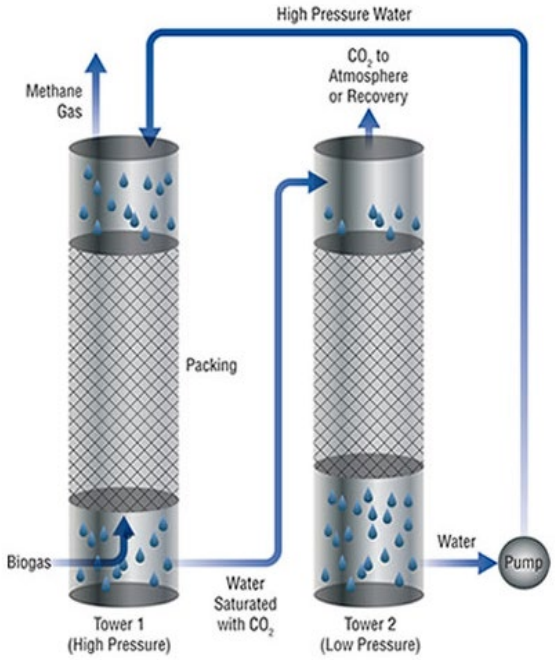
Technologies for Purification of Methane from Biogas



Pressure Swing Adsorption

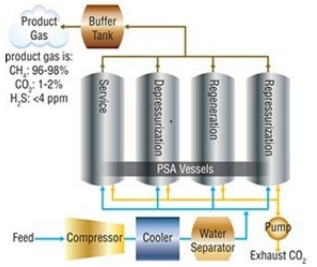


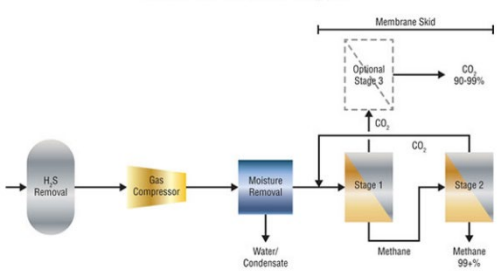
Membrane Separation

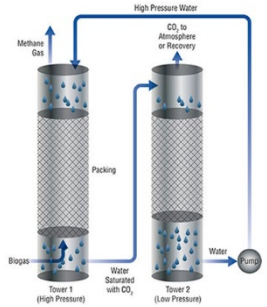


Water Sorption

Technical Considerations

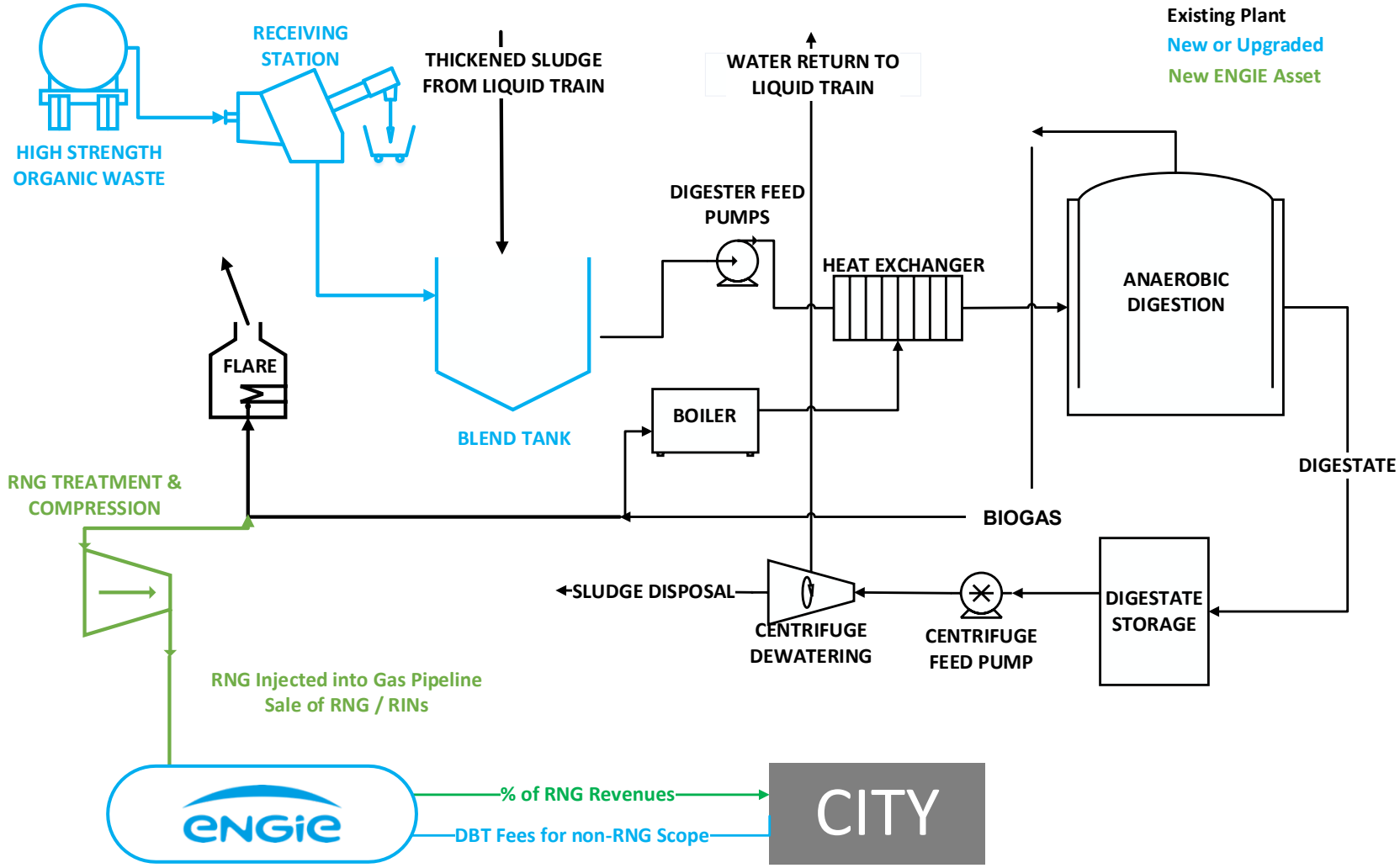






	Pressure Swing Adsorption	Membrane Separation	Water Sorption
Complexity	Simpler	Simpler	More Complex
Energy Use Intensity	Higher	Moderate	Low
Gas Yield	Similar	Similar	Similar
Need to Treat Tail Gas	Yes	Yes	No
CapEx Cost	Moderate	Lowest	Highest
OpEx Cost	Moderate	Highest	Lower
Noise	Manageable	Less	Less
Scale Considerations	Costly at Large Scale	Less Proven	Costly at Small Scale
Equipment Useful Life	20+	20+	30+
Vendor Options	Fewer, O&M Lock-in	Single, O&M Lock-in	Integration of Multiple
Water Consumption	No	No	Yes

Biogas Treatment to RNG with Pipeline Injection



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Biogas Utilization Examples

West County Wastewater District

Comprehensive Infrastructure Project

Need for Comprehensive Energy, Infrastructure, and Process Improvement

West County Wastewater District, located in Richmond, California, needed comprehensive energy, infrastructure, and process improvement programs designed to significantly reduce the organization's carbon footprint and greenhouse gas emissions.

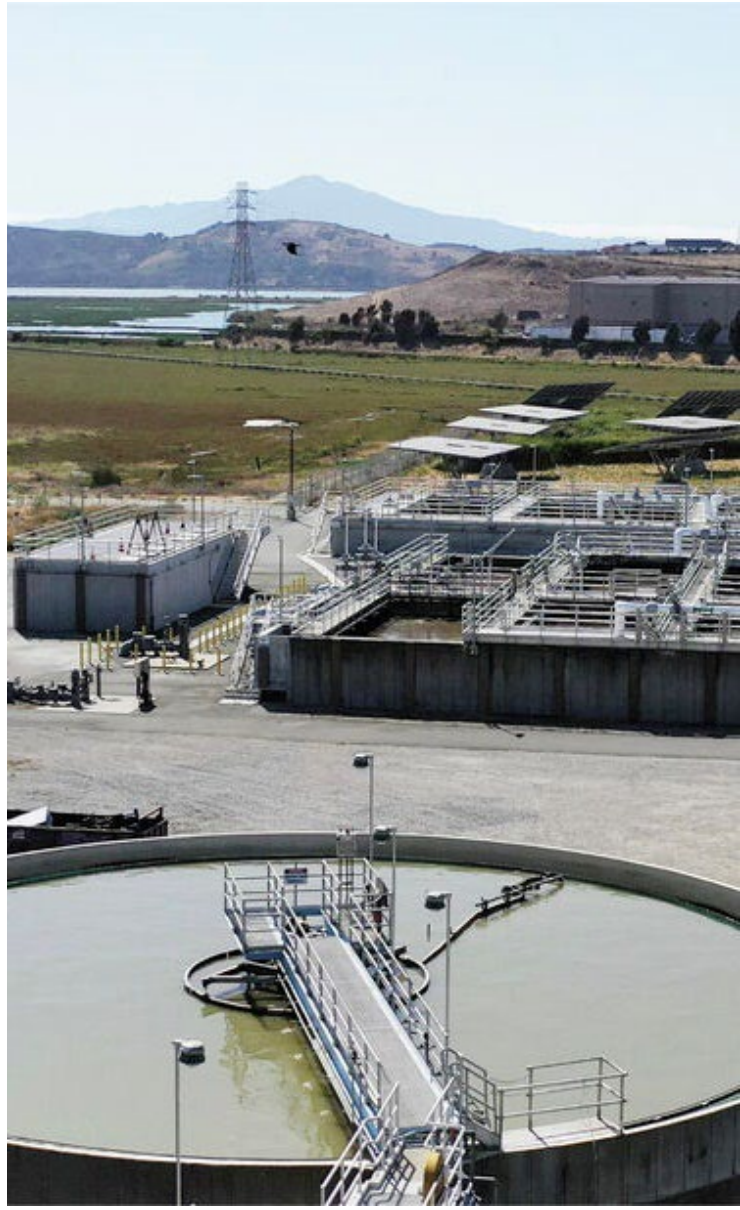
Solution

By partnering with ENGIE, the district will move toward a cleaner future, by:

- Implementing renewable energy generation: **1.1 MW** solar PV, LED lighting, and EV charging stations
- Upgrading the wastewater treatment plant
- Implementing a **450 kW** cogeneration system powered by biogas
- Generating Class A biosolid for agricultural and reclamation uses

Benefits

- **4.2 million** kWh energy use reduction per year
- **93%** greenhouse gas reduction over program life
- **$83 million** net program life savings
- Significantly improve process control over wastewater treatment and digestion
- Reduce disposal costs of organic material destined to landfills
- Includes robust community impact program with internship opportunities and career paths for high school and college students



Metro Water Recovery

Harnessing Energy from Methane Gas and Saving Costs

Need to Upgrade Outdated Biogas Infrastructure

Since 1984, Metro Water Recovery in Denver, Colorado harnessed energy from the methane gas from its digesters using a combined heat and power (CHP) plant. Now decades old, this infrastructure was inefficient to operate and maintain. Leadership wanted to deploy a better approach to co-generation while minimizing CapEx requirements.

Solution

Through an energy services agreement (ESA), ENGIE and Metro Water Recovery transformed co-generation:

- ENGIE financed, installed, owns, and operates two large, modern gas turbines that generate electricity and hot water to be used onsite.
- No CapEx funds were required from Metro
- Metro pays ENGIE for power and hot water consumed—at a lower rate than the local utility

Benefits

- **35,000+ mWh** of power generated onsite annually
- **30 million BTU/hour** of hot water capacity
- **Significant savings** on energy costs compared with purchasing from grid
- **Eliminated operational risk** for energy infrastructure

Broward County Wastewater Plant

Cost-effective Wastewater Treatment Upgrades

An Opportunity to Maximize Treatment Capabilities & Reduce Costs

In 2011, with the goal of lowering its overall operating costs, Broward County began investigating ways to better process fats, oils, and grease (FOG) and leverage cogeneration technologies at its wastewater plant.

Solution

ENGIE designed and implemented a turnkey, process improvement solution:

- New system collects FOG for more efficient treatment in anaerobic digesters
- Biogas cleaning system for the conditioning and transfer of gas to a cogeneration engine
- Cogeneration system capable of producing up to **1.99 MW of power**
- Electrical and control integration for operation of the new systems

Benefits

- Cogeneration system **offsets 25% of the electricity** the plant would otherwise purchase from the grid
- Reduces greenhouse gas emissions by **8,893 metric tons** annually, equivalent to removing 1,879 cars from the road
- **$26 million in guaranteed savings** over 17 years
- County received both **regional and statewide recognition** for sustainability leadership

04

Partnering for Plant Upgrades

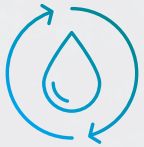
Challenged by Infrastructure Performance & Investment?

Are you dealing with **unfunded mandates or compliance issues**?

Is your staff bogged down by **individual component failures**?

Do you need to **expand services to keep up with demand**?

Do you need to **cut costs or boost revenues**?



Are you worried about **operational disruptions**?

Do you have the resources to **meet sustainability goals**?

ENGIE's Comprehensive Design-Build Approach

ENGIE is with you every step of the way providing detailed infrastructure audits, financing solutions, project management, and stakeholder engagement.

Planning

- **Infrastructure & inventory assessment:** state of current equipment and operations (needs assessment)
- **Solution integration:** technology options and configurations (sensors, controls, other peripheral smart technology)
- **Financial analysis:** cost and savings estimates, incentives, financing and ownership structures
- **Stakeholder engagement:** communications, outreach and approvals

Implementation

- **Site design:** engineering, mechanical and electrical design
- **Incentive applications:** filing and compliance support
- **Procurement:** energy system equipment, luminaires, nodes, controls, poles, wires, peripheral smart technology (cameras, sensors, data, etc.)
- **Installation:** construction, testing and commissioning

Operation

- **Operations & maintenance:** preventive maintenance and repairs
- **Energy management:** IOT platform (automatic/remote controls, outage detection, repair dispatch)
- **Measurement & verification:** report on performance and savings
- **Community engagement:** programming and project impact

About ENGIE

Delivering comprehensive, integrated services across the entire energy value chain. A preferred provider to cities, counties, universities, school districts, healthcare providers, and other social infrastructure organizations.

Clean Energy Leader

50 Years' Experience

in the U.S. researching, designing, operating, and investing in a wide range of energy solutions

Access to Intelligence

from ENGIE's $230 million annual R&D investment globally

1,740 Public Serving Organizations

served in the U.S. (municipalities, universities, schools, and hospitals)

38 GW

of renewable energy capacity worldwide in 2022

26 Mt

of CO2eq emissions avoided globally by ENGIE projects with customers

Questions?

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