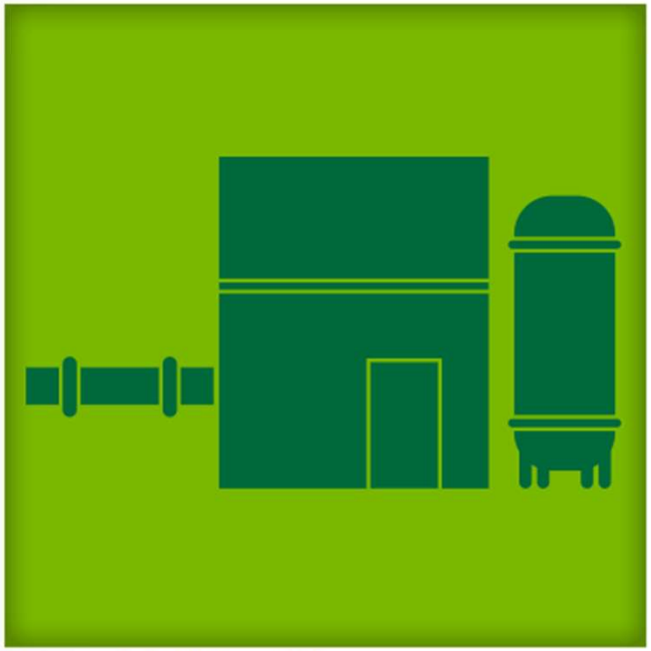


Renewable Natural Gas

Waste Management Renewable Natural Gas Overview for the Kentucky Clean Fuels Association

November 11, 2020

WM Renewable Energy

Louisville RNG Video

Waste Management At-A-Glance

The leading provider of comprehensive waste management services in North America, Waste Management holds a unique, fully integrated view that is unrivaled in our industry. Our asset portfolio spans across all components of RNG: landfills, RNG facilities, CNG/LNG fueling stations, landfill gas-to-energy facilities, and our hauling fleet.

RENEWABLE NATURAL GAS

Waste Management At-A-Glance[1]

OPERATIONS

43.7K employees

314 transfer stations

20M customers served

ENERGY

~10,100 alternative fuel vehicles

160 natural gas fueling stations

130 landfill gas-to-energy facilities

RECYCLING

44 construction and demolition recycling facilities

4 CORe® facilities

2 dual stream recycling facilities

44 single stream recycling facilities

40 composting/chipping/grinding facilities

28 commercial/paper only recycling facilities

14 other facilities

2018 FINANCIALS

$1.8B returned to shareholders

$3.6B cash from operations

$1.7B capital expenditures

$14.9B total revenue

LANDFILLS

247 active solid waste landfills

5 active hazardous waste landfills

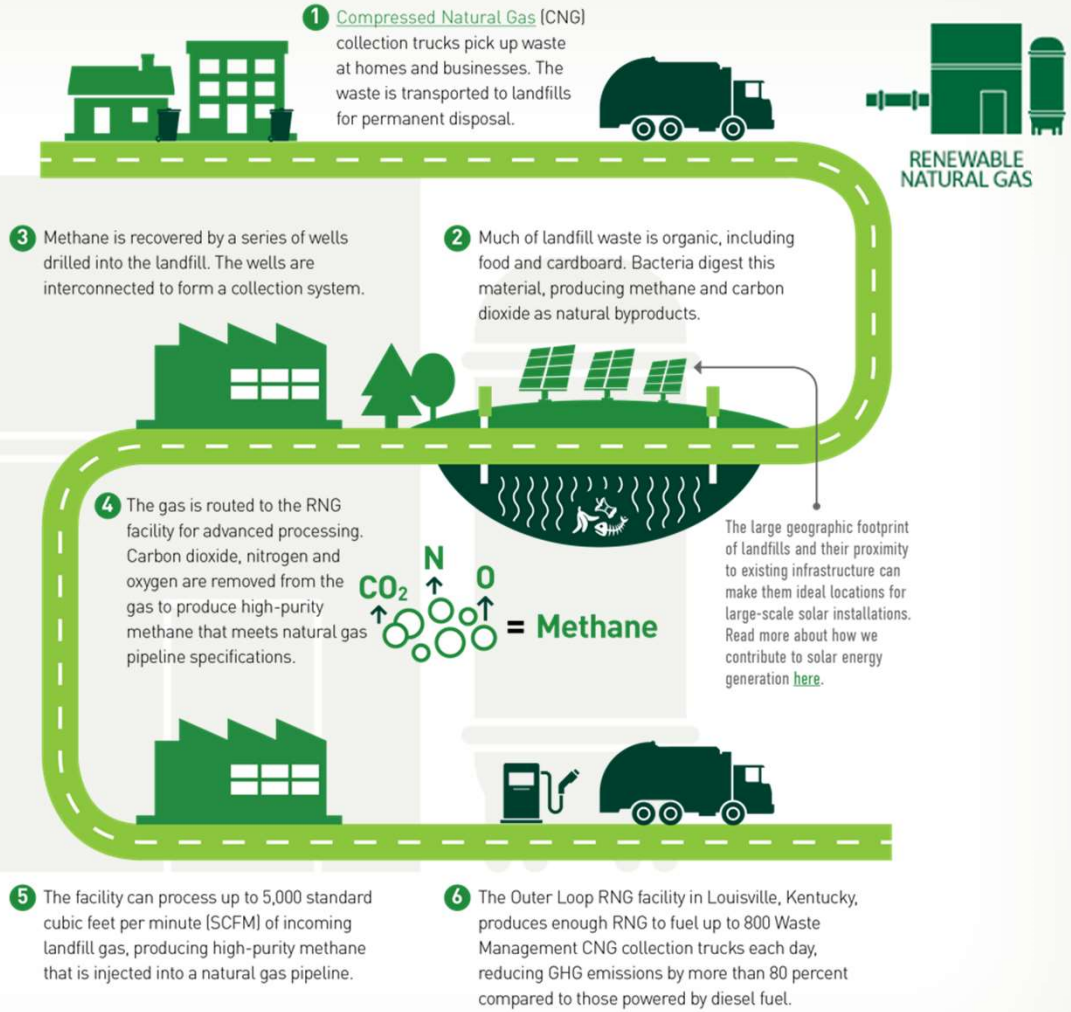
1 As of and for the year ended December 31, 2018. Waste Management, Inc. is a holding company, and all operations are conducted by its subsidiaries.

RNG Overview

- RNG is responsible for approximately 98 percent of the fuel used to satisfy the cellulosic biofuel category of the RFS, over 95 percent of which is derived from landfill operations.

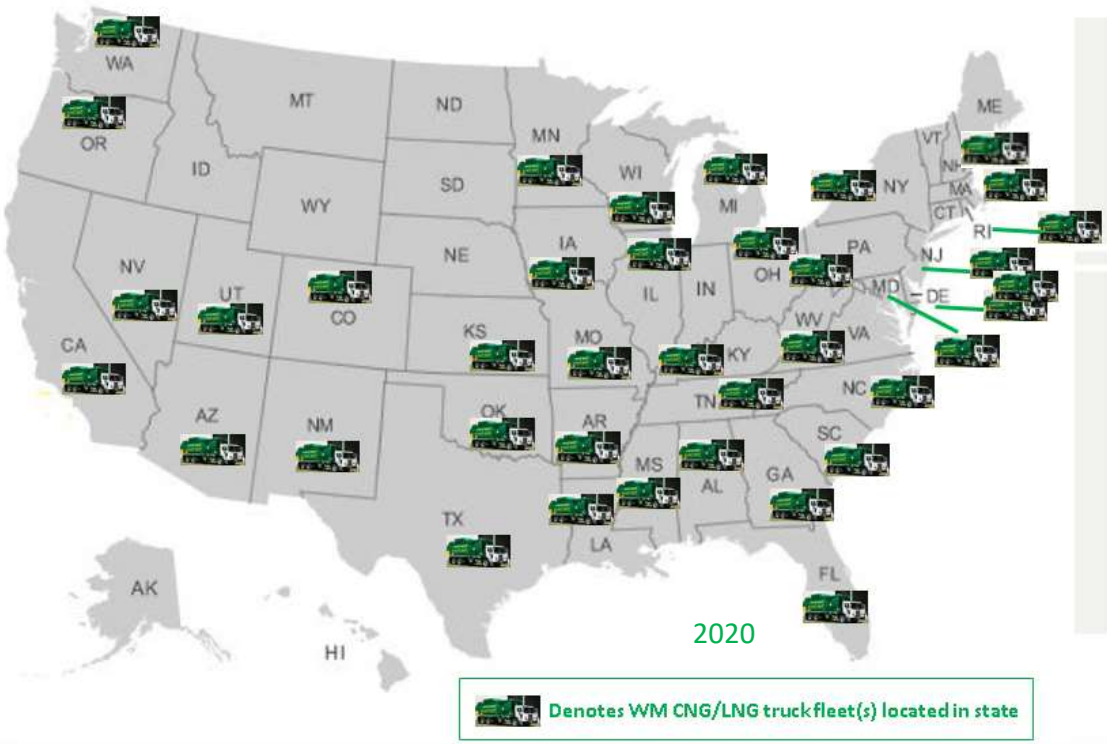
- RNG reduces up to 80 percent of CO_2 emissions relative to diesel fuel, improves local air quality, and facilitates a quieter driving experience for our customers and communities.

- Waste Management currently is among the largest producers of RNG, with significant investments in RNG facilities, CNG/LNG fueling stations, and CNG/LNG vehicles.



RFS/LCFS Drives Investment In Clean Vehicles

RENEWABLE NATURAL GAS



Current fleet & station portfolio

- **$2.7 billion investment:** ~10,100 active CNG/LNG trucks across 38 states
- **$340 million investment:** 160 fueling stations
- 25 public access stations providing dedicated fast-fill pumps open to commercial & consumer vehicles

Future fleet & station portfolio

- **$5 billion total investment**
  - ~16,000 total active CNG/LNG trucks by the late 2020's (assuming favorable market conditions), all manufactured in the United States
  - By 2025, potential for ~80% of WM's NGV fleet to run on RNG
- **$600 million total investment**
  - 260+ fueling stations

Participants in the RNG industry

WM is the largest landfill and fleet owner, and amongst the largest RNG developers in the United States.

RENEWABLE NATURAL GAS

Developers

WASTE MANAGEMENT

aria energy
FORTISTAR
Clean Energy
SEVANA BIOENERGY
Montauk energy
DTE Energy
AMERESCO
Green • Clean • Sustainable
AIR LIQUIDE
mas Energy
ampAMERICAS
ROESLEIN
MORROW RENEWABLES

Landfill Owners

WASTE MANAGEMENT

REPUBLIC SERVICES
WASTE CONNECTIONS
Connect with the Future

Municipalities & Counties

Fleet Owners

WASTE MANAGEMENT

REPUBLIC SERVICES
ups
FedEx
PEPSICO
ANHEUSER-BUSCH

Public Transit Agencies

Technology Providers

VILTER
IOGEN
ARI
GREENLANE BIOGAS
EVONIK INDUSTRIES
AIR LIQUIDE

QAP Providers

weaver
Assurance • Tax • Advisory
ecoengineers
GENSCAPE
RINtrust
RIN Verification Services

Obligated Parties

Chevron
bp
CITGO
PHILLIPS 66
VALERO
MARATHON
ExxonMobil
MOTIVA

Sample selection of RNG industry participants

Current RNG Production Facilities

RENEWABLE NATURAL GAS

- Waste Management has invested **$50 million** in two operating RNG facilities: Milam in St. Louis, MO (2015) and Outer Loop in Louisville, KY (2018).

Milam

Outer Loop

- 3 additional RNG facilities in engineering
- 4 in feasibility study phase
- 42 identified candidate sites for future RNG development

Skyline Renewable Natural Gas Facility

5,000 SCFM project
3,500 MMBtu/day

$46MM investment

Fueling 1,100 CNG trucks/day

RENEWABLE NATURAL GAS

Waste Management recently completed our newest & most advanced RNG facility, located on our Skyline landfill (Ferris, Texas)

The facility attained operational status in January 2020 & begin injecting **pipeline quality** gas into the Atmos Energy system

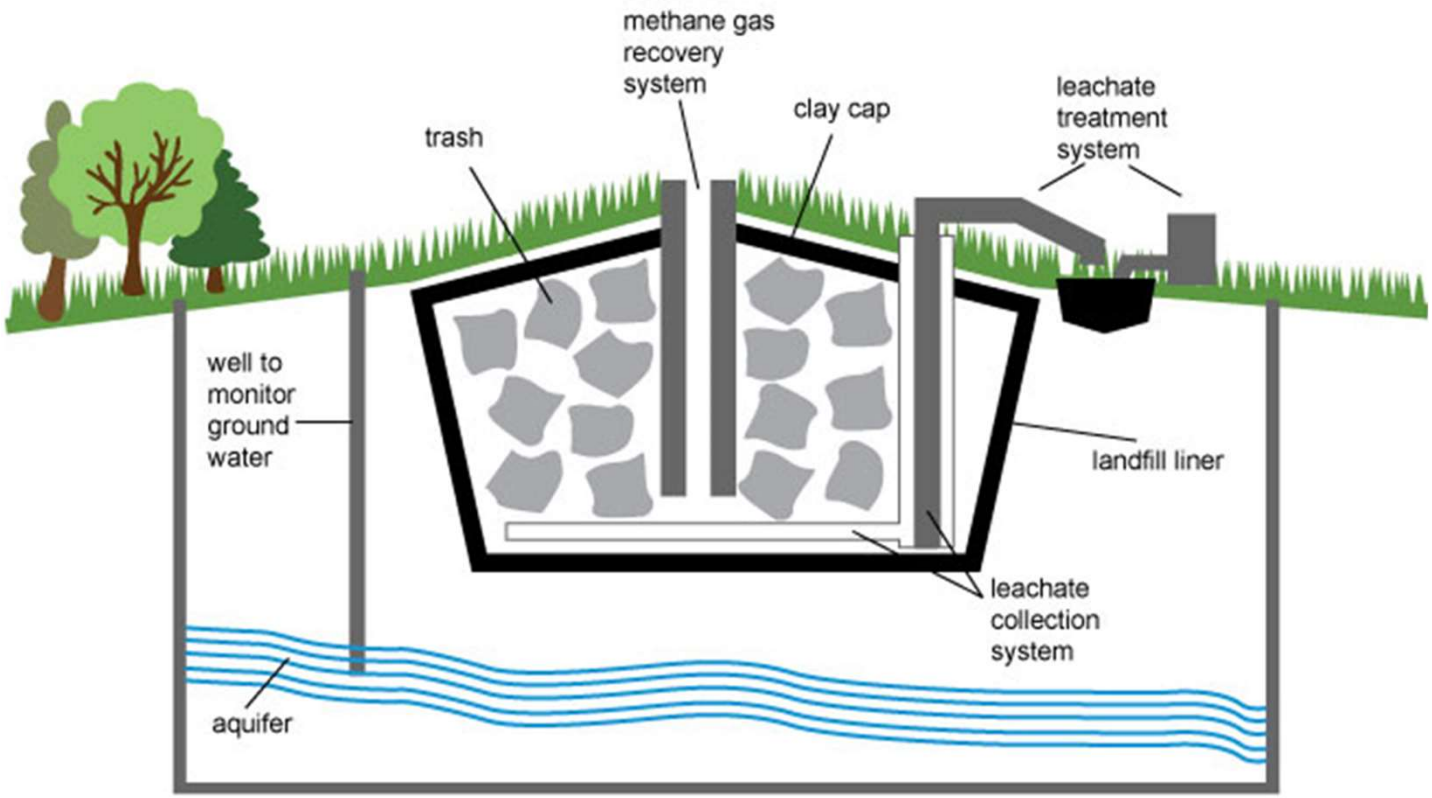
A membrane based separation system manufactured by Air Liquid Advanced Separations (ALAS) for removal of carbon dioxide from the raw landfill gas stream

The product gas from the ALAS is then processed for removal of nitrogen & oxygen by a pressure swing absorption (PSA) system manufactured by Adsorption Research, Inc. (ARI)

The ARI system will recover 96.14% of the methane in the product, while off gases will be destructed in a thermal oxidizer on site

Landfill gas basics: landfill construction and gas extraction

RENEWABLE NATURAL GAS



Landfill gas basics: gas composition

RENEWABLE NATURAL GAS

- Composition of landfill gas is reflective of the input waste to the landfill, but primarily composed of methane and carbon dioxide formed through the mesophilic anaerobic digestion of organic wastes:

$$\text{Ex. } C_6H_{10}O_5 + H_2O \rightarrow 3CH_4 + 3CO_2$$

- Primary constituents
  - Methane (45-60%) – generated from anaerobic digestion and decomposition of organics (paper, cardboard, food, yard wastes, etc)
  - Carbon dioxide (30-40%) - generated from anaerobic digestion and decomposition of organics (paper, cardboard, food, yard wastes etc)
  - Water vapor (5-10%) – gas is saturated with water vapor due to permeation of rainwater, recycled leachate, and wet wastes
  - Nitrogen (2-10%) – present due to air intrusion (drawn from atmosphere at gas collection leak points)
  - Oxygen (0-2%) – present due to air intrusion (drawn from atmosphere at gas collection leak points)
- Minor constituents
  - Carbon monoxide (<100 ppm) – generated in early aerobic digestion of organics
  - Hydrogen (<100 ppm) - generated in early aerobic digestion of organics
  - Sulfides (<500 ppm) – predominately H2S generated through the decomposition of gypsum / sulfates found in construction waste (wall board)
  - Siloxanes (<50 ppm) – generated from the decomposition of cosmetics and deodorants
  - NMOCs (<500 ppm) – volatilized from disposed chemicals and reactions between compounds (solvents, oils, refrigerants)

Landfill gas basics: processing to pipeline-grade gas

RENEWABLE NATURAL GAS

Raw LFG →

Pre-treatment

- Pressurization
- De-watering
- Particulate removal
- H_2S removal

- Compression
- Chilling
- Filtration
- Solid adsorbents
- Wet scrubber

→

Primary processing

- CO_2 removal
- Sulfides removal
- Siloxane removal
- H_2 and CO removal
- NMOC removal
- O_2 removal
- H_2O removal

- PSA's
- Membranes
- Solid adsorbents
- Physical solvents
- Chemical solvents
- Cryogenic separation
- DeOxy unit
- Dryer units

→

Final polishing

- Nitrogen removal

- PSA's
- Membranes
- Cryogenic separation

→ Pipeline gas

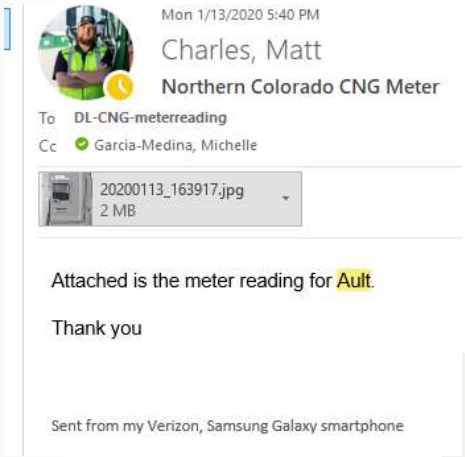
Meets quality specifications from pipeline tariff

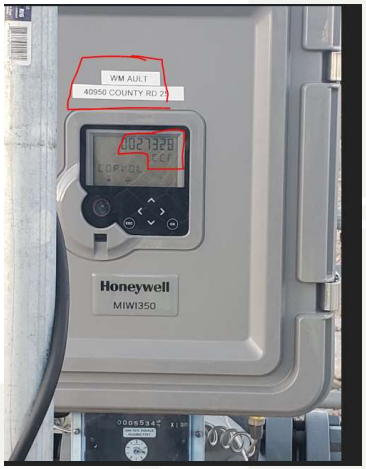
https://www.youtube.com/watch?v=vOBRajSRptE&feature=youtu.be

WM RNG fueling process (Ault, CO example)

RENEWABLE NATURAL GAS

#1: Weekly demand value

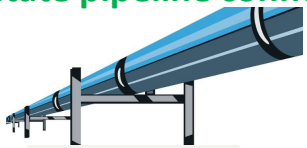




#2: Matched **entire** Ault, CO demand with RNG supply

Interstate pipeline connectivity

100 MMBtu CNG demand in Ault, CO



100 MMBtu RNG Supply at Outer Loop

Virtual fueling/displacement

#3: Generate environmental attribute

weaver
Assurance · Tax · Advisory

Sell D-3 RIN, LCFS, or to obligated parties

Waste Management utilizes the ability to fuel RNG through EPA, CARB, and ODEQ approved/preferred "virtual fueling/displacement" that does **not** require physical RNG to be delivered to CNG fueling sites. The **vast** majority of the RNG industry follows this fueling method, as **very few** CNG sites are fueled with physical RNG.

RENEWABLE NATURAL GAS

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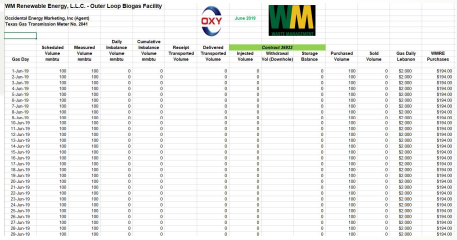
Matching process

Fleet demand (CNG)

Demonstrate pipeline connectivity

RNG production



CNG Demand ⟷ **RNG Supply**

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Check data before RIN generation

Thank you

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