Landfill Gas Utilization Industry Update

ESD· MWRA Solid Waste Technical Conference
March 27, 2019
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President & CEO, Aria Energy, Novi MI
Overview

• State of the LFG to Energy Industry

• Power Generation

• Renewable Natural Gas

• Current Opportunities

Canton, MI RNG Facility
Operational LFG Energy Projects by Type (February 2019)

- Electricity: 449
- Direct Use: 110
- RNG / Pipeline Injection: 52
- RNG / Local Use: 8
RNG Project Locations

USEPA Landfill Methane Outreach Program – February 2019
LFG Industry in the Early 1980’s

The first LFG projects produced pipeline quality gas

- Early projects High Btu – Pipeline Quality Gas
- 1982 - GSF Energy and Methane Development Corp (Brooklyn Union Gas/National Grid)
  - Teamed up to build the Fresh Kills RNG Facility
  - Producing RNG 37 years later
- Early 80’s energy prices where high and here to stay!
- Section 29 Non-Conventional Fuel Credit
- By mid 1980’s energy market changed

Fresh Kills RNG Facility
LFG generated power sold under long term fixed price contracts

- LFG is a qualified renewable resource
  - California Standard Offer #4 (1990’s California Program)
- State RPS requirements
  - Created market for renewable attributes
- Attractive rates for capacity and energy
  - Creditworthy counterparty
  - Renewable attributes easily monetized
  - Tracking and validation
- Federal tax incentives
  - Section 29 Non-Conventional Fuel Credit
  - Section 45 Production Tax Credit

Brevard, FL Power Project
LFG – Qualified Resource Under State Policy

Renewable Portfolio Standard Policies

www.dsireusa.org / October 2018

29 States + Washington
DC + 3 territories have a Renewable Portfolio Standard
(8 states and 1 territories have renewable portfolio goals)

Extra credit for solar or customer-sited renewables

Includes non-renewable alternative resources
Changes in Power Markets

Long term contracts less attractive

- QF under federal PURPA rules
  - PURPA challenged at state and federal level
  - Long term avoided cost below investment threshold
- State RPS requirements
  - Decrease in attribute values
  - Expanded rules favor new projects
  - Eligible NY Tier 1 Resources COD - Jan 1, 2015 or later
- New lows for capacity and energy prices over past three years
- Wind and solar cost significantly decreased
  - Contracts below $30/MWh
  - LFG no longer the low cost producer
- Federal tax incentives
  - No longer available for new LFG projects

Model City, NY Power Facility
Michigan Power Projects

Michigan a difficult market to develop power projects

- PURPA 1978 Law
  - Replacement being discussed in Congress
- Michigan PA2 of 1989
  - Long term fixed price power purchase agreements have delivery obligations and early termination penalties
- Expansion of Michigan RPS spurred new power project development in the late 2000’s.
  - Wind, solar, digester and landfill gas
- Proposed DTE and Consumers Energy avoided cost do not support in-state development of new power projects
  - Current discussion at Michigan Public Service Commission
  - National ramifications establishing avoided cost
• Biomethane:
  • Pipeline compatible gas derived from biomass or other renewable sources that has lower lifecycle CO2e emissions than geological natural gas.
RNG Projects in the US

USEPA Landfill Methane Outreach Program – February 2019
Fresh Kills, NY - Local RNG Resource
RNG Markets

RNG can be sold to utilities or used in the transportation sector

- RNG is processed on-site to utility specifications and transported through existing natural gas infrastructure
- Delivered to existing power plants
  - Generation resource qualifies to produce renewable energy
- Delivered to CNG/LNG fueling facility
  - Qualifies as a renewable fuel under the Renewable Fuel Standard as a cellulosic biofuel
- RNG prime drive in natural gas system decarbonization

Kansas City, KS RNG Facility
RNG Markets

RNG qualifies under state RPS requirements

- Allow traditional generation resources to produce renewable energy by consuming RNG
  - California
    - Encouraging development of in-state resources
    - Grandfathered qualified out of state resources
  - Connecticut
    - RNG produced in adjacent control areas qualifies to produce RECs
- New or increased RPS (Clean Energy Standards) qualify landfill and digester gas
  - New York
  - Massachusetts
  - North Carolina
LFG qualifies as a cellulosic biofuel

- The RFS requires obligated parties (importers and refiners of oil):
  - Blend renewable fuel into transportation fuel (ethanol, biodiesel)
  - Purchase RINs in order to meet renewable obligations
- RINs are typically obtained by obligated parties in one of two ways:
  - The obligated party purchases renewable fuel (ethanol, biodiesel) with an attached RIN which is then retired
  - Renewable fuel (RNG) is sold directly into the transportation market (CNG) generating a tradeable RIN sold to an obligated party
- One RIN is the equivalent of one gallon of gasoline (GGE)
- 11.727 RINs are generated by each MMBtu of RNG produced
- RNG produced from landfill gas is qualified for D3 RINs, which far exceeds the price of commodity natural gas and provide a valuable revenue stream
RINs were established to facilitate compliance with the Renewable Fuel Standard.
How does the Low Carbon Fuel Standard work?

- Fuels in the California transportation fuel pool that have a CI lower than the target established by CARB generate LCFS credits.
- Those fuels in the transportation fuel pool with CIs higher than the target generate deficits.
- A fuel producer with deficits must have enough credits through generation and acquisition to be in annual compliance with the standard.

What is the Low Carbon Fuel Standard?

- Established in 2007, the LCFS program is a market-based program designed to reduce greenhouse gas emissions in California.
- The program applies to fuels used for transportation, including gasoline, diesel and their alternatives.
- The program’s current goal is to reduce carbon intensities by 10% in 2020 and 20% by 2030.
RNG has access to premium offtake markets which provides the ability to earn additional revenue relative to commodity natural gas.

Source: SNL and Argus.
RFS Reform and Reset

- RFS was created by statute rather than directly by the EPA or Presidential executive order
  - An act of Congress is required to repeal, or even modify, the RFS
- Political support for the program and the political realities that Congress has faced, significantly mitigate against any immediate near-term risk of legislative repeal
- The Environmental Protection Agency (EPA) is required this year, in 2019, to modify or “Reset" the annual Renewable Volume Obligation (RVO) targets stated in the RFS statute.
- EPA considers – impact of renewable fuels on environment, energy security of the United States, expected production in each category, impact of renewable fuels on infrastructure, cost to consumers and job creation.
- EPA is required to consider same factors to set the volume requirements post 2022.
- EPA consistently raised annual RVO to reflect the growth in RNG industry resulting in 10x growth in demand for RNG over the past 5 years.
## Renewable Volume Obligation

<table>
<thead>
<tr>
<th>Million GGE</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D3 Cellulosic biofuel</strong></td>
<td>123</td>
<td>230</td>
<td>311</td>
<td>288</td>
<td>418</td>
</tr>
<tr>
<td><strong>Actual D3 Production</strong></td>
<td>140</td>
<td>190</td>
<td>251</td>
<td>312</td>
<td></td>
</tr>
<tr>
<td><strong>D4 Biomass-based diesel</strong></td>
<td>1,730</td>
<td>1,900</td>
<td>2,000</td>
<td>2,100</td>
<td>2,100</td>
</tr>
<tr>
<td><strong>D5 Advanced biofuels</strong></td>
<td>2,880</td>
<td>3,610</td>
<td>4,280</td>
<td>4,290</td>
<td>4,920</td>
</tr>
<tr>
<td><strong>D6 Renewable fuel</strong></td>
<td>16,930</td>
<td>18,110</td>
<td>19,280</td>
<td>19,290</td>
<td>19,920</td>
</tr>
</tbody>
</table>
Combined 17.6 MW power plant and 6,000 scfm RNG facility driven by environmental and interconnection considerations
Environmental Challenges

Regulations increasingly restrictive on power generation assets

- **National Ambient Air Quality Standard for Sulfur Oxides**
  - 1 hour standard
  - Modeling driving stack heights above 90 feet

- **Formaldehyde**
  - Regulated as a HAP and subject to MACT
  - Added to VOC calculations (NMHC + Formaldehyde)

- **Separate Source Determination**
  - Criteria: Same industrial grouping, contiguous property, common control

- **Replacement Engines**
  - Shop overhaul vs on-site overhaul

Sumpter Twp., MI Power Facility
Regulatory Drivers

**States that Ban Organics or Mandate Organics Recycling - October, 2014**

- **Ban/mandate some yard debris**: Arkansas*, Delaware, Florida*, Georgia*, Illinois, Indiana, Iowa, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska*, New Hampshire, New Jersey, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, South Dakota, Vermont, West Virginia, Wisconsin
  *Allow yard debris disposal in landfills that generate energy

- **Ban/mandate food scraps**: California, Connecticut, Massachusetts, Rhode Island, Vermont.

  Also of note: New York City, Seattle


**REDUCED ORGANICS = REDUCED GAS PRODUCTION**
### State Programs

<table>
<thead>
<tr>
<th>Program</th>
<th>Status</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vermont</td>
<td>Active</td>
<td>• In 2017, utility commission approved RNG program for Vermont Natural Gas (VGS) allowing it to offer RNG to customers.</td>
</tr>
<tr>
<td>DTE</td>
<td>Active</td>
<td>• Through ‘BioGreenGas’ program, DTE offers RNG to retail customers at $2.5 additional cost per month</td>
</tr>
<tr>
<td>California</td>
<td>Bill passed in Sept 2018</td>
<td>The bill requires CPUC to set biomethane procurement targets or goals for each gas utility.</td>
</tr>
<tr>
<td>Nevada</td>
<td>Bill introduced in Feb 2019</td>
<td>• Allowing utilities to make direct investments in RNG facilities, extending transmission and distribution to support RNG producers</td>
</tr>
<tr>
<td>Utah</td>
<td>Bill introduced in Feb 2019</td>
<td>• Commission may authorize utilities investment in fueling stations and RNG projects</td>
</tr>
<tr>
<td>Connecticut</td>
<td>Bill introduced in March 2018</td>
<td>• Initiated study to introduce RPS like program for RNG and procurement of electricity from Biomass facilities</td>
</tr>
</tbody>
</table>
### Utility Programs

<table>
<thead>
<tr>
<th>Program</th>
<th>Status</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minnesota</td>
<td>Proposal introduced by utility; being reviewed by the commission</td>
<td>• Center Point Energy proposes to offer RNG under a voluntary green tariff pilot program at $10 per month.</td>
</tr>
<tr>
<td>Dominion Energy</td>
<td>Investment in RNG</td>
<td>• Dominion Energy and Smithfield Foods formed a JV (called Align RNG) to invest in RNG projects in NC, VA and UT</td>
</tr>
<tr>
<td>SoCal Gas and SDG&amp;E</td>
<td>Proposal introduced by utility; being reviewed by the commission</td>
<td>• Filed a request with the California Public Utilities Commission seeking to offer RNG to its 21 million customers in Central and Southern California.</td>
</tr>
</tbody>
</table>
## Regulatory and Voluntary Programs

### LCFS Transportation Programs

<table>
<thead>
<tr>
<th>Program</th>
<th>Status</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oregon</td>
<td>Active</td>
<td>• Oregon Clean Fuels Program is similar to California's LCFS program with 10% reduction target by 2025.</td>
</tr>
<tr>
<td>Washington</td>
<td>Bill introduced</td>
<td>• Plan is to introduce program similar to California and Oregon LCFS program – 10% reduction by 2028 and 20% by 2035</td>
</tr>
<tr>
<td>New York</td>
<td>Bill introduced in February 2019</td>
<td>• The low carbon fuel standard is intended to reduce greenhouse gas emissions from the transportation sector by 20% by 2030.</td>
</tr>
<tr>
<td>Program</td>
<td>Status</td>
<td>Details</td>
</tr>
<tr>
<td>-------------------------</td>
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<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Apple</td>
<td>Active</td>
<td>• Using RNG to supply on-site generation at data centers</td>
</tr>
<tr>
<td>Google</td>
<td>Active</td>
<td>• Procuring RNG to help meet carbon reduction goals</td>
</tr>
<tr>
<td>University of California</td>
<td>Active</td>
<td>• Procuring RNG to help meet 2025 carbon reduction goals</td>
</tr>
<tr>
<td>Seattle Port Authority</td>
<td>RFP</td>
<td>• Seeking long term RNG supplies to meet carbon reduction goals</td>
</tr>
</tbody>
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BioGreenGas

Recycling Trash Into Renewable Natural Gas
BioGreenGas is a voluntary program supporting the local development of renewable natural gas by using the methane that arises naturally from landfills.

About BioGreenGas

As organic matter decays in landfills, it creates methane, a harmful greenhouse gas. Capturing this methane and removing the impurities creates a renewable source of pipeline-quality natural gas. For $2.50 per month, you can participate in the BioGreenGas program and join others in supporting renewable energy development to create a cleaner, more sustainable Michigan.
Voluntary RNG Program

Introducing our VGS Renewable Natural Gas Program

RNG Adder Calculator

Vermont Gas is committed to a sustainable future—that’s why we’re proud to offer our Renewable Natural Gas Program. Renewable Natural Gas is created from the methane produced by the organic material in landfills, wastewater treatment plants and farms. Our interactive Renewable Natural Gas adder calculator below can help you choose the amount that works with your budget and energy needs.
Voluntary RNG Program

Customer Annual Usage (in Ccf)?
Customers can obtain usage by reviewing recent VGS bill or logging into the Account Center. RNG Adder per Ccf is $1.2931. A typical residential home uses 900 Ccf.

900

Calculate

<table>
<thead>
<tr>
<th>Monthly</th>
<th></th>
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<tbody>
<tr>
<td>10%</td>
<td>$9.70</td>
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<tr>
<td>25%</td>
<td>$24.25</td>
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<tr>
<td>50%</td>
<td>$48.49</td>
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<tr>
<td>100%</td>
<td>$96.98</td>
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</table>

<table>
<thead>
<tr>
<th>Annually</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>$116.38</td>
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<tr>
<td>25%</td>
<td>$290.95</td>
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<tr>
<td>50%</td>
<td>$581.89</td>
</tr>
<tr>
<td>100%</td>
<td>$1163.79</td>
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</tbody>
</table>
RNG Delivery Specifications

More difficult to meet compared to power projects

- Molecules v Electrons
- Complexity processing gas – O2/N2 limits
  - Multiple components
  - Reliability
- RNG Specifications
  - 9 facilities in…
  - 8 different states with…
  - 9 different requirements for…
    - Quality
    - Monitoring
    - Metering
    - Pressure
    - Communication
    - Scheduling

Chromatograph and metering skid
# Interconnection Process

## Preliminary Evaluation
- Developer contacts pipeline operator & provides preliminary project scope description
  - Location
  - Anticipated interconnect pressure
  - Temperature
  - Pipe size
  - Heating value and specific gravity
  - Amount of gas
  - Flow
  - Variability in gas delivery
  - Biogas source and cleanup technology
  - Other key process variables

## Preliminary Review Meeting
- Review of ESA and GSA Requirements
- Developer/operator specific needs
- Local state, and/or federal regulator requirements (includes NYS code 16 NYCRR Part 229 Gas Quality Standards for Pipeline Injection)

## Engineering Feasibility Analysis
- Developer provides detailed technical proposal to pipeline operator (typically under NDA)
  - Description of chosen cleanup gas technology
  - Data proving cleanup technology is compatible with upgraded gas feedstock
  - Detailed analysis of raw biogas (can be from another project with same feedstock)

## Address Impact Issues on Pipeline System and Customers
- Examine pipeline capacity during varying load periods
- Zone of influence of trace constituent impact
- Impact on therm billing monitoring

## Reimbursement to Pipeline Operator for Full Technical and Economic Feasibility of the Project
- Making contact with a pipeline operator and executing an ESA does NOT guarantee acceptance of the project

## GSA or Interconnection Agreement
- Commercial aspects of accepting gas negotiated
  - Commodity compensation
  - Delivery obligations (volume, energy content, pressure, temperature, flow rate etc.)
  - Gas pairing agreements (blending)
  - Gas measurement requirements (schedule and periodicity, equipment, sharing of monitoring information and electronic signals etc.)
  - Operation and maintenance requirements (monitoring and measurement equipment maintenance, odorization and metering equipment maintenance etc.)
  - Facility access
  - Gas quality monitoring requirements
  - Conditions that impact acceptance of upgraded gas and facility isolation
  - Billing and payment terms
  - Tariff or a special contract for transporting the gas enabling the pipeline operator to facilitate the desired transaction for the Developer if the RNG will be sold to a third party
  - Begin discussion of pre-construction questions

## Construction/Commissioning
- Pipeline operator must be kept informed on progress of construction and specifications
  - Suggested interim meetings at 30%, 60%, 90% project completion points at minimum

## Address Pre-construction Questions
- Facility start-up procedures
- Discussion of odorization
- Final gas quality tariff specifications
- On-line instrumentation needs
- Schedule for monitoring of gas quality
- Identification of sampling points
- Identification of target COCs for periodic monitoring
- Initial sampling requirements
- Follow-up sampling requirements
- Steady state sampling requirements
- Trigger levels for specific COCs
- Response actions for out-of-compliance supply
- Emergency plans and procedures
- Facility O&M procedures

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**Draft Interconnect Process Visual**

[ nationalgrid ]
Our products and services make continual, automated, adjustments to valve position based on field measurements to respond to the constantly changing environment.

**MEASURE**
- H62 + 0.0729
- CH₄ 48.1%
- CO₂ 38.1%
- O₂ 0.2%
- Bal. Gas 13.6%
- Flow (SCFM) 10.0
- Pressure -18.7"
- Temp. 72.7°F

**CONTROL**
- Automated tuning through control algorithm
- User set performance thresholds

**SERVICE**
- Monthly calibration
- Routine maintenance
- Rapid troubleshooting leveraging field technicians
Loci uses Weather Forecasts, Plant GC, and Gas Composition from Wellfield to Optimize the Landfill Gas Collection Process

Loci’s fine tuning algorithm, is like having a technician at each well, 100% of the time.

Loci’s Threshold algorithm makes adjustments to many wells at the same time, based on changes in overall gas quality measured at the plant - something which can not be done manually.

**Fine Tuning Algorithm**

1. The Loci system takes hourly individual collection well readings (gas composition, flow, LFG temp, ambient pressure, temperature, valve position, and pressure above/below Loci’s automated valve).
2. Automation is used to make small incremental valve adjustments (<1% open or close) every 2 - 3 hours, based on last measurement. Finds optimum for each collection well.

**Pipeline Specs**

- **Pipeline Specs** (eg. 950 BTU energy content)

**Pipeline**

**Threshold Gas Composition Algorithm**

Loci’s automated system makes batch valve adjustments, changing multiple collection wells at the same time. Uses aggregate gas composition thresholds, with top level control variables: BTU, O2, and N2 as measured by plant Gas Chromatograph, or Precision O2 meter. There is a direct connection to plant measurement equipment via serial port to Loci Sentry.
LFG Project Considerations

- Landfill gas generated RNG is the lowest cost source of cellulosic biofuels (D3 RIN and LCFS credits)
- RINS have high value – and high price and regulatory risk
  - “We are bullish on RINS but we are not foolish” – Active Industry Lender
- History of long term fixed price power contracts set expectations
  - New power project opportunities still exist, limited
- Developers transferring skills to adjacent markets
  - Anaerobic digesters
- Conversion of existing power plants to RNG production
  - Economic evaluation
- Attracting investment and investors

RNG is very attractive in the current market

Oklahoma City, OK RNG Facility