

Gas Upgrading RNG Standards

Biogas to RNG for Pipeline Injection

April 2019

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What is RNG

- Renewable Natural Gas: Biogas which is a direct replacement for Natural Gas
- Either:
 - Compressed Natural Gas
 - Liquified Natural Gas

Biogas Sources

- Landfills
- Agricultural Digesters
- Waste Water Treatment Plants
- Food Waste Digesters



Biogas Makeup

- 30 to 70% Methane
- 20 to 50% Carbon Dioxide
- 0 to 20% Nitrogen
- 0 to 5% Oxygen
- 0 to 10,000 ppmv H₂S
- 0 to 20 ppmv Siloxanes
- 0 to 1000 ppmv other Organic Compounds

Medium BTU gas

- Uses
 - Engines
 - Turbines
 - Boilers
 - Direct Heat Applications
- Minimal Treatment:
 - Compression
 - Dehydration
 - Possible H₂S removal
 - Possible Siloxane Removal

High BTU Gas (RNG)

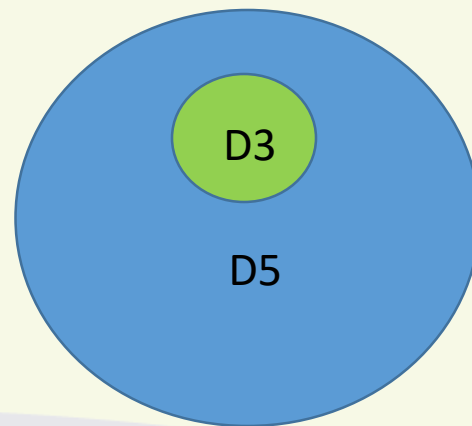
- RNG:
 - Compressed Renewable Natural Gas
 - Liquified Natural Gas Natural Gas
- Extensive Treatment:
 - Compression
 - Dehydration
 - H₂S, VOC, NMOC, N₂, O₂, CO₂, Siloxane Removal

RNG

- Making RNG is more expensive than other biogas use options.
So why do it?
 - To Generate RINs (Renewable Identification Numbers)
 - The RIN system was created by the RFS (Renewable Fuel Standard) program to reduce GHG emissions and reliance on foreign energy
 - California LCFS (Low Carbon Fuel Standard)

RIN Types

- There are multiple types of RINs but only two concern us:
- D3 RINS: Cellulosic Biofuel (highest value fuel)
- D5 RINS: Advanced Biofuel (lower value fuel)



D3 RINS

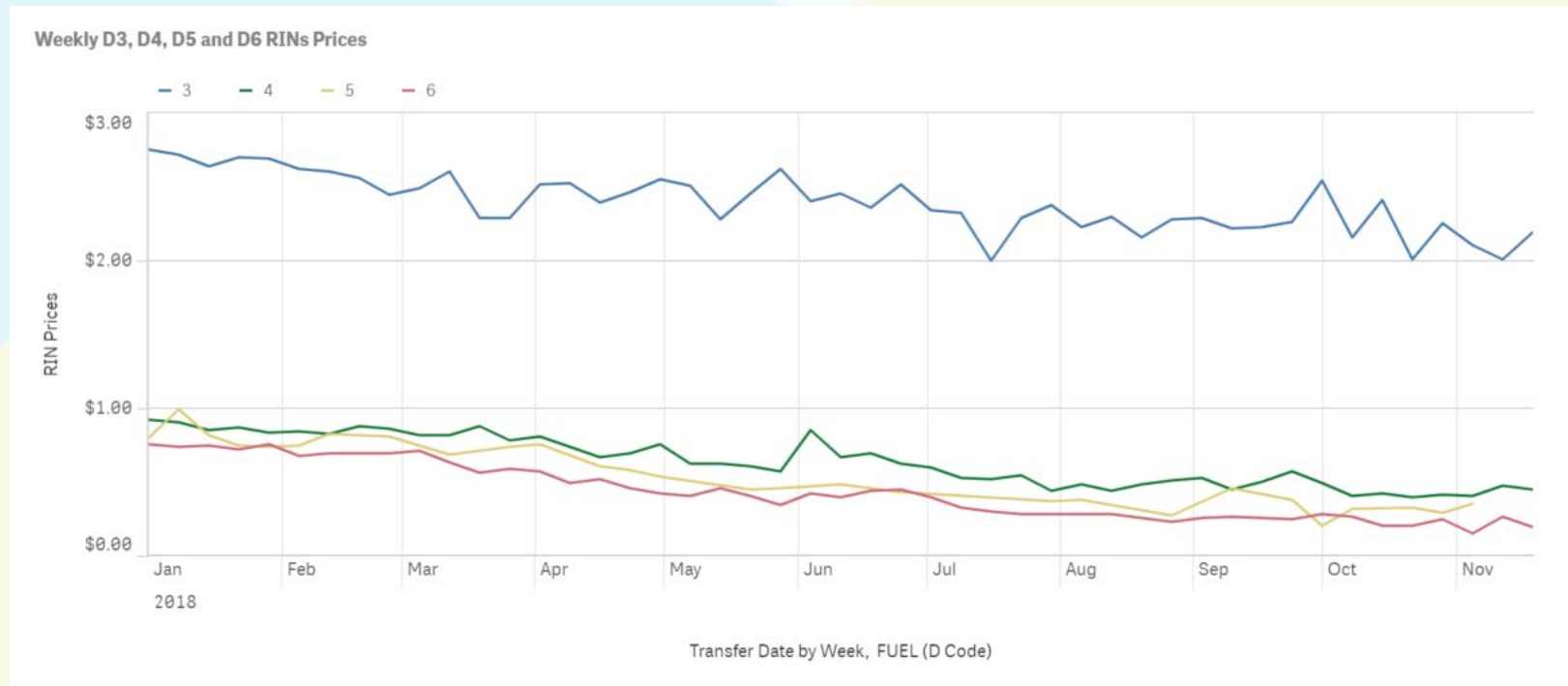
- Sources of D3 RINS

- Landfill Gas
- Agricultural Digester
- MSW Digester
- Waste with a 75% cellulosic content

- Sources of D5 RINS

- All other digester waste

Historical RIN Pricing



Value of D3 RINS

- Dairy Digester with 770 SCFM inlet Flow at 65% methane: 30 MMBTU/HR
- \$2.25/D3 RIN is equivalent to \$29/ MMBTU
- $30 \text{ mmBTU/hr} * 24\text{hr/day} * 365 \text{ days/year} * \$29/\text{mmBTU} = \$7.6 \text{ million/year}$
- Add to this Natural gas prices (approximately \$1 million/year)

RNG Standards

- To qualify for RINS the RNG must be put into a pipeline or sold as LNG
- Pipeline injection is the most common use
- The RNG must meet the requirements of the pipeline Tariff

LCFS Credits

- “Regulated Parties” who provide fuel in California, Oregon, and British Columbia are required to provide low carbon intensity fuel.
- Fuel sold into these markets are eligible for low carbon fuel standards (LCFS) Credits in addition to RINs.

Typical Pipeline Tariff

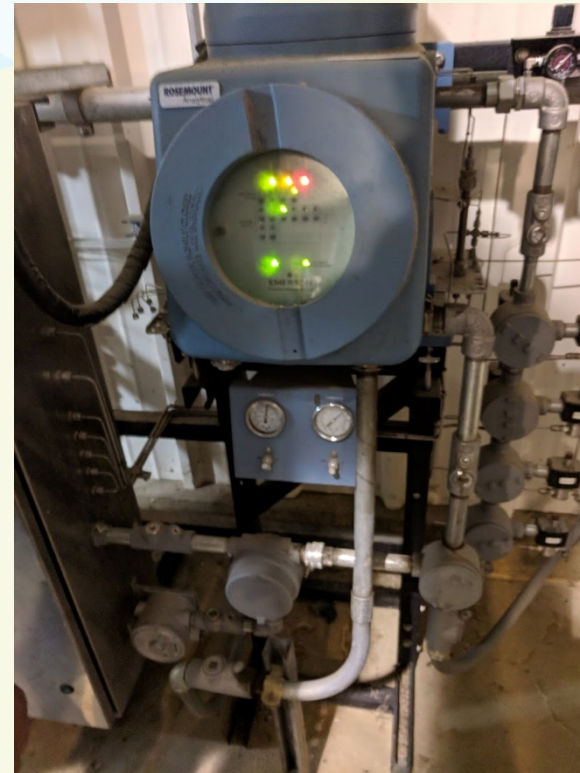
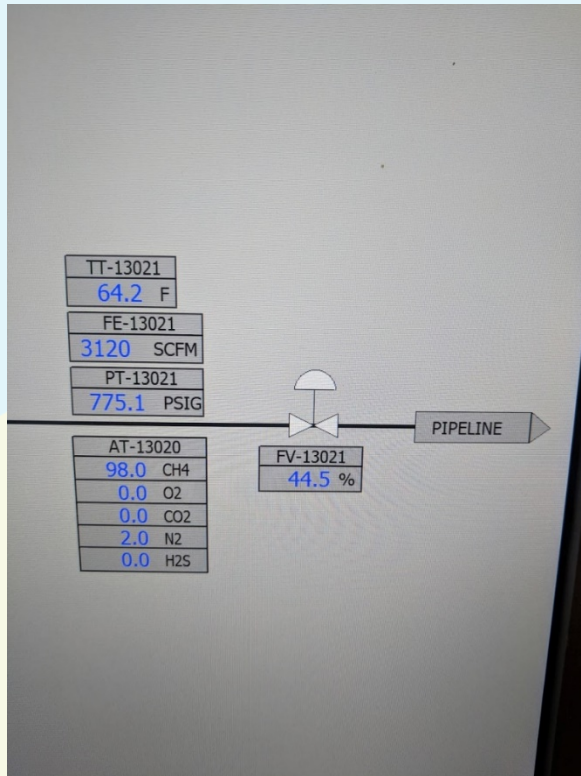
• Typical Tariff	Biogas
• 970 BTU/CF	400-700 BTU/CF
• 0.25 Grains H ₂ S(4 ppmv)	0-10,000 ppmv H ₂ S
• 0.02% Oxygen	0-5% Oxygen
• 1.25% Carbon Dioxide	30-50% CO ₂
• 4% Inerts	30-50% Inerts
• 7lbs/1000 CF Water	Saturated

Biogas Specific Tariffs

- Kinder Morgan REETHINK Program
 - Limits Siloxanes to 1 ppmv
 - Limits Vinyl Chloride to 3.3 ppmv
 - Requires Extensive Verification and Testing that can keep the facility out of the pipeline.

Verification of Gas

- Pipeline Gas Testing (Gas Chromatograph)



Valves and Flare

- Out of Specification Gas is diverted to the Flare

