Webinar:
Using Landfill Gas as Vehicle Fuel

November 13, 2014

Presenters:
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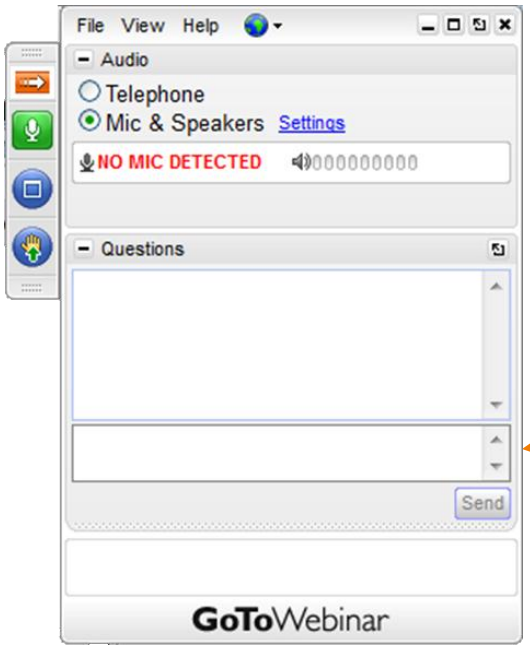
Katry Martin, St. Landry Parish Solid Waste Disposal District

Tips

- **All participants will be muted at the beginning of the webinar**
- **Please do not put this call on hold**
- **Questions submitted during the webinar will be reviewed during a general discussion at the end of the webinar**



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Enter your question

Welcome

- **Introductions**
- **Review of Agenda**

Webinar Agenda
Biogas Derived Fuels Under the Renewable Fuel Standard (RFS) Program
Landfill Gas to Renewable Natural Gas to Vehicle Fuel
Case Study - St. Landry Parish Sanitary Landfill, Louisiana
Discussion ▪ Questions and Answers ▪ Wrap-up & Conclusion

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Biogas Derived Fuels Under the Renewable Fuel Standard (RFS) Program

David Babson

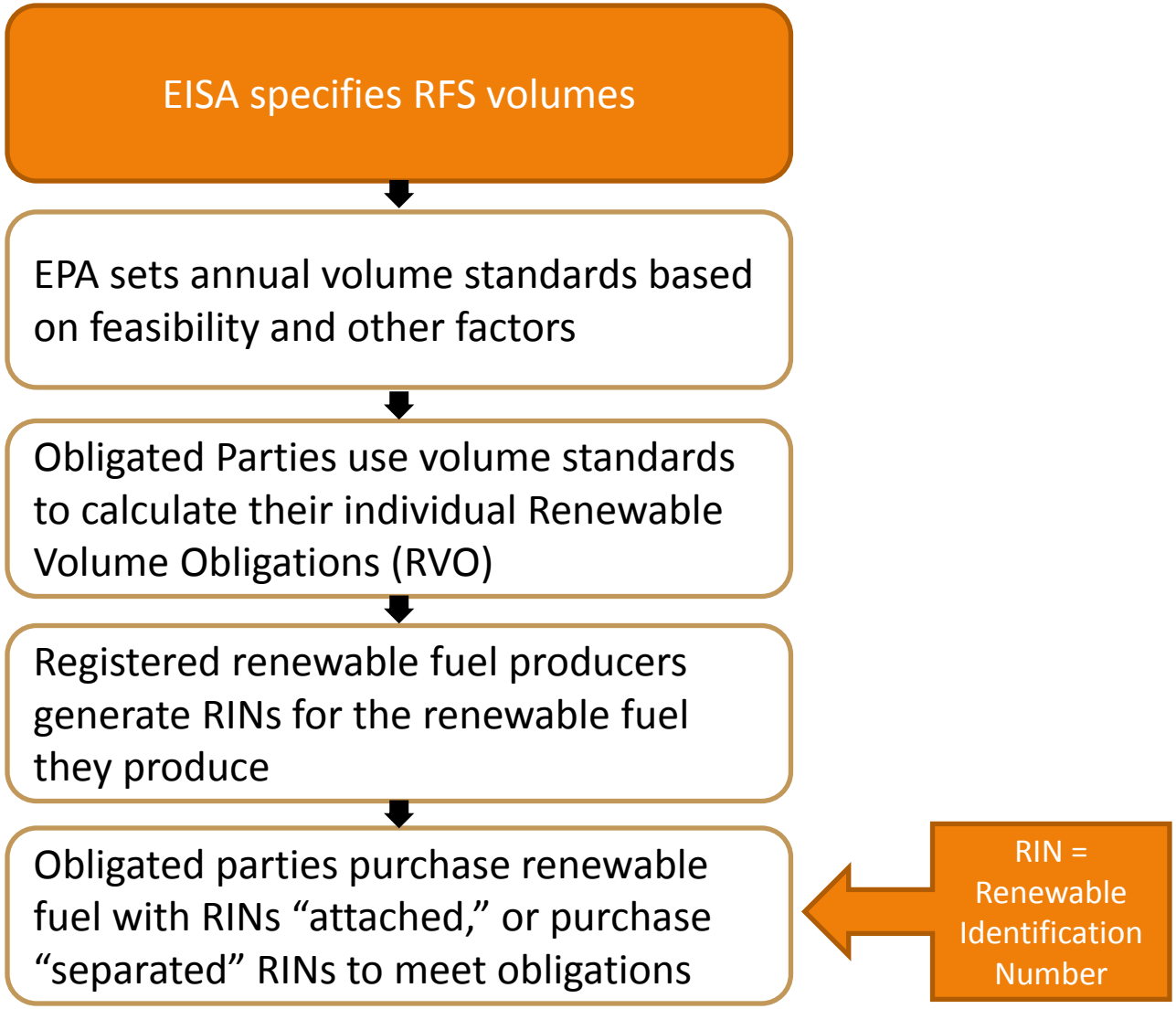
AAAS Science & Technology Policy Fellow

EPA

EISA – The maker of the Renewable Identification Number (RIN)

- **Energy Independence and Security Act (EISA) of 2007**
  - Sought to increase energy security and address climate change
  - Established the Renewable Fuel Standard (RFS) promoting energy efficiency and alternative fuels – particularly biofuels

RFS Implementation Overview

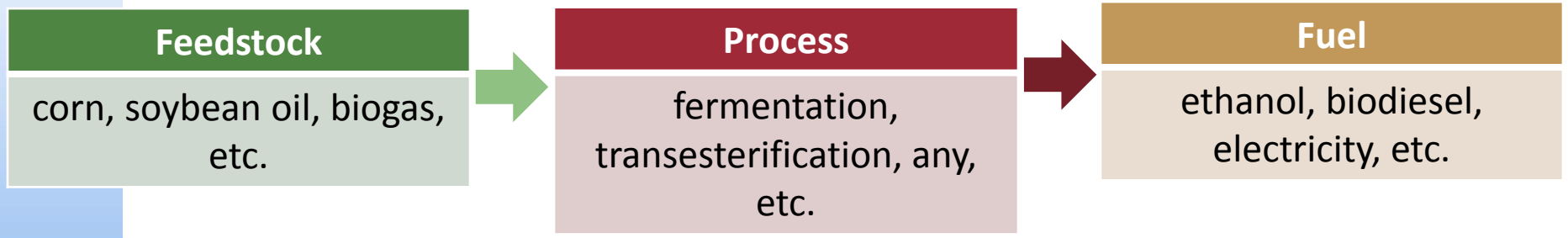


Biofuel Categories & RIN Codes

D Code	Fuel Type	Fuel	Greenhouse Gas Reduction Requirement
D3	Cellulosic Biofuels	Cellulosic ethanol cellulosic naphtha, etc.	60%
D4	Biomass-based Diesel	Biodiesel, renewable diesel, etc.	50%
D5	Advanced Biofuels	Sugarcane ethanol, biogas, renewable heating oil	50%
D6	Renewable Fuel (conventional, grandfathered, or 20% threshold)	Corn ethanol	20%
D7	Cellulosic Diesel	Fischer-Tropsch diesel from cellulosic material	60%

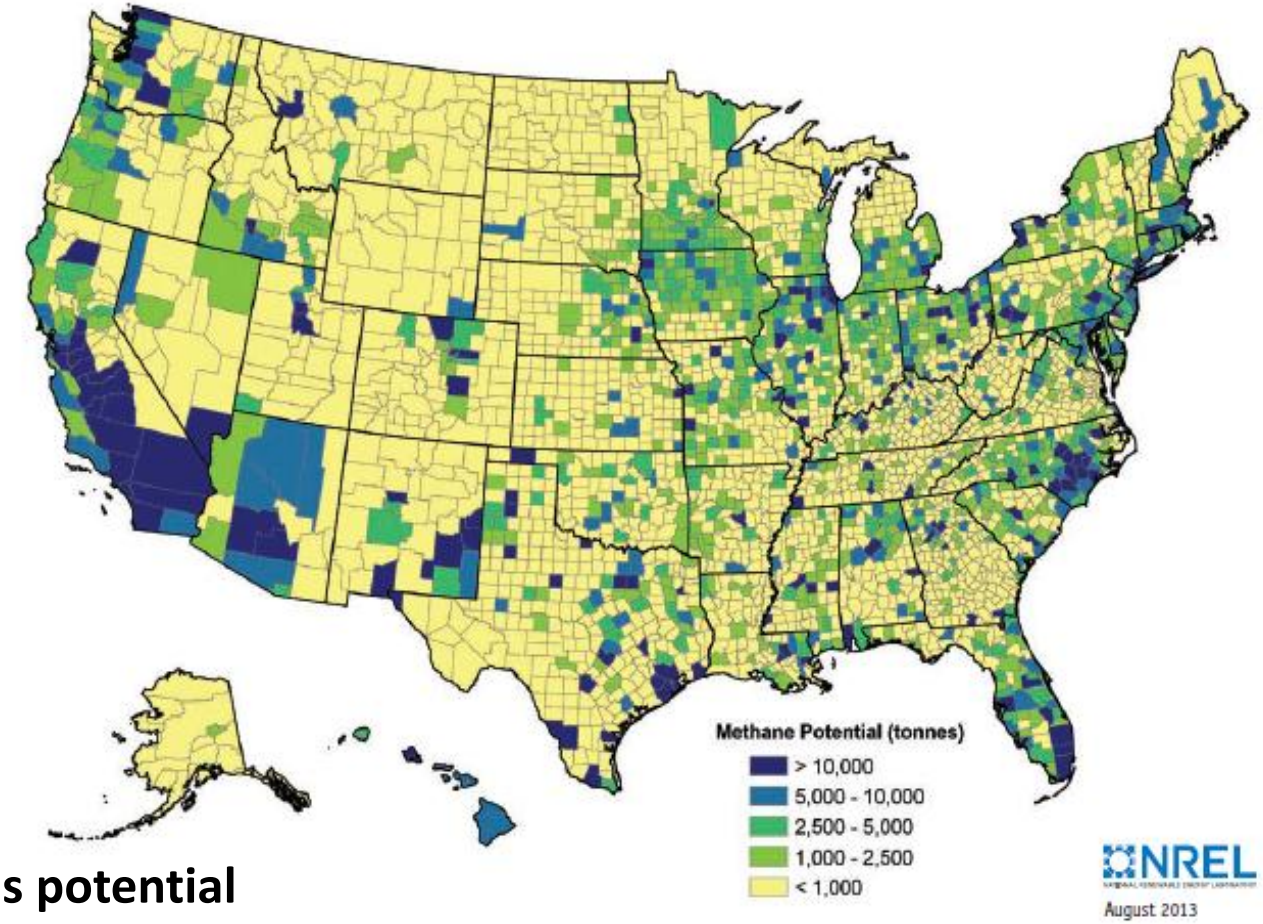
- **Biofuels produced using an approved pathway can generate credits or RINs under the RFS program**

Biofuel Pathways Under the RFS



- **An approved "pathway" consists of the unique combination of an approved feedstock, conversion process, and fuel**
- **For any approved feedstock there may be many approved conversion processes and approved fuels associated with it**

U.S. Biogas Potential



- **Biogas potential**
  - 7.9 million metric tons per year
  - If all of this was converted to compressed natural gas (CNG)/liquefied natural gas (LNG) and used in the transportation sector it would represent ~5 Billion RINs

History of Biogas Under the RFS

- **In 2010, EPA determined that biogas from *landfills, sewage and waste treatment plants, and manure digesters* with any process could qualify as advanced biofuels**
- **In the process of implementing the 2010 rules a number of questions were raised**
  - Biogas itself is not a transportation fuel which raised questions regarding registration
  - The categories of biogas sources could use clarification
- **The 2014 RFS rule sought to address these questions**

Recent pathway approvals

- **Pathways II**
  - Feedstock
    - Biogas from landfills, municipal wastewater treatment facility digesters, agricultural digesters and separated municipal solid waste (MSW) digesters (D3 RINs) or waste digesters (D5 RINs)
  - Fuels
    - CNG, LNG, and electricity
- **Biogas derived fuel**
  - Dimethyl Ether (D3 or D5 RINs)

New Biogas Rules and Implications

- **Established biogas to be the feedstock**
  - Adds value to biogas, and can distribute logistical costs throughout the supply-chain
- **Approved fuels that are functional transportation fuels from biogas**
  - CNG, LNG and electricity
- **Establishes that non-liquid/gas fuels can be viewed as biofuels (biogas-to-electricity pathway)**
- **Determined that biogas from most sources is considered cellulosic (must be anaerobically digested)**
  - Landfills, Municipal wastewater treatment facility digesters, Agricultural Digesters, Separated MSW digesters (organic fraction of MSW), Cellulosic portions of biogas generated in other waste digesters
    - Non-cellulosic biogas from the other waste digesters still qualifies for advanced RINs
  - Increases potential value of biogas and biogas derived fuels via cellulosic RINs
- **Pathway framework allows additional biogas derived fuels to be more easily approved**
  - Dimethyl ether, hydrogen, Fischer Tropsch products

Accounting and Compliance

- **Federal and State Interplay**
  - RFS does not pre-empt state programs
- **RINs can be generated for every 22.6 kW-hour of electricity or 77,000 btu (Lower Heating Value) of biogas derived CNG or LNG**
  - Biogas must be generated from a registered source and the biogas must be tracked through its clean-up and conversion to its transportation end-use
  - A separation plan is needed for biogas produced from separated MSW

Registering Biogas Pathways

http://www.epa.gov/otaq/fuels/reporting/producers.htm

Landfill Gas to Renewable Natural Gas to Vehicle Fuel

Chris Voell

Business Development Manager

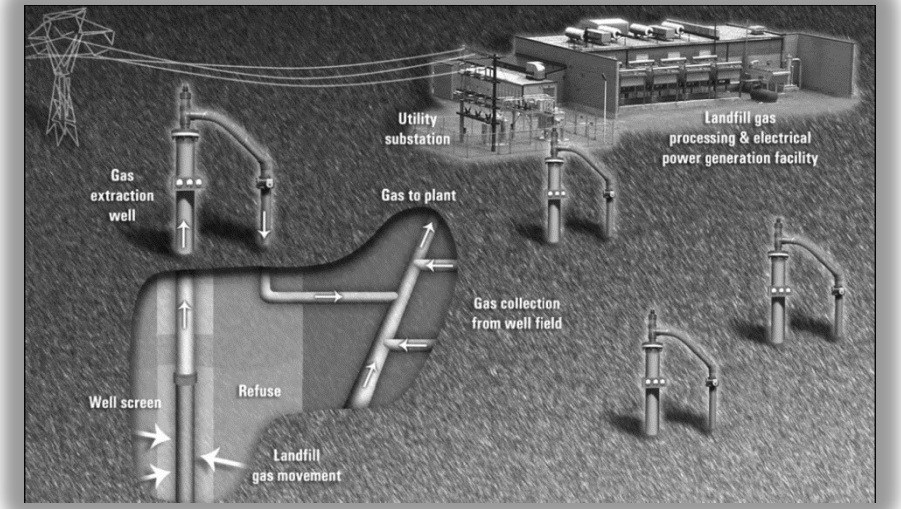
Aria Energy

Presentation Overview

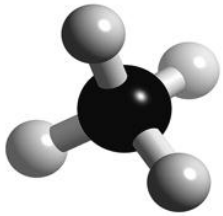
- Landfill Gas to Energy
- Renewable Natural Gas
- Energy Markets
- RNG Project Benefits and Challenges
- Technology
- Project Example
- About Aria Energy

Landfill Gas (LFG) Energy Recovery Projects

- LFG generation/collection
  - Breakdown of organic matter produces methane
  - Wellfield used to collect gas
- Three primary methods for utilizing LFG:
  - Electric power generation;
  - Medium-BTU industrial fuels; and
  - Renewable Natural gas (production and injection of high-BTU gas into utility pipelines)
    - RNG is not new: been in LFGE since late 70's – more than 3 dozen projects operating



Renewable Natural Gas



- For energy purposes, RNG is chemically identical to pipeline quality natural gas (NG)
  - 95-98% methane
- RNG is derived from renewable biogas sources generated from organic waste degradation
- RNG uses the same infrastructure as fossil NG: pipelines, gas compressors, refueling stations, and vehicle engine technology
- Major difference: **RNG is renewable & sustainable**

The Pathway from Waste to RNG

Wastes

All organic wastes contain energy.

Biogas

Anaerobic digestion of wastes at landfills or in digester plants produces energy-rich biogas.

RNG Fuel

Biogas upgrading removes carbon dioxide & impurities to make ***renewable natural gas*** (RNG).

Fuel Stations

RNG goes to on-site fueling stations, or by truck or pipeline to off-site pumps.

Vehicles

RNG works just like regular natural gas to power vehicles.

Potential RNG Feedstocks in US

- Landfills w/o LFGE (450 candidate sites)
- Wastewater Treatment Plants (~1,500 w/AD)
- Livestock Facilities (~8,000 dairy/hog/poultry)
- Commercial Food Waste (~30M tons)
- Residential Food Waste (~36M tons)

Potential for billions of GGEs of fuel annually from biogas sources

Current Biogas to Vehicle Projects

Waste Site	Location	Project Lead(s)	Vehicles Fueled
Altamont Landfill	Altamont, CA	Waste Management/Linde NA	300 refuse trucks
Columbus BioEnergy Digester	Columbus, OH	quasar energy group	25+ vehicles
Fair Oaks Dairy	Fair Oaks, IN	Fair Oaks/AmpCNG	42 milk trucks
Janesville Wastewater Plant	Janesville, WI	City of Janesville/BioCNG, LLC	40+ vehicles by 2020
Riverview Landfill	Riverview, MI	City of Riverview/BioCNG, LLC	40 vehicles by 2020
Rodefeld Landfill	Dane County, WI	Dane County/BioCNG, LLC	25-30 vehicles
Rumpke Landfill	Cincinnati, OH	Rumpke/Clean Fuels Ohio	10 refuse trucks
Sacramento Bio-Digester	Sacramento, CA	CleanWorld/Atlas Disposal	20 refuse trucks
Sauk Trail Hills Landfill	Canton, MI	Republic Services/Clean Energy Renewable Fuels	NA (offsite refueling)
Seminole Road Landfill	Dekalb County, GA	Energy Systems Group/ Dekalb County Sanitation	70 refuse trucks
St. Landry Parish Landfill	Beggs, LA	St. Landry Parish/BioCNG, LLC	20+ vehicles
Cedar Hills Landfill	Tacoma, WA	Pierce Transit/Puget Sound Energy/	143 Transit Buses

Source: www.energy-vision.org/organics-to-fuel-case-studies/

Options for LFG to Vehicle Fuel

- Fuel Types
  - Compressed Natural Gas (CNG)
  - Liquefied Natural Gas (LNG)
  - Dimethyl Ether (DME)
- Delivery Alternatives
  - On-site generation w/direct fueling
  - On-site generation w/local transport
  - RNG injection for off-site fueling
    - Opens regional and national markets

Biogas to Vehicle Fuel Project Examples

CleanWorld
Sacramento, CA

Fair Oaks Dairy
Indiana

St. Landry Parish
Louisiana

Cedar Hills Landfill
King County, WA

REDEEM™ by Clean Energy

- First commercially available RNG source
- 15 million GGEs of RNG (sourced from a number of landfills across the country) hit the market in 2013; Upwards of 50 million GGEs expected in 2014
- The latest figures suggest ~100,000 GGEs of REDEEM dispensed daily in CA

Energy Markets

- **Competing Sources of Energy**
  - High BTU – Natural Gas
  - Medium BTU – NG, Coal
  - Electricity
    - Demand (RPS) and NG Price Driven
  - Geographic Diversity
    - East and West Coasts
    - Mid Section
- **RNG Vehicle Fuel**
  - Competing with gas, diesel and NG-CNG
  - RINs and State incentives (LCFS) critical

RNG Project Benefits

- Minimal Noise Levels
- Lower Local Air Emissions (vs. Flaring or Power Generation)
- Less Permitting Requirements
- RNG can be transported to higher priced Energy Markets in most cases, offering better project economics
  - RNG sold to customers offsets the use of a corresponding amount of fossil-fuel derived natural gas

RNG Project Challenges

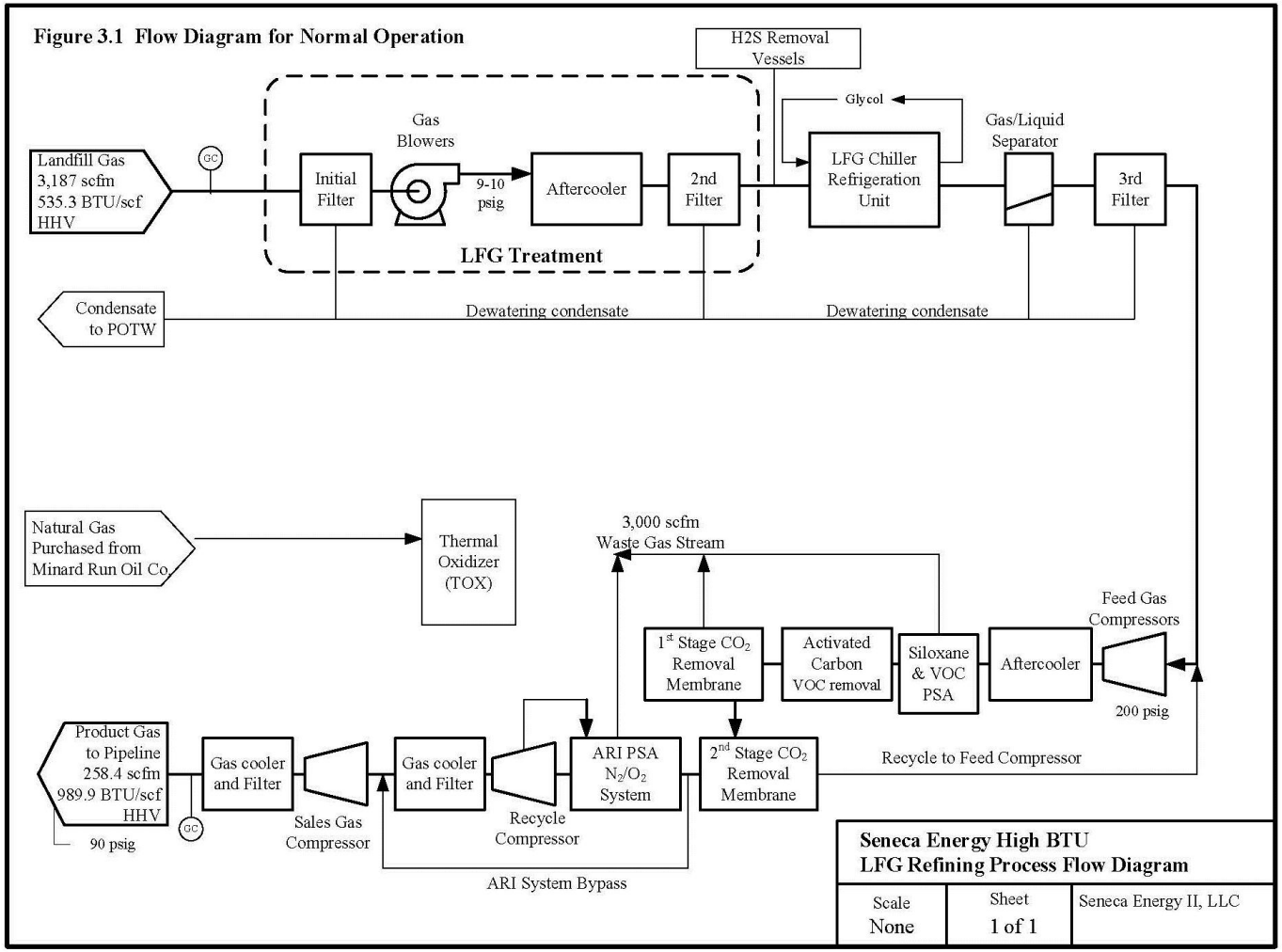
- Higher Complexity
  - Higher Level of Personnel Skillset Required
    - Increased Design, Construction and Operating Costs
- Pipeline Specifications Vary
  - Can change between states, utilities and regional locations, adding the risk of additional costs
  - Pressure, nitrogen, oxygen, other contaminants
- Market/Price Volatility
  - If Long-Term Contract Isn't Secured

LFG to RNG Process Overview

- Landfill Gas Purification
  - Removal of Inert Constituents
- Results in virtually pure methane with a heating value of near 1000 BTU per standard cubic foot
  - Roughly equivalent to the energy content of NG, which is 95-98% methane

Seneca Energy (Waterloo, NY)

Typical LFG Treatment & Refining Process



Summary of Composition & Flow Rates

Parameters	Inlet LFG	Waste Gas	Product Gas
Flowrate (scfm)	3,000-6,500	1,575-3,400	1,425-3,100
Methane Content(%)	55%	13%	98.9%
Water Content (mol%)	5%	<1%	<0.01%
Heat Value (BTU/scf, HHV)	556	132	1,000

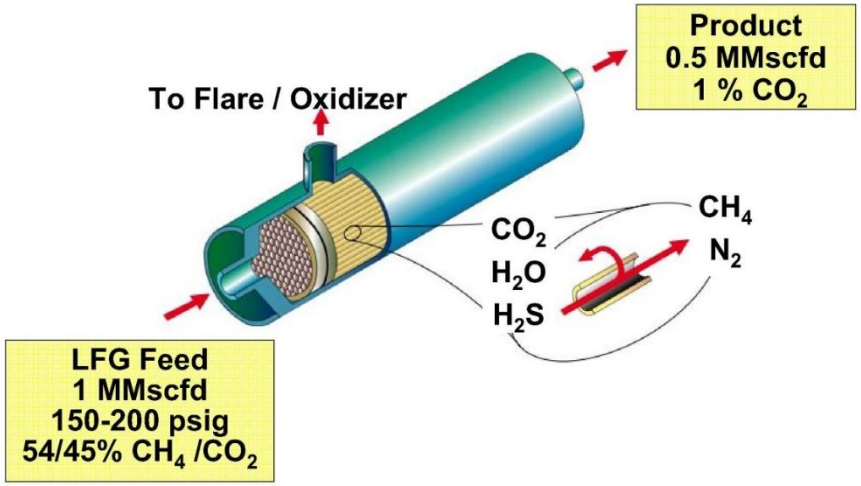
Design and Engineering

- ✓ High Pressure Gas Required for Processing
  - ✓ Landfill supplies gas at 0-2 psig
  - ✓ Need 200 psig
  - ✓ Design Feature: Multiple stages of gas compression
- ✓ Coolers
  - ✓ Dehydration through chilling

Design and Engineering

- ✓ Separation of CO_2 by use of a low pressure membrane
- ✓ Removal of NMOC/VOCs/Siloxanes
  - ✓ Siloxanes are unique to LFG & digester gas
- ✓ Air Liquide MEDAL system
  - ✓ Makes 90%+ methane recovery available with a two stage membrane system
- ✓ Nitrogen/oxygen removal
  - ✓ Pressure swing adsorption system that adsorbs methane and allows other LFG components, including nitrogen and oxygen, to pass through.

MEDAL Membrane



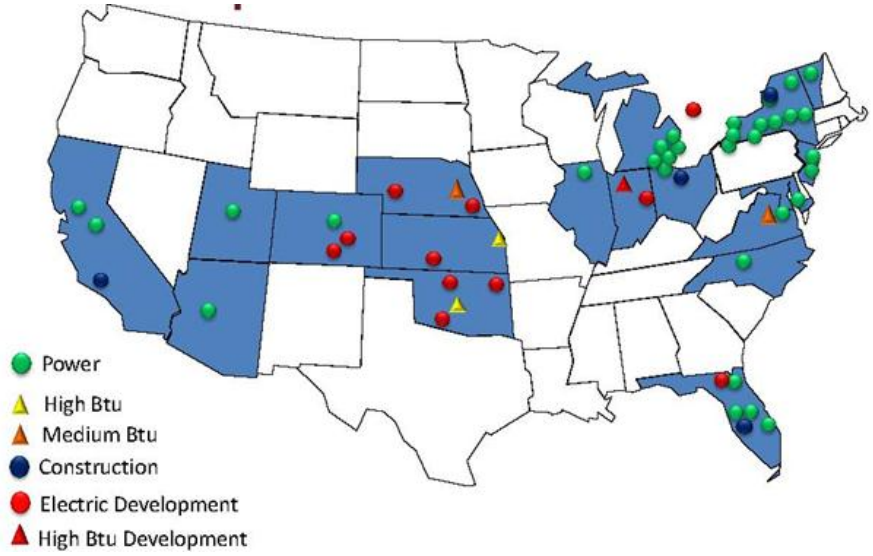
Construction and Operations

- RNG project construction typically ~7 months to complete, followed by three months of startup, testing and commissioning
- 24/7 operation
  - 3 full time onsite operators responsible for operations and maintenance

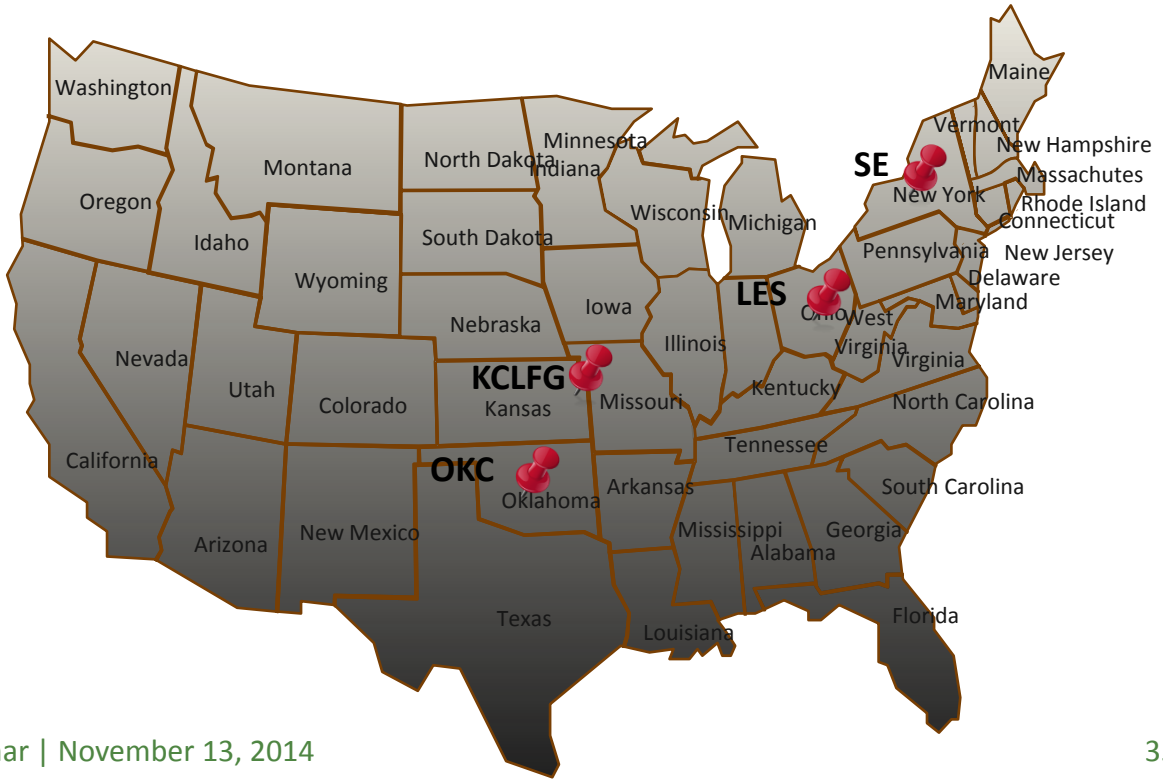
Aria Energy

(www.ariaenergy.com)

- Known previously as Innovative Energy & Landfill Energy Systems.
- Owns and/or operates a diversified portfolio of 44 electricity/RNG projects across 16 states, collectively representing 265.9 MW-equivalent of baseload renewable energy capacity.
- LFGE development since ’86.



Aria Energy High BTU Project Locations

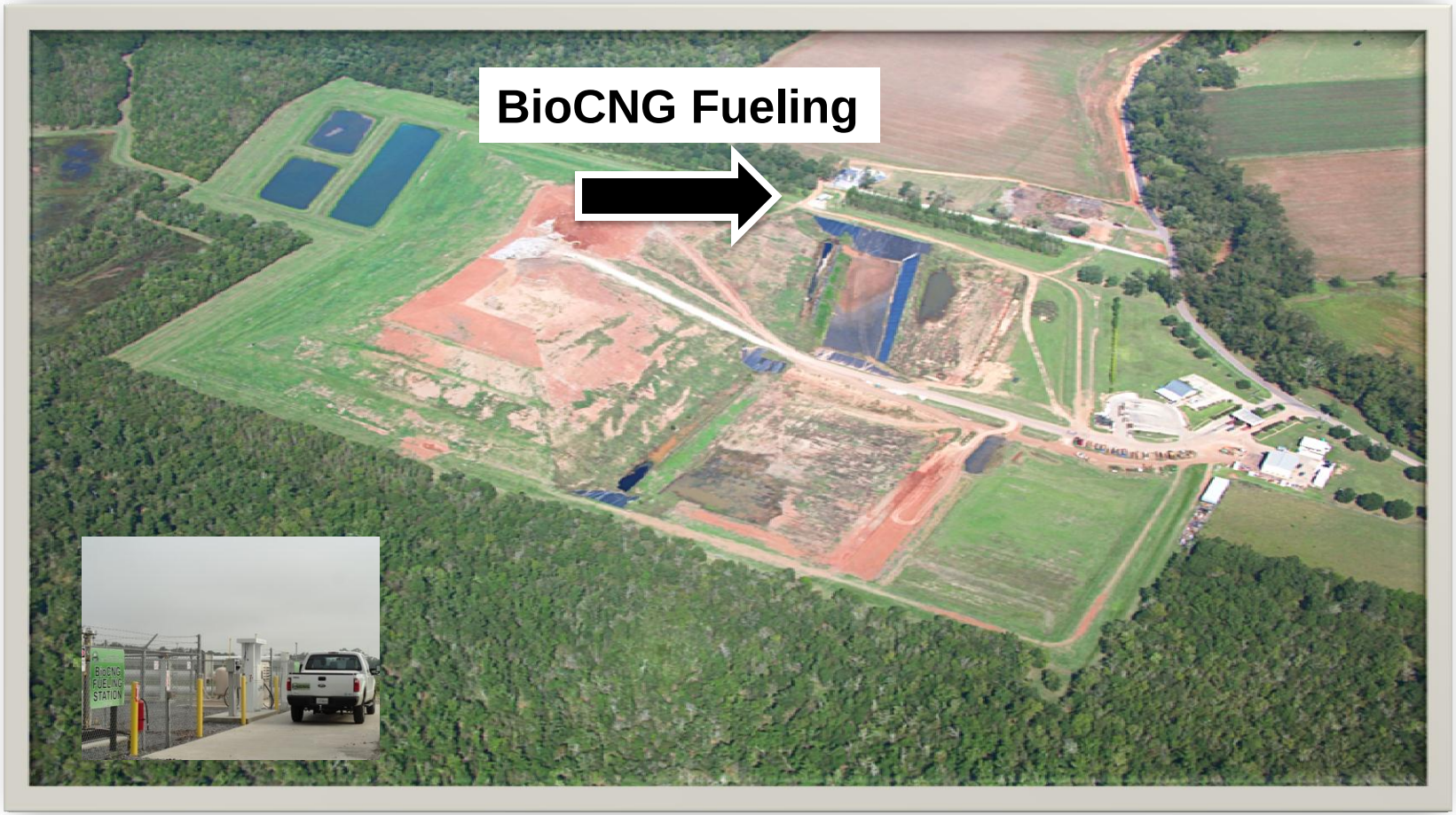


Case Study: St. Landry Parish Sanitary Landfill, Louisiana

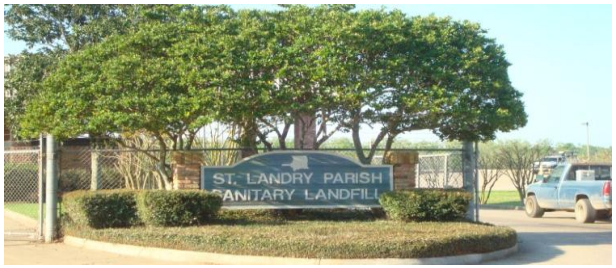
Katry Martin

Executive Director

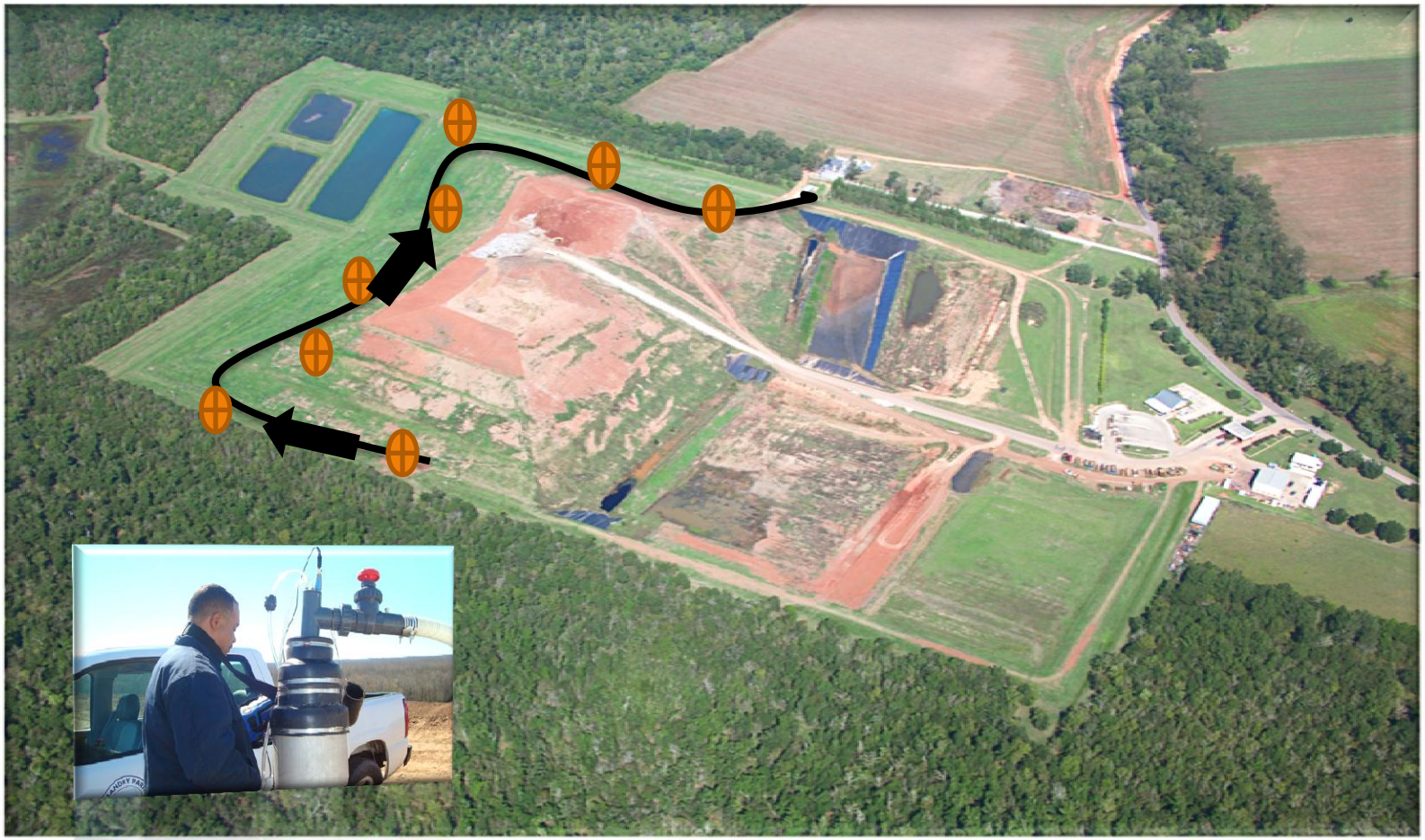
St. Landry Parish Solid Waste Disposal District



St. Landry Parish Sanitary Landfill



Gas Collection and Control System



Project Drivers

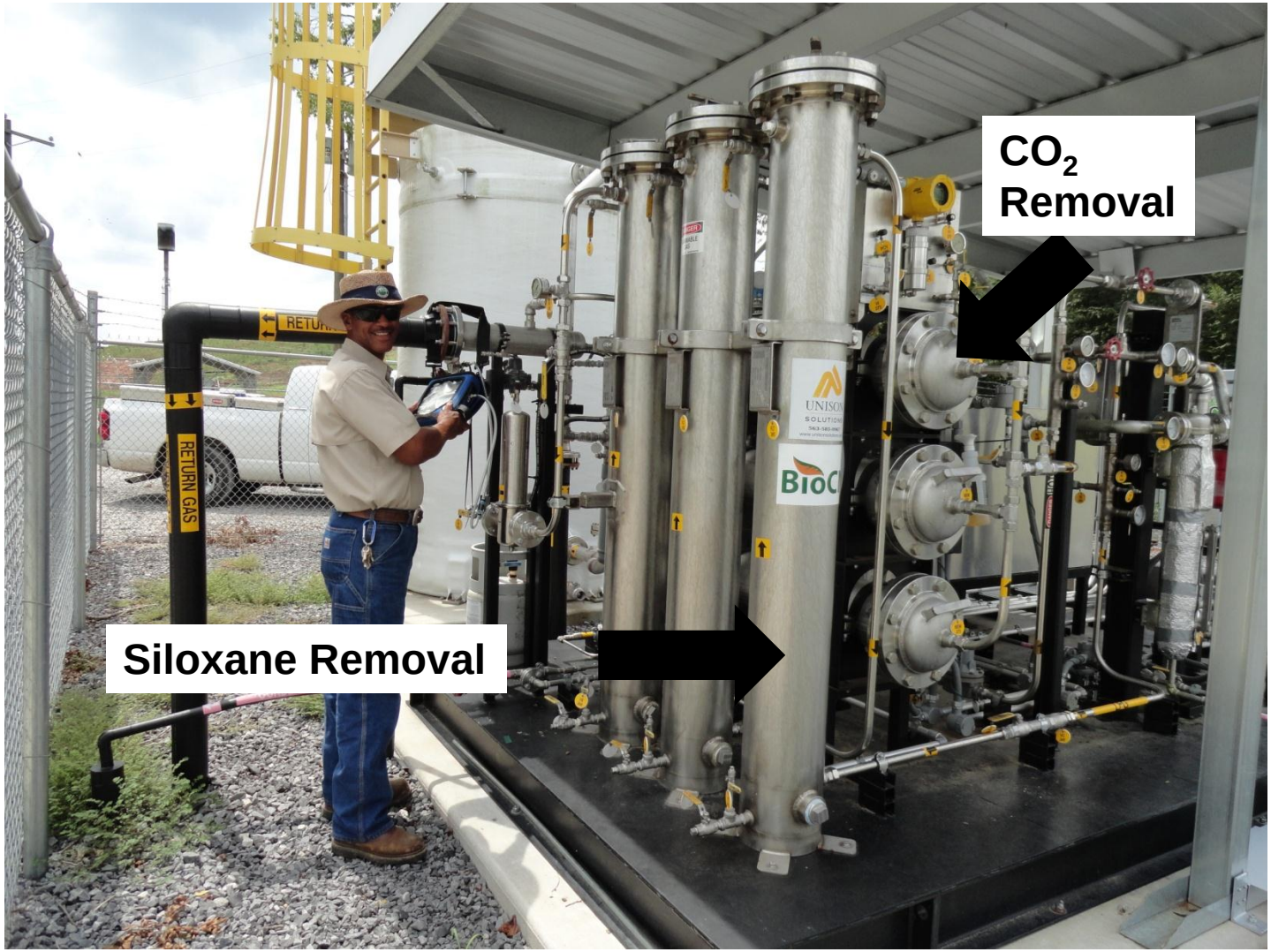
- Success of a carbon project
- Staff to operate and maintain the system
- Project control
- Understanding of the LFG composition
- Available Federal and state funding
- Access to fleet vehicles
- Historically high gas prices
- Long term environmental benefits and taxpayer savings

Project Budget

EmPOWER Grant		$550,000
Renewable Energy Tax Credits		$ 0
Local Resources		$450,000
	Total	$1,000,000
Fueling Station		$640,000
Site Work/Interconnection		$160,000
Vehicle Conversions		$200,000
	Total	$1,000,000

Sulfur Treatment

Gas Conditioning System



Compression and Storage

Dispensing


NATURAL GAS FOR VEHICLES
STOP MOTOR
NO SMOKING
FLAMMABLE GAS
FUELMASTER
ANGI
ENERGY SYSTEMS

Economics

	Projected	Actual
O&M / GGE	$1.20	$1.34
RIN (1.48 RINS/GGE)	$0.74/GGE	$0.74/GGE
Federal Fuel Tax Credit/GGE	$0.50	Ended 1/1/14
Consumption / Year	20,000 GGE	15,000 GGE
Efficiency (% of Capacity)	33%	20%
Market Price for Gasoline	$3.75/gallon	$2.75/gallon

RNG Charter Fleet

2014 Fleet Upgrade

Lessons

- **Understanding system operation is critical**
- **LFG composition/quality is key**
- **Fleet management is essential**
- **Many elements in determining operating costs**
  - Resource allocation
  - Media replacement
  - Gas sampling
  - Equipment servicing

Questions and Answers

Resources

- To learn more about EPA's LMOP and its activities to encourage the recovery and beneficial use of LFG as a renewable energy resource, visit LMOP's website at: http://www.epa.gov/lmop/
- For more information regarding the Renewable Fuel Standard program, visit the EPA's Office of Transportation and Air Quality's webpage at: http://www.epa.gov/otaq/fuels/renewablefuels/regulations.htm
- For information, data and tools on alternative fuels, visit the U.S. Department of Energy's Alternative Fuels Data Center website at: http://www.afdc.energy.gov/

Wrap-up & Conclusion

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