A Simple and Energy Efficient Approach to Cleaning Biogas

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Outline

- Background
- MMSD Pilot
- Summary and Next Steps

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Biogas projects provide multiple benefits

- Generate renewable fuel with a low carbon content
- Reduce reliance on fossil fuel
  - Reduce greenhouse gas (GHG) emissions
  - Reduce local air pollutant emissions
- Reduce the use of synthetic fertilizers
  - Generate a soil amendment
  - Offset fossil fuel use and reduce GHGs emissions from fertilizer manufacturing
- Help achieve Federal and state goals

Implementation of beneficial gas use must analyze:

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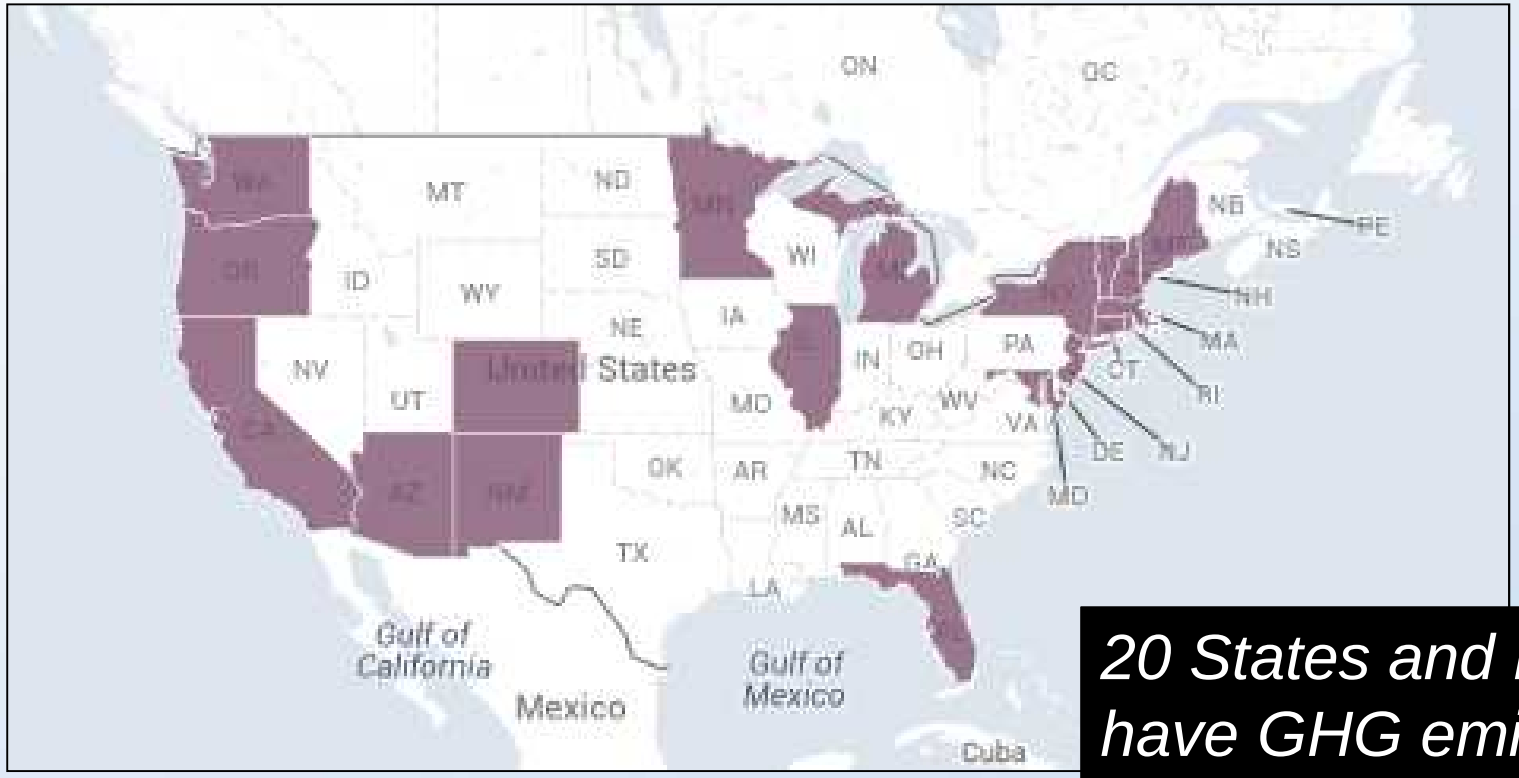
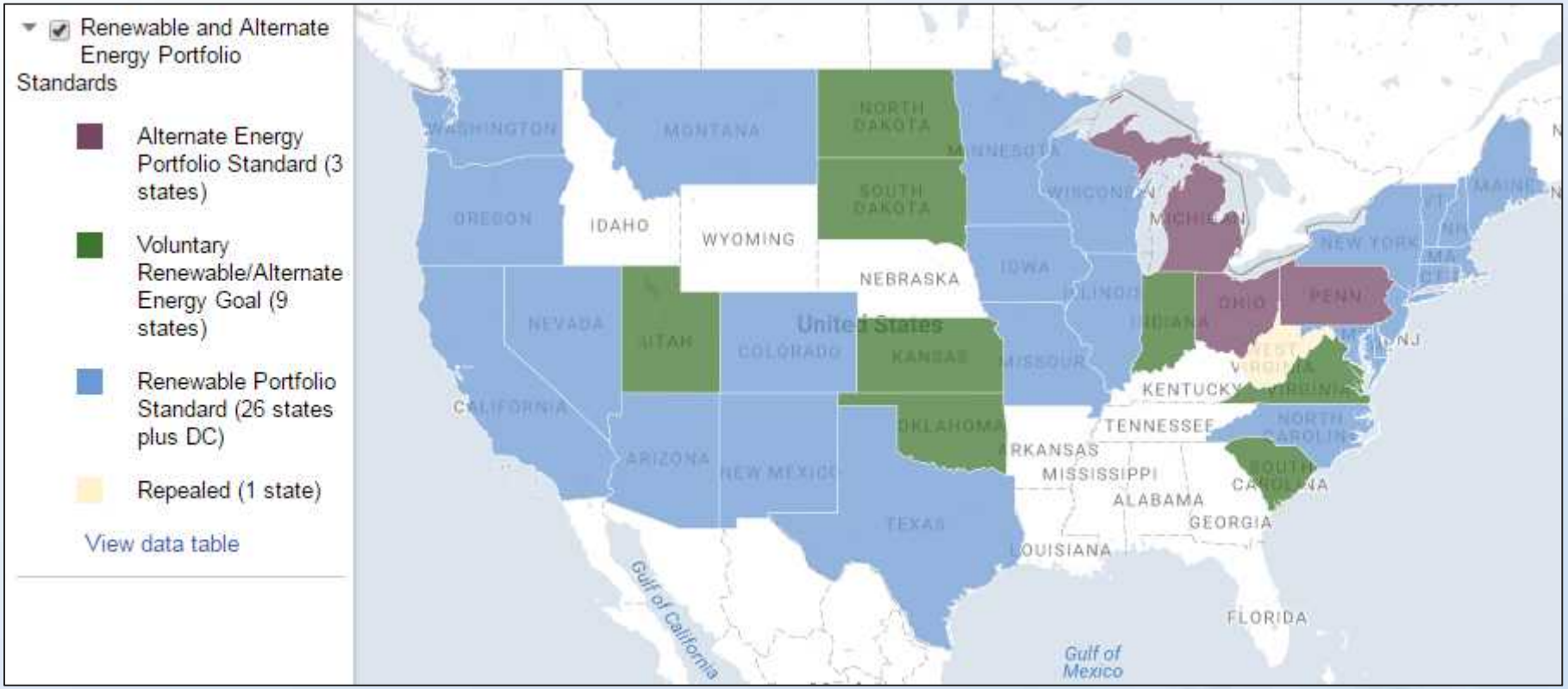
Many states have climate change related goals that incentivize bioenergy projects



20 States and D.C. have GHG emissions reduction targets and associated goals

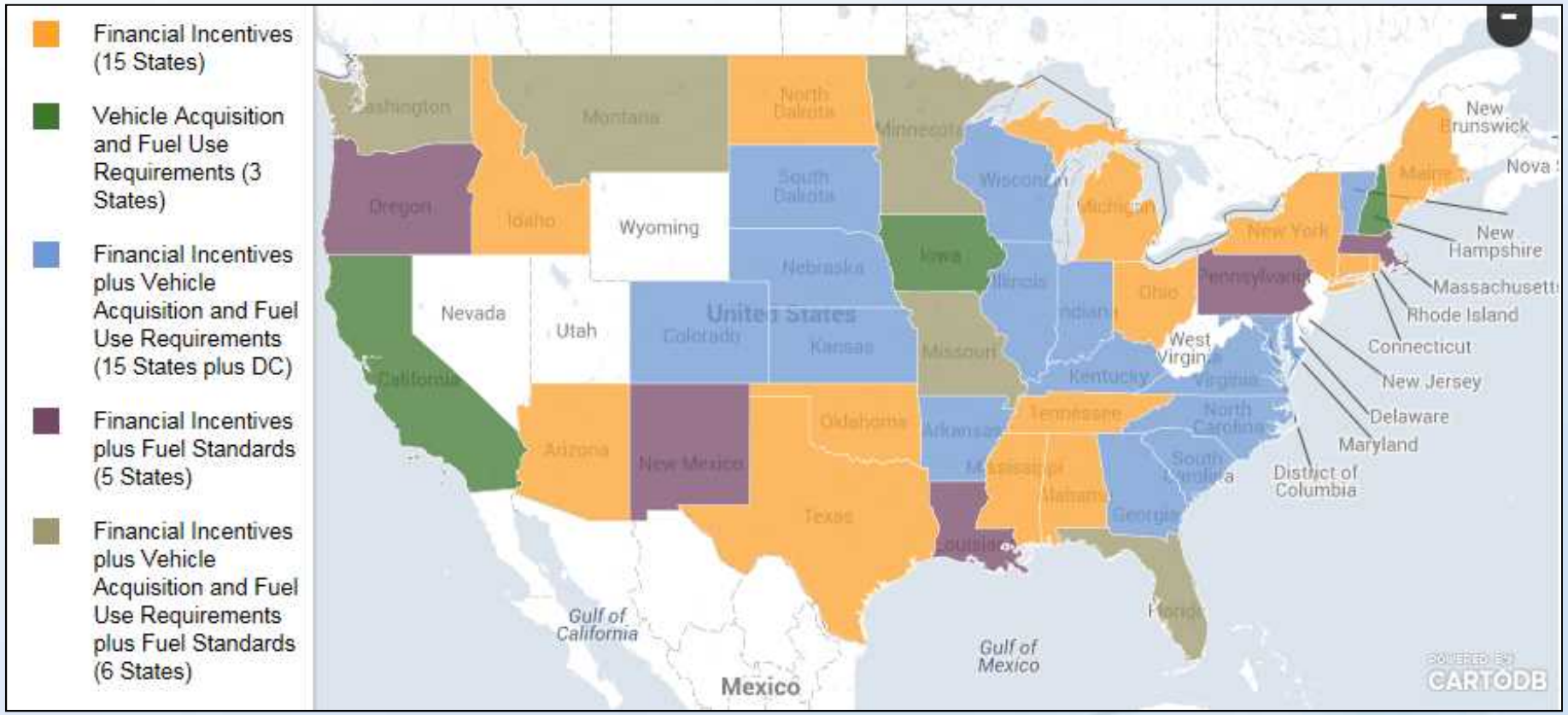
https://www.c2es.org/us-states-regions/policy-maps

More states have renewable and alternative energy standards



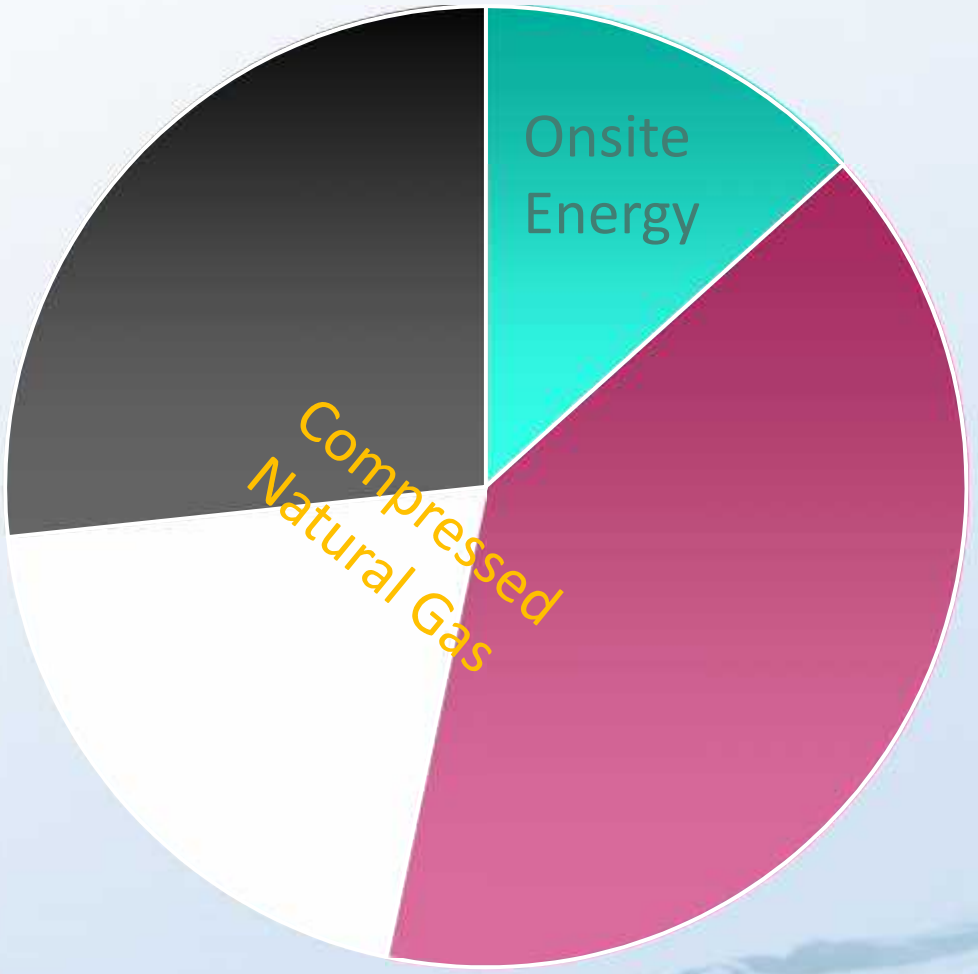
https://www.c2es.org/us-states-regions/policy-maps/renewable-energy-standards

And even more states have goals that incentivize biofuel production

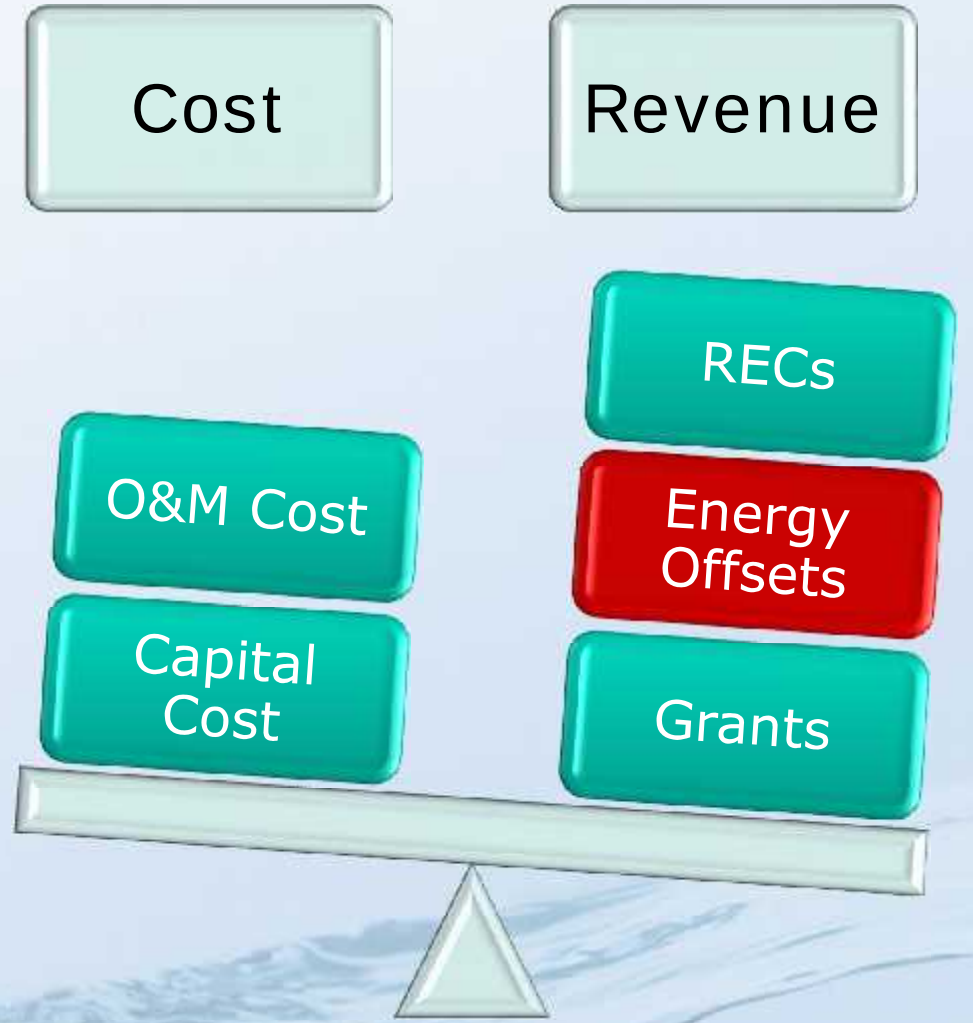


http://www.c2es.org/us-states-regions

Incentives for production/use of biogas are increasing…



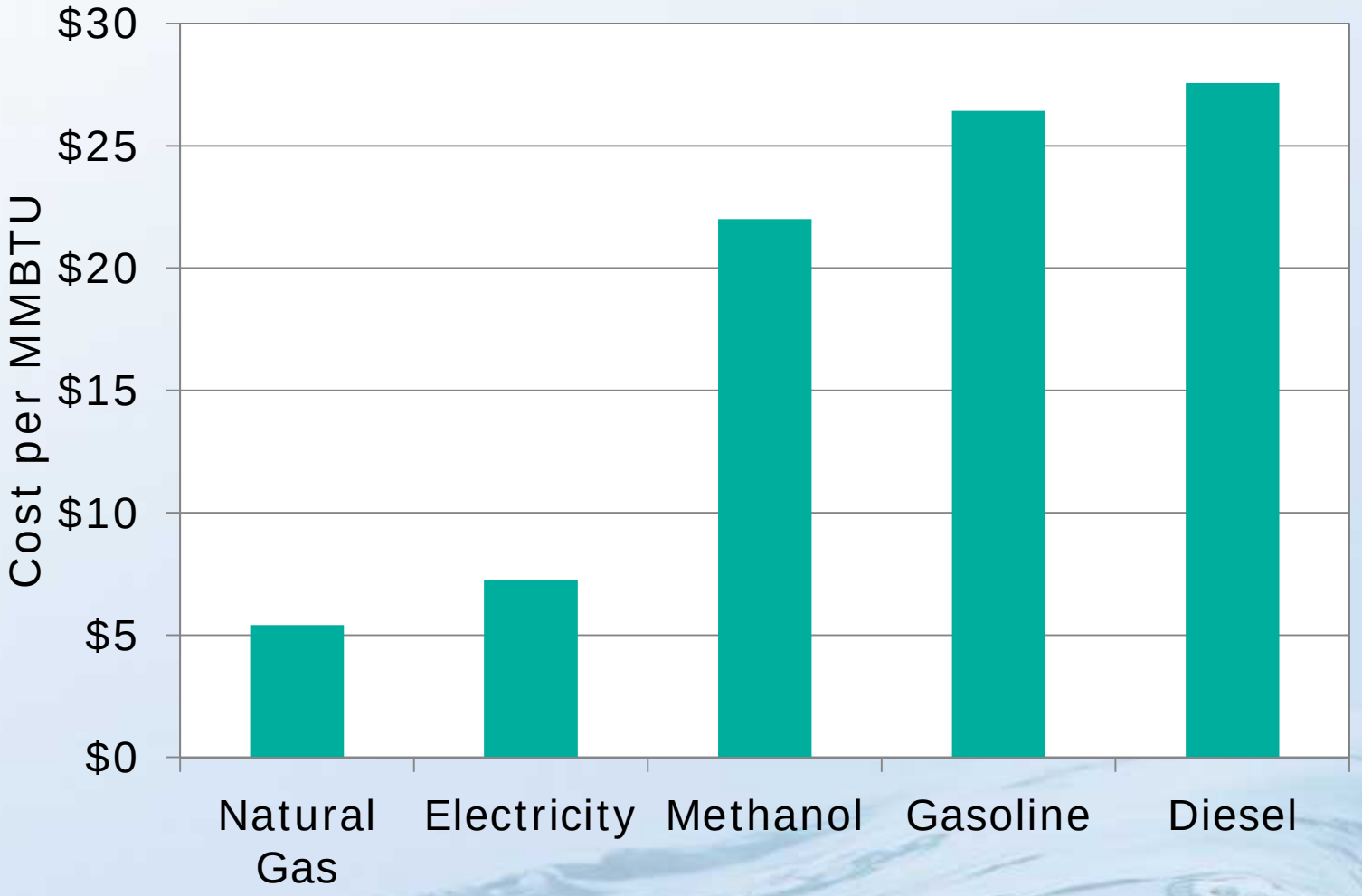
- Renewable Energy Credits
- Renewable Fuel Standard
- Low Carbon Fuel Standard
- Alternative & Renewable Fuel & Vehicle Technology

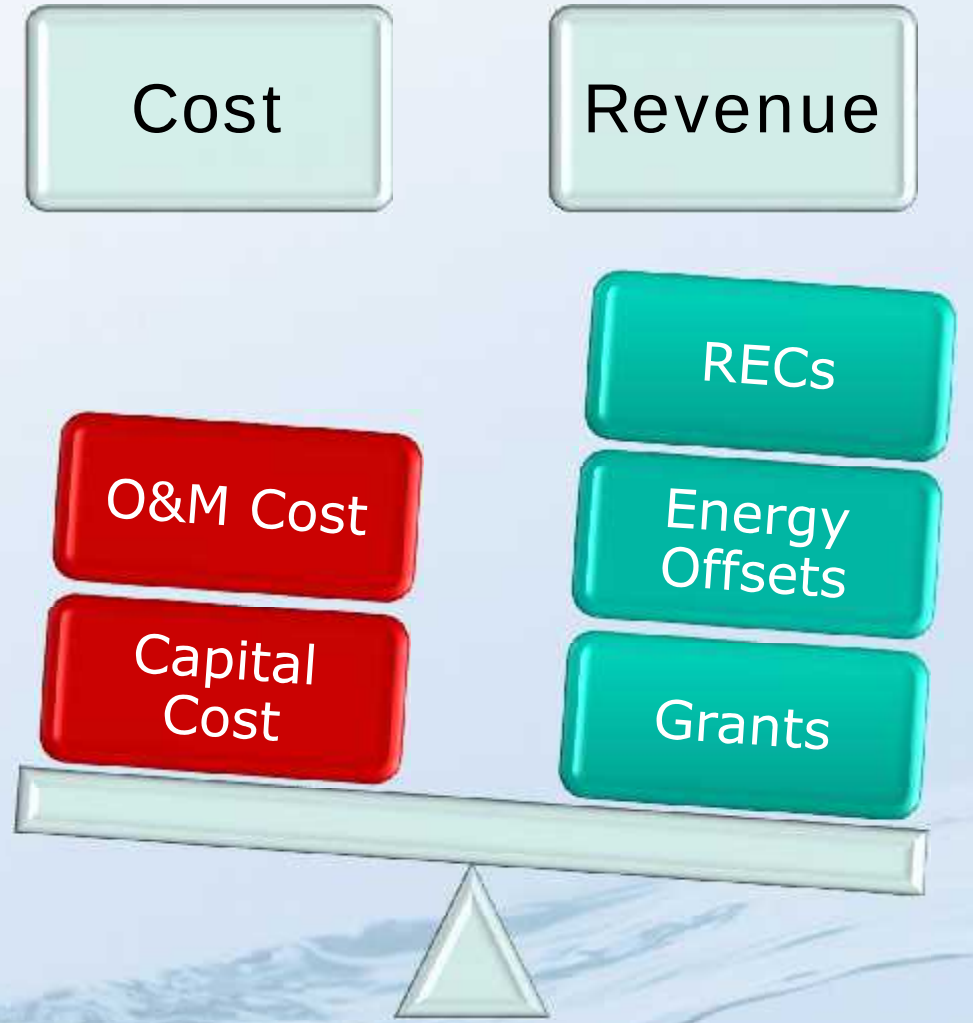

Cost
Revenue
RECs
O&M Cost
Energy Offsets
Capital Cost
Grants

Beneficial biogas use offsets fuel costs

VALUE

The value of biogas depends on what fuel it is offsetting

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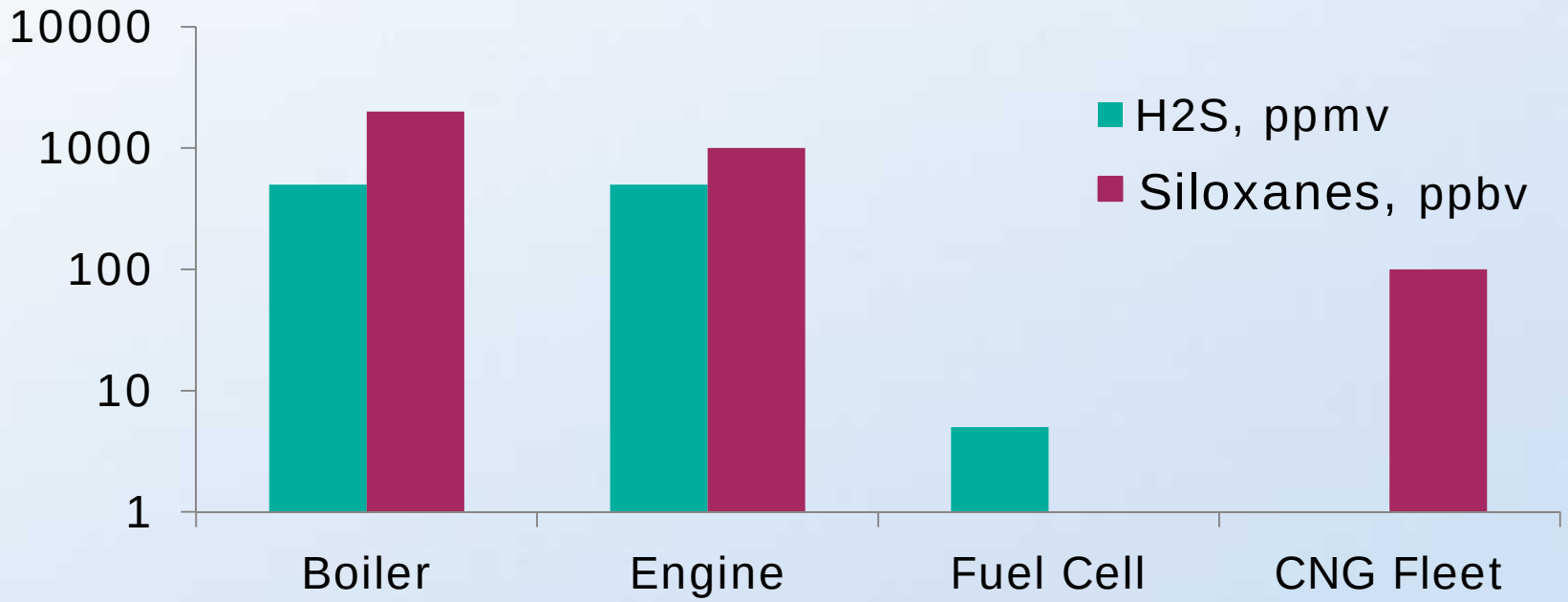
Biogas conditioning is an important component for beneficial use

Parameter	Typical Range
Methane, % by volume	50 – 65
CO_2, % by volume	35 – 50
H_2S, ppmv	100 – 10,000
Siloxanes, ppbv	500 – 5,000

H_2S and siloxanes damage mechanical equipment

CO_2 reduces energy value and increases compression cost

The level of biogas treatment depends on the type of beneficial use



Commercial biogas treatment can be achieved through different processes

- H2S removal
  - Iron salt addition
  - Adsorption systems
  - Caustic scrubbers
- Siloxane removal
  - Chillers
  - GAC systems
- CO2 removal
  - Pressure swing adsorption

New Unison biogas scrubber addresses industry challenges

- Removes H_2S
- Removes CO_2
- Reduces siloxanes
- Chemical-free treatment for digester gas
- No moving parts
- Only uses water

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South Shore Water Reclamation Facility

NACWA Platinum Award 20

300 MGD Full Treatment Capacity

90 MGD Annual Average

Liquid Treatment Processes

-Preliminary/Primary/ Secondary/Disinfection
-Chemical P removal

Solids Handling & Disposal

-Interplant pumping of solids
-GBTs and Plate and Frame
-Digesters Methane 1.3 MMCF

South Shore Digester Gas Production and Utilization

Plant Electric Load 4.5 MW

Gas Storage Spheres
0.42 MMCF @ 50psi

Gas Compressors

Digester Gas/Natural Gas

Flares

Digester Gas

Boilers

CAT Engine Generators- 0.9 MW each

White Superior Engine Generator- 1.5 MW

Feed Sludge
-Primary Sludge
-Airport Deicing Fluid
-High Strength Waste
-TWAS

Anaerobic Digesters
15 MG
98°F

Heat Recovery System

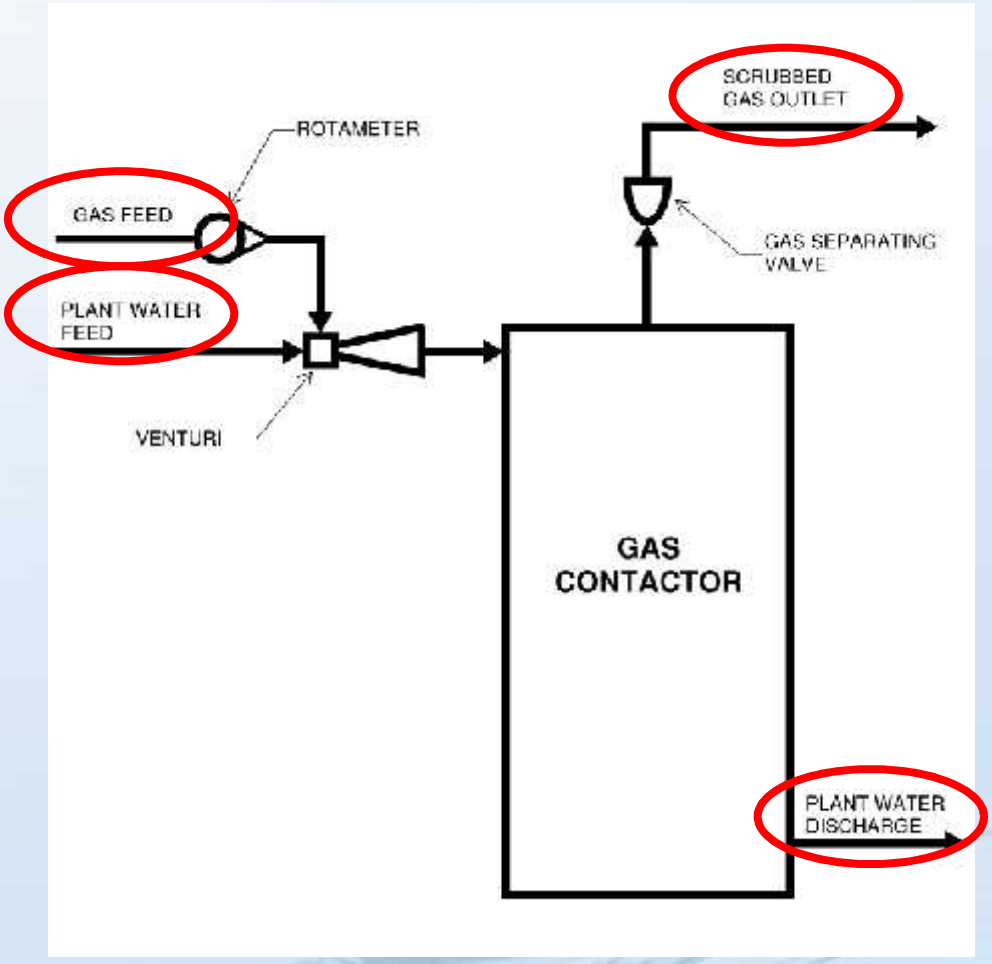
Digested Sludge
Sent to Jones Island for Milorganite Production

Building Heat

South Shore Digester Gas Quality and Quantity

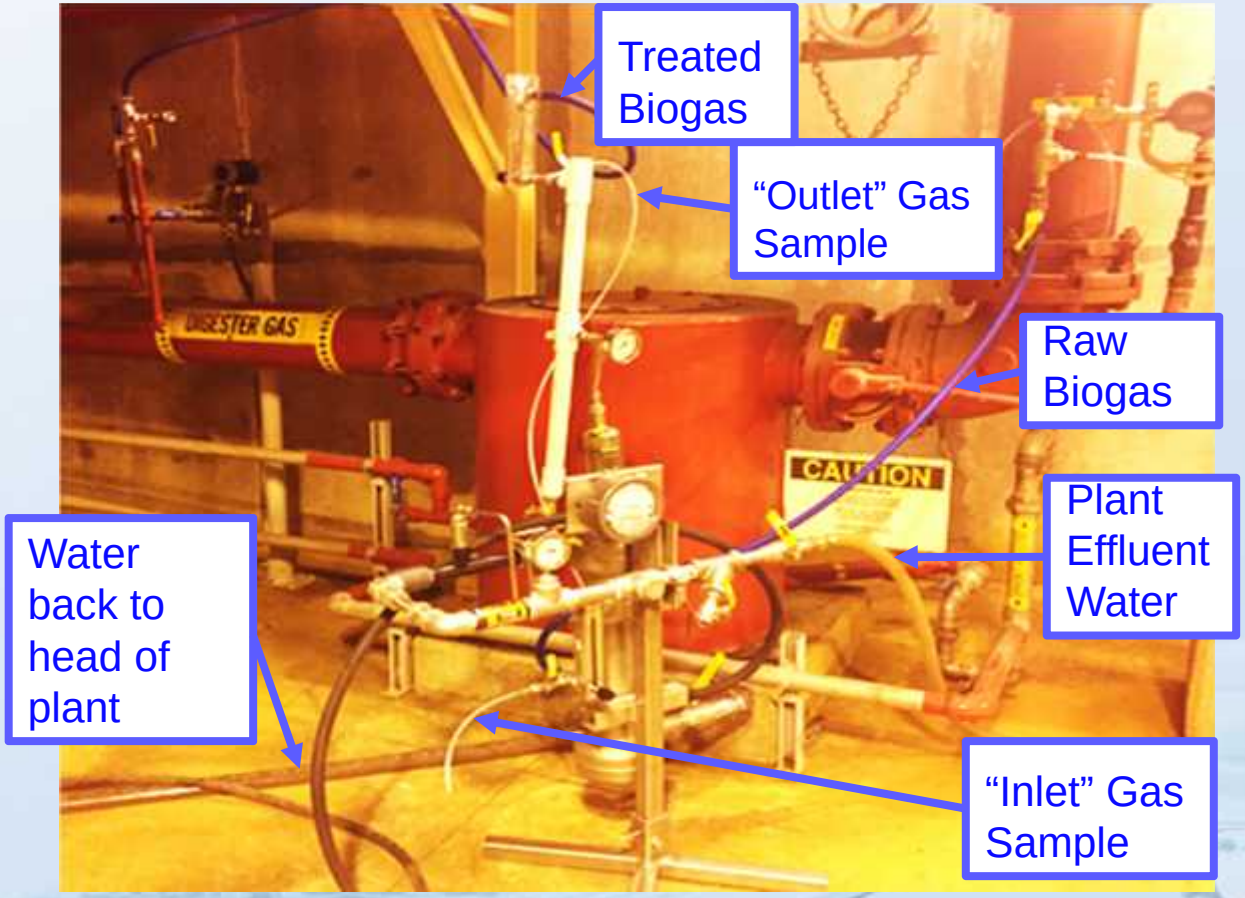
MMSD Plant Data[1]				
Information Item	Unit	Average	Maximum	Notes
Quantity of digester gas available to be treated	Scf/Day	1,320,000	2,120,000	
Gas Quality:				
• Methane	%	59	63	
• Low Heat Value	Btu-LHV/scf	530	565	
• Carbon Dioxide	%	33.2	38	
• Hydrogen Sulfide (ppm)	ppmv	21.7	34.9	Iron added to primary influent
• Total Siloxanes	$mgSi/Nm^3$ CH_4	22.16	320	Concentration Si in methane fraction
• Total Siloxanes	$mgSi/Nm^3$	13.28	202	Concentration in digester gas
Notes:				
(1)Based on 2014-2016 data.				

The technology itself is simple



Pilot Unit Setup

- Located in digester gallery of South Shore WRF



Venturi and Gas Contactor/Moisture Separator

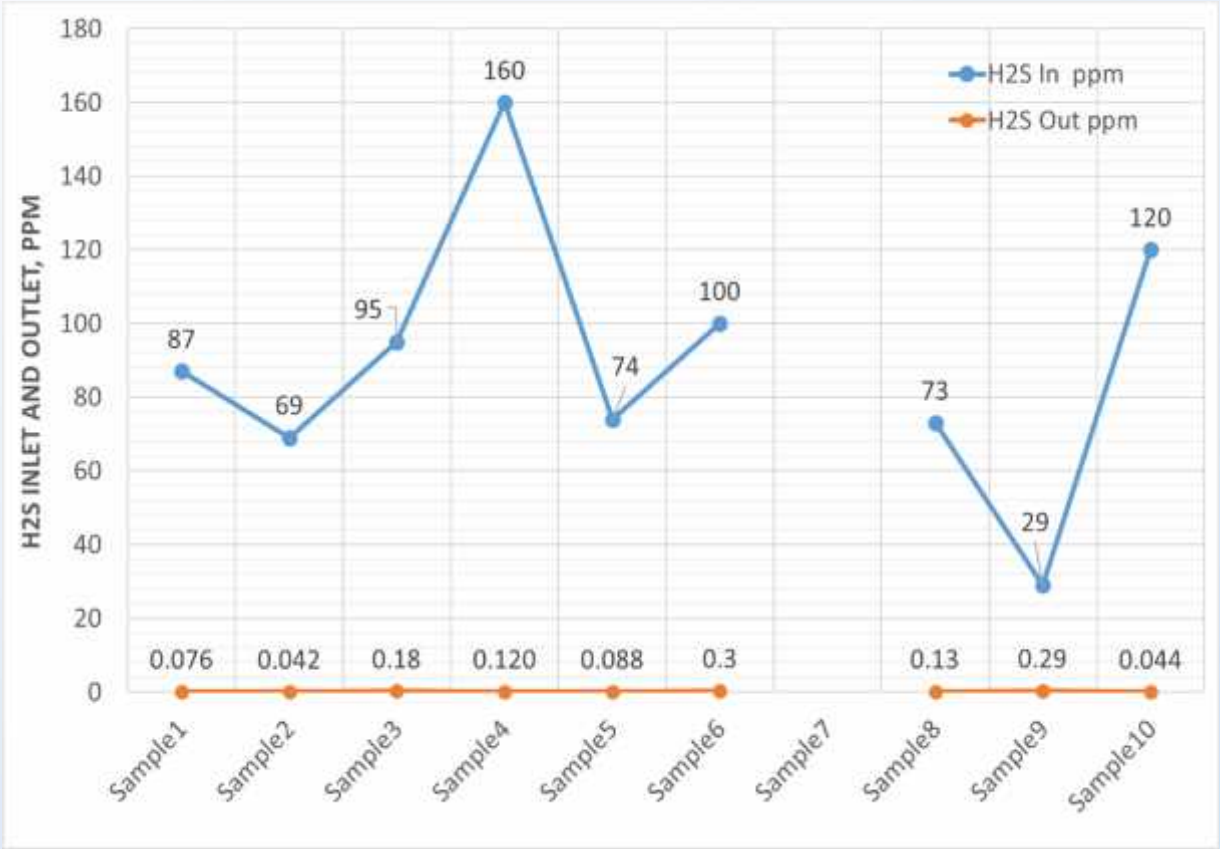
- Plant Effluent Water Used
- Inlet water Pressure 30 psig
- Discharge water pressure= 4 psig
- Water Inlet Flow = 12 gpm

Inlet Outlet Reading Hand Held Device

Digester Gas Sampling

- **Raw gas samples** (INLET) and
- **Treated gas samples** (OUTLET)
- Grab samples collected in pressurized Canisters analyzed for
  - Methane
  - CO_2
  - H_2S
- 30 min samples collected with Sorbent tubes and analyzed for
  - Siloxane

H_2S Removal Rate During the Pilot



- Average Inlet H_2S= 90 ppm
- Average Outlet H_2S =0.14 PPM
- % H_2S Removal rate was 99.8 %

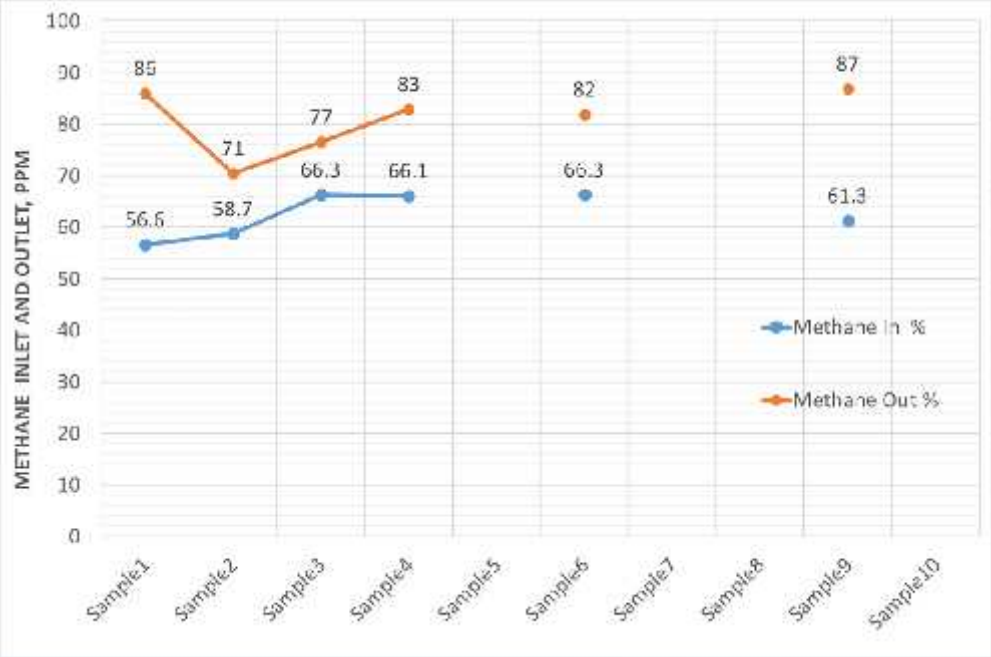
Siloxane Removal Rate During the Pilot

- Average Inlet Siloxane= 3,244 µg/m^3 as Si
- Average Outlet Siloxane = 1143 µg/m^3 as Si
- % Siloxane Removal rate 65%

CO_2 Removal Rate During the Pilot

- Average Inlet CO_2= 32%
- Average Outlet CO_2 = 6%
- % CO_2 Removal rate 80%

Methane Surge During the Pilot



- Average Inlet CH_4 = 63%
- Average Outlet CH_4 = 81%
- % Methane Surge 29%

Pilot Unit Results

Parameter	Average Inlet Concentration	Average Outlet Concentration	Average Percent Change
H_2S (ppmV)	90	0.14	99.8% ± 0.3%
Siloxanes (ppmV as Si)	2.9	0.92	65% ± 13.6%
Methane (%)	63	81	29% ± 16%
Carbon Dioxide (%)	32	6.3	80.3% ± 14%

Challenges during the Pilot

- Too good to be true
- Plant Water Pressure and Flow impacts the treatment
- Gas pressure Fluctuation causes additional time in sampling

Preliminary Full Scale Estimate

- Pilot to be installed in the low pressure side
- Recommended gas pressure <12 in H20
- For 1.3 MMCF gas production we need ~12 MGD plant water without recirculation (for MMSD)
- If we add water recirculation loop the anticipated water consumption can go down to < ~6 MGD
- In general 7 to 10 gpm per 1 scfm depending on available water pressure (without recirculation)

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Summary and Next Steps…

- Full scale pilot to be installed soon in Southern California
- Additional small scale “proof of concept” pilots around upper Midwest
- Refine water recycle loop which will reduce the inlet water requirement to the system
- Further improve methane quality in the product gas stream
- Collect additional data on various siloxane sources to better determine which species are efficiently removed using this process