Pressure Swing Adsorption for Natural Gas Separation and Emissions Reductions at Facilities

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2025 UNVEILING THE MAGIC OF MIDSTREAM INNOVATION
GPA MIDSTREAM CONVENTION

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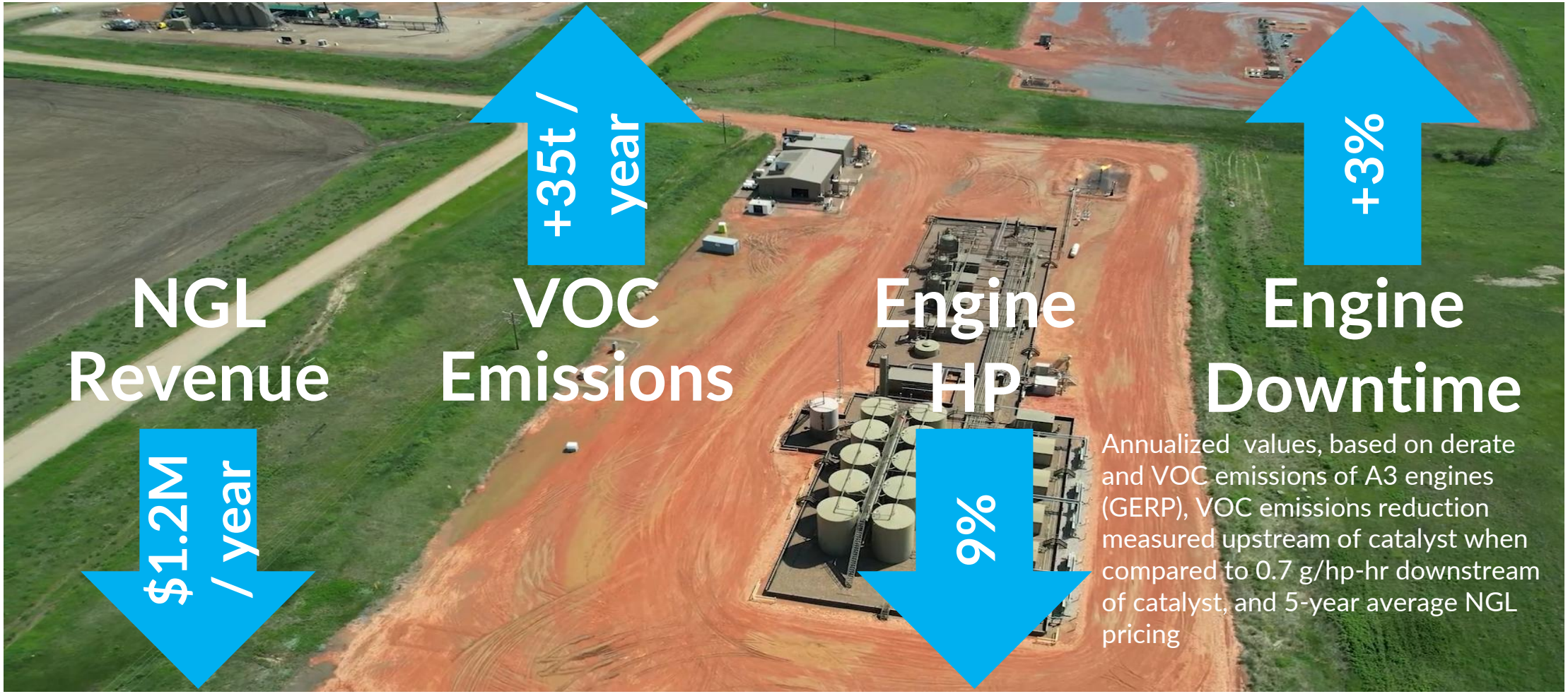
The Problem of Burning Rich Gas in Compressor Engines

- Creates significant Volatile Organic Compouns (VOC) emissions
- Compressor engine horsepower (HP) is derated
- Higher compressor downtime (shut in production / reduced throughput / detonations) due to burning rich gas as opposed to lean gas
- Burning Natural Gas Liquids (NGL's) as opposed to processing and recovering them costs midstreamers / producers significant revenue

➢We address this problem with our MaCH4 NGL Recovery Solution

Examples of issues related to burning 1,310 BTU gas at a 8,250 HP compressor station



Current Solutions For Reducing Fuel Gas BTU's

	J-T Skid	MRU	Residue Line	$MaCH_4$
				
< 1,100 BTU Fuel Gas	No	No	Yes	Yes
C_2 Recovery	< 0.5%	< 5%	N/A	60%
C_3 Recovery	< 25%	< 50%	N/A	> 90%
C_4+ Recovery	~ 50% - 80%	~ 80% - 95%	N/A	> 95%
VOC Reductions	Minimal	Moderate	Maximum	Maximum
NGL Value Discounted – Trucking	Yes	Yes	No	Minimal
Consumables and OPEX	Moderate	High	N/A	No
Permits and / or ROW Required	No	Yes	Yes	No
Independent of Ambient Temp.	Yes	Moderate	No	No

$MaCH_4$ vs JT Skid by the Numbers

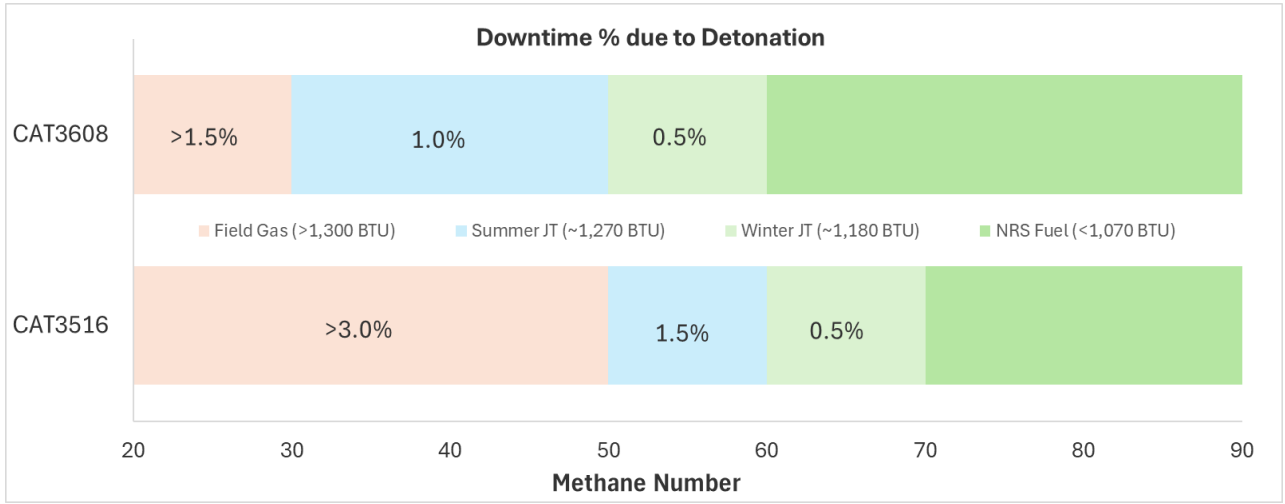
10,000 Horsepower Permian Station

10,000 HP Permian Station 1.5MM Fuel Gas			VOC Emissions				Detonation Downtime		Monthly NGL Revenue
			3516 J		3608 A4		3516 J	3608 A4	
Fuel Gas Type	BTU	Methane Number	Tons/Year	% Reduced	Tons/Year	% Reduced			
Field Gas	1375	50.7	85.5	0%	112.1	0%	3.0%	1.0%	$ -
JT Skid Summer	1266	54.3	60.9	29%	78.0	30%	1.5%	0.5%	$ 10,000.00
JT Skid Winter	1182	64.2	44.8	48%	50.8	55%	0.5%	0.0%	$ 20,000.00
MaCH4	1070	75.3	35.5	58%	22.8	80%	0.0%	0.0%	$ 102,000.00

VOC emissions and downtown due to detonation depend on the Methane Number and engine type

Month	Day Temp [°F]	Night Temp [°F]	Average Temp [°F]	JT Skid BTU
January	65	48	57	1180
February	69	51	60	1189
March	77	57	67	1210
April	83	63	73	1228
May	90	70	80	1249
June	95	75	85	1264
July	98	76	87	1270
August	99	78	89	1276
September	92	75	84	1261
October	85	66	76	1237
November	74	57	66	1207
December	68	51	60	1189
Averages	83	64	73	1230

JT fuel gas quality is heavily depending on ambient temperatures



Data on Detonation and JT Skid gas qualities provided by Permian customers.

$MaCH_4$ NGL Recovery Solution

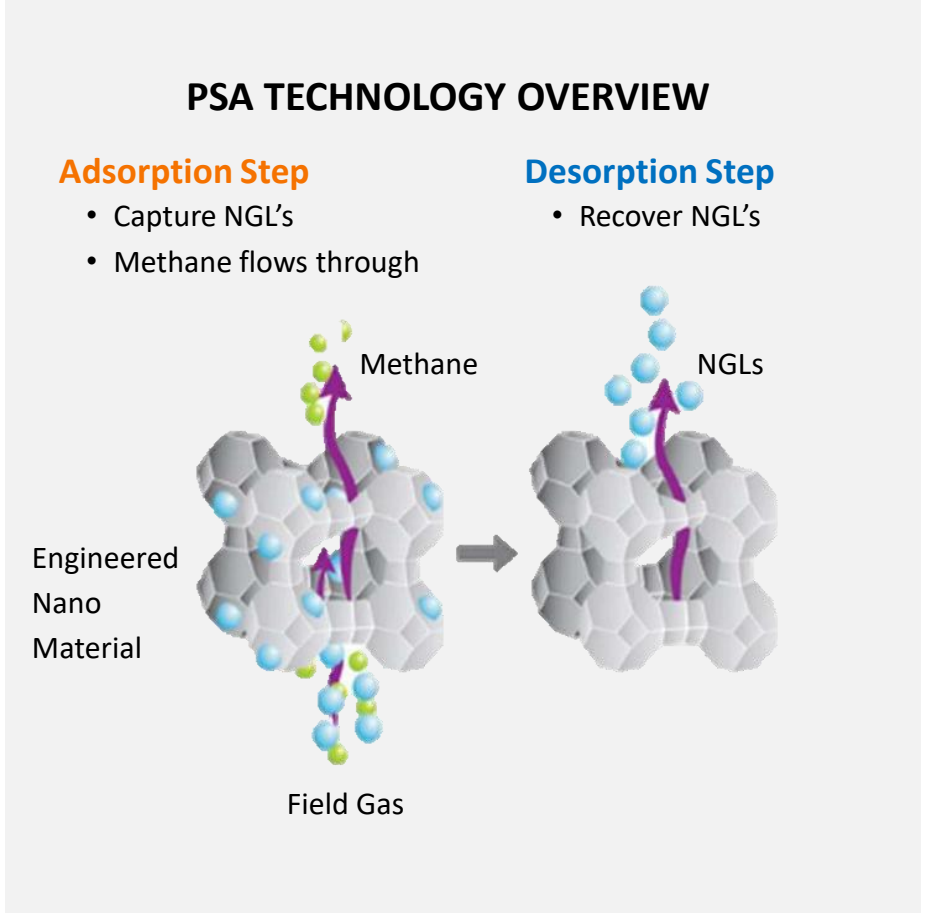
Patented, based on Pressure Swing Adsorption (PSA), selectively recovering NGL's that would otherwise be combusted

- **Effective** – Captures 60% of C_2 and 90+% of C_3+ hydrocarbons; delivers 90+% methane purity product
- **Easy to Deploy & Operate** – No tanks, compressors or generators
- **Modular** – Can be stacked to support multi-engine clusters
- **Reliable** – No rotating equipment, >99% demonstrated availability

➢ Provides residue quality gas without the residue line

Pressure Swing Adsorption (PSA) Technology

- Approach widely used for N_2 and H_2 purification as well as CO_2 removal in Renewable Natural Gas applications
- Proven process reliability in e.g. O_2 recovery in space station
- **Process adapted and patented for field gas**
- Engineered commercially available nano material to “filter” NGL’s from Methane
- Proven NGL Recoveries of C_2 – 60%, C_3 – 90%, C_{4+} – 98%
  - Lab validated for 2+ years
  - Field validated for 18+ months
  - Scalable and adaptable through modeling and simulation



Simple Integration – Minimum Connections*

FIELD INLET GAS TO COMPRESSOR

Stage 1 → Stage 2 → Stage 3

FIELD GAS + NGL PIPELINE

NGL'S IN GASEOUS FORM REINJECTED INTO PIPELINE
- 5,270 gallons / day
- 45,790 bbl / year
- $1.23MM value / year

Values assume 2,500 MSCFD inlet; 1,310 BTU gas

FIELD GAS+ < 1,400 psig

COMPRESSOR SLIP STREAM**
- Up to 2,500 MSCFD
- 1,150 to 1,650 BTU
- Saturated

C_1 GAS 90 – 200 psig → **COMPRESSOR ENGINE**

COMPRESSOR FUEL GAS**
- 1,500 MSCFD
- <1,100 BTU HHV
- Dehydrated

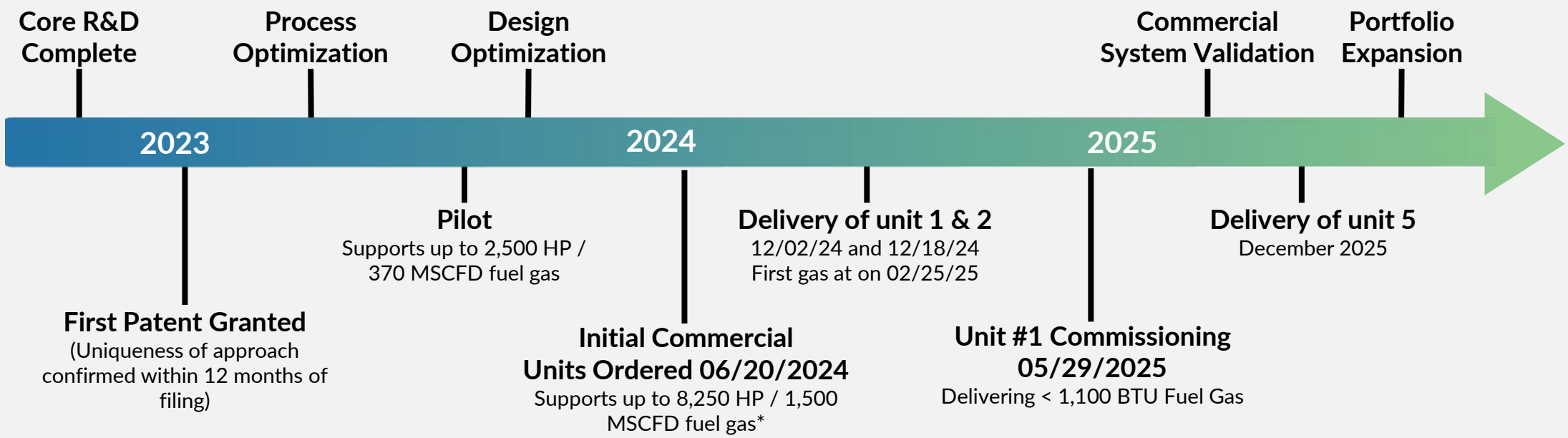
NGL RECOVERIES (Vapor)
C_2 – 60%
C_3 – 90%
C_4+ – 98%

C_2+ GAS < 100 psig

* Inlet: Field Gas, Instrument Air / Outlets: Fuel Gas, NGL's, Drain; 110V / 50 Amps
** Based on 8250 HP Compressor Station. A single $MaCH_4$ can support up to 11,000 HP
\+ Inlet Temperature: supplied by customer or gas fired heater

From Pilot To Commercial

$MaCH_4$ development started in 2020 using a new technical approach



* Based on 1,310 BTU field gas. 6,000 HP limit at 1,440 BTU field gas

Field Validation

Pilot Deployment

Compressor Station - Canadian County, Oklahoma

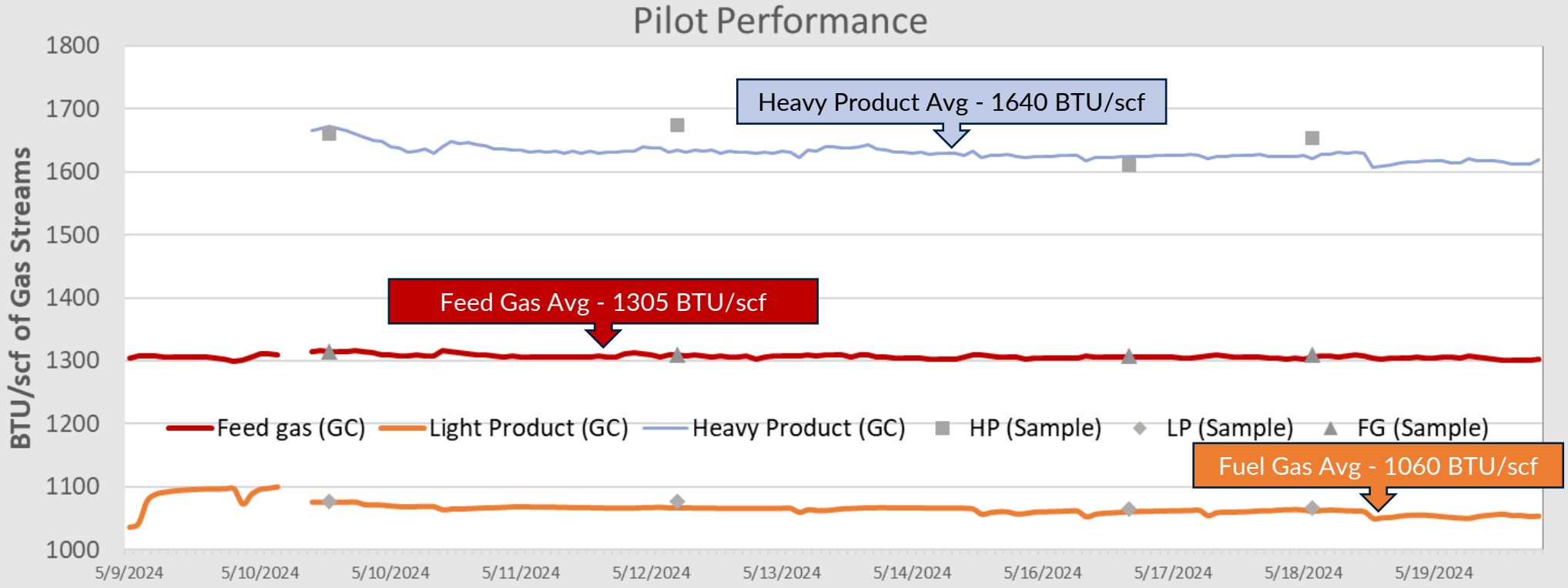
Pilot Site Data

- 6x 3608 A3 engines (2,280 HP each)
- 1,305 BTU field gas
- J-T skid delivers 1,245 BTU fuel gas
- Pilot supports up to 2,500 HP

Results

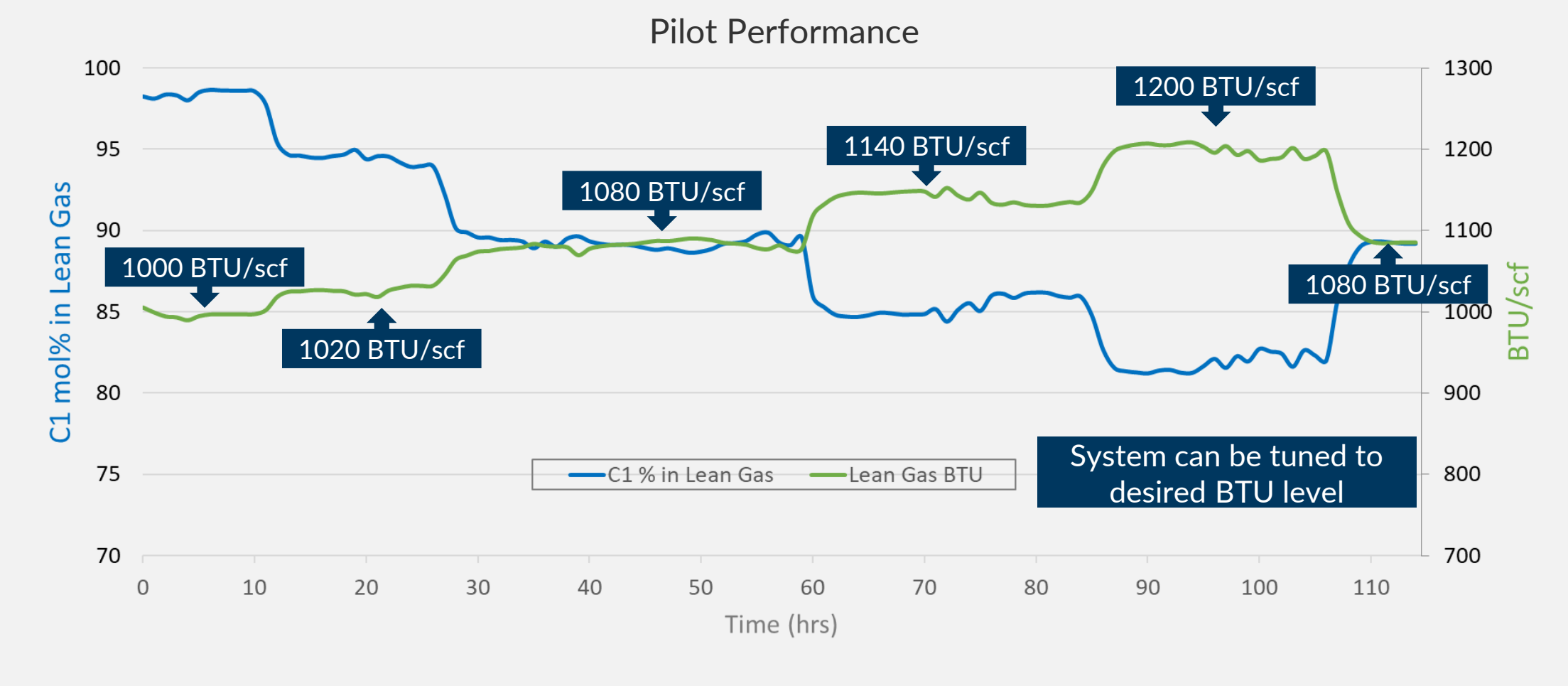
- ✓ Operational since 12/15/2023
- ✓ System consistently delivers < 1,070 BTU fuel gas
- ✓ Demonstrated availability of +99%
- ✓ Fully demonstrated remote operation capability
- ✓ Minimum Maintenance – Only Filter Changes

Consistent, High Quality Fuel Gas
Validated With 3rd Party Gas Analysis

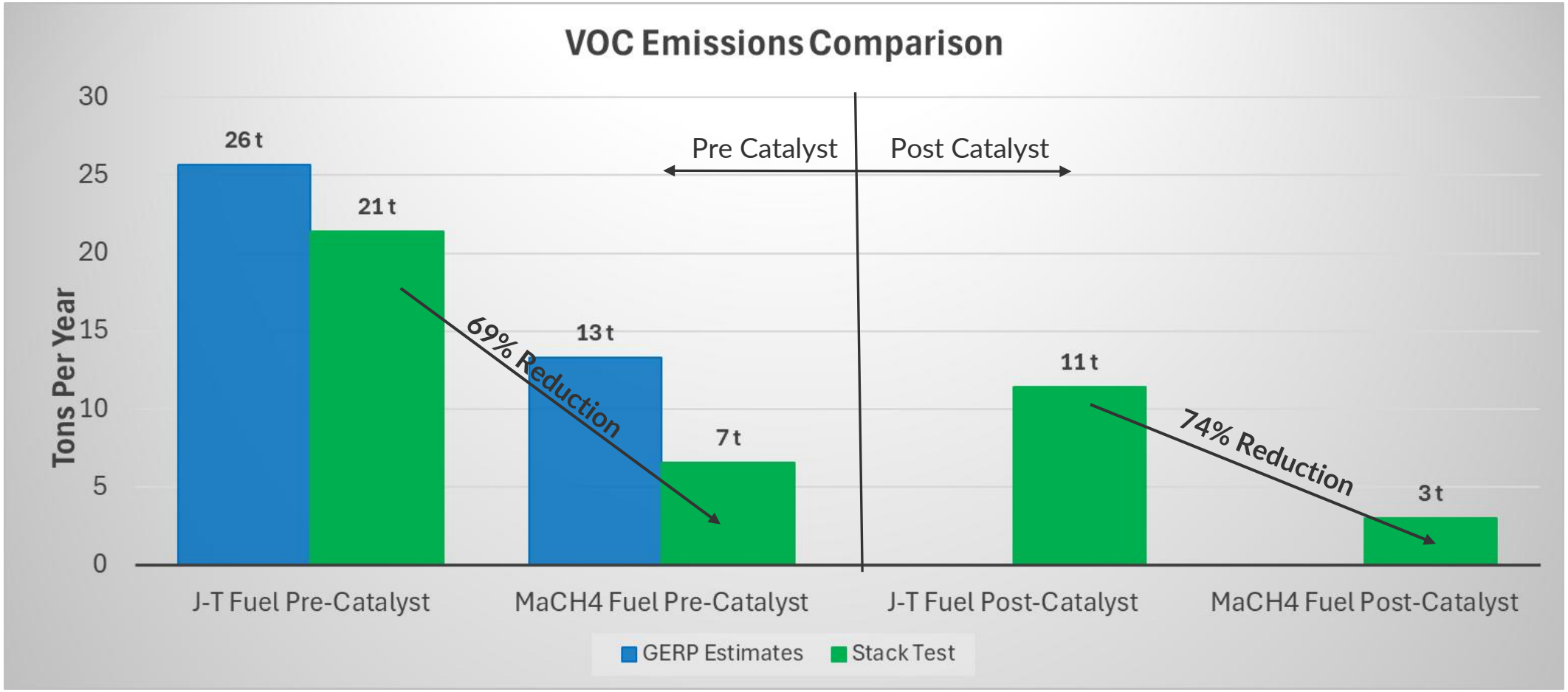


- Continuous monitoring of Feed gas, Lean gas and recovered HHCs in the Heavy product
- 3rd party gas analysis done periodically to verify pilot GC analysis

Fuel Gas BTU Value Can Be Controlled



VOC Reduction – Stay In Permit Limits



Emissions test conducted on CAT 3608 Engine. Test runs in accordance with EPA Methods 1 and 2 in 40 CFR Part 60 Subpart JJJJ Appendix A-7. MKS MultiGas 2030 FTIR was used for all measurements.

Field Validated Performance

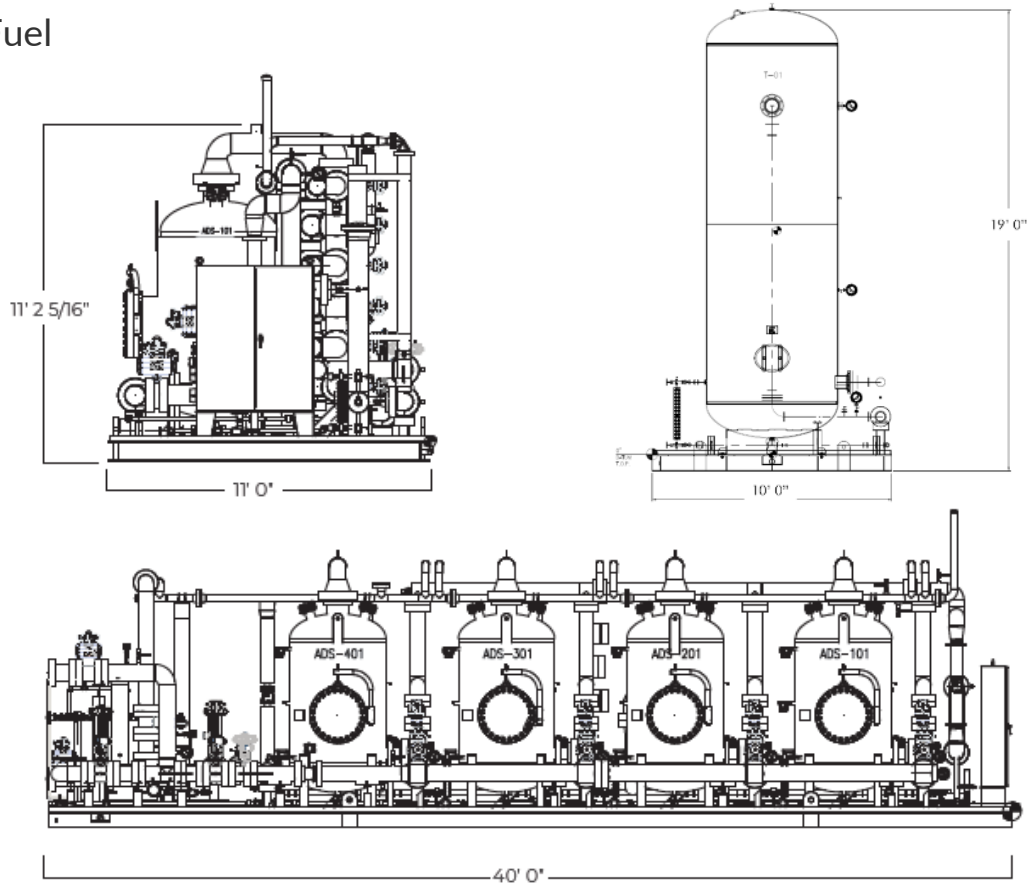
Goal/KPI	Results
Heavy Hydrocarbon Recovery	>= 60% C2 >= 90% C3 >= 98% C4+
Light Product BTU value	< 1,100 BTU HHV
Dehydrate Fuel Gas	< 5 lb/MMscf
VOC Reduction	70% Reduction in VOC emissions
Processing Capacity (500Mscfd)	Flow control and metering operating as designed
Adaptation to Raw Gas Inconsistency	3rd party gas analysis (1260 BTU to 1315 BTU)
Equipment Uptime (Mechanical/Electrical/Pneumatic)	>99% uptime to date (adjusted for changes implemented)
No performance impact from typical contaminants	Confirmed no impact in lab and no performance degradation at pilot site to date

Commercial Deployment
Beckham County, Oklahoma

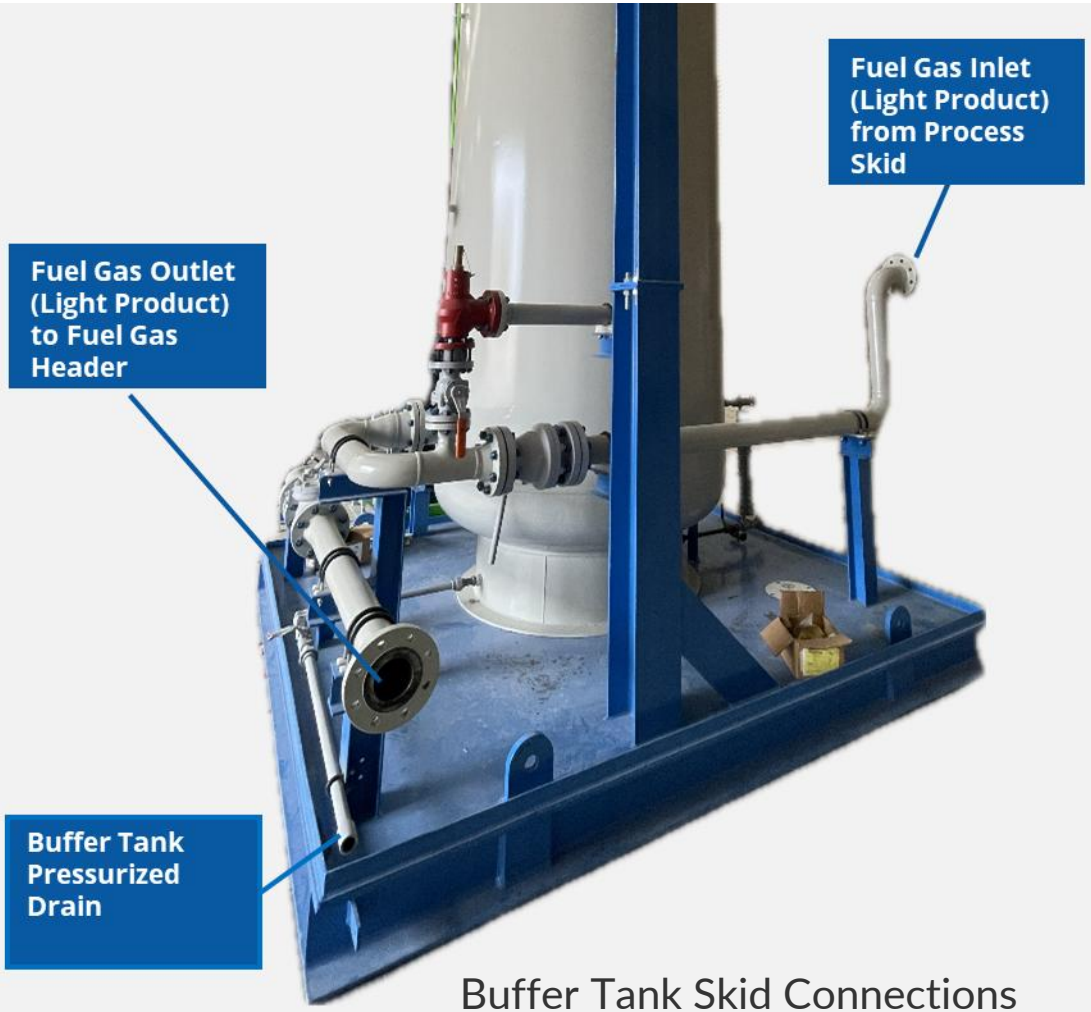
Commercial Unit Overview

Initial Commissioning February 25, 2025, at first customer site (Oklahoma)

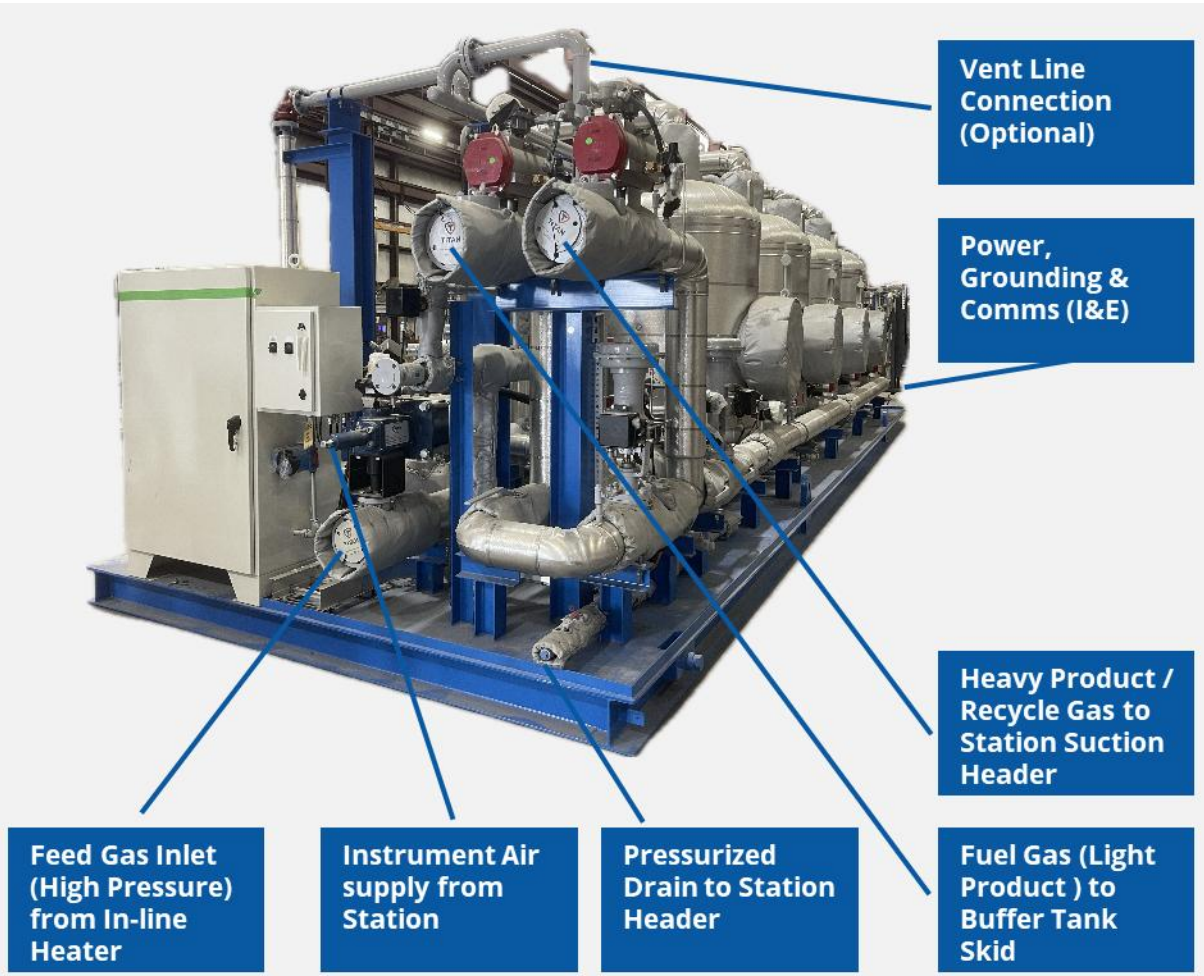
- Processes up to 2,500 MCF/D and provides ~1,500 MCF/D Lean Fuel
- Processing skid – 40 ft x 11 ft x 11.5 ft, 76,000 lbs
- Buffer tank skid – 10 ft x 10 ft x 22 ft, 12,000 lbs



Simple Connections



Buffer Tank Skid Connections

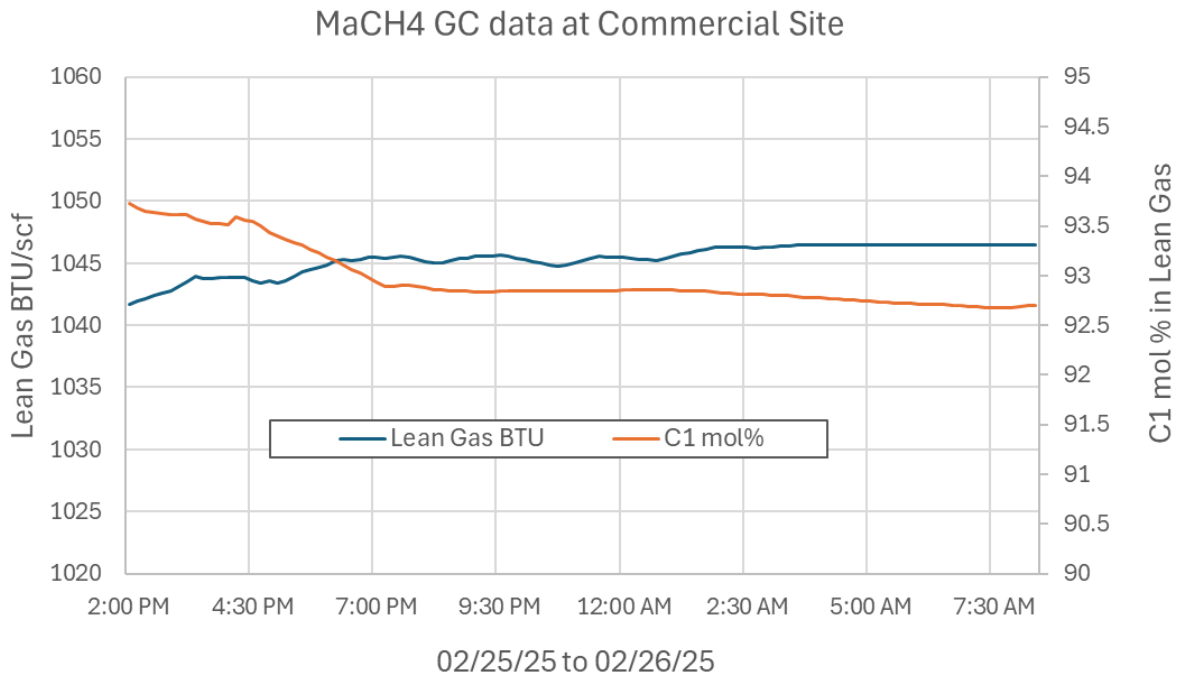


$MaCH_4$ Skid Connections

Initial Commercial Results

- Deployed at compressor station in Beckham County, Oklahoma
- First gas was provided to $MaCH_4$ System on 02/25/25
  - 1,045 BTU lean fuel gas was produced with hours of startup
- Full commissioning started on 05/28/25
  - **Delivering 1,055 BTU fuel gas with 1,200 BTU field gas**
- Fueling compressor station started 6/19/2025
  - Adjusted fuel gas to 1,065 BTU – seamless switch over

Produced 1045 BTU lean gas



A Compelling Value Proposition

Quantifiable value over no Fuel Gas Conditioning solution

- Additional capacity as well as higher BTU field gas result in significant additional value

Broad range of use case

- Supports up to 8,250 HP* with field gas equal or less than 1,310 BTU
- Supports up to 6,000 HP with field gas of 1,440 BTU
- Additional benefits when used for lean burn engines
- **Customer payback period of less than 3 years based on $250k to $350k installation cost**

* **Depending on station specific conditions, up to 11,000 HP can be supported with a single MaCH$_4$ system**

	1,310 BTU	1,440 BTU
Incremental NGL Value	**8250 HP**	**6000 HP**
Net NGL Benefit	$ 1,229,595	$ 1,142,678
Throughput		
Recycle cost of compression	$ (60,200)	$ (93,411)
Operations Cost		
O&M / Electricity Cost	$ (32,628)	$ (32,628)
Incremental Value A4 Engine	$ 1,136,767	$ 1,016,640
Eliminating 8.8% derate		
Compression cost reduction	$ 144,540	$ 105,120
Incremental Value A3 Engine	$ 1,281,307	$ 1,121,760
VOC Emissions		
VOC Reductions (TPY)	(35)	(23)

All values shown are annual for year average NGL pricing, **no cost of methane.** VOC emission reduction measured upstream of catalyst when combusting a lean fuel gas compared to 0.7 g/hp-hr downstream of catalyst.

A $1.1B / Year Industry Opportunity

NGL Value

Captured instead of burned

VOC Emissions

Reduced through burning lean gas

Gas Value

Additionally moved by eliminating detonation related downtime

Based on estimated 3,500,000 installed HP on field gas, adjusted for use of JT Skids. Engine downtime due to detonations estimated at average 1% and converted into lost natural gas revenue

Benefits for Midstreamer and Producer Collaboration to install MaCH4 at all rich Compression locations

- NGL Revenues
  - Whether a percentage of proceeds, keep whole, or other type of processing agreements, midstreamers and/or producers benefit from significant additional processing revenues
- Additional throughput through less downtime and optimal HP usage
  - Additional revenue to producer from oil and gas sales and additional transport revenue to midstreamer
- Environmental benefits
  - VOC reductions help the stewardship efforts of producers and midstreamers
- Additional transport and fractionation throughput
  - Benefit to midstreamer if they own the facilities downstream of processing plant
- The estimated value per system to be shared by midstream and producer is estimated at $3+MM per year

Thank You!

Maximize Value - Minimize Emissions