Welcome!

The program will begin soon.

You will not hear audio until we begin.

Abatement Of GHG Emissions By Simplifying Field Architecture With Multiphase Flowmeters In Onshore US Shale: A Field Case Study

Katharine Moncada - SLB

Amin Amin - Belsim S.A.

Dec 1st, 2023

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Agenda

- Methane Emissions Abatement in the O&G fields and EPA factors
- The Proposed Multiphase Flowmeter (MPFM) Solution
- Eagle Ford Operator Implementation – Field Case Study
- Permian Basin Implementation Examples
- Conclusions

Methane Emissions Abatement in the O&G fields and EPA factors

Methane: A more Potent Gas over Shorter Periods

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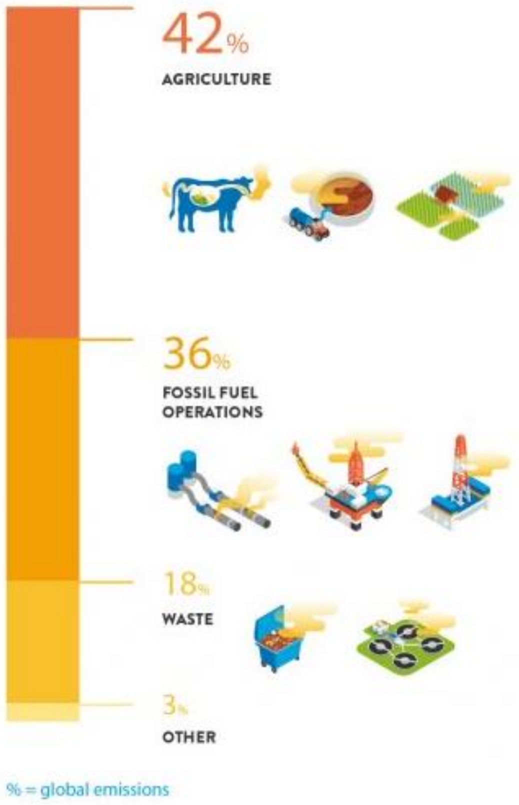
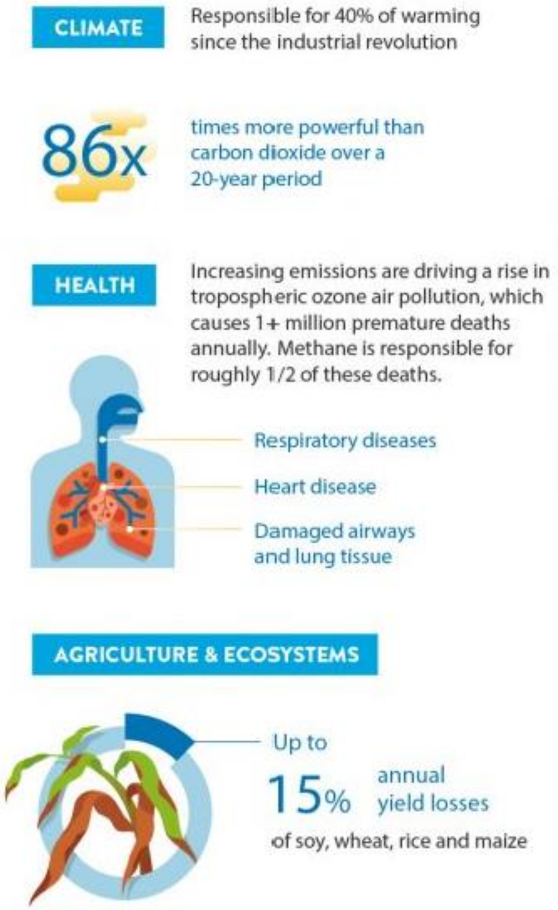
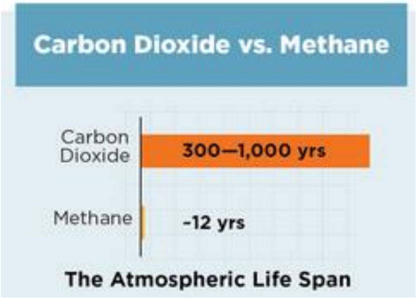
Sources



Negative Impact



CH_4 Abatement Benefit



The Global Methane Pledge

"The International Energy Agency (IEA) estimates methane emissions from the industry must be reduced by 75% by 2030 to align with net zero,"

(IEA)

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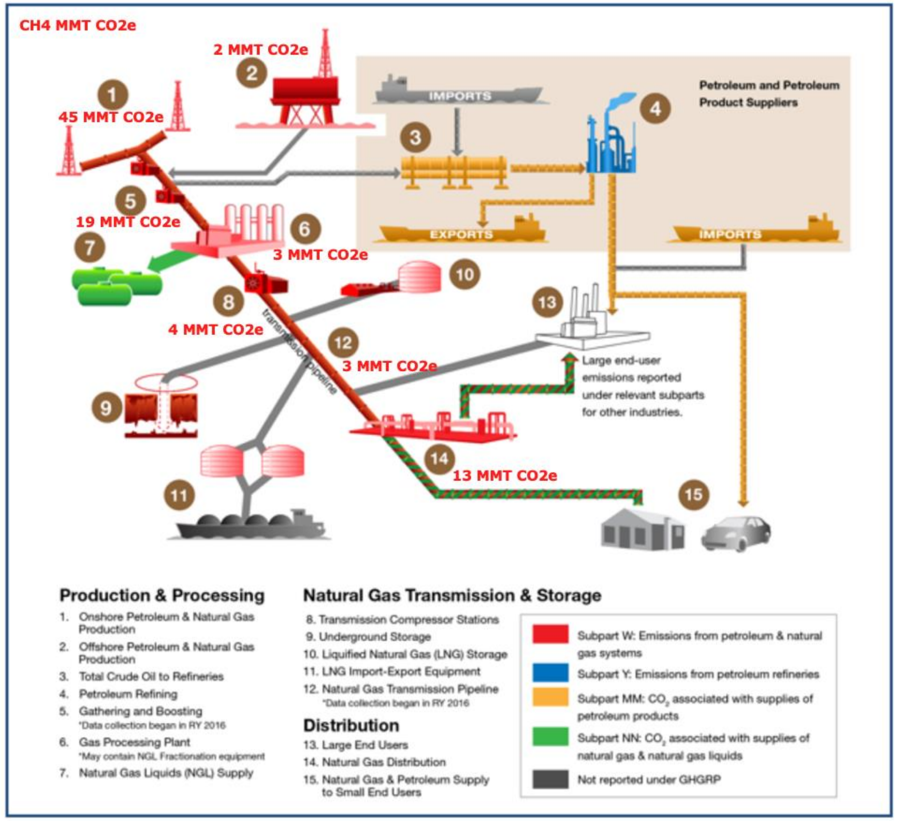
Source: www.ccacoalition.org/methane

EPA - Methane Emissions O&G Industrial Profile

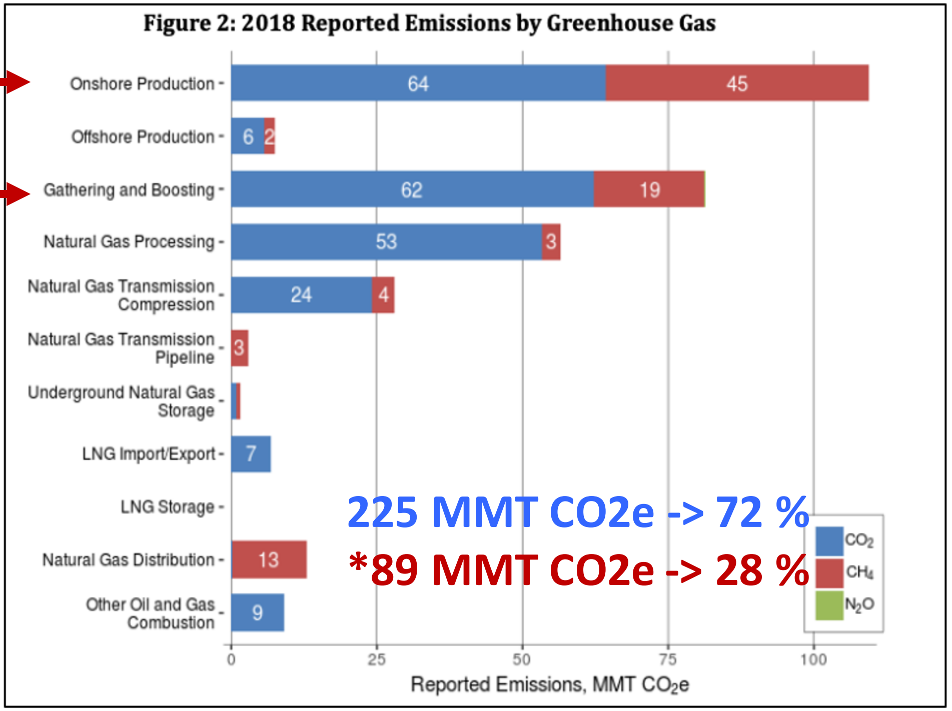
US 2018 Reported GHG Emissions



72% of Methane Emission from Wellsite and Gathering and Boosting Facilities

51%

21%



*1 kg of methane (CH4) is equal to 25 kg CO2 equivalents

EPA - Methane Emissions O&G Industrial Profile

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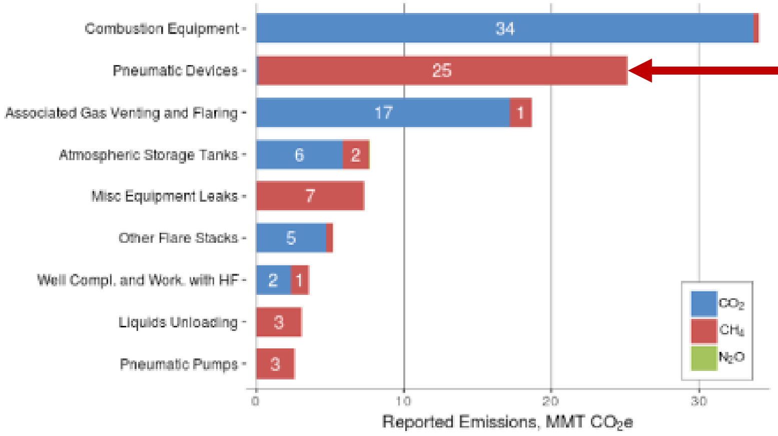
US Onshore Production: 2018 top reported emissions sources

Onshore Production

The EPA received annual reports from 500 facilities in the onshore production segment and reported emissions totaled 109.4 MMT CO_2e. Methane emissions totaled 45.2 MMT CO_2e and carbon dioxide emissions totaled 64.2 MMT CO_2e. Combustion Equipment (34.1 MMT CO_2e) and Pneumatic Devices (25.2 MMT CO_2e) were the top reported emission sources, followed by Associated Gas Venting and Flaring (18.7 MMT CO_2e), Atmospheric Storage Tanks (7.7 MMT CO_2e), Misc Equipment Leaks (7.3 MMT CO_2e), and Other Flare Stacks (5.2 MMT CO_2e). Onshore production emissions by greenhouse gas from the top reported emission sources are presented in Figure 5 for 2018.

Figure 5: 2018 Onshore Production: Top Reported Emission Sources



56 %

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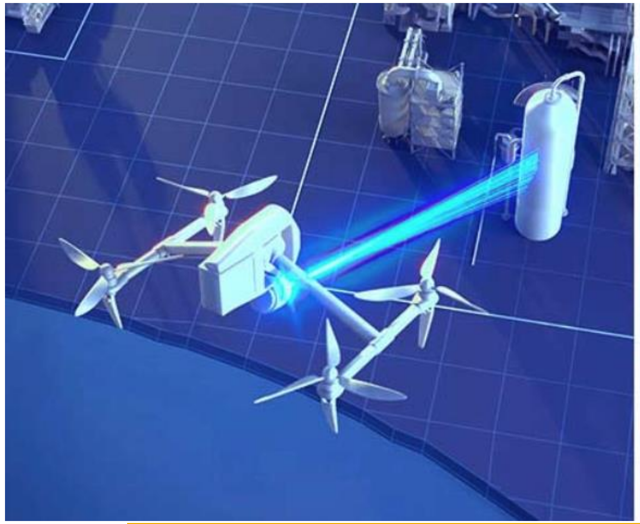
Onshore Wellsite Pads Facilities – Sep & Storage

Natural gas—which is primarily made of methane—leaks unburned at every stage from fracking to combustion. Photograph by Ed Kashi / VII / Redux

Methane Emission Detection and Estimation

Periodic Surveillance

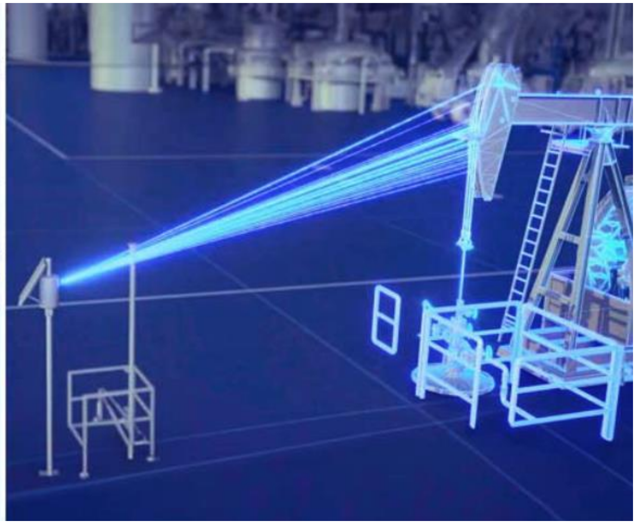
Fly-over &
Drone Surveys



Method 21

Continuous Surveillance (in favorable conditions)

Point Sensing



LiDAR
Laser imaging, Detection, and Ranging

OGI
Optical Gas Imaging

EPA – Pneumatic Devices Emission Report

United States Environmental Protection Agency

GRI-94 / 0257.29
EPA - 600/R-96-080i
June 1996

PB97-143036

Research and Development

GRI 1994

EPA 1996

METHANE EMISSIONS FROM THE NATURAL GAS INDUSTRY

Volume 12: Pneumatic Devices

Methane Composition

The percentage by volume of methane in produced natural gas was determined to be 78.8% ± 5%. Details about this value are available in the report, *Methane Emissions from the Natural Gas Industry, Volume 6: Vented and Combustion Source Summary.*[26]

Emission Factor Calculation

The weighted emission factor per device was calculated for production facilities as follows:

$$\text{Weighted Emission Factor} = \left(\text{Fraction of Intermittent Bleed Devices} \times \text{Intermittent Bleed Emission Factor} + \text{Fraction of Continuous Bleed Devices} \times \text{Continuous Bleed Emission Factor}\right) \times \text{Methane Composition} \quad (1)$$

The site data were used to estimate the fraction of intermittent bleed versus continuous bleed devices: 65% ± 43% intermittent bleed and 35% ± 43% continuous bleed (Table 4-5). Table 4-6 summarizes the emission factor terms, where the emission factors for the individual device types (intermittent versus continuous bleed) were based on the field measurements from the United States and Canada discussed previously.

The final result is an average device methane emission factor of 345 scfd/device ± 40% (90% confidence interval), or 126,000 scf/device annually.

TABLE 4-6. PRODUCTION EMISSION FACTOR CALCULATION

Device Type	Fraction of Device Type	Selected Natural Gas Emission Factor, scfd/device
Intermittent Bleed	0.65 ± 43%	323 ± 34%
Continuous Bleed	0.35 ± 43%	654 ± 31%
Methane Emission Factor for Average Device = 345 ± 40% scfd/device		

Or 48% at 95% CL

CFR-2021-title40-vol23-part98

TABLE W–1A TO SUBPART W OF PART 98—DEFAULT WHOLE GAS EMISSION FACTORS FOR ONSHORE PETROLEUM AND NATURAL GAS PRODUCTION FACILITIES AND ONSHORE PETROLEUM AND NATURAL GAS GATHERING AND BOOSTING FACILITIES

Onshore petroleum and natural gas production and Onshore petroleum and natural gas gathering and boosting	Emission factor (scf/hour/component)
Eastern U.S.	
Population Emission Factors—All Components, Gas Service[1]	
Valve	0.027
Connector	0.003
Open-ended Line	0.061
Pressure Relief Valve	0.040
Low Continuous Bleed Pneumatic Device Vents[2]	1.39
High Continuous Bleed Pneumatic Device Vents[2]	37.3
Intermittent Bleed Pneumatic Device Vents[2]	13.5
Pneumatic Pumps[3]	13.3

[1] For multi-phase flow that includes gas, use the gas service emissions factors.
[2] Emission Factor is in units of "scf/hour/device."
[3] Emission Factor is in units of "scf/hour/pump."

13.5 x 24 hrs = 323 scfd/device

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Methane Emission Monetization

Accreditation

$$Methane\ Intensity\ \% = \frac{Methane\ Emitted\ (Mscfd)}{Methane\ Throughput\ (Mscfd)}\ x\ 100$$

$$= \frac{Tanks\ Venting + Fugitive\ Leak + Event\ Releases (Mscfd)}{Methane\ Throughput\ (Mscfd)}\ x\ 100$$

Calculated **Intensity** = $\frac{\text{Methane emitted}}{\text{Natural gas produced}}$	**Robust Monitoring Technology Deployment** at Facility- and Source-levels.	**Company Practices** Policies and procedures for methane emissions management.

Accredited third-party Certifying Bodies audit and verify

≤ 0.05%	Quarterly	Stringent	A
≤ 0.10%	Semi-annually	High	B
≤ 0.20%	Semi-annually	Medium	C
≤ 0.50%	Annually*	Mandatory minimum	D
≤ 1.00%	Annually*	Mandatory minimum	E
≤ 2.00%	Annually*	Mandatory minimum	F

*Source-level only

Source: https://miq.org/the-technical-standard/

IRA "Waste Emission Charge

The Inflation Reduction Act (IRA) of 2022 imposes a methane fee on facilities that emit more than 25,000 metric tons of carbon dioxide equivalent per year and exceed applicable waste emissions thresholds. The fee is called a "waste emissions charge".

The fee will start at $900 per metric ton of methane in 2024, increase to $1,200 in 2025, and hold at $1,500 in 2026 and thereafter. The fee applies to methane emissions in excess of a small allowance that depends on the type of operation.

The Proposed Multiphase Flowmeter (MPFM) Solution

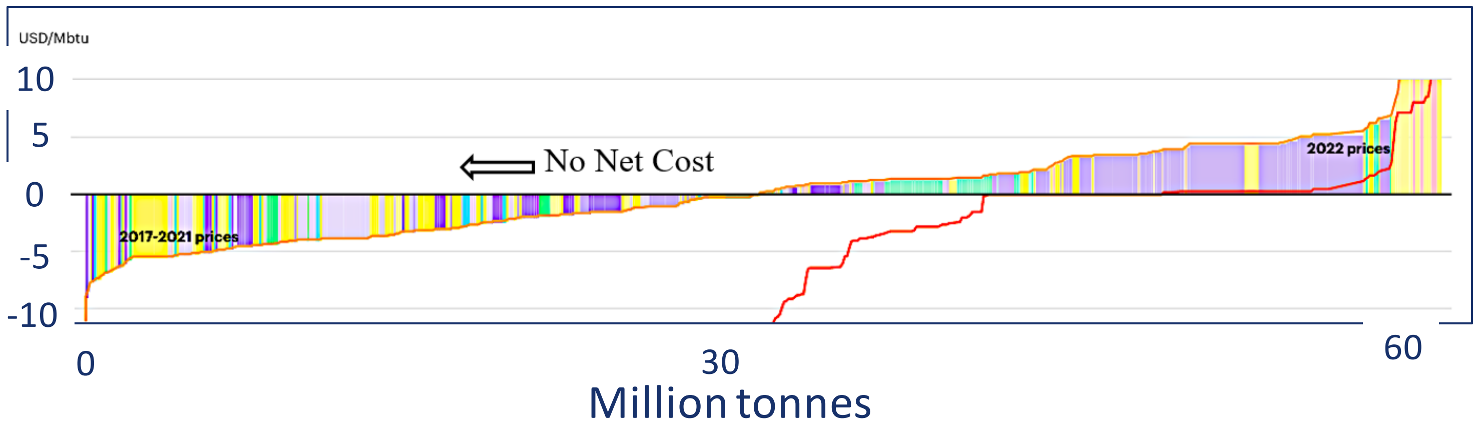
Top 10 Reasons for Simplifying Well-pad Facility Using MPFM Technology

1. Primary objective: **Reduces Scope 1** emission more than 69% (Case Study)
2. Well-pad **capex and opex savings** (~50%)
3. **Replaces** logistically and operationally demanding field **test separators**
4. **Minimal equipment** and piping costs—single multiphase line instead of lines for each phase
5. **Minimal hardwa**re and instrumentation maintenance—no moving parts
6. More **flexible operation**—flexible MPFM installation upstream or downstream of the choke
7. **Minimal manpower** and human intervention—remote monitoring, diagnostics, and operation
8. Allows for **central VRU**—eliminates venting from the storage tanks to reduce emission further
9. **Minimal footprint**—spillage and permitting
10. Overall, more **elegant and efficient** wellsite facility infrastructure

Emission Abatement Cost

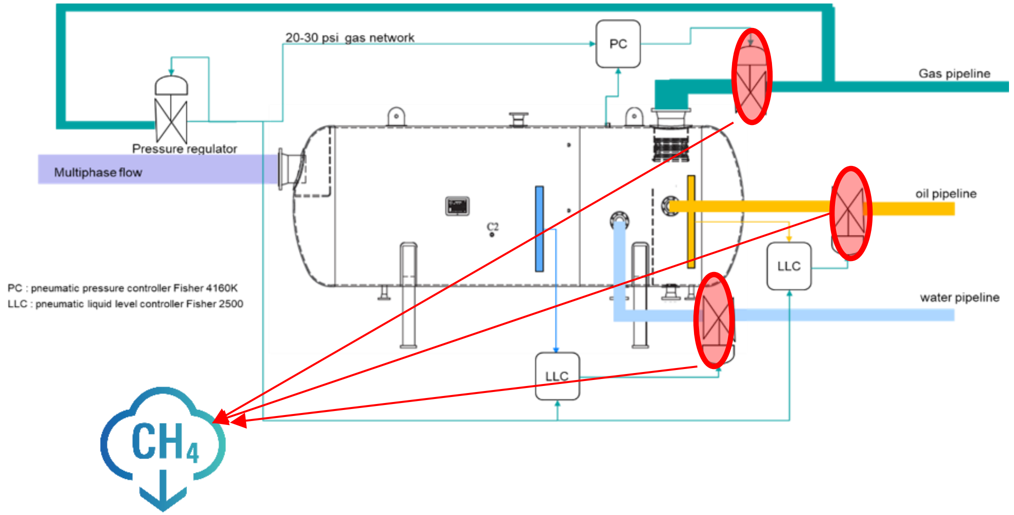
- Replace with instrument air systems
- Replace with electric motor
- Blowdown capture
- Upstream LDAR
- Downstream LDAR

Oil and gas methane abatement cost curve at 2017−2021 prices and 2022 prices (updated February 2023).

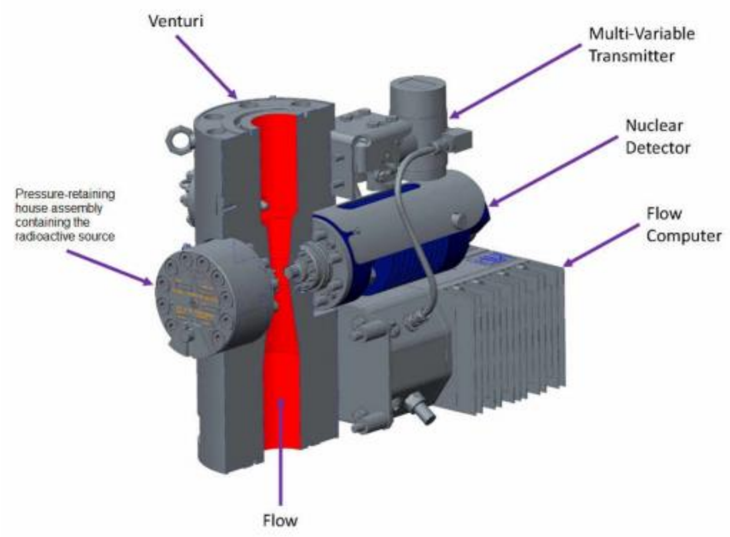


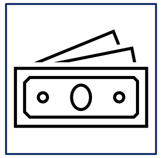
Emission Abatement – The Multiphase Flowmeter Solution

Test Separator



Venturi/Gamma Ray Spectroscopy Combination Multiphase Flow Meter (MPFM)





CAPEX Reduction

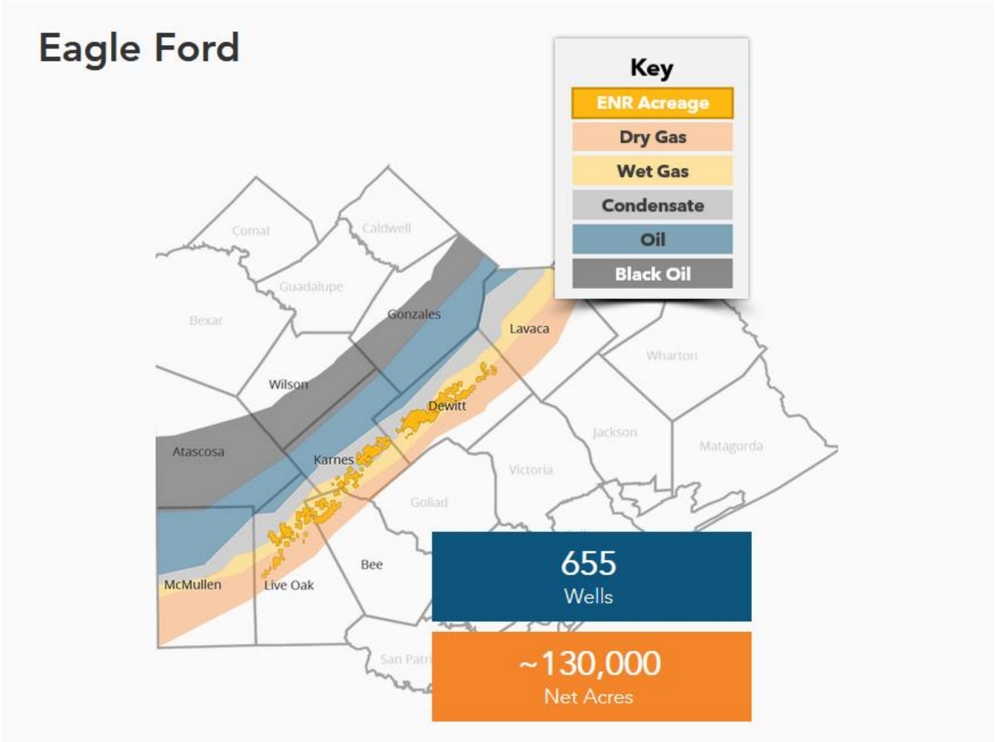
50%

OPEX Reduction

25%

Eagle Ford Operator Implementation – Field Case Study

Eagle Ford Operator Sustainability Objectives



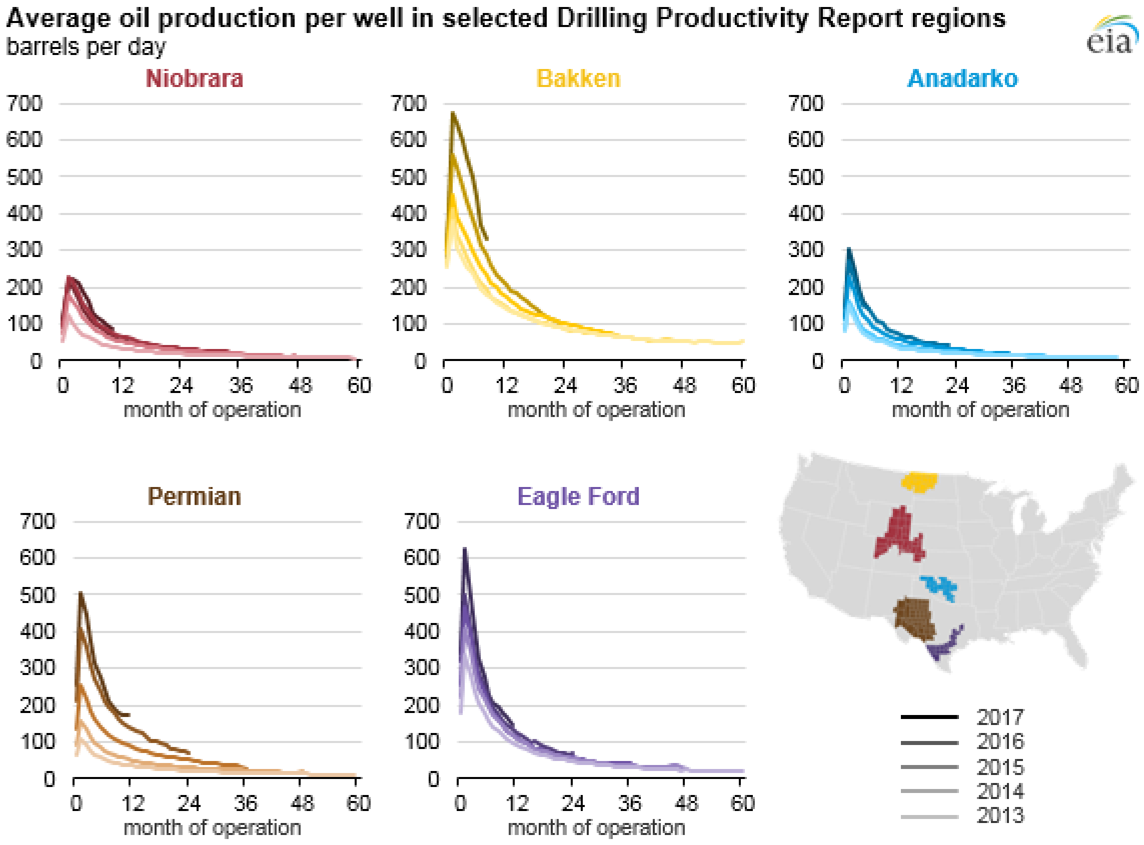
"We are setting a goal to be in the top quartile for lowest emission intensity among our peers in the Eagle Ford!"

"We've installed equipment that reduces emission overtime and Planning further implementations in 2022"

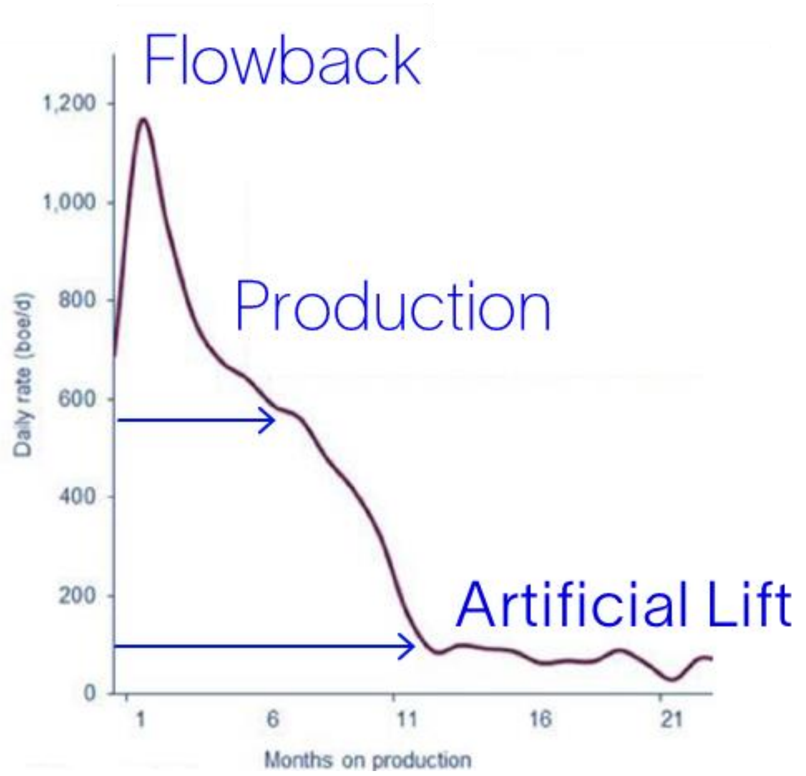
Solution must be:

- Cost effective
- Efficient
- Scalable

The North America Challenge



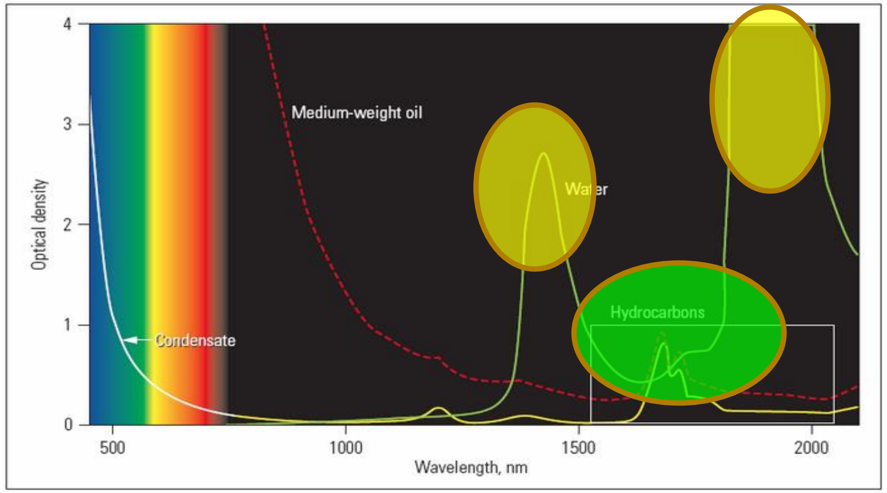
Lifetime of unconventional well



MPFM solution is required to have good accuracy for rapid changing condition

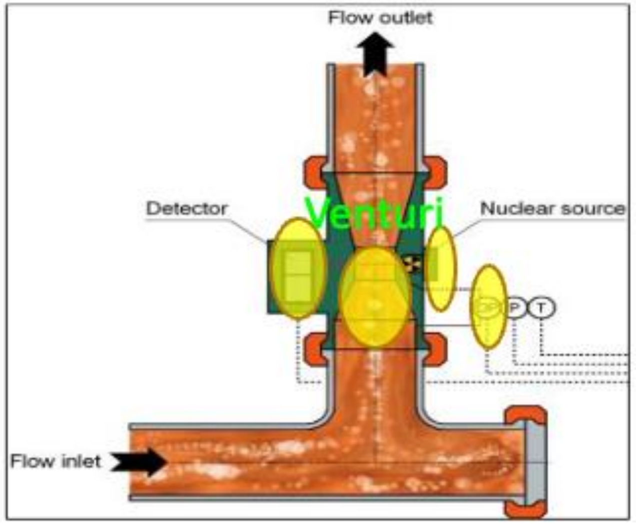
MPFM Technologies Evaluated

Technology 1 - Optical Sensing Method: Near-Infrared (NIR) Spectroscopy



- Measurement of oil and water fractions can be easily distinguish
- Water salinity does not affect the absorption response
- Presence of wax or asphaltenes can affect the measurement

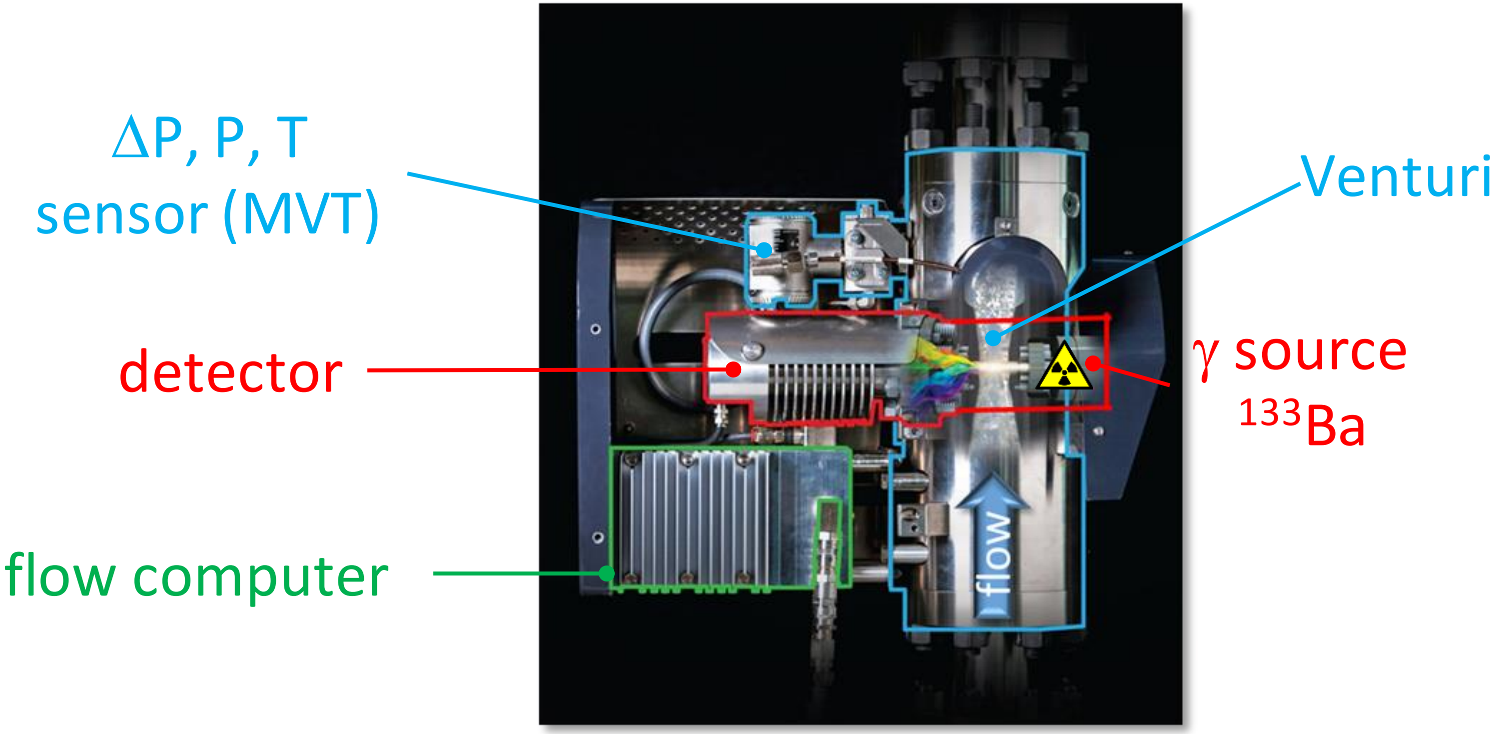
Technology 2 - Differential Pressure/ Gamma-spectroscopy Meter Combination



- Single-point measurement at venturi throat
- Independent of flow regimes
- Measurement of both:
  - total mass flow rate
  - phase volume fractions of oil, water and gas.
- Changes in water salinity can affect the measurement

MPFM Technology Selected - How Does it Work

Technology 2 - Differential Pressure/ Gamma-spectroscopy Meter Combination



- venturi & ΔP, P, T
- Nuclear system
- flow computer

total mass @ LC

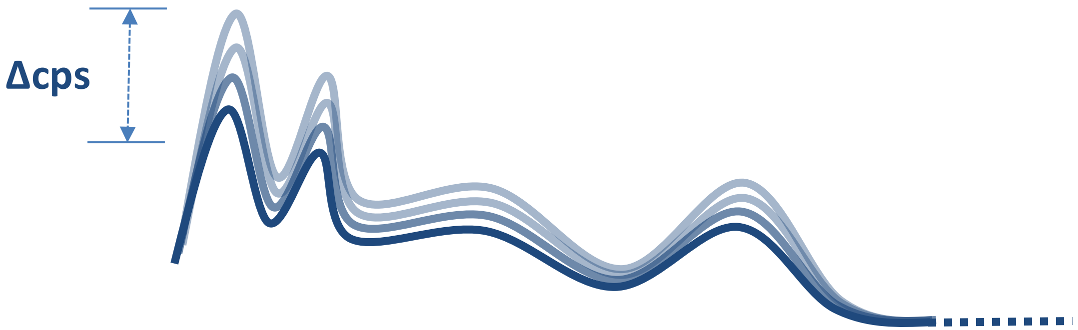
phase fraction (α_w, α_o ,α_g) @ LC

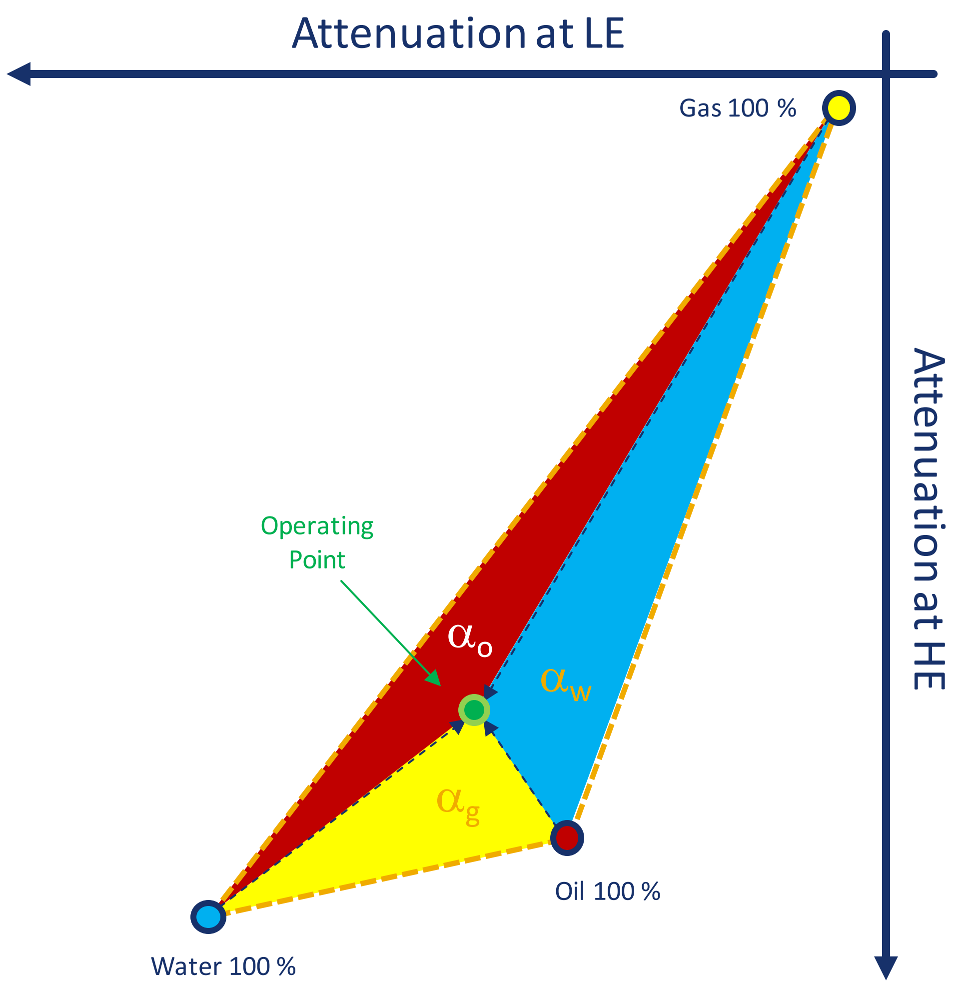
Single phase flow rates (q_w, q_o,qg) @LC & SC

Fraction Meter & Gamma Ray Attenuation

Nucleonic Fraction Meter

- Nuclear Measurement is based on the attenuation of the fluid
- Based on Gamma ray attenuation and it is possible to draw the Nuclear Triangle Solution
- This leads to the measurement of the fraction of oil, water, and gas





Eagle Ford Operator Implementing 4 Well-pad using MPFM

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Traditional test separator based well-pad facility

Transitioned to

Hybrid 4 well pad combining MPFM and only 1 test separator

MPFM removes min 3 pneumatic devices per test separator:

- Water Liquid Level Controller
- Oil Liquid Level Controller
- Gas Level Controller

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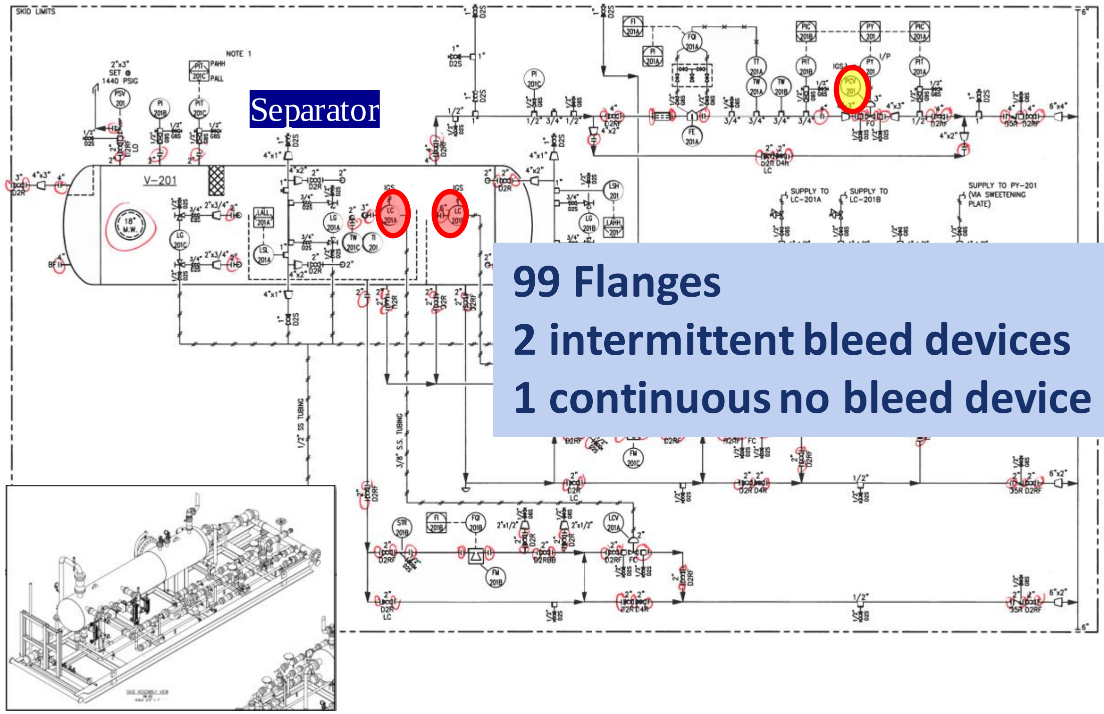
Wellsite Equipment Transition

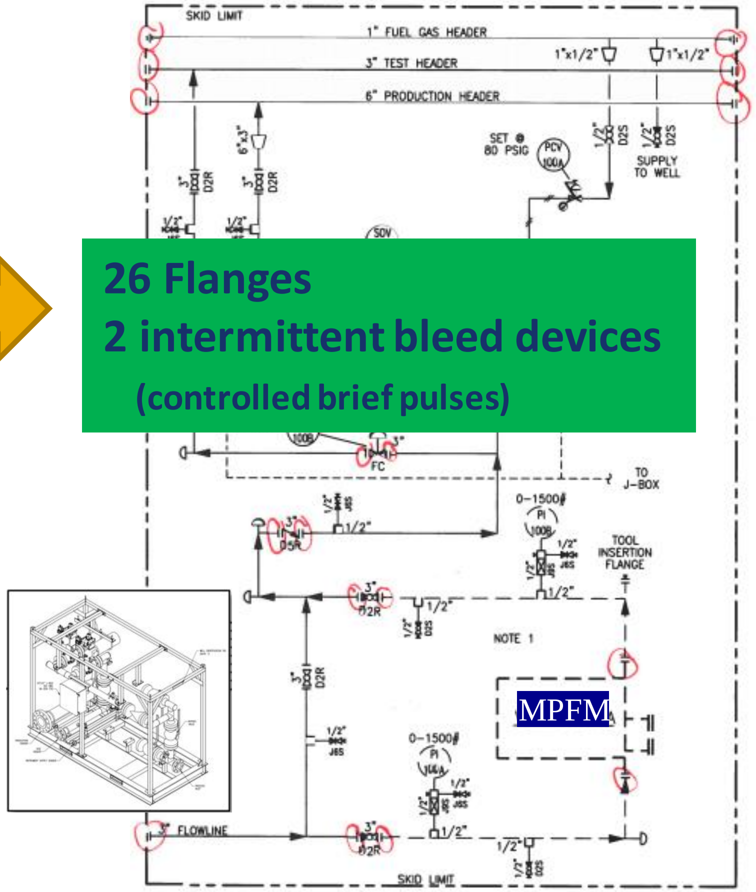
Traditional test separator flanges and control valve details



99 Flanges
2 intermittent bleed devices
1 continuous no bleed device

Transitioned to

MPFM flanges and control valve details



26 Flanges
2 intermittent bleed devices
(controlled brief pulses)

- Flanges
- Intermittent bleed devices (liquid level controllers)
- Continuous low bleed device for the pressure control valve (PCV)

4 Well-pad Equipment Emissions Estimates

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Traditional layout – 4 separators

Transitioned to

Hybrid layout – 1 separator and 4 MPFM

Emitting Components	Number	Usage/Frequency	EPA Factor (scf/hr/device)	EPA Factor (scf/D/device)	Total scf/D
Flanges (assumed connector value)	99×4 = 396		0.003	0.072	28.51
Intermittent devices	2×4 = 8	Once an hour	13.50	323.00	2,584.00
Continuous low-bleed devices	1×4 = 4		1.39	33.36	133.44
Total					2,745.95

Emitting Components	Number	Usage/Frequency	EPA Factor (scf/hr/device	EPA Factor (scf/D/device)	Total Scf/D
Flanges for 1 separator (assumed connector value)	99		0.003	0.072	7.13
Flanges for four MPFMs (assumed connector value)	26 ×4 = 104		0.003	0.072	7.49
Intermittent devices for one separator	2	Once an hour	13.50	323.00	646.00
Intermittent devices for four MPFMs	2×4 = 8	Twice a day	13.50	27.00	216.00
Continuous low-bleed devices for one separator	1		1.39	33.36	33.36
Total					909.98

Emissions Reduction

67%

4 well-pad site/day

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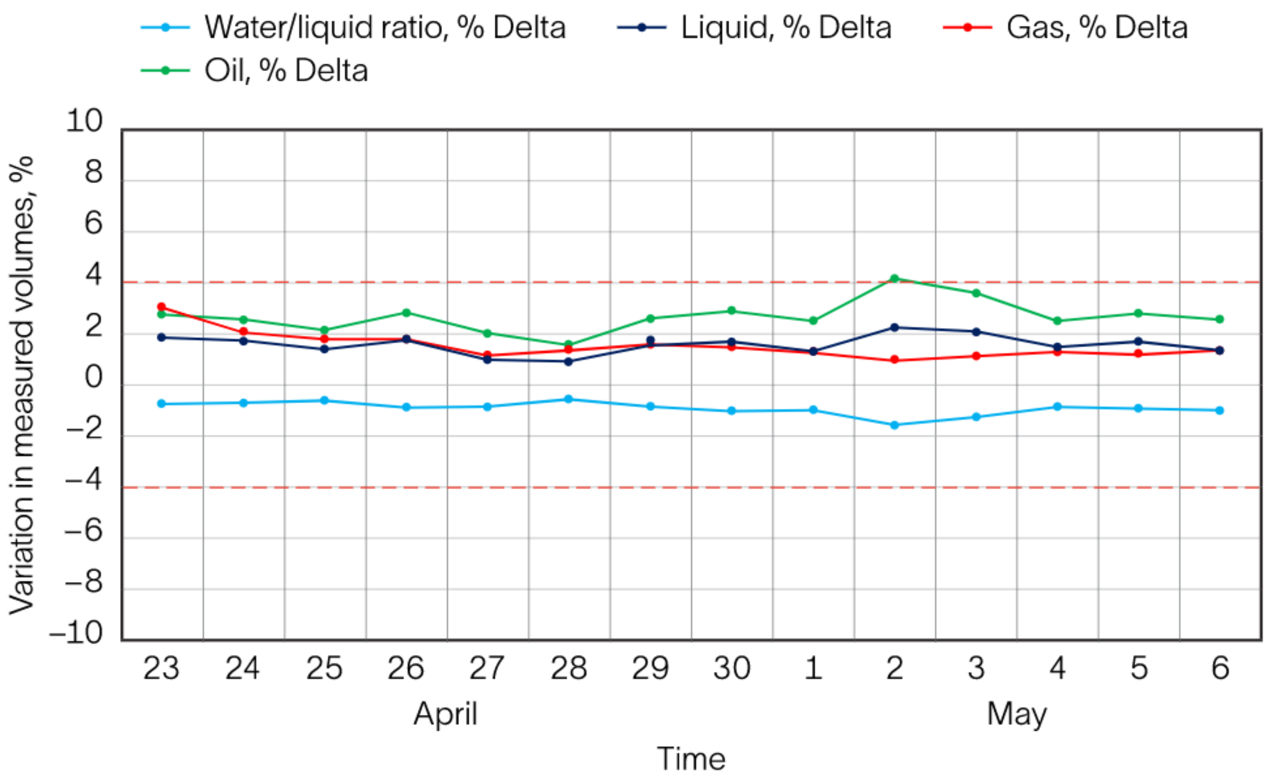
Measurement Metrology

Field Test Results and Additional Benefits

Uncertainty results between MPFM and test separator



Accuracy

+/- 5%

Up to 95% GVF/well

CAPEX Reduction

50%

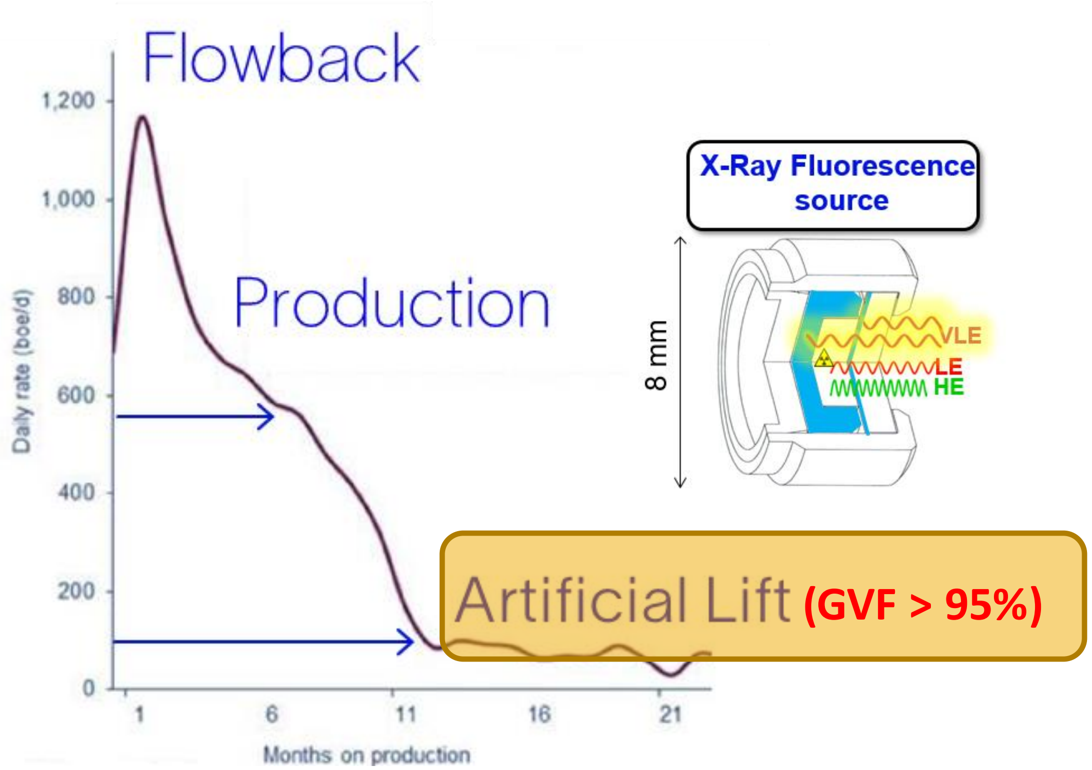
OPEX Reduction

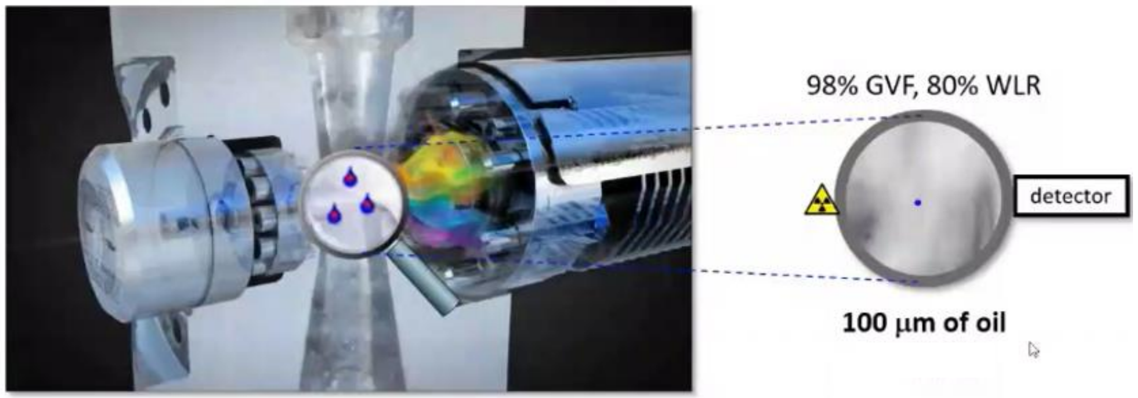
25%

Reference: SPE 215151 Abatement of GHG Emissions by Simplifying field Architecture with Multiphase Flowmeters in Onshore US Shale: A Field Case Study

Improved Accuracy for More Challenging Conditions

Lifetime of unconventional well



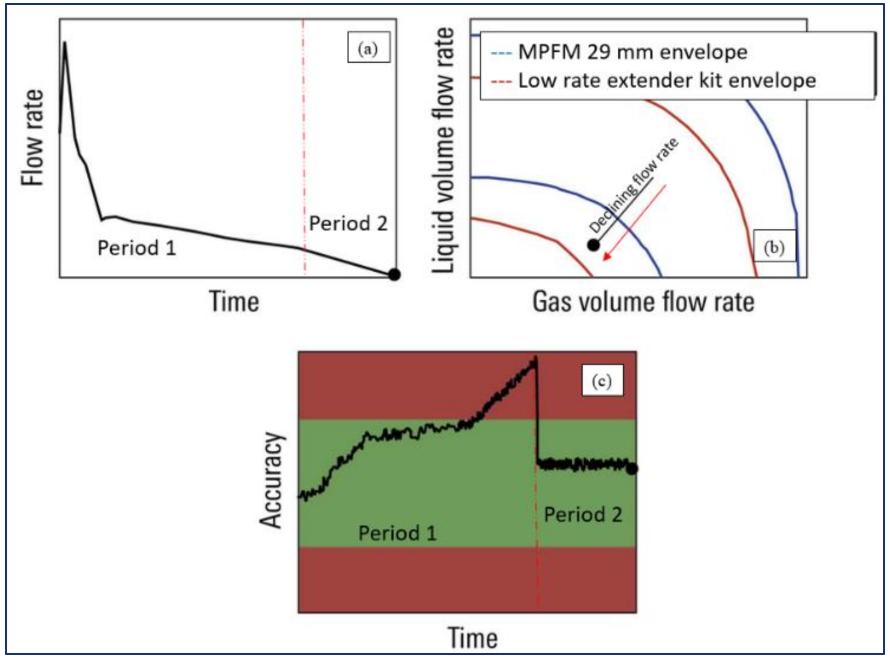


- XRF Improves accuracy for more challenging flow conditions
  – Liquid uncertainty ≤ |10%| even at GVF ($flow_{gas}/flow_{total}$) > 95%

Differential Pressure/ Gamma-spectroscopy Meter Combination MPFM – Turndown Feature

Low-rate extender kit

MPFM 29mm venturi size down to 19mm

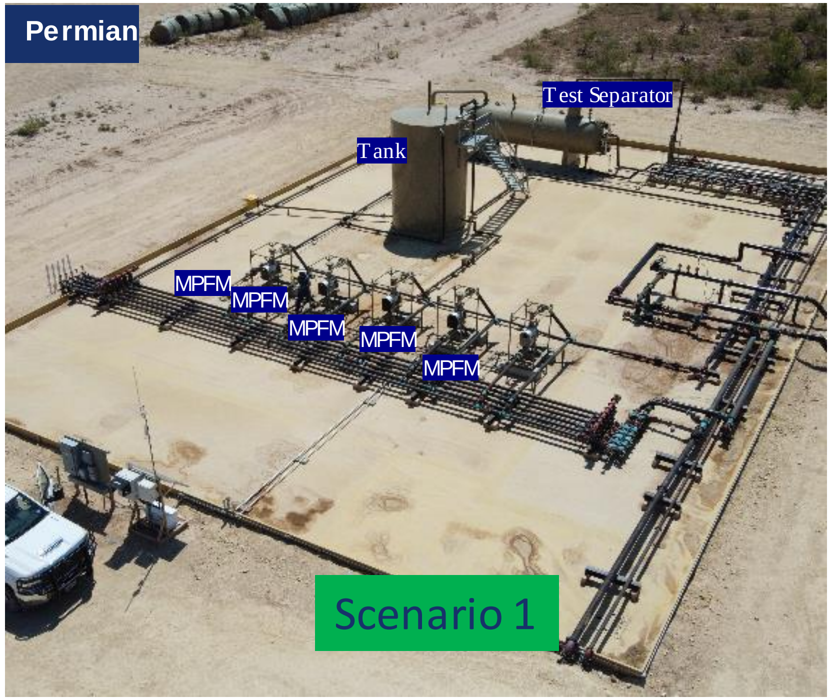


- Using an insert feature to reduce the cross-section, then reducing the meter size area without replacing the complete meter
- Reduce capex and nonproductive time
- Increase meter turndown ratio
- Extend operational envelope
- Maintain high-accuracy

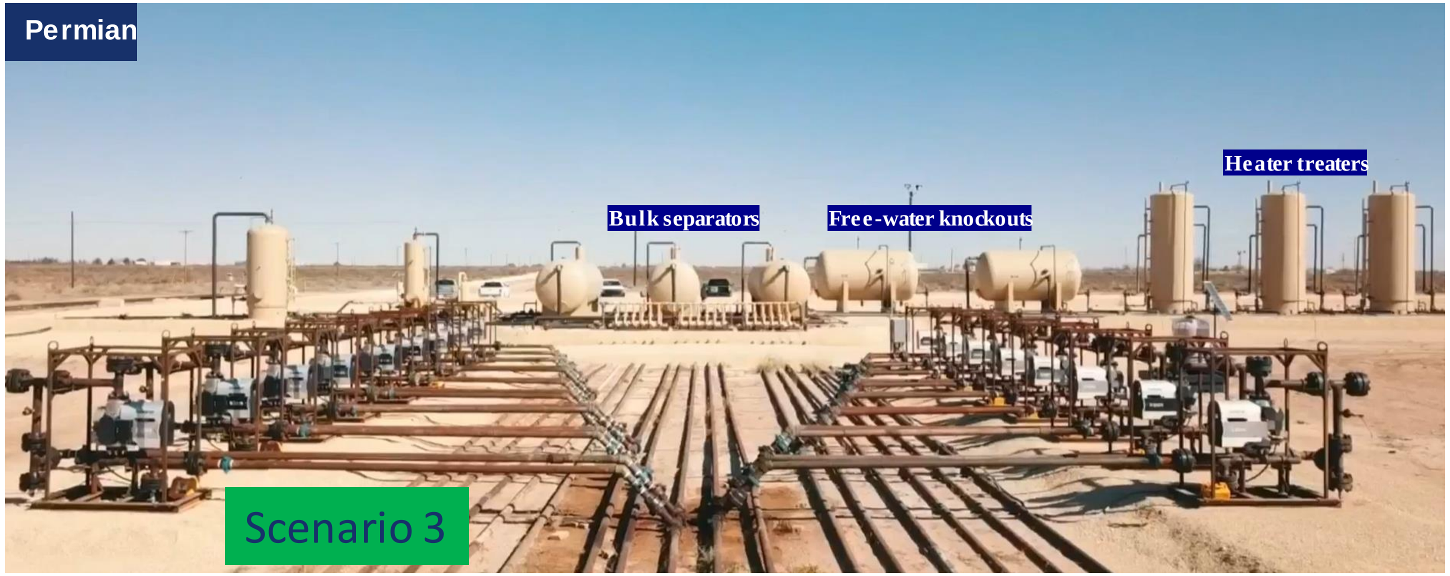
Permian Basin Implementation Examples

Other Examples of MPFM-based Well-Pad Implementations

Hybrid layout – 1 test separator and 5 MPFM



Central Processing - 3 separators and 18 MPFM



Scenarios - Methane Emissions Reduction Estimates

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Additional scenarios potential methane emissions reduction

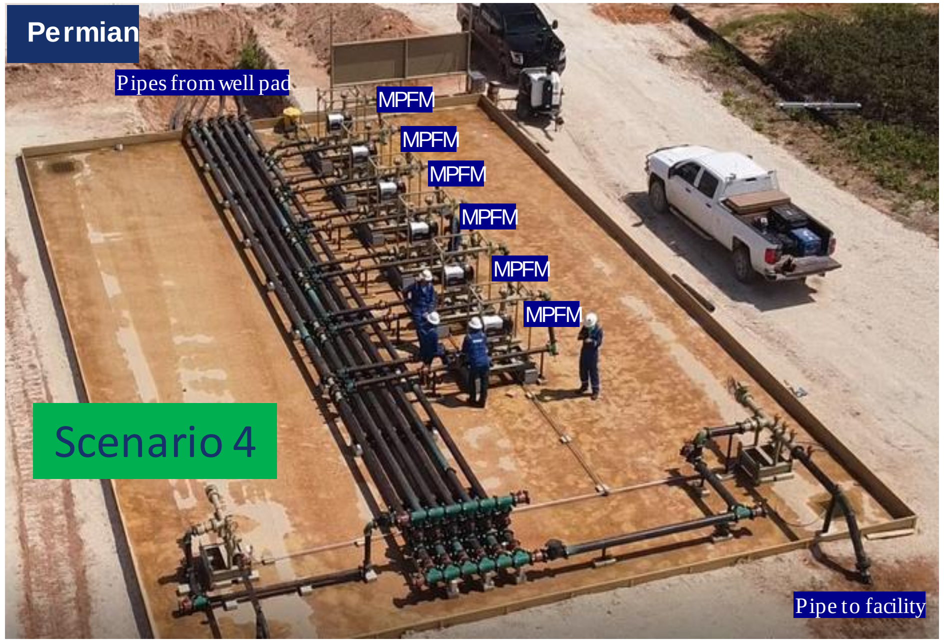
Scenario	Emitting Components Combination	Total scf/day	Emitting Components Combination	Total scf/D	Emissions Reduction
1	5 Separators	3,432.44	1 Separator + 5 MPFM	965.85	72%
2	6 Separators	4,118.93	1 Separator + 6 MPFM	1,021.72	75%
3	18 Separators	12,356.78	3 Separator + 18 MPFM	3,065.16	75%
4	6 Separators	4,118.93	6 MPFM	335.23	92%

Emissions Reduction

92%

6 well-pad site/day

Satellite tankless wellsite location with 6 MPFM



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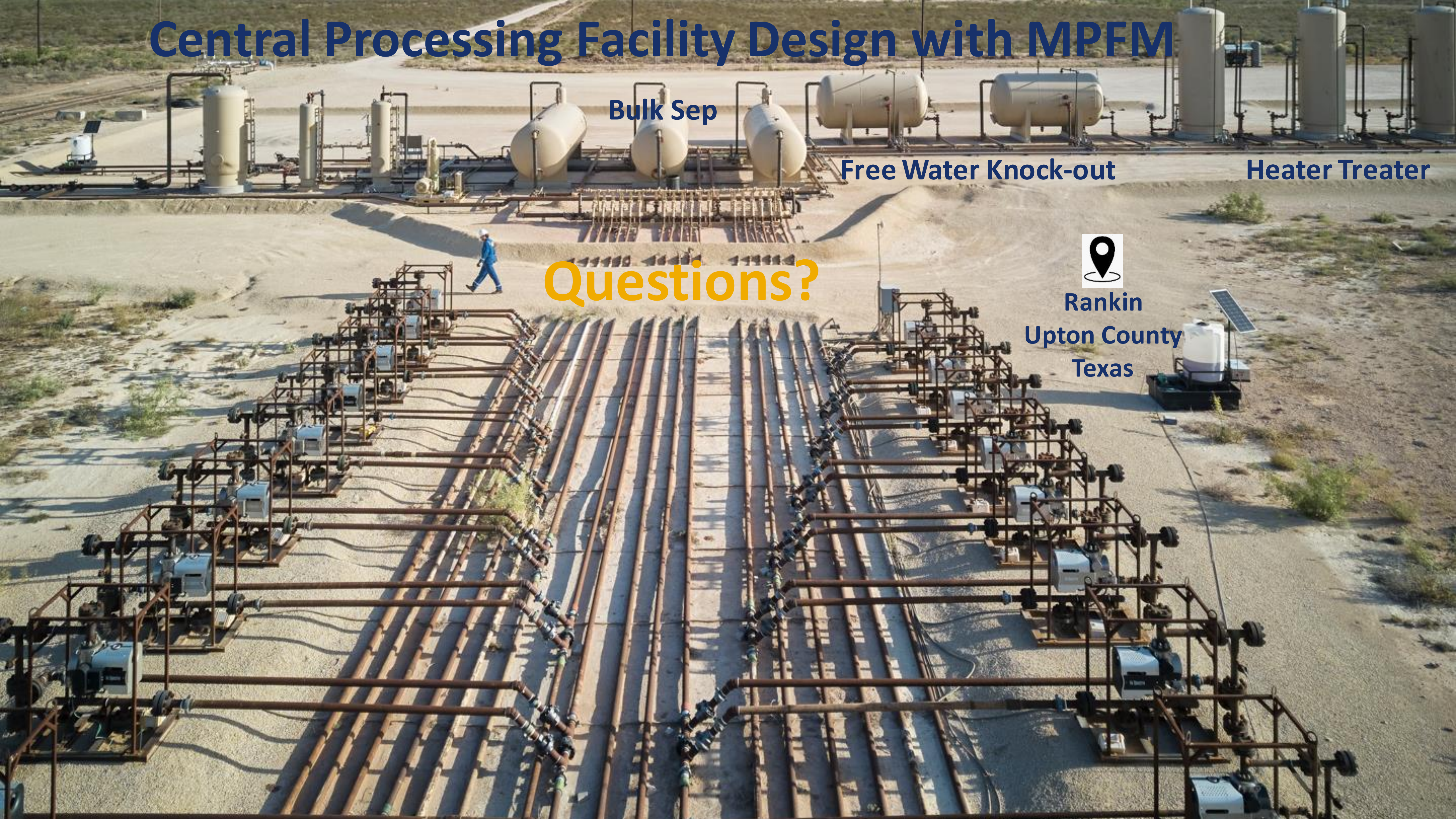
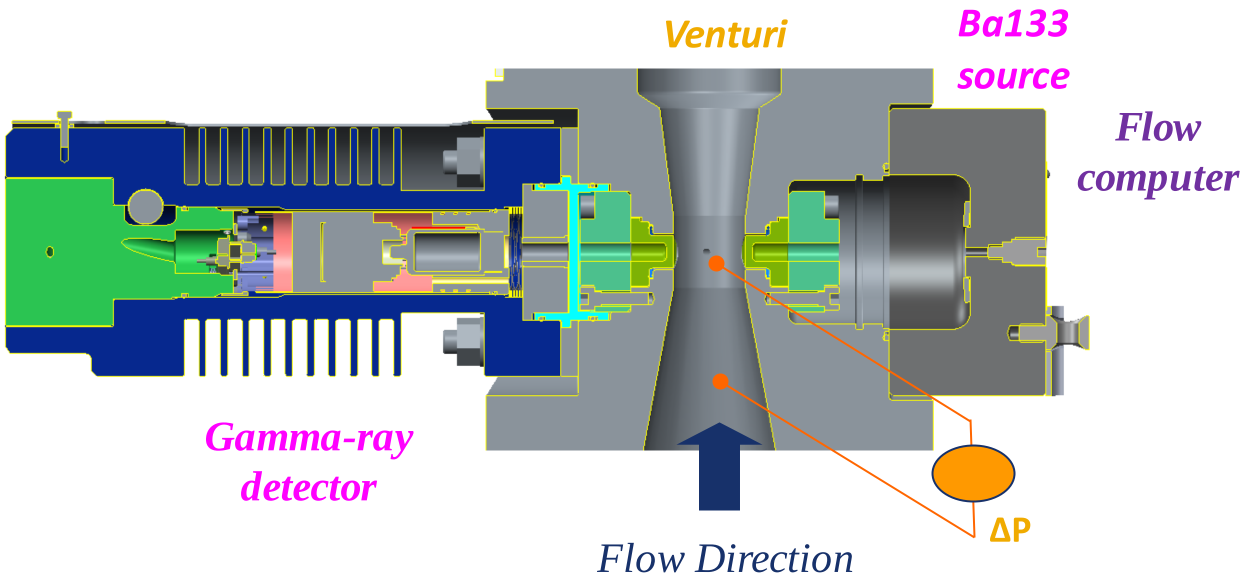
Conclusions

- Onshore production well-pads, **gathering and boosting stations** are responsible for the majority of **methane emissions (~72%) produced** by the O&G industry
- **EPA factors** to report GHG emissions are **subjective and may underestimate** the real values (some studies indicate up to 60% underestimation)
- To detect and measure accurately GHG emissions is still challenging and needed but **we need strict emission reduction strategies** in order to meet 2030 targets
- **Simplified wellsite facilities using MPFM** provides a **speedy, cost effective, efficient and scalable** solution for scope 1 GHG emissions abatement
- A case study showed how **MPFM can help reduce emissions up to 92%,** with a **50% reduction in capex, 25 % reduction in opex** providing **+/- 5 measurement uncertainty**
- Support by regulators and industry is needed


Central Processing Facility Design with MPFM
Bulk Sep
Free Water Knock-out
Heater Treater
Questions?
Rankin
Upton County
Texas

MPFM Technology 2: Distinct Sections



Fluid Mechanics – Flow Model

→ Total Mass Flow Rate (Bernoulli)

Nuclear Physics – Nuclear Model

→ 3 Phase Fractions (Nuclear Equations)

Fluid Behavior – PVT Model

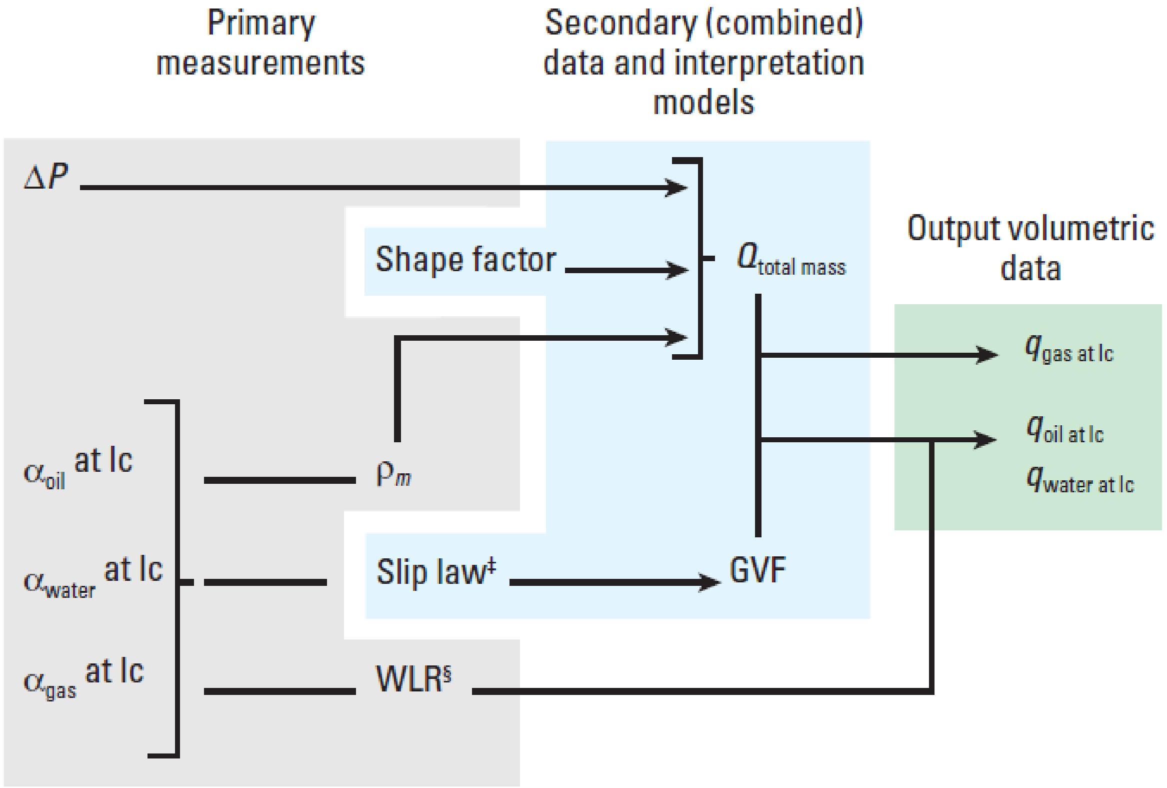
→ Convert from Line to Standard Conditions

Single-point measurement at the venturi throat at **high frequency** and **independent of flow regimes**

Technology Calculations Overview

Input parameters @ ambient conditions

gas S.G | ρ_w | ρ_o | μ_o



‡ Assumption: model for gas-liquid slippage
§ No oil-water slippage

Figure 6-23. Vx model data processing and assumptions.

*From Fundaments of Multiphase Flow Metering

Total Mass Flow Rate & Fraction Calculation

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Flow Model

$$Q_{TotalMass} = K\sqrt{2\rho_{mix}\Delta P_{dyn}}$$

Nuclear Model

3 equations with 3 unknowns

$$N^{le} = N_0^{le} e^{-D\left[\mu_o^{le}.\rho_o.\alpha_o + \mu_w^{le}.\rho_w.\alpha_w + \mu_g^{le}.\rho_g\,\alpha_g\right]}$$

$$N^{he} = N_0^{he} e^{-D\left[\mu_o^{he}.\rho_o.\alpha_o + \mu_w^{he}.\rho_w.\alpha_w + \mu_g^{he}.\rho_g\,\alpha_g\right]}$$

$$\alpha_o + \alpha_w + \alpha_g = 1$$

PVT Model (Black Oil Model): Oil, Gas, Water Volumetric Flowrates Outputs at Standard Conditions

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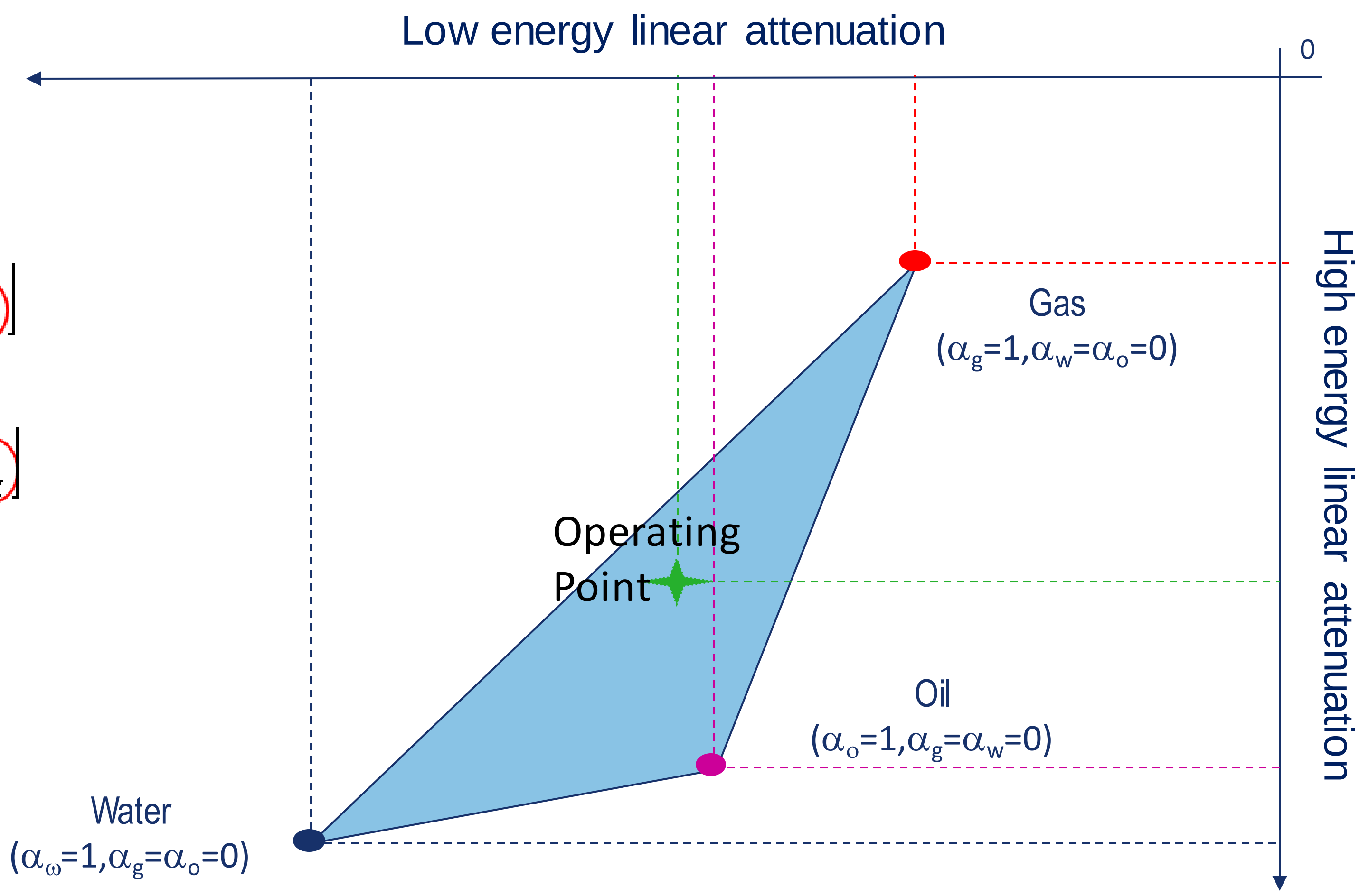
Phase Measurements Mechanism

$$\alpha_o + \alpha_w + \alpha_g = 1$$

$$N^{le} = N_0^{le} e^{-D\left[\mu_o^{le}.\rho_o.\alpha_o + \mu_w^{le}.\rho_w.\alpha_w + \mu_g^{le}.\rho_g.\alpha_g\right]}$$

$$N^{he} = N_0^{he} e^{-D\left[\mu_o^{he}.\rho_o.\alpha_o + \mu_w^{he}.\rho_w.\alpha_w + \mu_g^{he}.\rho_g.\alpha_g\right]}$$

$$\rho_{mix} = \alpha_o\rho_o + \alpha_w\rho_w + \alpha_g\rho_g$$



Linear Attn = Mass Attn (Composition) x Density (P, T)

Value Proposition – Permanent Installations

	Permian Installation	Permian Installation	Eagle Ford Installation	Eagle Ford Installation
Units installed	100	120	50	70
Construction time savings	3-4 weeks	3 weeks	1-2 weeks	2 weeks
CAPEX savings	30K $/well	50K $/well	100K $/well	50K$/well
OPEX savings	10k/well/year	10k/well/year	25k/well/year	20k/well/year
ESG	50-100t CO2e			
Lead time savings	Up to 10 months			
Reduction PVF	30-40%			