



Best Practices – Recip Methane Reduction

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A large white flag with the Williams logo (the word "Williams" in black with a blue swoosh) waving against a blue sky with light clouds. The flag is attached to a silver pole on the left.

Williams

Agenda

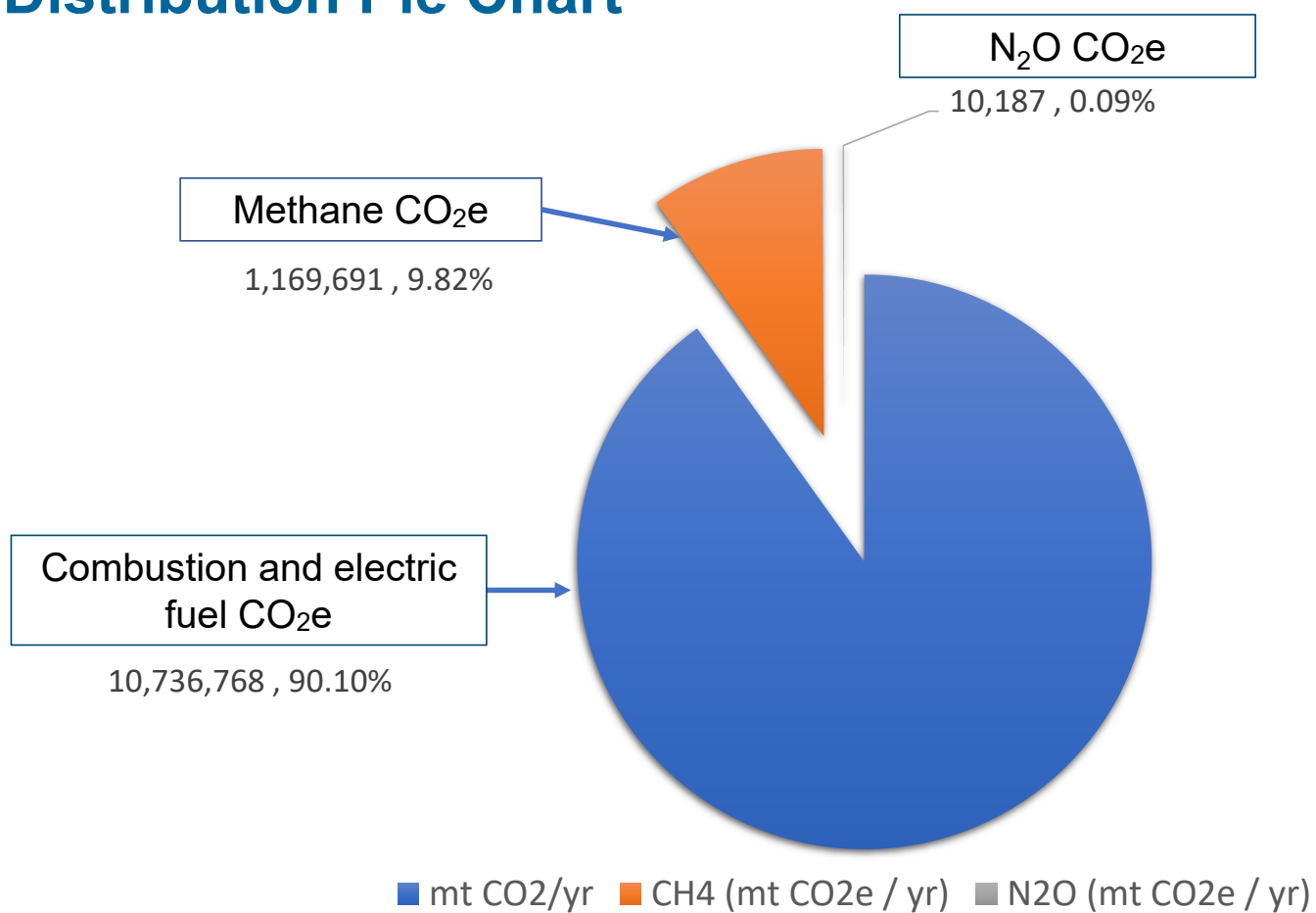
- > Methane vs CO₂e
- > Sources of CO₂e
 - Engine
 - Compressor
- > Options to mitigate / improve CO₂e
- > Pros and Cons of Options

2021 CO₂e GHG Emissions Profile

Reporting Year	2021						
Industry	mt CO ₂ /yr	CO ₂ % of tot	CH ₄ (mt CO ₂ e / yr)	CH ₄ % of tot	N ₂ O (mt CO ₂ e / yr)	N ₂ O% of tot	mt CO ₂ e / yr
Gathering	3,682,135	88.6%	471,961	11.4%	2,929	0.1%	4,157,026
Other	1,832	99.3%	5	0.3%	8	0.4%	1,845
Processing	3,844,957	96.4%	139,973	3.5%	4,204	0.1%	3,989,134
Transmission Compression	3,207,754	86.9%	480,272	13.0%	3,046	0.1%	3,691,071
Transmission Pipeline	84	0.1%	72,907	99.9%	-	0.0%	72,992
Underground NG Storage	5	0.1%	4,573	99.9%	-	0.0%	4,579
Total	10,736,768	90.1%	1,169,691	9.8%	10,187	0.1%	11,916,646

More than 90% of our CO₂e comes from compression while less than 10% is from methane

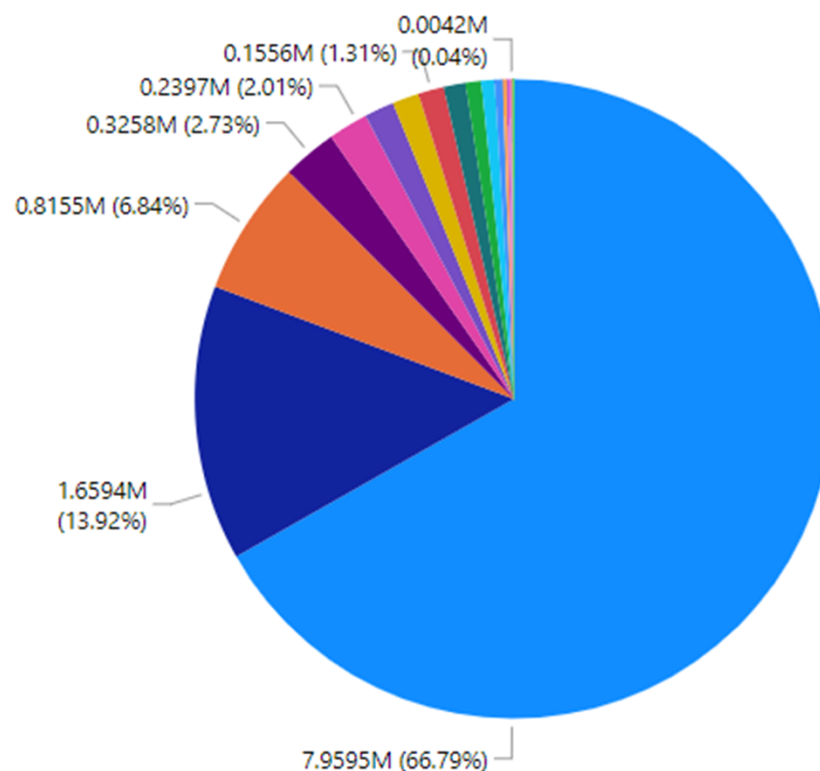
2021 CO₂e Distribution Pie Chart



2021 CO₂e Distribution (includes methane and N₂O)

(SELECT YEAR) WILLIAMS SCOPE 1 AND SCOPE 2 EMISSIONS (mt CO₂e / yr)

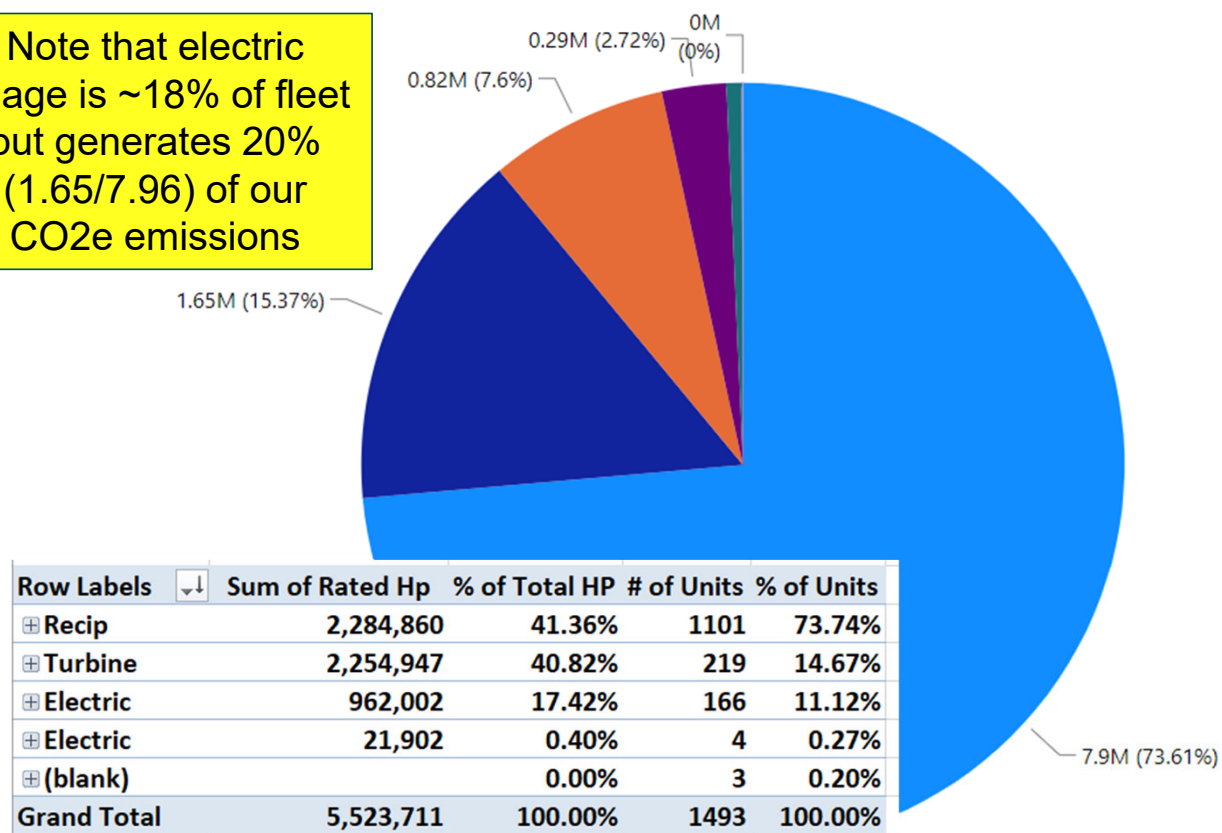
- Subpart W/C (Combustion) - Stationa...
- Scope 2, Electrical Usage
- Subpart W - Acid Gas Removal Vents
- Subpart W - Flare Stacks
- Subpart W - Blowdown Vent Stacks
- Subpart W - Pneumatic Device Venting
- One Future, Dry Seals on Centrifugal
- Subpart W - Equipment Leaks
- Subpart W - Dehydrator Vents
- Subpart W - Centrifugal Compressor ...
- Subpart W - Reciprocating Compress...
- Subpart W - Miles of Pipeline
- One Future, Acid Gas Removal
- Subpart W - Storage Tanks
- Subpart W - Natural Gas Driven Pneu...
- One Future, Gathering PL Dig-ins
- One Future, Transmission Miles of PL
- One Future, Compressor Starts
- One Future, Dehydration
- One Future, Storage Blowdowns
- Subpart W - Dehydrator (Desiccant)



2021 CO₂ Distribution (no methane, just CO2)

- Subpart W/C (Combustion) - Stationary Fuel Combustion Sources
- Scope 2, Electrical Usage
- Subpart W - Acid Gas Removal Vents
- Subpart W - Flare Stacks
- Subpart W - Dehydrator Vents
- Subpart W - Storage Tanks
- Subpart W - Centrifugal Compressor Venting
- Subpart W - Blowdown Vent Stacks
- Subpart W - Pneumatic Device Venting
- Subpart W - Equipment Leaks
- One Future, Dry Seals on Centrifugal
- Subpart W - Reciprocating Compressor Venting
- Subpart W - Miles of Pipeline
- Subpart W - Natural Gas Driven Pneumatic Pumps
- One Future, Transmission Miles of PL
- One Future, Dehydration
- One Future, Storage Blowdowns
- One Future, Compressor Starts
- Subpart W - Dehydrator (Desiccant)

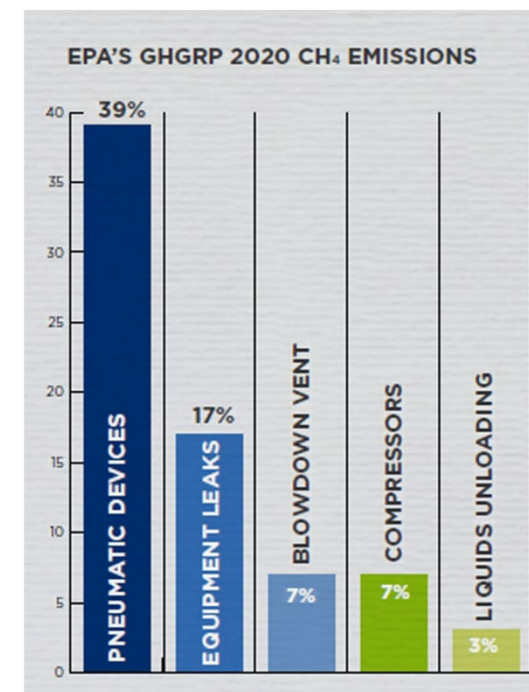
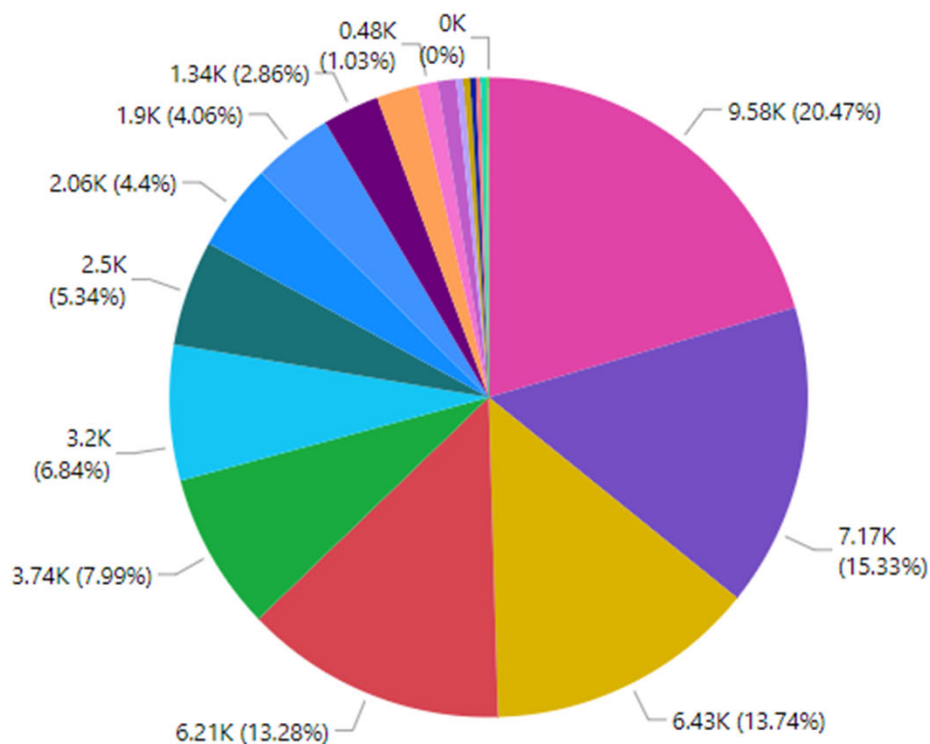
Note that electric usage is ~18% of fleet but generates 20% (1.65/7.96) of our CO₂e emissions



2021 Methane Distribution (less than 10% of our CO₂e)

(SELECT YEAR) WILLIAMS SCOPE 1 AND SCOPE 2 EMISSIONS (mt CH₄ / yr)

- Subpart W - Blowdown Vent Stacks
- Subpart W - Pneumatic Device Venting
- One Future, Dry Seals on Centrifugal
- Subpart W - Equipment Leaks
- Subpart W - Centrifugal Compressor ...
- Subpart W - Reciprocating Compress...
- Subpart W - Dehydrator Vents
- Subpart W/C (Combustion) - Stationa...
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Recip Engine CO₂e sources and Mitigation options

Sources

- > Fuel consumed
- > Fuel slip (out the exhaust – unburned)
- > Crankcase Vents (fuel leaks past valve stems)

Solutions

- > Engine retrofits to high or medium pressure fuel systems
- > Engine retrofits to simple “clean-burn” systems
- > Fuel pressure increase
- > Upgrade to electronic governors
- > Use TER control rather than simple curves
- > Adding pre-chambers or other enhancements to the (prechamber design or ignition system, etc...)
- > Auto-balance systems (there are simple ones)
- > New engine hard iron (pistons / rings / heads) designed to reduce GHG

Recip Compressor CO₂e sources and Mitigation options

Sources

- > Packing vents
- > Leaking compressor valves
- > Inefficient or incorrectly sized compressor valves
- > Compressor bore not sized correct (unloaded)
- > Suction control valve cutting pressure
- > Operating in recycle
- > Tight orifice plates due to wide design speed
- > Blowdowns for maintenance
- > Leaking piston rings

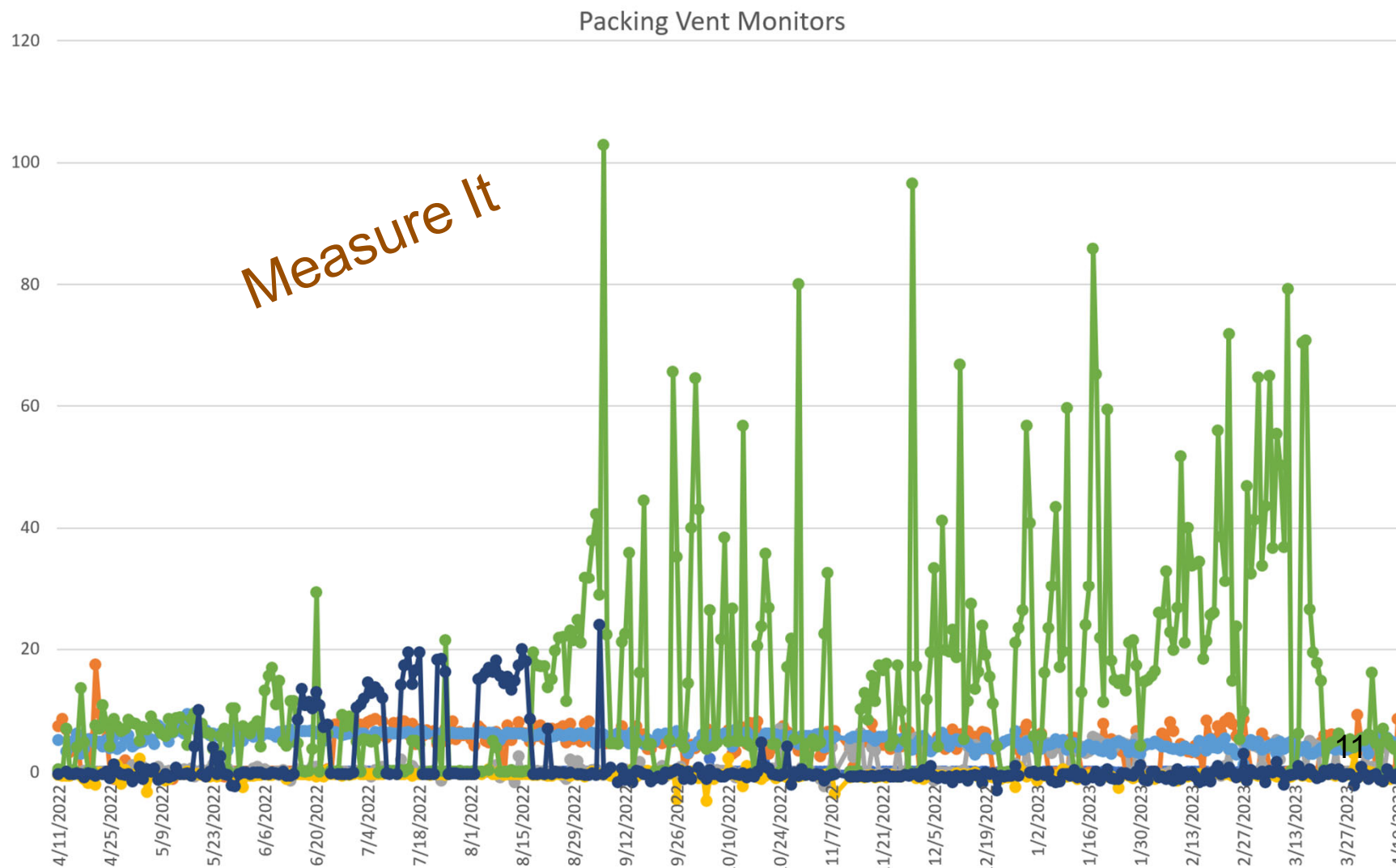
Solutions

- Blow-down / packing solutions
 - burn down (routed to station fuel)
 - Slipstream: route packing gas to engine air intake
 - recompression
 - pressurized holds – static clamp
 - flare's
- Optimize design (reduce trapped physical volume by moving valves closer to the unit)
- Reduce pressure drop
 - High efficiency pulsation bottles
 - Optimize orifice plates, or use variable
 - Remove suction control valve
- Use automatic fixed unloaders or eVCP's
- leak monitoring more often (FLIR camera surveys)
- Use weld x weld valves rather than flanged
- Monitor and compare HP/MM on efficiency curve

So – Best Practices for compressor vents

1. Measure it at a minimum
2. Burn as useful energy
 1. Slipstream right back into the engine
 2. “burn down” all blowdowns
 3. Route to heaters
3. Burn as wasted energy
 1. Flare

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Burn it for useful energy!



Best Practices for compression efficiency

> Design it right

- Optimize unit valve placement
- Optimize compressor sizing – compressor cylinder selection
- Optimize pulsation control to minimize pressure drop (orifice plates and bottles)
- Minimize the use of suction pressure control valves -
- Optimize compressor valve design
- Include automatic loading / unloading

> Monitor compression efficiency

- Operate as close to peak as possible

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Next steps – move from unit efficiency to facility efficiency

> Develop “facility” efficiency curves

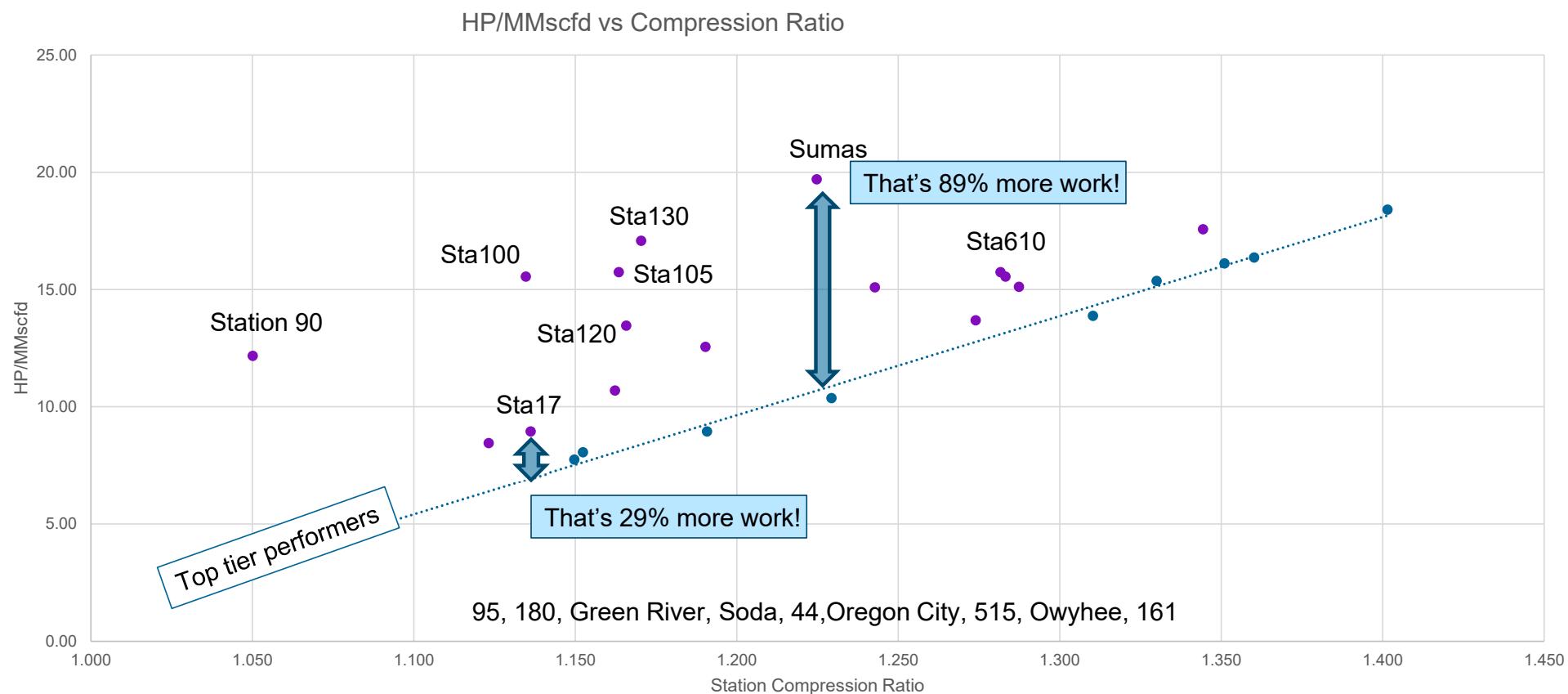
- Use station level compression ratio, fuel, and flow
- Factors in pressure drops within the facility
- Factors in fuel leaks and other fuel consumption (heaters, dehy, etc...)
- Allows facility's to be plotted against each other to identify opportunities.
 - Develop an expected facility efficiency curve, could use pseudo carbon tax internally based on level above or below the standard like done in Canada.
- Can change metric to CO₂ rather than fuel.

> Develop a “facility” pressure drop curve

- Allows us to identify inefficient outliers and can dig in from there

> Many opportunities to use efficiency metrics to help E&C, Gas Control and Ops and others make decisions that improve our carbon footprint

Compressor Station Efficiency “standard” idea



Summary – how to reduce CO₂e emissions

- > Minimize the compression required (reduce or eliminate pressure drop)
 - Use internally coated pipe, crossovers open, suction control valves 100% open
 - Replace old small pipe with larger rather than add compression for expansion projects
 - Develop metrics to identify pressure drop opportunities inside and outside the fence
- > Operate the most “compression efficient” machines first
- > Replace machines only when results are carbon negative
 - Don’t replace efficient equipment with less efficient equipment.
- > Upgrade existing machines to improve efficiency (driver and driven)
 - Combustion upgrades like PCC’s or autobalance on legacy recip.
- > Never operate in recycle

Questions?

