



Emission Tracking and Reductions from Turbine Driven Equipment

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Methane and total emissions from combustion

Figure 11: Offshore methane emissions by source, 2018–2021 (source: NAEI)

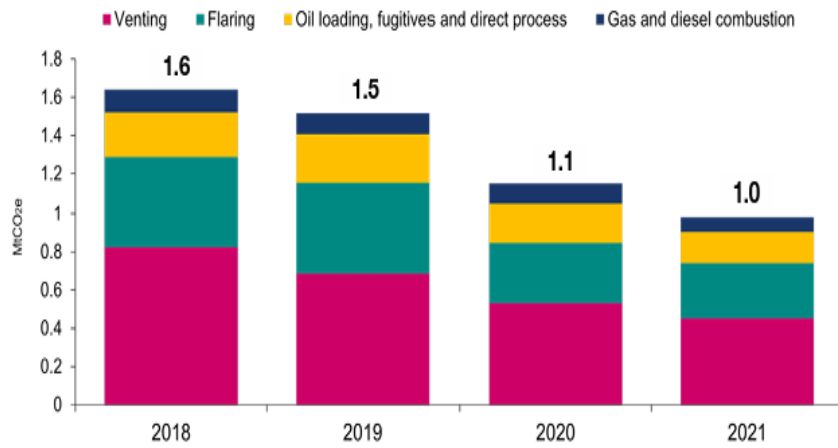
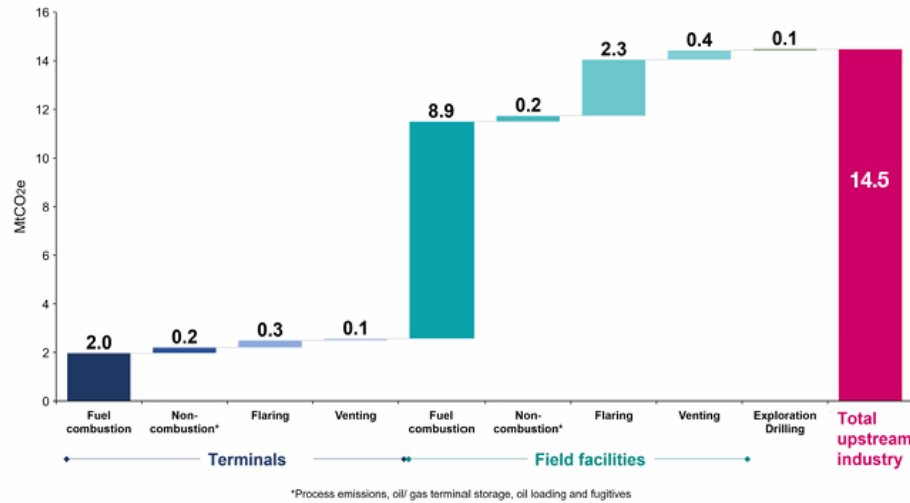


Figure 4: 2021 industry GHG emissions by source (source: NAEI)



Methane from incomplete combustion is a material source of emissions in the oil and gas industry

Abatement should always be explored in the context of wider issues including total emissions, fuel value and reliability

This is a global challenge - especially where there is large-scale gas export or other power requirements

Options for measuring Methane from turbines and compressors

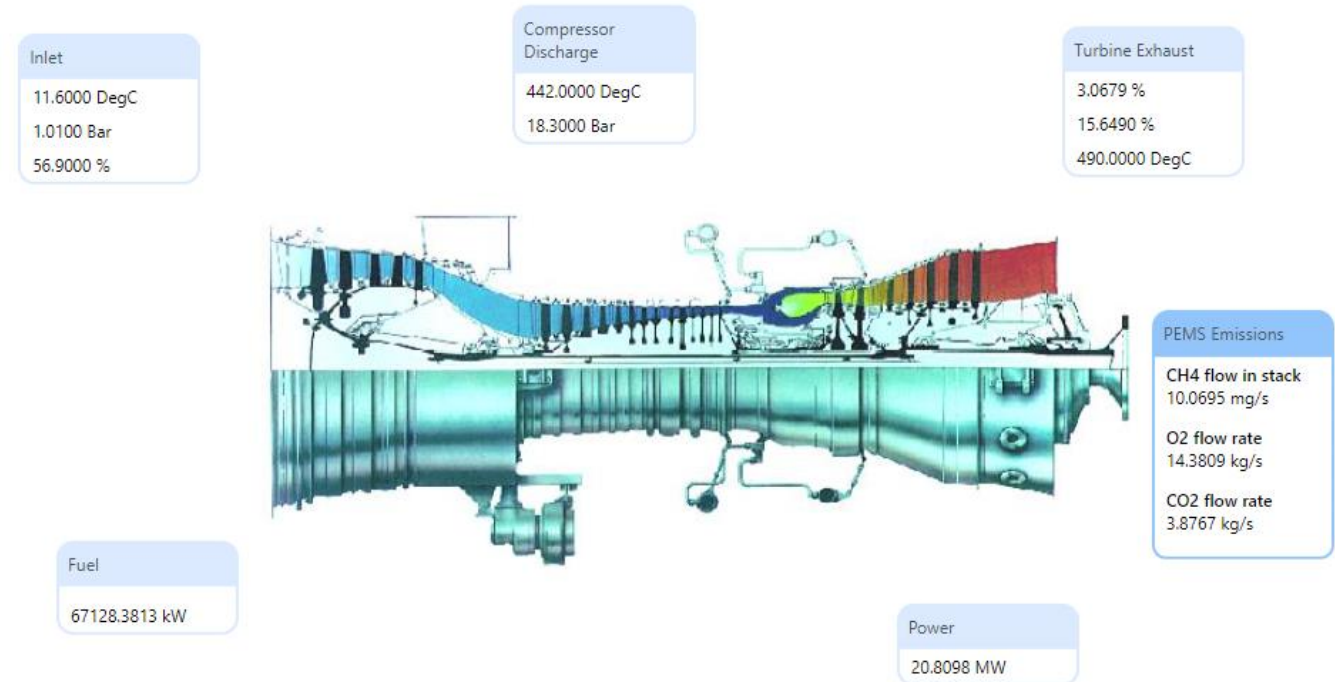


Method	Source Specificity	Time resolved emissions	Traceability and uncertainty for reporting	Physical footprint	Installation and maintenance
Adopting published Emission factors	Low	Low	No	n/a	n/a
Locally Derived emission Factors	Variable	Variable	No	n/a	Limited guidance available
Continuous Emissions Monitoring Systems	High	High	Yes	Significant	Significant ongoing technician support
Predictive Emissions Monitoring Systems	High	High	Yes	n/a	Episodic calibration checks



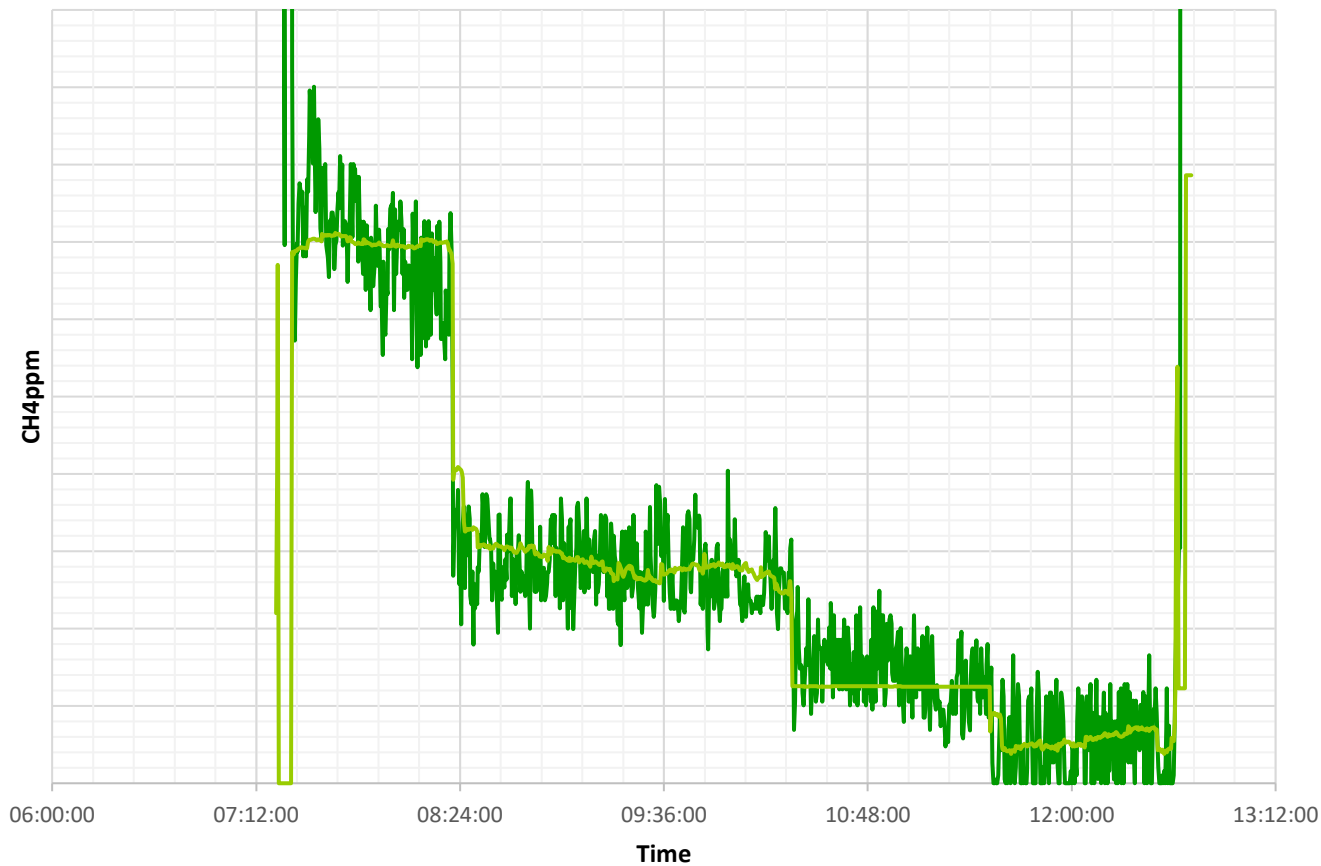
PEMS – Predictive Emissions Monitoring System

- Unburned methane in combustion gases
 - Incomplete combustion
 - $M_{CHh} = (1 - \eta_{Comb}) \cdot M_{fuel} \cdot x_{CH4}$
 - x_{CH4} methane mass fraction in fuel
 - η_{Comb} Combustion efficiency
- Calculate η_{Comb}
 - Combustion zones
 - 2-8 zones
 - Combustion reaction network
 - Kinetic reaction rates
 - Controlling parameters
 - Combustion zone temperatures
 - Residence time
- Combustion conditions calculated from Energy and mass balances
- Stack measurements used to fit model



Accuracy and traceability

Each deployment is calibrated against FTIR measurements
Traceability and uncertainty independently assessed*



CH ₄ Concentration	Average Value [ppm]	Expanded Uncertainty Absolute [ppm]	Expanded Uncertainty Relative [%]	Standard Deviation Absolute [ppm]
-				
Low Load 2.7 MW	1.422	± 0.013	± 0.86	± 0.006(2)
Medium Load 8.2 MW	0.251	± 0.003	± 0.83	± 0.001(1)
High Load 11.0 MW	0.051	± 0.005	± 8.60	± 0.002(2)

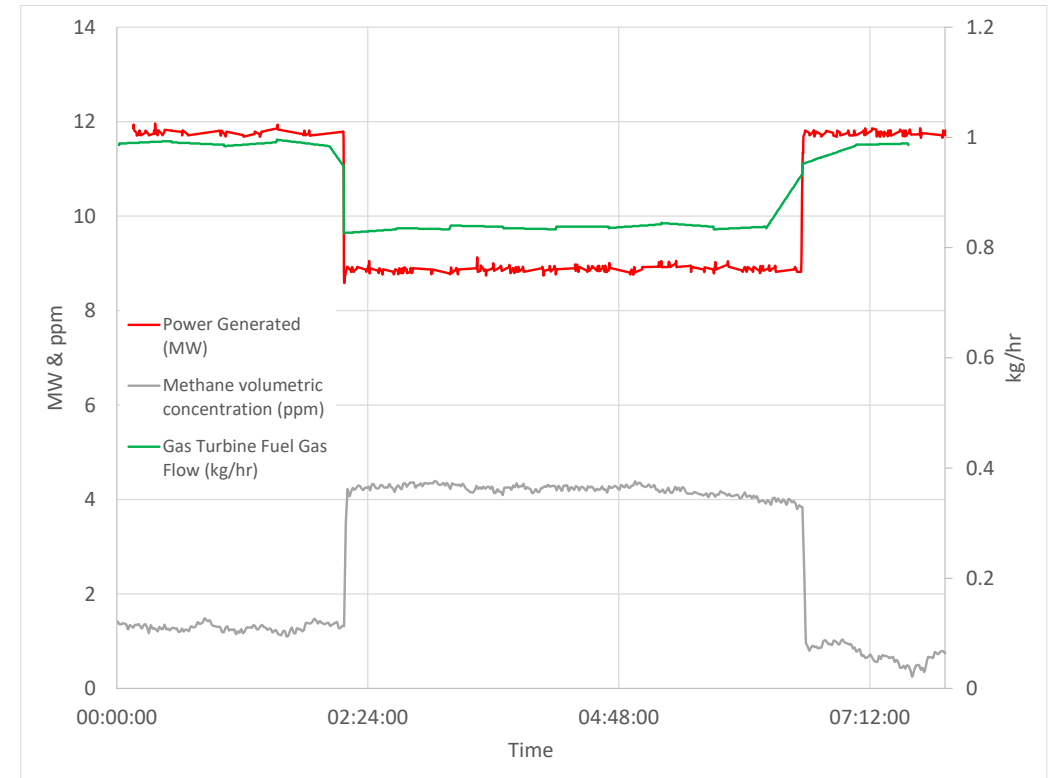
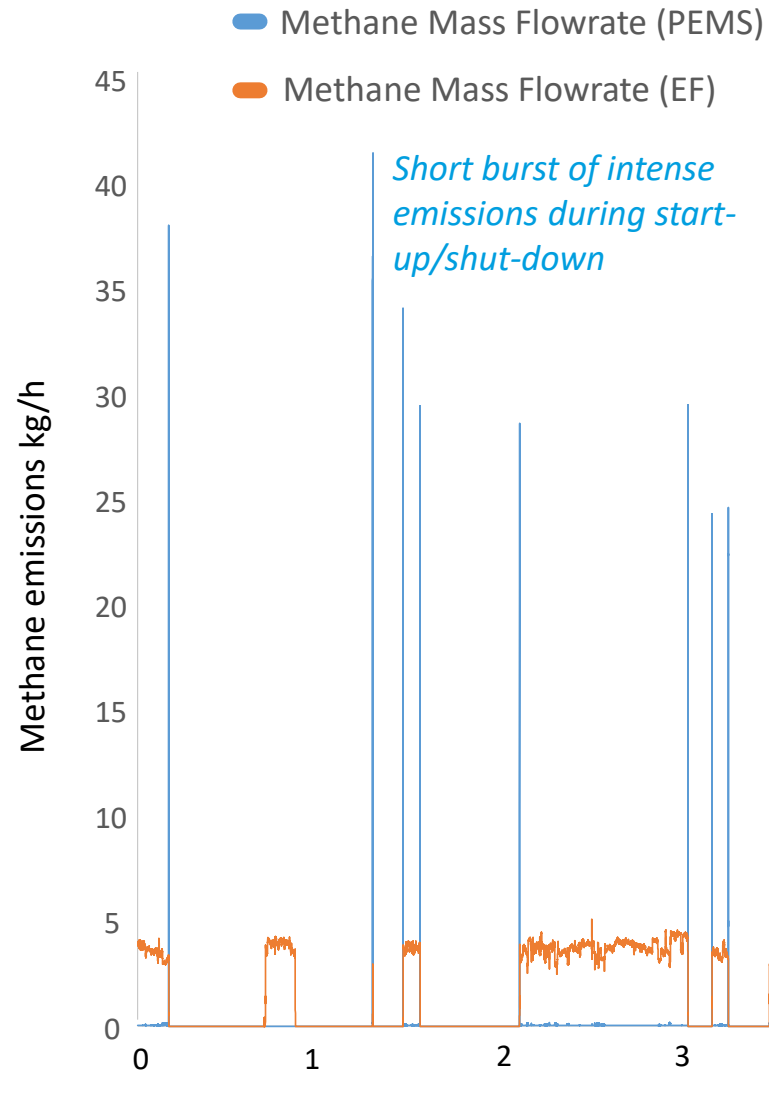
— Ref
— PEMS



*The uncertainty of a unique Predictive Emissions Monitoring System based on hybrid development
Sandvig et al.
Global Flow Measurement Workshop 2022



Time-resolved mass emission rate

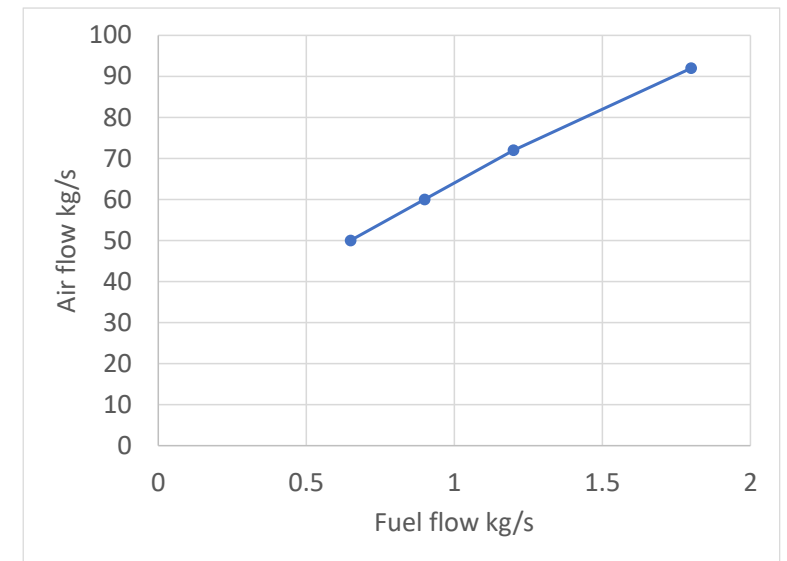
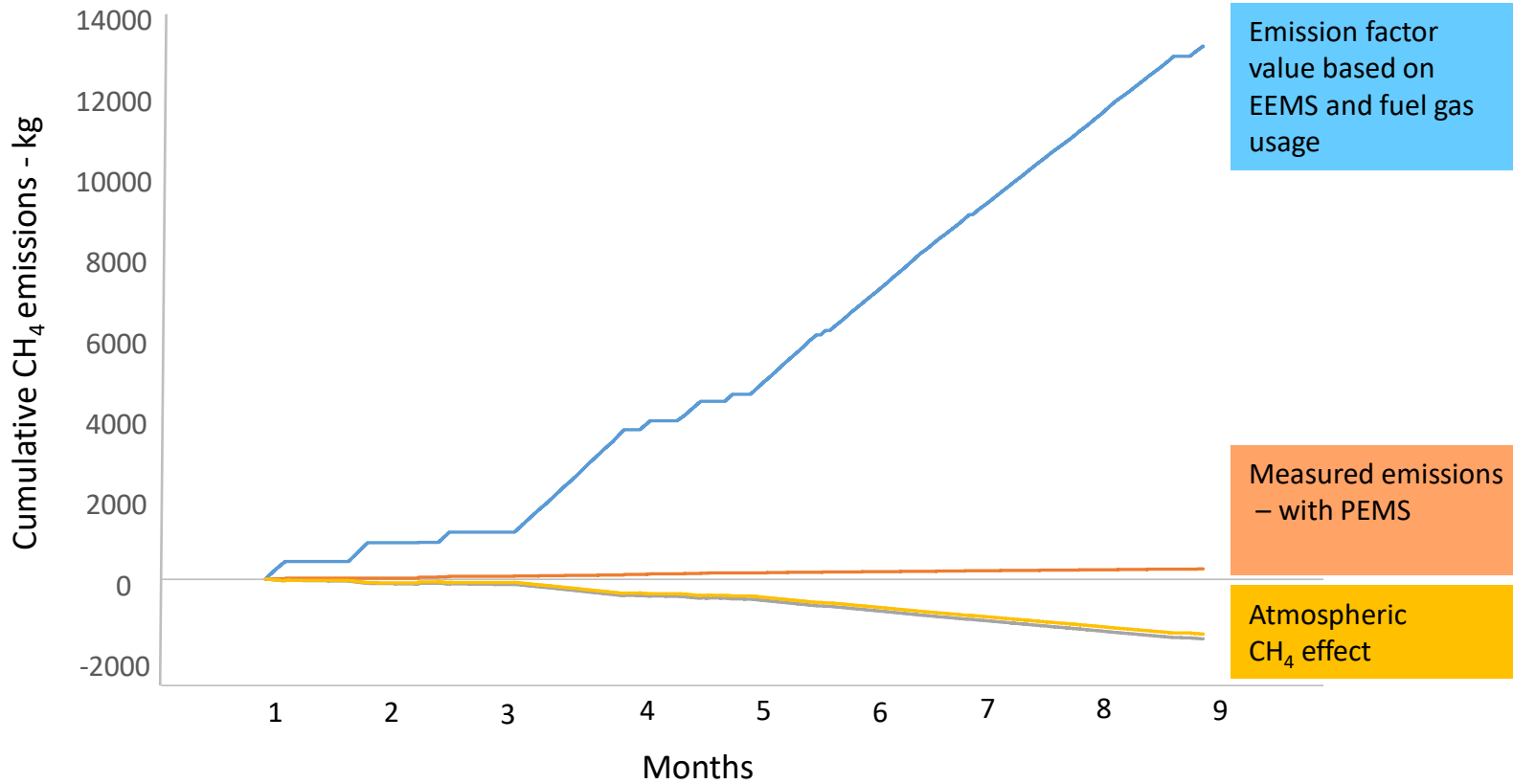


Emission factor estimates track fuel gas usage

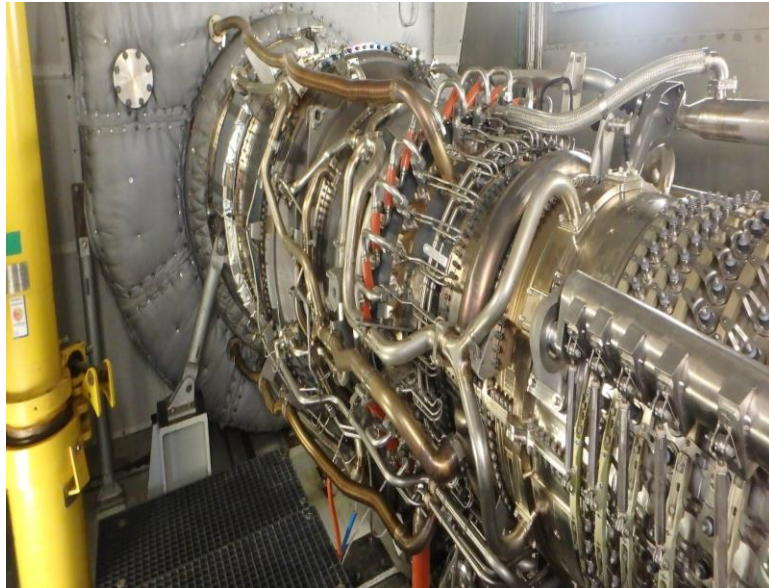
Long periods of low emissions when running close to optimal load

Tracking cumulative emissions over time

GT operating close to optimal load near continuous operation



Translating measurement into emissions reductions



Spinning reserve



NOx



'below background' paradox