Characterization of Emissions from Oilfield Engines: First Results

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Uinta Basin Air Quality

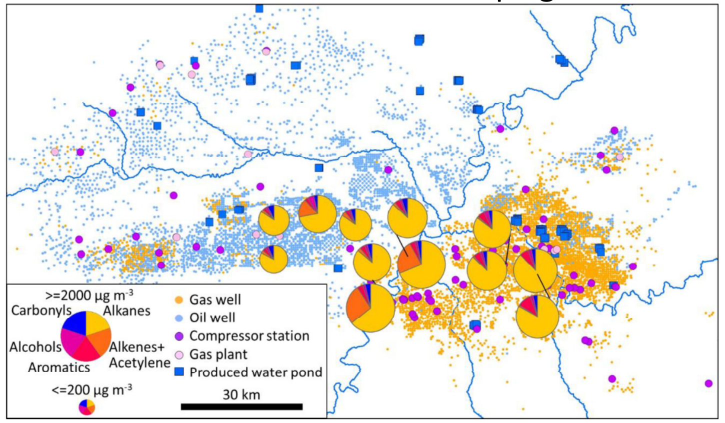
- Utah's Uinta Basin is an enclosed basin (mountains on all sides) that often experiences strong, multi-day wintertime temperature inversions.
- During these inversion episodes, pollution primarily emitted from the local oil and gas production industry reacts in the atmosphere to make ozone.

Not Enough Reactive Organics

- Photochemical models of the Basin simulate much lower ozone than exists in reality, making it difficult to use these models for regulatory decision-making.
- The official emissions inventory (database of all emission sources) gets total emissions in the right ballpark, but it does poorly at simulating the emissions composition.
- In particular, inventoried reactive organics (i.e., compounds that make a lot of ozone, such as alkenes, carbonyls, and aromatics) are much too low.

Engines an Important Source of Alkenes?

- Ambient air measurements have shown higher alkenes, and ethylene and propylene in particular, from areas of the Uinta Basin with more oil wells and lift engines (i.e, natural gas-fueled engines that power pumps to pull oil from the ground). The map below shows one such measurement campaign.



Methods to Measure Engine Emissions

- We measure engine emissions by the following methods:

Ecom J2KN Pro Industrial
- Exhaust velocity
- Exhaust temperature
- Water vapor
- NO and NO_2 (NO_x)
- Carbon dioxide
- Carbon monoxide
- Oxygen

LGR FGGA greenhouse gas analyzer
- Methane

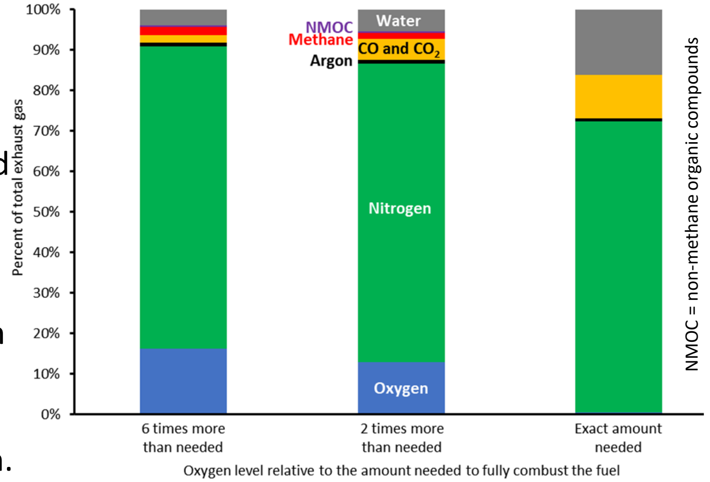
Whole-air canister samples +GCMS analysis
- 54 C2-C10 hydrocarbons
- 3 Light alcohols

DNPH cartridges + HPLC analysis
- 13 aldehydes and ketones

Non-methane organics are sampled through a heated line to eliminate condensation.
Meteorological conditions, which may impact engine performance, are recorded.

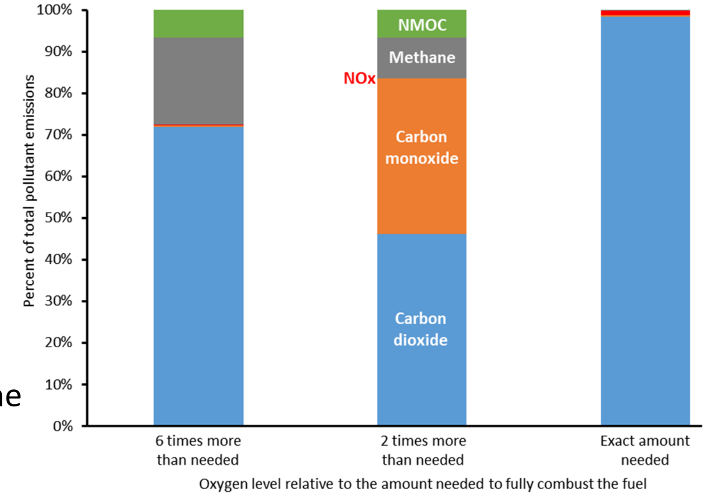
Emission Composition Depends on Oxygen Intake

Most lift engines were operated "lean," meaning that the oxygen taken in was more than what was needed to fully combust the fuel. Some were operated without excess oxygen. The figure shows average exhaust composition from engines operated lean, intermediate, or rich.



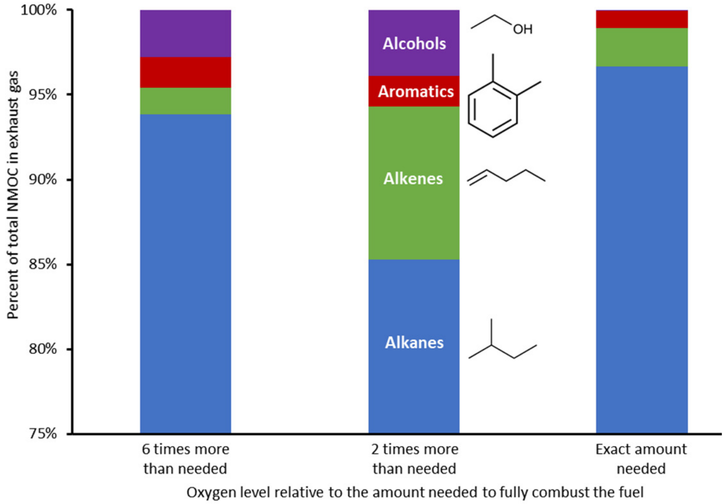
Trade-offs: NO_x Versus Organics Emissions

- The figure below shows that, on average, engines with the most excess oxygen also had more organic compounds in their exhaust. In other words, much of their fuel passed through the engine uncombusted.
- Excess air keeps the engine cooler, which leads to poorer combustion and less NO_x.
- For the engines with the most excess oxygen, 59% of the fuel was uncombusted (by carbon mass), in contrast to 0.5% for the engines without excess oxygen.
- NO_x emissions were ten times higher in the engines without excess oxygen.



Intermediate Oxygen Intake Results in Higher Carbon Monoxide and Reactive Alkenes:

- The figure at right and the one above show that engines with intermediate levels of excess oxygen had much higher emissions of carbon monoxide and alkenes. The reason for this behavior is not yet clear.



We thank the Uinta Basin energy companies that have provided site access and data for this project.