Bingham Research Center
UtahStateUniversity

Fact Sheet: Emissions from Oilfield Pumpjack Engines

What the Research Found

Utah State University researchers directly measured what comes out of natural gas-fueled "pumpjack" engines in the Uinta Basin. The key finding: these engines release far fewer nitrogen oxides (NOx) and much more volatile organic compounds (VOC) than older emission estimates assumed. Because these pollutants drive the Basin's winter ozone, getting the numbers right matters for improving air quality.

What are Pumpjack Engines?

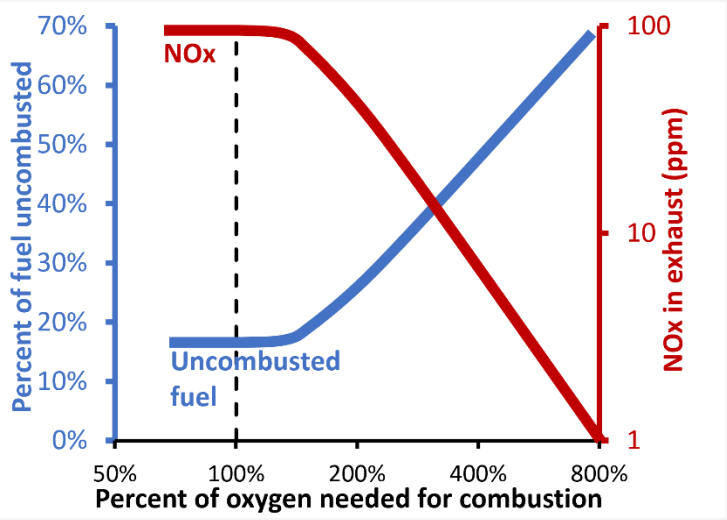
Pumpjack engines are small engines that power the pumps lifting crude oil to the surface. In places with electrical access, this work is done with electric motors, but in remote areas pumpjack engines are fueled by natural gas. More than 3,000 natural gas-fueled pumpjack engines operate across the Uinta Basin. Each is small, but because so many run continuously year-round, their combined emissions matter for regional air quality.

- Most are 2-stroke, one- or two-cylinder engines. They are used because they are mechanically simple, need little maintenance, and can run in harsh, remote conditions.
- Because a 2-stroke engine takes in fuel at the same moment exhaust is leaving, some raw fuel slips through unburned. Most also run "lean" (taking in more air than the fuel needs), which cools the combustion chamber and leaves even more fuel incompletely burned.

What Direct Field Measurements Told Us

The Bingham Research Center measured a full suite of pollutants from 58 pumpjack engines. They found that how engines were operated determined what their emissions were. Engines pulling in lots of extra air burn cooler and make little NOx, but they let more unburned fuel (VOC) escape. The leanest-running engines in the study (the ones with the most extra oxygen) passed more than half their fuel through uncombusted and produced very little NOx.

Older regulatory emissions inventories treated engines as if running at full load, which leads to hotter combustion, higher NOx, and less uncombusted fuel. In reality most pumpjack engines run at low load with lean conditions. Compared with the emission values in an older regulatory inventory, the field measurements told a very different story. Nitrogen oxides (NOx) emissions averaged only about 10% of the inventory estimate, while volatile organic compounds (VOC) were about 15 times higher, and formaldehyde and carbon monoxide



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were each more than 5 times higher. This discrepancy is not unique to Utah. The Bingham Center's work showed that regulatory agencies around the U.S. apply similar assumptions when developing emissions estimates for pumpjack engines.

Why Our Estimates and New Regulatory Inventories are Still Different

The Bingham Center directly measured exhaust flows and pollutant concentrations to determine emissions with as few assumptions as possible. The U.S. Environmental Protection Agency (EPA) performed a separate study with a regulatorily approved method: they measured pollutant concentrations in exhaust and applied those concentrations in an empirical formula that scales emissions using the engine's maximum rated horsepower (essentially assuming the engine runs at 100% load), leading to higher estimates than the Center's direct measurements. Pumpjack engines operate at about 50% load on average, and NOx emissions fall sharply as load drops, so the 100% load assumption leads to large overestimates.

The Bingham Center and EPA methods both showed that NOx emissions are lower than originally assumed, and that VOC emissions are higher, but the EPA estimates of NOx emissions are about 10 times higher than Bingham Center estimates and about three times higher for VOC.

Why this Matters for Uinta Basin Air Quality

The Uinta Basin is one of the few places on Earth with high ozone in winter. Temperature inversions trap pollutants near the ground, and sunlight reflected off snow drives the chemical reactions that form ozone. Both NOx and VOC feed that chemistry, so accurate emission numbers are essential for choosing control strategies that actually work. Correcting the engine values lowered basin-wide NOx from all oil and gas sources by about a third and raised VOC by about 15%.

What this Means for Air Quality Management

✓ **Inaccurate emissions data can lead to unproductive emissions reduction efforts.** When crafting air quality policy, it is critical that industry and regulators have a correct understanding of how much of what kind of emissions come from what source.

✓ **Careful management of the NOx–VOC seesaw is needed.** Pushing engines toward hotter, more complete combustion tends to lower VOC and raise NOx, so any change in engine operations should be evaluated for its net effect on winter ozone before it is adopted.

✓ **Use electric motors where possible.** Electric motors emit neither NOx nor VOC and are the cleanest option for lifting oil from the subsurface.

More Information

This work was conducted at Utah State University's Bingham Research Center and published in two peer-reviewed papers: Lyman et al. (2022), and Mansfield et al. (2026). Additional reports and data are available at binghamresearch.usu.edu/papers-and-reports. A summary of all Uinta Basin air quality research is at usu.edu/binghamresearch/cumulative-research-summary.

Contact us at seth.lyman@usu.edu or visit binghamresearch.usu.edu for more information.