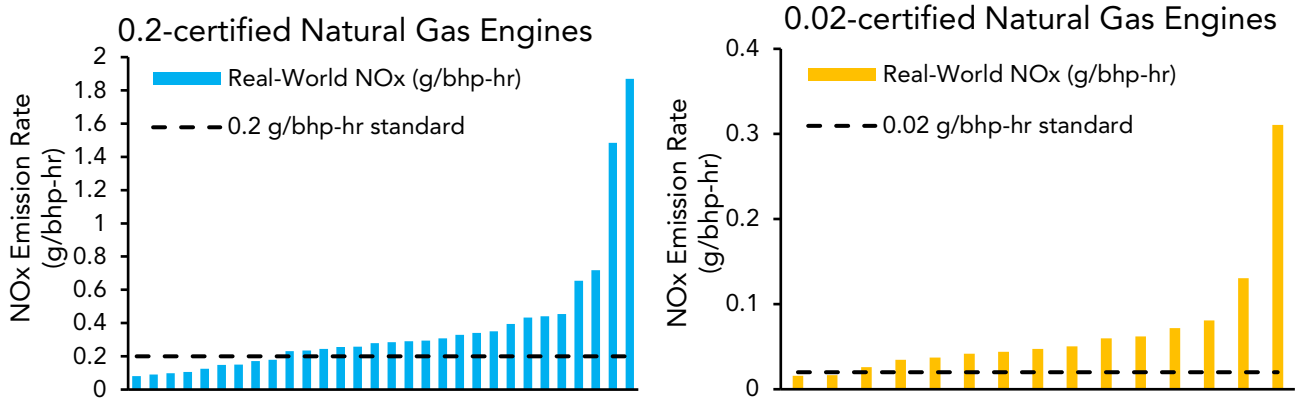
In-Use Emission Performance of Heavy Duty Natural Gas Vehicles

Lessons Learned from 200 Vehicle Project

The 200 vehicle in-use study, or commonly referred to as "200-Vehicle Project", is an extramural contract funded by the South Coast Air Quality Management District (SCAQMD), California Energy Commission (CEC), the California Air Resources Board (CARB), and SoCal Gas[1]. The goal of this study is to gain a better and more comprehensive understanding of real-world (or in-use) emissions and activity of modern medium and heavy heavy-duty diesel and natural gas vehicles, including delivery trucks, school buses, transit buses, refuse trucks, and goods movement trucks. In this study, real-world emissions were characterized using an on-board vehicle emissions testing device known as Portable Emissions Measurement System (PEMS) and during controlled laboratory tests on a chassis dynamometer. Real-world testing was conducted during a test vehicle's one-day operation under its regular driving conditions. This data is valuable for understanding the in-use performance of newer technologies under real-world conditions. This study is still in progress and the results presented in this document are being finalized.

This document focuses on the in-use emission performance of two types of heavy-duty engine technologies: natural gas (NG) engines certified to today's standard of 0.2 g/bhp-hr NOx (hereafter referred to as 0.2-certified) and NG engines certified to optional low NOx[2] standards of 0.02 g/bhp-hr (hereafter referred to as 0.02-certified), also known as low NOx natural gas. In this study, emissions from 30 0.2-certified and 15 0.02-certified NG engines were measured with PEMS. Emission rates in unit of grams per bhp-hr for these vehicles are shown in the figure below, where each bar represents results for one vehicle and the dashed line represents the certification standard. Real-world emission rate is the average rate of a vehicle emissions over the course of a single day.

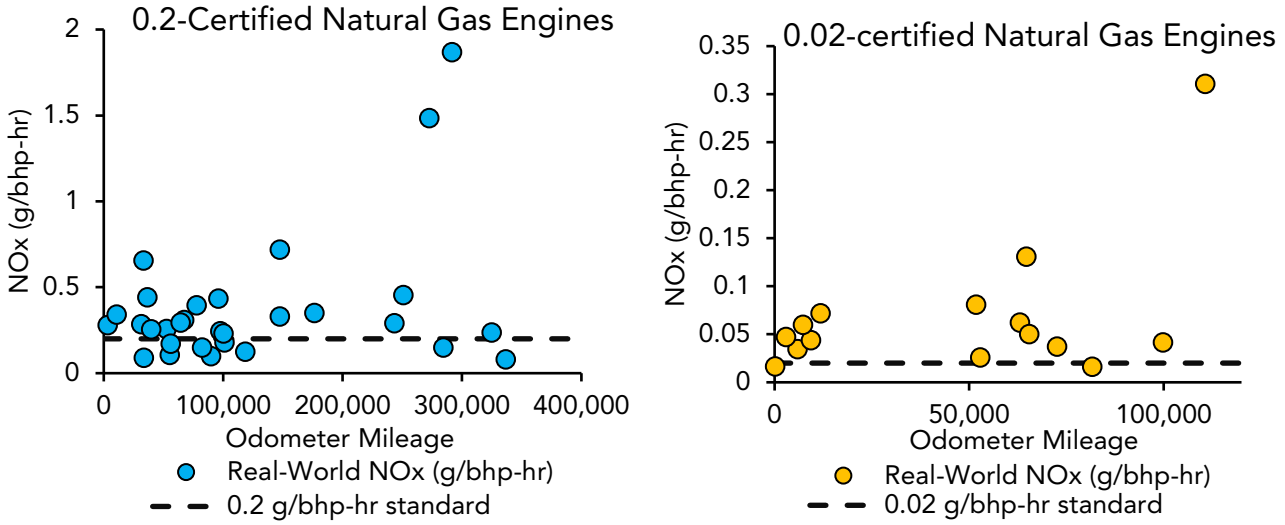


On average 0.2-certified engines had an average NOx emission of 0.38 g/bhp-hr as compared to 0.07 g/bhp-hr from 0.02-certified engines. While 0.02-certified engines generally have shown much lower emission rates than 0.2-certified engines, of the fifteen

[1] *http://www.aqmd.gov/docs/default-source/Agendas/Governing-Board/2016/2016-Apr1-003.pdf?sfvrsn=10*
[2] *https://ww2.arb.ca.gov/our-work/programs/optional-reduced-nox-standards*

0.02-certified engines, 13 of them had emissions above 0.02 g/bhp-hr, with 5 of them having emissions more than 3 times higher than the certification standard. It is noteworthy to mention that for goods movement trucks with 0.02 g/bhp-hr NG technology, researchers have found higher emissions during on-road operation PEMS measurements as compared to chassis dynamometer measurements.[3] This indicates that various operational characteristics (e.g., fraction of idling time) as well as duty cycles can have significant impact on emissions from internal combustion engines.

As vehicles age and accumulate mileage, emission control systems can deteriorate as a result of natural degradation or mal-maintenance, which can lead to emissions that are often much higher than their certification standard. Researchers reported higher emission rates for NG vehicles with increasing accumulated mileage.[3] Real-world NOx emission rates for both 0.2 and 0.02-certified engines are shown in the figure below as a function of their odometer mileage. At higher mileages, in-use NOx emissions for some vehicles significantly exceeded their respective emissions standard .



In general, 0.02-certified NG engines have significantly lower NOx emissions than 0.2-certified diesel and natural gas technologies. However, in-use emissions performance of 0.02-certified technology can limit those emission reductions. This contrasts with zero emission technology (e.g. battery electric or fuel cell electric vehicles), which have zero tailpipe emissions and whose energy production emissions are constrained by continuous monitoring at traditional Electric Generating Units (EGUs), the increasing fraction of the Renewable Portfolio Standard and similar considerations for hydrogen production, and thus resulting in air quality benefits throughout their entire vehicle lifetimes. CARB staff will continue to

[3] Arvind Thiruvengadam, Marc C. Besch, Berk Demirgok, Saroj Pradhan, Filiz Kazan, Beti Selimi, Rasik Pondicherry, Allen Duffy, Jordan Leatherman, Chakradhar Reddy, Cem Baki, Jason England, Aaron Leasor, Daniel K. Carder. In-use emissions and chassis dynamometer emissions rates of heavy-duty diesel and alternative fueled vehicles operating in Southern California. 30th CRC Real World Emissions Workshop (March, 2021)

explore and utilize in-use performance data for modern combustion technologies (e.g., HD Omnibus) including natural gas powered engines.