KEVIN
DOWNING

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March 9, 2023

Senator Janeen Stollman, Chair
Senator Lynn Findley, Vice Chair
Members of the Senate Committee on Energy and Environment

RE: SB 803

Thank you for the opportunity to testify in favor of SB 803. Besides the testimony following presented before the committee on March 9, I am also including documentation showing pollution reduction benefits of renewable diesel, both for human health and climate concerns.

I have more than 20 years' experience while at DEQ working to convince fleet owners to take steps to reduce the harm that comes from the exhaust of their diesel engines. These are marvelous pieces of technology, still the most efficient internal combustion engine more than 140 years after they were first invented. But also still the only engine whose whole complete exhaust, not just its constituents, is a known human carcinogen while simultaneously at current concentrations is the third largest human influence altering climate from Black Carbon.

I listened to the testimony in favor of SB 803 and against and I have to say it was compelling on both sides and makes the task before you very hard. Opposition to taking responsibility for the external costs of business is common. More than once when pitching clean diesel actions to fleet managers I was told they would only act if regulated.

What I heard from people opposing SB 803 is that they very much don't want to be mandated to take this step, to use a cleaner fuel that runs better in their existing engines, that would be a greater step towards protecting human health and climate, not to mention water availability, than current efforts to electrify medium and heavy duty vehicles, that they would just get to it in their good time. And yet there is no evidence that this approach has ever worked well for those facing externalities of pollution. With the EPA 2007 heavy duty truck rule we are still waiting, and will continue to wait at least another 10-15 years under current practices[1], for the relief from lung and cardiovascular disease associated with diesel exhaust exposure that results in an excess cancer risk for more than 80 percent of Oregonians[2].

Now we begin to understand the challenge that climate change also presents to us. We don't have the benefit of time. The fruitlessness of waiting as a strategy comes home to me in a report on a

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[1] https://nepis.epa.gov/Exe/ZyPDF.cgi/P100K576.PDF?Dockey=P100K576.PDF
[2] https://www.epa.gov/AirToxScreen/2017-airtoxscreen-assessment-results; https://www.oregon.gov/deq/FilterDocs/airtox-abc.pdf

phenomenon known as climate departure[3]. For this, scientists considered variability in recorded temperatures over the last 150 years around the globe and projected when the climate will move beyond those thresholds, more or less when the high temperatures of today become the low temperatures then. For Oregon, relying on business as usual, the projected time for this to occur is 2048, which may seem like a long way off. I am likely to be dead by then, but my children and their children will be alive for this unsettling momentous time.

My experience in these matters has provided me with the insight that people, even with best intentions, are slow to respond when the impact of their activity is not borne by them. And the way to make these externalized costs recoverable is for government to set clear signals and expectations for performance on a reasonable time frame. SB 803 does this. To wait or delay is to say that diesel exhaust has acceptable consequences from its pollution when the evidence is entirely to the contrary. At an estimated social cost of $5 per gallon[4], this is not a trivial problem and Oregonians should not have to subsidize the use of diesel fuel with these hidden costs when viable alternatives are at hand.

We urge your careful consideration and support of this legislation.

P.S. The first attachment following is an analysis showing that a late model diesel operating with R99 can actually emit less carbon dioxide than a similar battery electric truck powered. The current Oregon grid although is projected to reduce carbon intensity associated with generation, still has a substantial climate impact further reinforcing that renewable diesel is an accessible and effective climate strategy in the near term.

P.P. S. The second attachment following is a summary of recent research showing the impact of R100 on regulated emissions, i.e., particulate matter and nitrogen oxides, the two major pollutants of concern from diesel engines that directly affect human health. The results indicate that, unlike biodiesel, renewable diesel can reduce emissions of both pollutants in older, uncontrolled as well as late model, well controlled engines. In the graphics that follow, compare the results in each engine scenario between CARB diesel, the baseline petroleum fuel, and R100, Renewable diesel. The other combinations were studied to evaluate whether a blend of renewable diesel was sufficient to offset the NOx increase that comes from use of biodiesel.

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[3] https://www.nature.com/articles/nature12540
[4] https://link.springer.com/article/10.1007/s10584-015-1343-0

Comparing Emission Reductions – Old diesel to new diesel vs. electric

Starting with a skid steer loader and an excavator, both Tier 0, and a Class 8 semi tractor, 2007 model year. Using default operational values for the nonroad equipment from the EPA Diesel Emission Quantifier and from a truck owner (60,000 miles per year), we calculate emissions for respirable and carbon dioxide in tons per year (tpy). Fine particulate or $PM_{2.5}$ is the respirable pollutant of concern because it impacts climate and health simultaneously. We project replacing each vehicle, with a Tier 4 engine for the non-road equipment and a 2023 engine for the truck.

| | Baseline PM (tpy) | New diesel PM (tpy) | Percent Reduced |
|---|---|---|---|
| Excavator | 0.025 | 0.0 | 100% |
| Skid Steer | 0.014 | 0.0001 | 99.6% |
| Truck | 0.042 | 0.0 | 100% |

Of course, the electric truck and, if available, electric nonroad equipment, reduces all tailpipe emissions by 100%.

There remains the issue of climate change. The new replacement diesels may or may not improve fuel economy, so we will assume no change for purposes of this demonstration. The fine particulate from diesel engines is predominantly in the form of black carbon, a potent short term climate forcer, calculated below, which is reduced by the same exhaust control eliminating fine particulate previously discussed. Carbon dioxide is calculated from diesel fuel use.

| | BC (tpy) | $CO_2$ (tpy) | Total (tpy) | Percent reduced by new engines | Percent overall reduced with renewable diesel |
|---|---|---|---|---|---|
| Excavator | 182.25 | 68.2 | 250.45 | 73% | 90% |
| Skid Steer | 31.5 | 15.7 | 47.2 | 67% | 88% |
| Truck | 85.5 | 119.9 | 205.4 | 42% | 79% |

When accounting for the influence of black carbon, replacement to late model diesel engines clearly delivers significant climate benefits that are readily achievable with current technology. Running these engines with renewable diesel results in further reductions of carbon dioxide. In the next scenario we compare the electric truck to the late model diesel running with renewable diesel. Note that while tailpipe emissions from an electric truck are zero, electricity generation in Oregon does have associated carbon dioxide emissions. We cannot perform this comparison for the non-road equipment because we lack a reliable measure of kWh per hour of operation.

| | $CO_2$ (tpy) | Percent Reduced |
|---|---|---|
| Truck – R99 | 43.7 | 78.7% |
| eTruck | 53.7 | 73.8% |

Low Emission Diesel (LED) Study: Biodiesel and Renewable Diesel Emissions in Legacy and New Technology Diesel Engines

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Presented to CARB November 2021

## Summary

The study aimed to evaluate Nitrogen Oxides (NOx) and fine particulate matter (PM) resulting from use of renewable diesel fuel and selected renewable/biodiesel blends in an older, so-called legacy, off-road diesel engine and in highway and off-road late model technology diesel engines. The renewable diesel/biodiesel blends were to investigate whether and at what bend level renewable diesel can mitigate expected increases in NOx emission resulting from biodiesel use, described as “excess NOx”. The baseline fuel was CARB diesel, a product required in California that results in 4-6% lower NOx and PM than the federal ultra-low sulfur diesel used in the remaining states.

A mix of test procedures were used to operate engines under expected conditions of operation including federal test procedures for certifying highway and off-road engines for sale in the United States.

R100 generally reduces or makes no significant difference in emissions of NOx and PM from older off-road and late model off-road and highway diesel engines as compared to the baseline fuel. In both late model engines blending renewable diesel and biodiesel did not reduce excess NOx, in contrast to the legacy off-road engine where increasing blend levels reduced excess NOx.

Legacy Off-road

100% Renewable diesel (R100) reduced NOx emissions by about 5 percent and PM by about 30 percent. Renewable diesel at the biodiesel blend levels tested reduced excess NOx. Higher blend concentrations provided greater benefits in reduced PM.

New Technology Off-road Diesel Engine

R100 resulted in a modest increase in NOx but the difference was not statistically significant. The resulting emissions were still below the engine certification limits for engines of this model year. Neither biodiesel blend level reduced excess NOx.  While PM emissions were higher for R100 and the blend levels tested, the increases were not statistically significant and still remained well below federal emissions certification limits for engines of this model year.

New Technology Highway Diesel Engine

R100 resulted in a modest increase in NOx but the difference was not statistically significant. The resulting emissions were still below the engine certification limits for engines of this model year. Neither biodiesel blend level reduced excess NOx. PM emissions were reduced with R100. Increasing concentrations of the renewable/biodiesel blend did show greater reductions in PM, although the

results were not statistically significant. For both pollutants and under all test scenarios, the resulting emissions were below federal engine certification limits for this model year engine.

## Test scenarios

| Engine Type | SCR Equipped? | DPF Equipped? | HP | Model Year | Manufacturer | Vocation |
|---|---|---|---|---|---|---|
| Off-Road Legacy Engine | No | No | 115 | 2009 | John Deere | Construction |
| Off-Road New Technology Diesel Engine (NTDE) | Yes | Yes | 225 | 2018 | Caterpillar | Industrial Off-Road |
| On-Road Heavy Duty NTDE | Yes | Yes | 450 | 2019 | Cummins | Class 7 or 8 truck |

| Test Cycle | Engine Application | Description |
|---|---|---|
| Non-Road Transient Cycle (NRTC) | Off-Road | Transient test used for engine certification procedure of off-road diesel engines |
| D2 ISO 8718 (D2) | Off-Road | Steady state cycle test used for certification of constant speed off-road engines |
| Federal Test Procedure (FTP) | On-Road | Transient test used for engine certification of heavy-duty on-road engines |
| Ramped Modal Cycle (RMC) | On-Road | Supplementary emissions test used in federal certification |
| C1 cycle (C1) | Off-Road | Used in certification of variable speed off-road engines |

## Off-Road Legacy Engine Results

Nitrogen Oxides

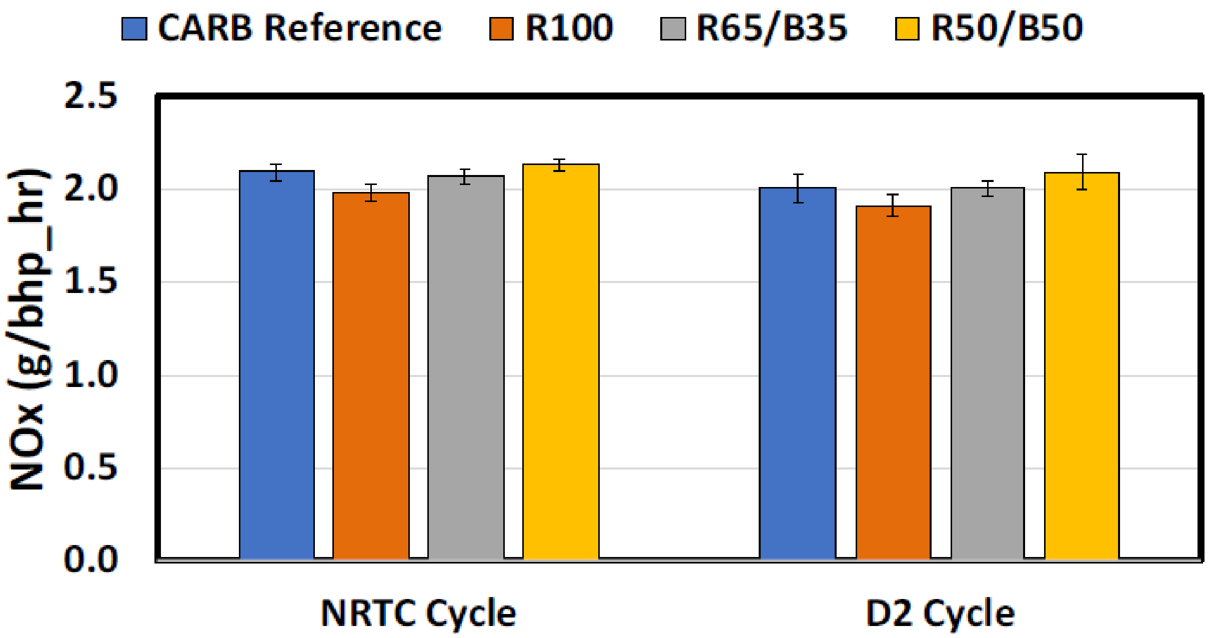


*Figure 1 (from Durbin et al) Average NOx Emissions for the Off-Road Legacy Engine*

*Table 1 NOx Emissions, Percentage Differences, Statistical Comparisons Between Biofuels and CARB Reference Fuel, Off-Road Legacy Engine*

| Test Cycle | Fuel Type | Avg. (g/bhp-hr) | % Diff vs. CARB | p-value (t-test) |
|---|---|---|---|---|
| NRTC | CARB reference fuel | 2.09 | - | - |
| | R100 | **1.98** | -5.4 | **0.00** |
| | R65/B35 | 2.07 | -1.2 | 0.18 |
| | R50/B50 | **2.13** | 1.8 | **0.05** |
| D2 | CARB reference fuel | 2.01 | - | - |
| | R100 | **1.91** | -4.9 | **0.00** |
| | R65/B35 | 2.01 | 0.0 | 0.97 |
| | R50/B50 | **2.09** | 4.2 | **0.02** |

Statistically significant results are bolded and their percent differences are shown in red.

Particulate Matter

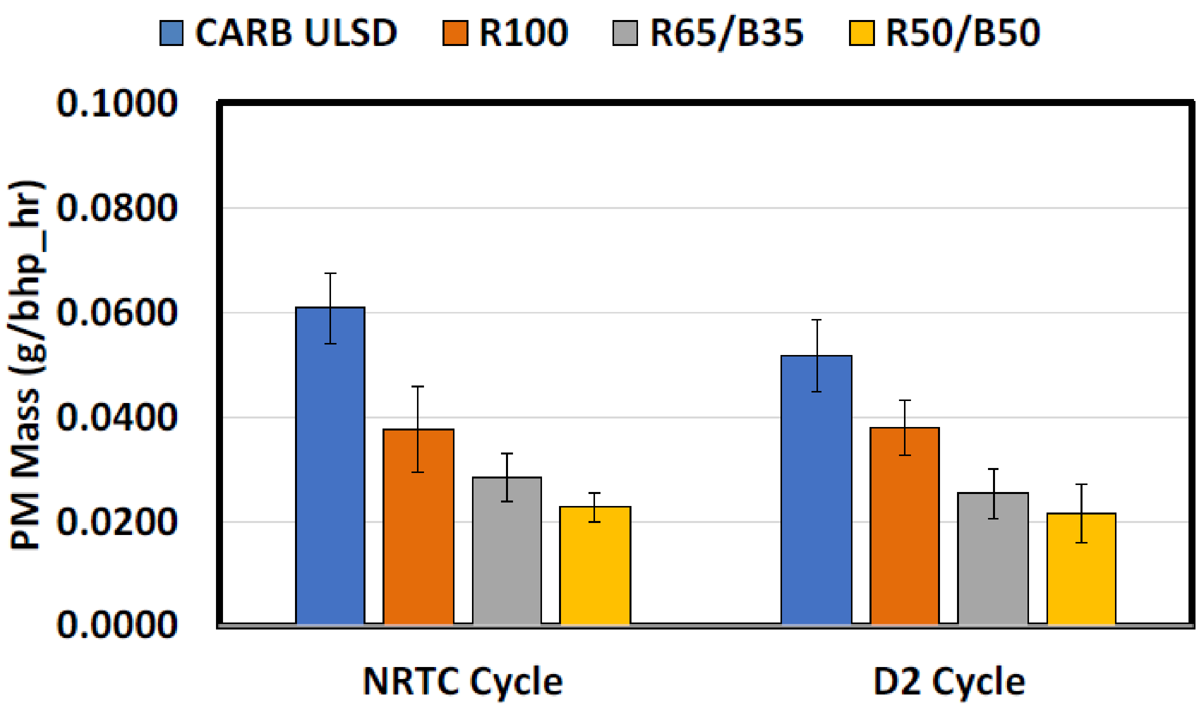


*Figure 2 Average PM Emission Results for the Off-Road Legacy Engine. Note: Federal Engine Certification Limit for PM for this engine is 0.17 g/bhp-hr.*

*Table 2 PM Emissions, Percentage Differences and Statistical Comparisons Between Biofuels and CARB Reference Fuel for Off-Road Legacy Engine*

| Test Cycle | Fuel Type | Avg. (g/bhp-hr) | % Diff vs. CARB | p-value (t-test) |
|---|---|---|---|---|
| NRTC | CARB reference fuel | 0.061 | - | - |
| | R100 | **0.038** | -38 | **0.00** |
| | R65/B35 | **0.028** | -53 | **0.00** |
| | R50/B50 | **0.023** | -63 | **0.00** |
| D2 | CARB reference fuel | 0.052 | - | - |
| | R100 | **0.038** | -27 | **0.00** |
| | R65/B35 | **0.025** | -51 | **0.00** |
| | R50/B50 | **0.022** | -58 | **0.00** |

Statistically significant results are bolded and their percent differences are shown in red.

## Off-Road New Technology Diesel Engine

Nitrogen Oxides

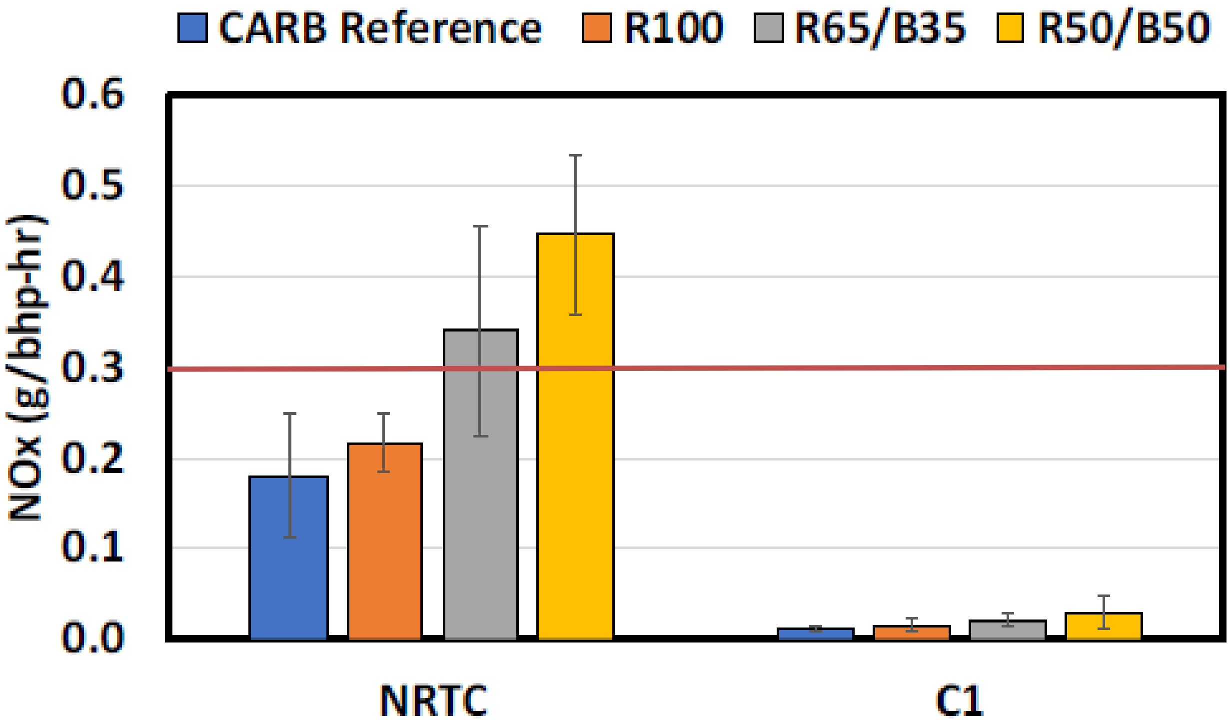


*Figure 4 Average NOx Emissions for Off-Road NTDE. Note: Federal Emission Certification Limit for NOx for this engine is 0.30 g/bhp-hr*

*Table 3 NOx Emissions, Percentage Differences and Statistical Comparisons Between Biofuels and CARB Reference Fuel for Off-Road NTDE*

| Test Cycle | Fuel Type | Avg. (g/bhp-hr) | % Diff vs. CARB | p-value (t-test) |
|---|---|---|---|---|
| NRTC | CARB reference fuel | 0.18 | - | - |
| | R100 | 0.22 | 20.1 | 0.11 |
| | R65/B35 | **0.34** | 88.3 | **0.00** |
| | R50/B50 | **0.45** | 146.9 | **0.00** |
| C1 | CARB reference fuel | 0.014 | - | - |
| | R100 | 0.015 | 10.5 | 0.56 |
| | R65/B35 | **0.021** | 55.1 | **0.01** |
| | R50/B50 | **0.030** | 119.4 | **0.01** |

Statistically significant results are bolded and their percent differences are shown in red.

Particulate Matter

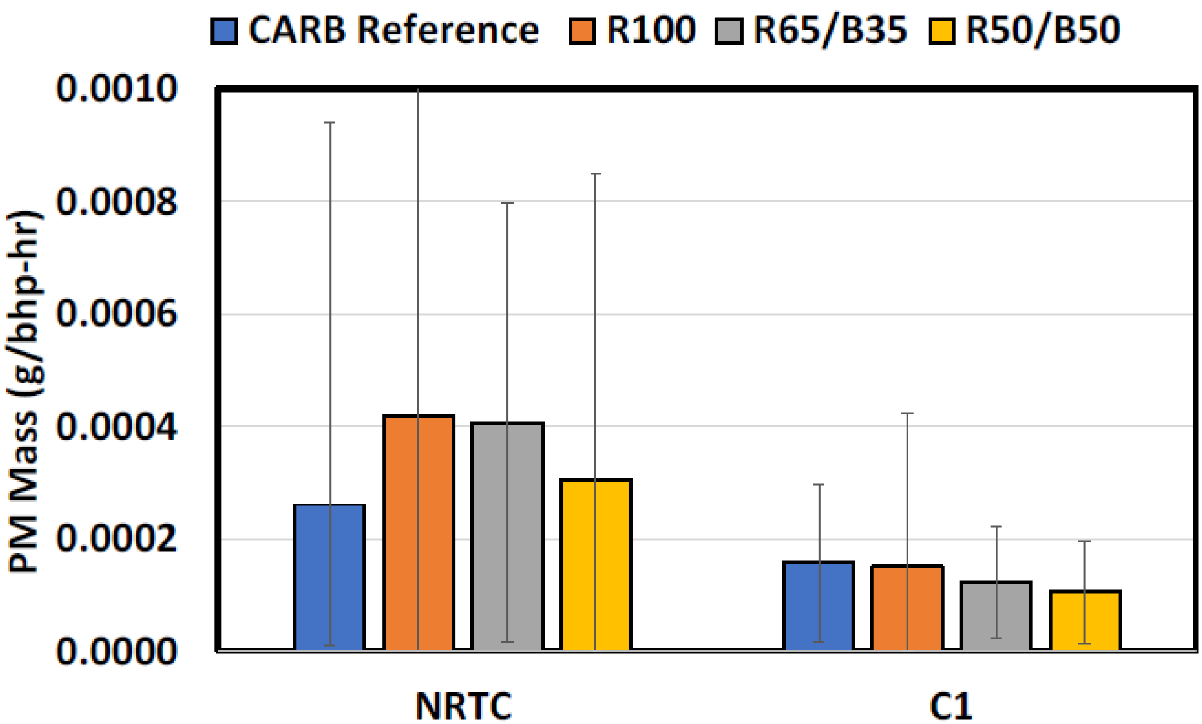


*Figure 4 Average PM Emission Results for the Off-Road NTDE. Note Federal Emission Certification Limit for PM for this engine is 0.015 g/bhp-hr*

*Table 4 PM Emissions, Percentage Differences and Statistical Comparisons Between Biofuels and CARB Reference Fuel for Off-Road NTDE*

| Test Cycle | Fuel Type | Avg. (g/bhp-hr) | % Diff vs. CARB | p-value (t-test) |
|---|---|---|---|---|
| NRTC | CARB reference fuel | 0.00026 | - | - |
| | R100 | 0.00042 | 60 | 0.56 |
| | R65/B35 | 0.00041 | 56 | 0.53 |
| | R50/B50 | 0.00031 | 17 | 0.86 |
| C1 | CARB reference fuel | 0.00016 | - | - |
| | R100 | 0.00015 | -4 | 0.95 |
| | R65/B35 | 0.00012 | -22 | 0.54 |
| | R50/B50 | 0.00011 | -33 | 0.43 |

## On-Road New Technology Diesel Engine

Nitrogen Oxides

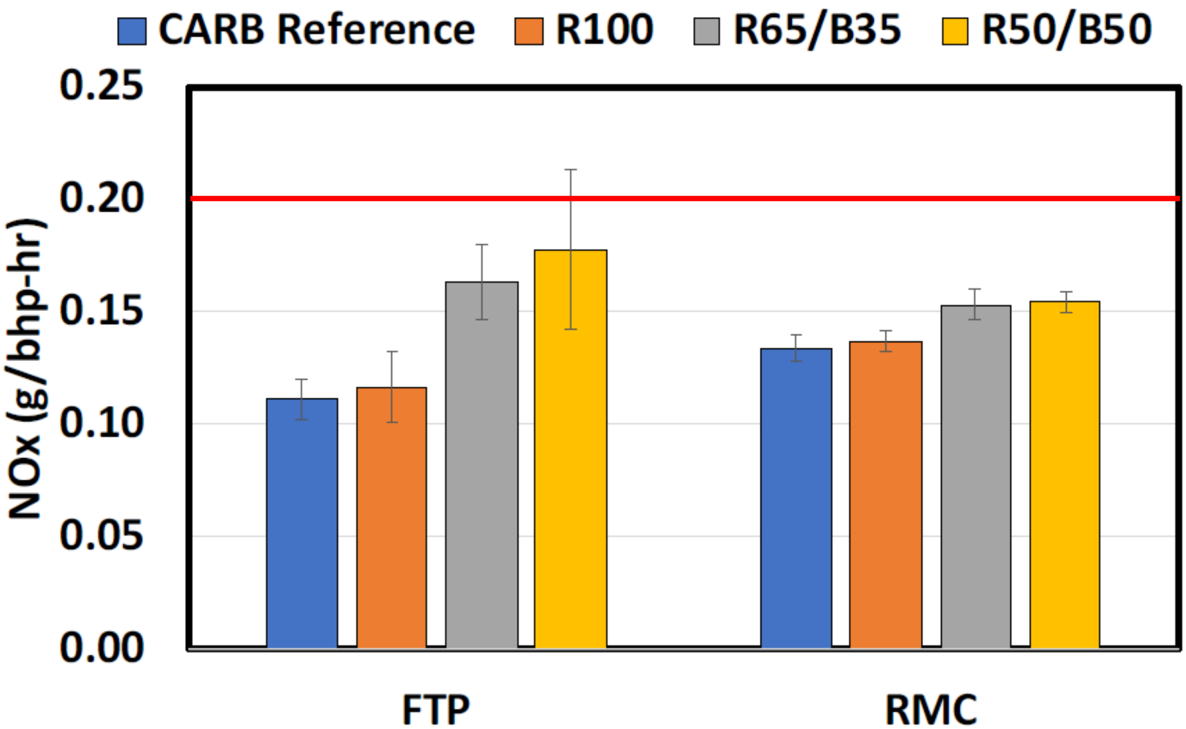


*Figure 5 Average NOx Emission Results for On-Road NTDE. Note: Federal Emission Certification Limit for NOx for this engine is 0.2 g/bhp-hr*

*Table 5 NOx Emissions, Percentage Differences and Statistical Comparisons Between Biofuels and CARB Reference Fuel for the On-Road NTDE*

| Test Cycle | Fuel Type | Avg. (g/bhp-hr) | % Diff vs. CARB | p-value (t-test) |
|---|---|---|---|---|
| FTP | CARB reference fuel | 0.11 | - | - |
| | R100 | 0.12 | 4.8 | 0.34 |
| | R65/B35 | **0.16** | 46.6 | **0.00** |
| | R50/B50 | **0.17** | 49.5 | **0.00** |
| RMC | CARB reference fuel | 0.13 | - | - |
| | R100 | 0.14 | 2.3 | 0.19 |
| | R65/B35 | **0.15** | 14.2 | **0.00** |
| | R50/B50 | **0.15** | 15.4 | **0.00** |

Statistically significant results are bolded and their percent differences are shown in red.

Particulate Matter

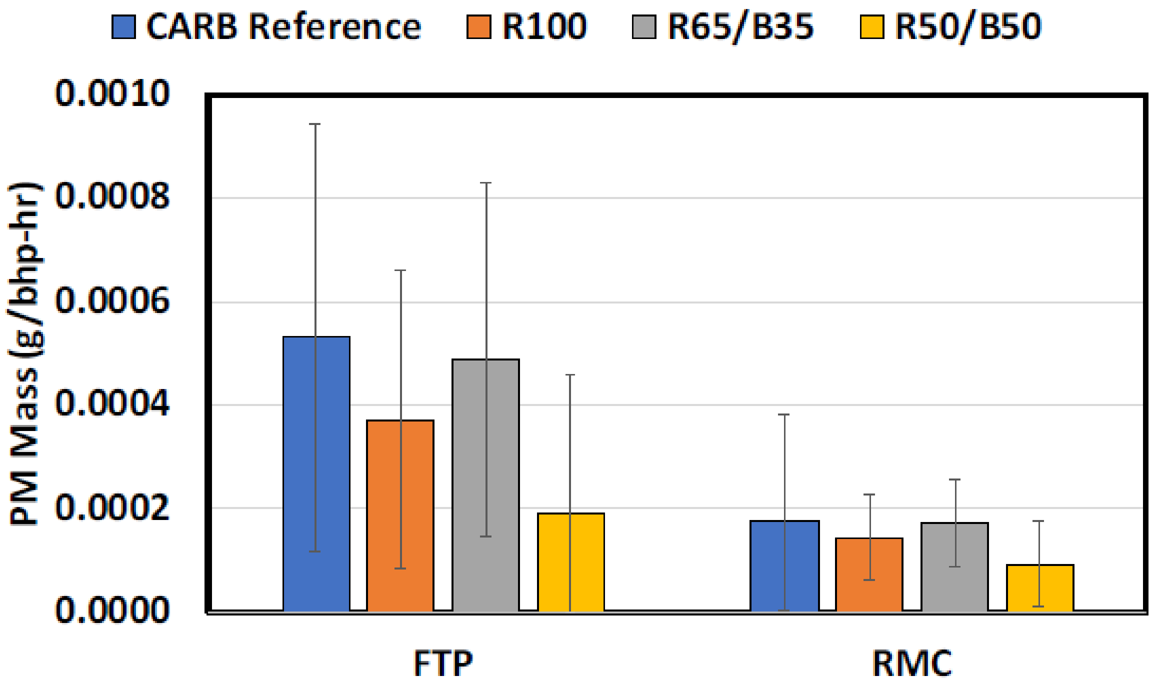


*Figure 6 Average PM Emissions for the ON-Road NTDE. Note: Federal Emission Certification Limit for PM for this engine is 0.01 g/bhp-hr*

*Table 6 PM Emissions, Percentage Differences and Statistical Comparisons Between Biofuels and CARB Reference Fuel for On-Road NTDE*

| Test Cycle | Fuel Type | Avg. (g/bhp-hr) | % Diff vs. CARB | p-value (t-test) |
|---|---|---|---|---|
| FTP | CARB reference fuel | 0.00049 | - | - |
| | R100 | 0.00036 | -28 | 0.38 |
| | R65/B35 | 0.00052 | 6 | 0.86 |
| | R50/B50 | 0.00018 | -64 | 0.06* |
| RMC | CARB reference fuel | 0.00018 | - | - |
| | R100 | 0.00015 | -18 | 0.66 |
| | R65/B35 | 0.00017 | -4 | 0.94 |
| | R50/B50 | 0.00009 | -47 | 0.26 |

*Indicates marginally significant result