Modeling Idling Reduction Options for Heavy-Duty Diesel Trucks

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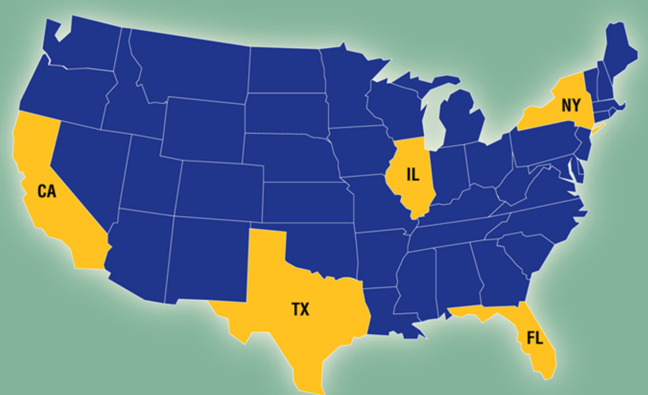
Overview

Heavy-duty trucks idle during rest periods and extended stops for a variety of reasons, most notably so the driver can stay comfortable. A variety of idling reduction (IR) technologies are now available commercially that can help truckers to cut the number of hours they idle. This clearly saves energy and fuel costs, but how much do these devices help in the quest to reduce the harmful emissions that result from idling? To date, pollution and energy analyses of different IR technologies have been largely limited to localized vehicle emissions and have not considered upstream and regional emissions impacts. Although regulations are generally based on emissions at the vehicle, overall environmental impacts are determined by the full-fuel-cycle effects and atmospheric chemistry contributing to air quality. This analysis addresses full-fuel-cycle emissions.

In this effort, we estimated upstream emissions together with published vehicle operations, climate, energy, and emissions data — comparing emissions, energy use, and proximity to urban populations for nine technology scenarios. These include idling of both a 2001 model truck and one compliant with 2007 standards, electrified parking spaces (EPS), auxiliary power units (APU), direct-fired heaters (DFH), battery-electric cooling (BEC), and several combinations of these for heating and air conditioning (AC). Specifically, we compared effects for the United States as a whole and for five populous, highly urbanized states individually: California, Florida, Illinois, New York, and Texas.

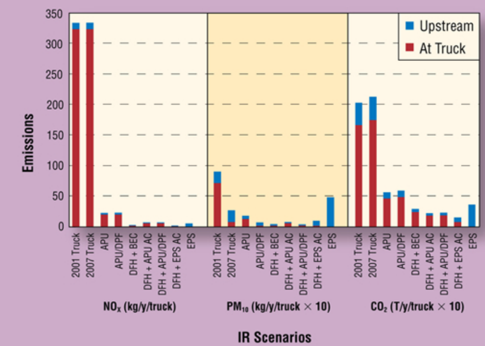


Methodology

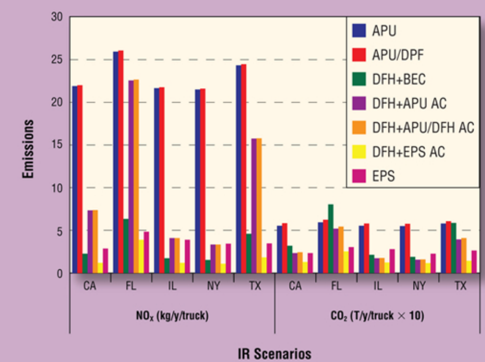
We created an Excel spreadsheet model[1] to calculate annual urban and rural energy use and emissions from idling and IR technologies. Using the Greenhouse Gases, Regulated Emissions, and Energy use in Transportation (GREET) model, we considered upstream emissions and energy use, starting from the point at which the fuels are extracted from the ground. We also used published vehicle operations, energy data, and emissions data to estimate device emissions and vehicle energy use.

We generated fuel consumption and emissions estimates of particulate matter of 10 microns and less (PM_{10}), nitrogen oxides (NO_x), hydrocarbons (HC), carbon monoxide (CO), sulfur oxides (SO_x), and carbon dioxide (CO_2) for heating and cooling modes for the nine IR technology scenarios considered. The analysis considered the distinct electric grid profiles (including fuel mix and urban share of generation for each fuel) for the five states studied, in addition to the U.S. average. Costs were not considered in this analysis, nor was quality or availability of the service provided.

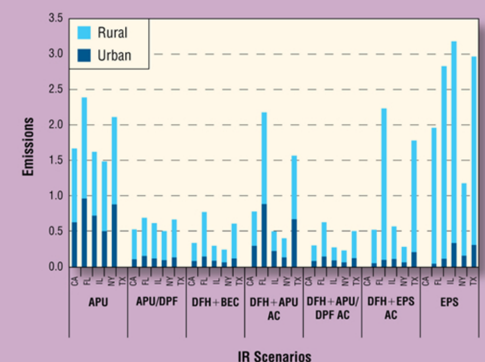
[1] Solomon, M.J., 2006, "Modeling Idling Reduction Options for Heavy-Duty Diesel Trucks: A Comparison of Full-Fuel-Cycle Emissions, Energy Use, and Health Costs in Five States," Master's Thesis, University of California, Davis, Aug.



U.S. average emissions for idling and IR technologies



IR technologies PM_{10}, NO_x, and CO_2 by states



PM_{10} urban rural split by state for IR technologies

Conclusions

National-average emissions impacts from all on-board IR options were found to be lower than those from an idling truck that is compliant with 2007 emission standards. Total PM_{10} emissions from electrified parking spaces were found to be greater than those from a 2007 truck for the entire U.S. average and for states that use more coal for electric generation, and lower for states that use less coal (though the urban component is low). We found four major causes of variation in emissions rankings:

- Technology
- Climate (heating vs. cooling loads)
- Electric generator types and fuel
- Urban vs. rural emitter location

This analysis was based on an assumed 2,100 hours per year of idling, but this assumption does not impact the relative rankings of the technologies. Findings for U.S. average and all states on a full-fuel-cycle basis include the following:

- Annual emissions of different idle reduction technologies can vary significantly.
- Assumptions concerning the amount of heating and cooling significantly influence the results, as does the electric power mix.
- A direct-fired heater combined with an auxiliary power unit fitted with a diesel particulate filter (DPF), or a heater combined with battery-electric cooling produces the lowest PM_{10} emissions.
- A direct-fired heater combined with electrified parking spaces for cooling produces the lowest energy use and CO_2 emissions.
- On an emissions basis (PM_{10}, NO_x, CO_2), all IR technologies reduce emissions, although NO_x emissions for 2007 truck idling are uncertain due to lack of data.
- Technology- and state-specific results are shown in the table below.

Heating

Auxiliary power units produce the highest NO_x and energy/CO_2 of IR options; PM_{10} has significant urban component, PM_{10} at the truck exceeds tailpipe emissions from 2007 truck.

Electrified parking spaces produce the highest total PM_{10}, but mostly in rural settings, so few people are exposed. There are no impacts at the parking site.

Direct-fired heaters have lowest emissions of heating methods in all cases, but do not provide cooling.

Cooling

Auxiliary power units produce the highest NO_x of IR options; PM_{10} has significant urban component.

Electrified parking spaces produce the highest PM_{10}, but mostly in rural settings. There are no impacts at the parking site.

Battery-electric cooling produces the highest CO_2/energy of air conditioning options (based on assumptions; measurements needed).

State-to-State Comparison

States with high coal-based electric generation (e.g., Illinois) have highest PM_{10} from electrified parking spaces.

States with high/low heating loads show most/least benefit from direct-fired heaters.

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