Mobile Idle Reduction Technology Project:

A Case Study by NC State University and Volvo Technology of America

To view the full report and a short video about the project, visit
http://www.engr.ncsu.edu/ncsc/transportation/MIRTproject.htm

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Project Overview

With $500,000 funding from the U.S. Environmental Protection Agency (EPA), the NC Solar Center at NC State University (NCSU) conducted a 34-month Truck OEM APU Prep Kit Design and Installation Project that began in October 2005 and concluded in August 2008. Goals for the project were to (1) evaluate in-use performance of mobile idle-reduction technology (MIRT) by characterizing actual idle reduction times from an idling baseline provided by the fleet from existing trucks; (2) work with partners to evaluate fuel, maintenance, engine life savings, payback times, and user reactions; and (3) submit a final case study report to EPA at the conclusion of the study, and publicize the case study to the trucking industry to increase the knowledge, awareness, and lessons learned from the project.

Through a competitive solicitation to Truck Original Equipment Manufacturers (OEMs), Volvo Technology of America (VTA) was awarded a $350,254 subcontract to develop a Prep Kit to facilitate MIRT installations, demonstrate auxiliary power units (APUs) in a minimum of twenty over-the-road trucks, and track MIRT use, truck idling and driver acceptance. VTA collaborated with three principal technology providers to develop two APUs (APU-A and APU-B) that were utilized by two fleets (Fleet A and Fleet B). The twenty trucks participating in the field demonstration operated for over 2.8 million miles in 42 states during the sixteen-month data collection period, which ranged from September 2006 to February 2008. From this field test and additional research conducted by NCSU, data was compiled to assess fuel displacement, cost saving and emissions benefits.

The Prep Kit designed by Volvo accommodated APU- A and APU- B; however, due to the time requirements of the project; the Prep Kit was not utilized by the field study trucks. Nevertheless, development of the Prep Kit drove standardized mounting locations and methods assuring more secure MIRT installations and generated savings of an estimated 150 minutes in “prep time” per installation for the MIRT service provider. As of August 2008, Volvo had received 572 new truck orders with the Prep-Kit option selected.

The APUs utilized by Volvo’s project partners were comprised of three components: an engine (2006 Kubota Z482 048 liter engine), a generator, and a Heating Ventilation Air Conditioning (HVAC) system supplied by Dometic Environmental Corp that utilized a "split system" in which the evaporator and condenser are mounted separately. The fleets selected by Volvo for the field demonstration represent a wide spectrum of the company’s customer base. Fleet A had a self-reported annual idling rate of 2,500 hours with predominantly single drivers utilizing Volvo's largest black cabs while Fleet B utilized mid-size white cabs with predominantly team drivers that have a reported average annual idling time of 800 hours per truck from information provided to Volvo via truck dealerships.

As of August 2008 a total of 136 APUs had been ordered by new truck customers, in addition to the 20 trucks with APUs that participated in the field study and two additional trucks that were outfitted with APU- A and APU- B at the start of the project. VTNA has made a business decision to target the AC/HVAC type MIRT systems. AC/HVAC refers to an HVAC system that can be used from a 120Vac power source while the vehicle is parked. The primary reason for this is the ability to operate the complete HVAC system from plug-in shore power, thus eliminating the need to run the diesel-powered generator set when shore power is available. Through August, Volvo had received 4 orders for Dometic HVACs, a product that requires an electric hook up or shore power (SP).

A data acquisition system was installed by Volvo in each of the 20 trucks participating in the field test to determine idling hours and use of MIRT. The data acquisition system was comprised of four major components: an electronic control unit (ECU), additional sensors, a data logging system, and Volvo Link^{TM}. NCSU College of Engineering researchers, Dr Chris Frey and graduate student Po-Yao Kuo, tracked and interpreted data from the field test trucks. Fuel-based emission factors for the base and APU engines were estimated based on fuel properties and emissions measurements using a Portable Emission Measurement System (PEMS). Fuel use rates were also calculated for the base engine using ECU data, for which the field truck data vary depending on ambient temperature, and the APU, which was calculated as a function of electrical load.

Results and Discussions

Previous avoided fuel use rates and emissions benefits from APUs may be optimistic: Avoided annual average fuel use and CO_2 emissions for all stops were 22 and 5 percent for Fleets A and B, respectively, which are lower than literature estimates of 50 to 80 percent. Avoided annual average NO_x emissions for all stops are 46 and 14 percent for Fleets A and B, respectively, which are also significantly lower than literature estimates of 70 to 90 percent. Thus, the reported estimates appear to be optimistic in that they assume that all trucks in the on-road fleet would have similar performance. Although the sample of trucks in this study is not a nationally representative sample, the trucks observed here represent a proportion of those on the road. The differences in real world versus previously estimated avoided fuel use and emissions are because of differences in fuel use rates and emissions factors, lower hours of idle reduction activity, and double-dipping (simultaneous use of the main engine and APU), which accounts for 0.1 to 29 percent of the field demonstration's cumulative powered stop duration. Nevertheless research related to the field study concludes that at mild temperatures, 100% substitution of APU usage instead of the base engine leads to an 80 to 90 percent reduction in NO_x emissions, 36 to 47 percent reduction in CO_2 emissions and fuel use, and 10 to 25 percent reduction in PM emissions. Therefore driver behavior plays a significant role in determining APU benefits.

With more stringent regulated emissions standards for engines, APU benefits are reduced and costs increased although CO_2 and avoided fuel use benefits remain: As new base engines, which are subject to increasingly stringent emissions standards, enter the on-road fleet, the relative advantage of APUs may be decreased with respect to emission rates, especially for NO_x and PM. However, the advantages with respect to reduced fuel use and CO_2 emissions are likely to remain. New APUs in California need to control PM emissions by routing APU exhaust through the truck PM filter or installing an extra APU PM filter after 2008. These new emission standards are likely to increase the cost of APUs.

Incentive programs are needed to encourage low engine RPM, high APU use and reduce double dipping: In order to reduce energy use and emissions for APU-equipped trucks operated by single drivers, driver incentive programs and training should be developed to encourage low base engine RPM and high APU utilization levels and discourage double-dipping. During the 18-month field test, six trucks had 25 hours or more of activity in which the base engine and APU were operating simultaneously, which increases fuel use and emissions. The trucks operated by team drivers should consider other idle reduction options because it is almost impossible for them to have net cost savings for the use of the APU because team drivers do not have to rest for 10 hours after driving 11 hours like solo drivers do. In addition, as engine RPM increases, fuel use rate increases.

New methods developed through this project can be applied to additional idle reduction technology: SP typically has a significantly lower energy use and emission rate (except for SO_2) than either a base engine or APU. Although SP facilities are currently unavailable at most truck stop locations, further geospatial analysis is recommended for identifying suitable SP facility spots. The cost effectiveness of the SP facilities for the chosen spots should be estimated based on the measured electrical loads for the APU because they are indicative of the loads that could be supplied by SP if such facilities had been available. Methods developed by Dr. John Stone and graduate students can be used for quantifying activity patterns, avoided fuel use and emissions for additional trucks and extended to include other types of anti-idling methods.

Payback periods may not justify APU use unless APU use and fuel costs are high: The economics of APUs are sensitive to the annual avoided fuel use. Many studies appear to use high values for base engine fuel use and low values for APU fuel use, combined with assumed but uncertain hours of substitution of APU usage for that of the base engine, which leads to estimated payback periods of 1.4 to 4.3 years. Sensitivity analyses conducted by Dr. Frey and graduate students for net cost savings per unit of energy use reduction and payback periods for each of the 20 trucks are based on actual fuel use and emission rates and activity patterns, using discount rates of 0 to 10 percent, fuel price of $2.56 to $8.00 per gallon, APU capital cost of $8,500 to $13,000, and annual APU non-fuel operations & maintenance (O&M) cost of $400 to $600.

For $4.50 per gallon or lower diesel fuel price, no truck has positive net cost savings because the reduction in fuel cost is not enough to offset levelized capital cost or non-fuel O & M cost, even if the latter are at the low end of their ranges. Payback periods for all trucks range from longer than 5 years to no payback period (no net discounted savings) for fuel price of $4.50 per gallon and lower. For low APU capital cost, no discount rate and $8 per gallon fuel price, only six trucks have payback periods shorter than 5 years and the shortest of these is 3 years. As discount rate increases, the payback periods increase.

However, payback period time calculations have multiple variables which can change significantly from case to case. In a more generalized sensitivity analysis conducted by Dr Stone using an assumed APU cost of $8400, $4.00 per gallon fuel costs and 8 hours per day use of APU instead of base engine idling the payback period is 3.5 years. If the 20 field trucks had higher avoided fuel use rates (by using the APU more rather than idling base engine), the payback rates would be reduced significantly and would bring field test payback periods more in line with the generalized sensitivity analyses. This underscores the need for driver incentives and training to maximize APU usage.

APUs are used for short and long duration stops, however total rest stops are less than typically estimated: Trucks with single drivers have significantly more and longer stops than trucks with team drivers, however the total idling time for rest stops is less than typically estimated. APUs are used for both short and long duration stops.

Rate of APU use varies within fleets and between fleets that employ single versus team drivers: With fleet purchases of APUs the field study demonstrated that driver preference for APU versus base engine idling varies. The field data imply that the APU is used by single drivers for an average of 59% of idling and by team drivers for an average of only 25% of idling. It can be assumed that individual owner operators who purchase APUs will have a higher percentage of usage and therefore a quicker/better rate of return on the investment.

Conclusions

Differences in base engine speeds, ambient weather conditions, accessory loads, or combinations of these, as applicable, can have significant effects on energy use and emissions rates for the base engines, APUs and SP systems. Through this field test, new methods have been developed for estimating fuel or energy use rates and emission factors taking into account variations of key factors in real-world conditions.

In addition to the physical characteristics of the base engine and APU, driver behavior plays an important role in the effectiveness of MIRTs to reduce base engine idling. Team drivers generally do not use the APU because idling time is low, and thus APUs are not cost effective for team-driven trucks. For trucks operated by single-drivers, APUs are used in the field both for long duration rest stops and for some shorter stops that are likely to be during loading or unloading of the truck. The APUs are cost-effective and provide significant environmental benefits for those drivers who most actively used the APUs.

The idling activity patterns were similar for the single drivers regardless of whether they preferred to use the base engine or the APU. Thus, the results imply that if drivers who otherwise are not using the APU can be encouraged or required to use the APUs (which can include long duration rest stops as well as shorter stops), the payback period will decrease to acceptable levels. Fleets should closely analyze their needs to assess the value of purchasing MIRTs and once idle reduction technology has been adopted insure usage by providing training and incentives for use.

Finally, by having an OEM offer MIRTs as part of their product line, in addition to a prep-kit, customers will have confidence that the APU is of the same quality as all its products. Having a truck OEM, such as Volvo offering an APU as part of their product offering is a significant result of this project that will increase market acceptance for MIRTs. Moreover, methods developed by project researchers to track and analyze MIRT use, avoided fuel use and emissions can be adopted to evaluate other idle reduction technologies while adding to the body of “ real world” idle reduction technology and fleet evaluations.

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