ELECTRIC POWER RESEARCH INSTITUTE

case study

Diesel Engine Idle Reduction in Class 8 Trucks Using On-Vehicle Equipment With Optional Shore Power

Electric Transportation Program

EPRI and the Sacramento Municipal Utility District (SMUD) teamed with the U.S. Environmental Protection Agency (EPA) and participating trucking fleets to demonstrate the potential cost savings and emission reductions that could be realized through the use of alternatives to idling truck main engines during driver rest periods.

Background

For years, truck drivers have idled their main engines during federally mandated driver rest periods to ensure driver comfort—to power truck sleeper cabin heating or air conditioning, lighting, and appliances for cooking meals or entertainment. Idling the main heavy-duty truck engine to provide for these relatively small power requirements is inefficient, highly polluting, and expensive.

New technologies enable the driver to shut off the main engine while parked and instead use electricity from onboard battery storage or an off-board electrical connection known as "shore power" to power equipment and appliances in the truck cab.

Shore-power idle-reduction technology can save money and cut fuel use and pollution. In 2003 the trucking industry consumed nearly one billion gallons of diesel fuel while idling. The savings in fuel costs, alone, could amount to more than $1 per hour or approximately $2,000 per year per truck without sacrificing driver comfort.

There are three barriers to adoption of idle-reduction systems:

1. Most trucks do not have engine-independent equipment to keep the driver comfortable.
2. Most places trucks stop during rest periods do not provide electrical outlets.
3. Using shore power will require truck drivers to adopt new behaviors, which will require outreach and training by industry groups.

This project was established to address the first barrier, with the hope that it would complement efforts to address the other barriers.

Objectives

The objectives of this project were:

- To demonstrate a cost-sharing and reinvestment approach to installing engine-independent idle-reduction equipment
- To evaluate the different idle-reduction equipment available for trucks
- To quantify the cost and emission savings resulting from installing shore power-capable idle-reduction equipment

Project Description

Electric-powered onboard idle-reduction equipment was installed and used on 34 trucks from nine fleets. Each fleet chose different brands and combinations of equipment.

Project Partners—Financial and In-kind Participation

EPA grant funds in the amount of $200,000 were matched by $113,161 in fleet expenditures for equipment and system installation. EPRI program costs of $50,830 and SMUD program costs of $97,740 bring the total project expenditures to $461,731. Equipment and its installation accounted for 51% of reported project costs. Project management and data collection and analysis accounted for the balance of the costs.

Participating fleets signed an agreement that stipulated they would cooperate by:

- Contributing half the cost of the idle-reduction equipment
- Selecting and installing equipment
- Providing baseline idling percentages and engine computer downloads to track performance
- Assisting with driver surveys
- Reinvesting energy and maintenance cost savings from the first year of operation in additional idle-reduction equipment

The idle-reduction equipment manufacturers also contributed significantly to the project. One company provided trained personnel to install the HVAC systems for seven of the nine fleets. Another contrbuted to the development and design of the all-electric, grid-independent onboard system at the inception of the project.

Generating Fleet Interest

The project commenced in early 2003 with one fleet agreement. This fleet was a relatively small regional carrier with a high level of interest in idle reduction. EPRI and SMUD worked closely with this fleet to define the project's needs and design the system.

In 2003, SMUD contacted more than a dozen fleets to solicit participation in the project, but none joined—a discouraging result. A second fleet partner finally joined in January 2004 and a third in June 2004. During the summer of 2004, the price of diesel fuel briefly rose to more than $2.50 per gallon and interest in the project suddenly increased. Six more fleets joined.

As of April 2004, 16 months into the project, only six trucks had been outfitted with idle-reduction systems. By the end of 2004, an additional 28 trucks had been equipped, for a total of 34 systems in the demonstration project.

Equipment Installation

The basic set of equipment includes an auxiliary electric heating, ventilating, air conditioning (HVAC) system, an electric inverter-charger capable of providing both 120-volt AC and 12-volt DC electricity, and the wiring and controller needed to operate the system. In addition, because most truck parking locations do not have electrical outlets available—and many favored locations such as public rest areas, roadsides, and shopping center parking lots, may be difficult to electrify—each truck was equipped with auxiliary batteries sufficient to power the system when shore power was unavailable, as shown in Figure 1. Four different manufacturers provided the equipment.

Dometic

The Dometic system was installed on 19 trucks from five fleets, including the first two systems installed for the project. Data loggers also were installed to help assess system use and understand driver needs and habits. Each truck tested a different auxiliary battery configuration. Before operation, the systems were tested to confirm that the air conditioning performed adequately during hot weather. It was somewhat difficult to provide adequate air flow to and from the Dometic air conditioning system installed under the bunk in the sleeper cab, as shown in Figure 2. Ducting was carefully installed to the bulkhead to prevent short-circuiting and to provide adequate air circulation within the sleeper.

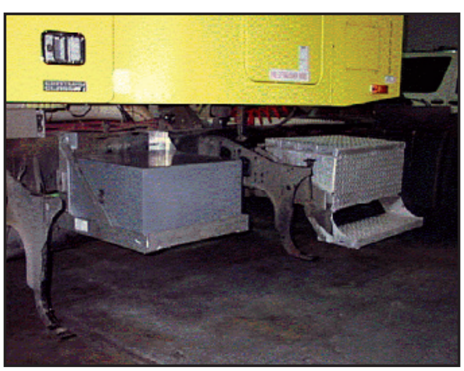

Figure 1. Box Holding Deep-Cycle Batteries

Bergstrom NITE

The Bergstrom NITE (no-idle thermal environment) system was installed in four trucks from two fleets. With a lower power output than Dometic, the NITE system had difficulty maintaining a comfortable cabin temperature when outside temperatures exceed 90° F. The NITE system is generally used with a fuel-fired heater for heating the sleeper cab. Using the NITE system with shore power could be accomplished by installing an AC-DC converter (like a battery charger) to provide 12-volt DC power to the air conditioner, auxiliary battery, and any 12-volt accessories or lights in the sleeper.

Idling Solutions

The Idling Solutions system was installed on eight trucks in two fleets. One six-vehicle fleet had great success with this system, a battery-powered air conditioner that is mounted on the back of the sleeper cab, as shown in Figure 3. It appears that this mounting location offers an air distribution benefit within the cab. The Idling Solutions system includes a heating capability, using a combination of heat pump and resistance heating, but is not currently shore-power compatible.

Proheat

One fleet installed the Proheat system in two of its vehicles. The system is normally powered by an engine-driven generator set, however, it is also shore-power capable. The shore-power option is installed with a transfer switch that switches off the gen-set and allows battery charging and air conditioner operation when shore power is available. The complete system—with gen-set, air conditioner, battery charger, and shore power transfer switch—is slightly lighter than the standard Dometic system.

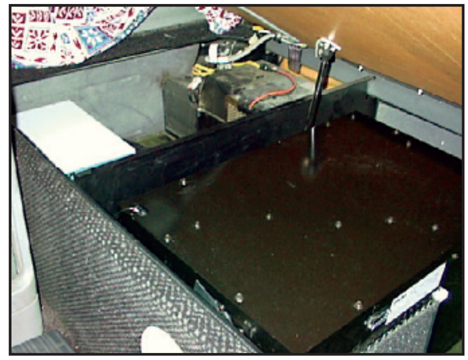

Figure 2. Dometic Air Conditioner and Xantrex Inverter (white) Installed Under Bunk in Truck Sleeper Cab

Project Challenges

The project encountered numerous challenges, but two, in particular, contributed to project complexity and affected the overall results.

Data Collection

Project managers focused more on getting equipment into the hands of drivers and fleet managers in order to learn about their needs and start generating cost savings, and less on acquiring data. They encountered challenges both in establishing the baseline

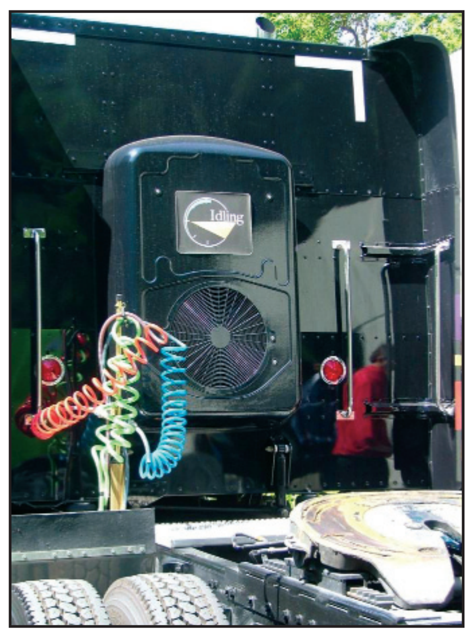

Figure 3. Idling Solutions System Installed on Back of Cab

idling rates and in tracking the actual idle reductions after the equipment was installed.

Participating trucking fleets were required to provide baseline data on idling times before equipment was installed. Some fleets, however, simply did not have this data. Where data was unavailable, a best estimate was used. Having an accurate baseline was critical because it would enable calculation of the actual fuel and maintenance cost savings achieved by installing the idle-reduction equipment, which in turn would provide the basis for calculating the annualized amounts that the fleets were required to reinvest in additional idle-reduction equipment.

To determine actual idle reduction savings, project managers used the trucks' existing engine control module (ECM) data and formulated a method of estimating reduction in idling hours. The ECM data downloads came from three different modules, however, and the resulting incongruities complicated data comparison.

Systems Bigger than Necessary

Although the original hope was to install electric air conditioning systems that would use shore power for extended rest periods, fleets universally elected to install larger battery packs that would enable rest periods of up to 10 hours without plugging in. This choice resulted in an increase in air conditioning system complexity and cost, and a decrease in the number of trucks actually outfitted compared to the original plan. The systems eventually installed included electric air conditioners, inverter-chargers, batteries and controllers, and were cost competitive with auxiliary power units or generator sets currently being considered as an alternative to truck main-engine idling.

Results

The program achieved, on average, a 50% idling reduction compared to baseline, resulting in a payback period of 4.9 years for the project. The best-performing fleet was able to eliminate 70% of its baseline idling, for a 2.2-year simple payback period. The average truck experienced a reduction of 690 idling hours per year, while the best-performing truck reduced idling by 2,078 hours per year. This difference shows the degree of variation in equipment use and idling practice.

The project managers estimated that on an annualized basis, these trucks would reduce emissions of nitrogen oxides (NO_x) by 6,555 pounds per year, and save more than 16,968 gallons of fuel by cutting their idling hours. Reduced idling also would extend engine life. These fuel and extended engine life figures would amount to $46,248 in annualized savings on a one-time investment of $226,561.

The annualized savings figure was calculated by estimating an average monthly savings during the demonstration period and then multiplying that figure by 12. (Many of the installations did not experience a full year of operation.) This result is not seasonally adjusted. Some of the data is for trucks operated during winter months, when the electrical HVAC might not be used. Higher idling reductions probably occur during the summer months due to air conditioner use.

Perhaps the most successful aspect of the project was that the fleets reinvested more than five times the annual savings generated by the project in idle-reduction equipment, $266,247 as of the last tally.

Based on the annualized emission reductions and assuming a five-year equipment life, the projected cost per ton of emissions reduced was $10,679. The best-performing fleet had a cost per ton of emissions reduced of $4,420.

Lessons Learned

1. **Trucking fleet managers are motivated by cost savings.** While fleet managers are highly aware of fuel costs, it is often difficult to attribute cost savings to the idle-reduction equipment, since the actual savings may be masked by variations in routes, driver behavior, and destination climates. Every trucking fleet involved in this project had to observe a positive cost savings calculation before agreeing to try the equipment.
2. **It is difficult to measure the cost savings from idle reduction.** Savings in fuel consumption are not easy to measure. More than one fleet manager participating in the project expressed doubt about the fuel consumption reductions claimed by the project.
3. **Data collection methods could be improved.** In the future, ECM data downloads should be augmented with component hour meters or inexpensive data acquisition systems that record actual system operation and operating choices made by the drivers.
4. **Driver behavior is an important variable.** An idle-reduction system in the sleeper cab of one driver allowed a very significant reduction in idling time, while the same system in the cab of another resulted in essentially no change, or even an increase in idling. Maximum idle reduction seems to come from programs that include ongoing training and discussion of idle-reduction savings with drivers at weekly safety meetings.
5. **Climate is also an important variable.** Because most long-haul trucks travel throughout the country, they may occasionally need peak cooling or heating capability, so the industry typically designs systems to meet these needs in extreme climate conditions. An alternative approach might be to design a less powerful and therefore less expensive system that does the job most of the time, but requires the driver to idle in some extreme temperatures.
6. **Idle-reduction equipment effectiveness is a third important variable.** If the equipment can meet the driver's comfort needs without idling, it will displace more idling, and reduce costs.
7. **Driver comfort and choices must be considered.** More consideration of driver comfort and choices might help fleets find solutions that drivers want to use and better understand how to train drivers, ultimately resulting in increased idle reduction and greater cost savings.
8. **Financing must be made easier for owner-operators.** Many truck drivers are interested in receiving support for capital expenditures to reduce idling.

They view the equipment as expensive, and there is not enough operating data so far to establish the reliability of this equipment, which would further reassure truck owners.

9. **It is important to keep the project simple.** This project required both sharing of the original installed system costs and reinvestment of savings. These requirements made the project seem complex to some of the fleet managers. A further indication that the project might have seemed too complex is the fact that to date, no fleet has independently provided a calculation of its cost savings, as required by the participation agreement; all the fleets have accepted the project calculations.

10. **It is important to keep the technology simple.** It is possible that one reason some drivers limited their use of the idle-reduction equipment was that they didn't fully understand the technology. Simpler, more automated controls would certainly help. Better operator training and a simple operation guide may also be necessary.

Conclusions

This project demonstrated that shore-power onboard technology can provide adequate driver comfort and substantial reductions in idling in sleeper-equipped trucks. The project also demonstrated the motivations of fleet managers relative to idling reduction and to opportunities to reduce costs. The significant variability in idle-reduction results is attributable to differences in driver behavior, differences in climactic conditions during the data-sampling period, and differences in equipment effectiveness at meeting drivers' needs. In the future, more attention should be given to driver satisfaction, variations in climate and rest period conditions, and driver motivation.

Shore-power onboard technology has a great potential to reduce idling costs, and project managers believe drivers and fleets would use shore power to realize further cost savings if it were available. While an average truck might consume $20 worth of fuel for a rest period, using batteries charged by the engine or using an APU for the same period costs about $4.41, and using batteries charged by shore power costs $1.20. Drivers seem to like the quieter rest period and the idea of saving fuel and reducing emissions. Additional cost savings would be possible if thermal insulation were installed in the truck sleeper.

Although the original intent of the project was to work with two or possibly three fleets to install more units per fleet, the project ended up installing 34 systems in trucks from nine fleets. Due to the limited state of knowledge about idle-reduction systems, most fleets continue to experiment with solutions on a few trucks rather than installing them fleet-wide. Truck drivers still need to be sold on the benefits of changing behavior related to idling, and on-truck systems need to be improved to better meet the needs of truck drivers.

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