21ST CENTURY TRUCK PARTNERSHIP

August 27, 2007

# Heavy-Duty Truck Idle Reduction Technology Demonstrations

# 2006 Status Report

Fred Wagner
Energetics Incorporated

FreedomCAR

U.S. Department of Energy
Energy Efficiency and Renewable Energy
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## NOTICE



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## Acknowledgements

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## Executive Summary

**Schneider National, Inc.** completed its project, titled "*Cab Heating and Cooling*," which demonstrated engine-off cab heating and cooling, in September 2005. This project equipped nineteen Freightliner trucks with the Cab Cooler and Nite Systems, and 100 trucks were equipped with a self-contained diesel-fueled air heater to demonstrate engine-off cab heating. For detailed information on the results of this demonstration, see the Heavy Duty Truck Idle Reduction Technology Demonstration 2005 Status Report. Schneider National has installed Webasto cab heaters on all MY03, and newer, tractors as a result of the U.S. Department of Energy (DOE) supported demonstration. Schneider is also continuing to evaluate the Webasto Parking Cooler, the Bergstrom Nite Battery System and a similar product from the Netherlands, and cost-effective insulation packages.

**Caterpillar, Inc.** is demonstrating its technology in a project titled "*Demonstration of the New MorElectric™ Technology as an Idle Reduction Solution*," which applies electrically driven accessories for cab comfort during engine-off stops and for reducing fuel consumption during on-highway operation. Five trucks were equipped and operated with the technology in conjunction with International Truck and Engine Corporation and Cox Transfer. Data collection began in the Fall of 2004 and includes compilation of fuel, operation, and maintenance data. Preliminary results show that the MorElectric™ trucks are idling an average of 13% versus 27% for control vehicles leading to a 0.14 MPG improvement in fuel economy. It is important to note that the control fleet was also equipped with an idle reduction device that automatically starts and stops the main engine. This is equivalent to a savings of approximately 400 gallons of diesel fuel per truck per year. Early systems performance issues have largely been resolved and in 2006 the MorElectric™ trucks logged equivalent mileage as control trucks indicating robust technology. The field test was concluded at the end of 2006 as all five trucks were converted back to their original condition.

**Espar Heater Systems** has been leading a project titled "*Idle Reduction Technology Demonstration and Information Dissemination*," that demonstrates combined cab heating and cooling systems. Equipment installation was completed in May 2004, which included installing Bergstrom air conditioners and Espar bunk heaters as a combination package in 20 International trucks, for use by Wal-Mart Transportation, LLC. Tripac auxiliary power units, which provide heating, cooling, and accessory power, and an Espar bunk heater, were installed into an additional five trucks. Subsequent to the March 2006 data download, the trucks originally equipped with the Bergstrom Nite Battery System were refitted with Tripacs. As of December 2006, results indicate a test truck fuel economy of 7.24 MPG (Nite System originally) and 7.28 MPG (Tripac originally), compared to the benchmark truck fuel economy of 7.01 MPG. This equates to a 3 – 4% fuel economy improvement.

**International Truck and Engine Corporation** is leading a project titled "*Factory-Installed Idle Reduction System for International Sleeper Trucks*," to complete engineering development activities for the integration of on-board idle reduction technology into heavy-duty trucks as an original-manufacturer, factory installed equipment option. International was successful in developing, testing, factory releasing, and manufacturing an idle reduction system for International's 9000 series sleeper trucks. Five field test evaluation vehicles with idle reduction systems were built in July and September 2006 and delivered to customers. The five fleet evaluation vehicles will be monitored for fuel economy and idle time through 2007. In addition, deliveries of production orders for the factory-released system began in October 2006, providing for immediate fuel economy and emissions savings beyond the original five-truck evaluation. The project scope includes the following: 1) development of idle reduction system and subsystem requirements; 2) design, fabrication, and testing of APUs and electric HVAC systems; 3) installation and testing of developed systems and improved cab insulation in a pre-production pilot truck; and 4) installation and field testing of the idle reduction systems in 5 custom-ordered vehicles, allowing for hot and cold season testing to gain customer acceptance. The idle reduction system has four principal elements: an auxiliary power unit (APU), electric air conditioner, cab and engine preheater, and improved cab insulation. This project was started in August 2005 and is scheduled for completion in July 2007.

In addition to the four demonstration projects, this report briefly describes other idle reduction activities, including the CoolCab project to apply thermal management technologies to truck cabs, Clean Cities, and the Environmental Protection Agency's (EPA's) Smartway Transport Partnership.

## Background

In 2002, DOE's AVTA initiated a study of diesel truck engine idle reduction technologies, which identified several barriers to widespread use of existing technologies. These barriers included initial cost, driver education and receptiveness, reliability, and maintenance requirements. The results of the study were used to develop a demonstration plan that defined a pathway to idle reduction technology implementation. The goal of the demonstration and evaluation effort outlined in the plan was to gather objective in-use information on the performance of available idle reduction technologies by characterizing the cost; fuel, maintenance, and engine life savings; payback; and user impressions of various systems and techniques.

Several phases of the demonstration plan have been completed, including a workshop for gathering industry input, held in April 2003 in Philadelphia. Input from the workshop was used to design a DOE solicitation for technology demonstration projects as well as help prioritize data types for collection and evaluation. A second workshop was held to identify cost reduction strategies; DOE subsequently released a technology introduction plan that outlines a path to implementation of these cost reduction strategies and refines the technology implementation strategies addressed in the earlier demonstration plan. In late 2003, two idle reduction demonstration projects were awarded (Schneider and Caterpillar), a third project was awarded in 2004 (Espar), and a fourth (International) in 2005. This report provides the status of these projects, as well as a brief synopsis of other idle reduction activities of the Federal Government.

### Demonstration Projects

The four projects consist of teams of a truck fleet, truck manufacturer, and idle reduction technology manufacturer. Including all these major participants on the teams ensures successful implementation and demonstration of the complete onboard idle reduction systems. Highlights are presented above in the Executive Summary, and details are presented below:

- Schneider National Inc.—"Cab Heating and Cooling"
- Caterpillar Inc.—" Demonstration of the New MorElectric™ Technology as an Idle Reduction Solution"
- Espar Heater Systems—"Idle Reduction Technology Demonstration and Information Dissemination"
- International Truck and Engine Corporation—"Factory-Installed Idle Reduction System for International Sleeper Trucks"

## Schneider National, Inc.

Schneider National, a Wisconsin-based provider of truckload and intermodal services throughout North America, teamed up with truck manufacturer Freightliner and Webasto Thermosystems and Bergstrom to devise and test truck cab heating and cooling technologies to reduce idling to five percent of total engine operating time. Schneider National has historically taken a proactive stance to reduce idling in its fleet of 15,000 trucks and offered incentives to its drivers to keep idling time to a minimum. Schneider National trucks idle considerably less than the industry average: 480 hours/year vs. 1,830 hours/year for the industry.

For this evaluation, Schneider National chose to demonstrate heating and cooling technologies separately, to take advantage of climatic extremes in evaluation and data collection – testing spanned two summers for cooling and two winters for heating applications. All Schneider trucks in this evaluation were equipped with the "Artic" insulation package (a significantly upgraded "Extreme" insulation package is becoming available at Freightliner but was not used in these demonstrations). During the evaluation period, three separate technologies were tested: a Webasto Airtronic diesel fired heater for cold weather operation, a Webasto Parking Cooler phase change storage system, and a Bergstrom Nite Battery System 12 volt electrical air conditioner for cooling applications. Data on system operation were collected using temperature data loggers and driver records. The Schneider project was completed in September 2005. For a detailed discussion and the results of this DOE supported project, see the Heavy-Duty Truck Idle Reduction Technology Demonstration 2005 Status Report. The 2005 report also includes the results of a survey of Schneider National drivers who participated in this idle reduction fleet demonstration.

The following provides an update of Schneider's subsequent idle reduction activities, since the completion of the DOE-supported effort in September 2005:

- Webasto Cab Heaters – The demonstration project with DOE was so positive on tractors equipped with the diesel fired cab heaters that within three months of starting the project all tractor model years 2003 and newer were retrofitted with the heaters. Heaters were also specified as a standard option on all new equipment. The Schneider National company-wide idle rate for January 2007 was 11%, which includes about 20% of the units without heaters, units older than 2003. Over 90% of the trucks with cab heaters idled less than 5% in January. There was some increase in jump-starts; however, this is partly due to the number of 12 Volt accessories drivers are using. Schneider is also beginning to see some reliability issues as the units enter their third and fourth years of operations. However, even with the additional costs the economics still remain positive.

- Webasto Parking Cooler – The evaluation of the Webasto Parking Cooler uncovered demonstrated satisfactory performance at ambient temperatures of up to 85ºF, however several issues were uncovered. The cooler took a long time to recharge, did not have enough capacity in higher ambient temperatures, and the recharge cycle lowered the capacity of the cab air conditioner when the system was recharging. Data obtained from the DOE supported project enabled Webasto to redesign the cooler, including a self-contained compressor so the unit could recharge without the need to take capacity from the tractor A/C system. The cooler unit was moved to an outside location freeing up space within the cab. An option exists, in extreme temperatures, to add batteries so the unit can recharge during use without the need to start the engine. With these improvements, it is estimated the unit should provide air conditioning for 8 – 10 hours at 95 º F. A continuing drawback to the Webasto Parking Cooler system is that the retrofit is still difficult and not recommended. Any future usage would require an OEM installation. Schneider National will be evaluating 100 of these units in the summer of 2007 through a grant with EPA.

- Bergstrom Nite Battery System – – Although drivers who consistently used the Nite system were overwhelmingly positive about its performance, the DOE/Schneider evaluation uncovered issues similar to the Parking Cooler; specifically the units did not have enough capacity in very warm temperatures. With the data from the evaluation, Bergstrom made several improvements to the system. The Nite 2 system has additional capacity from a higher output compressor and utilizes up to four batteries for increased run time. The air duct system was redesigned to improve the circulation and effectiveness of the air flow. Interestingly, Schneider's initial Nite system will be going into its fourth year with the original batteries. Schneider will be evaluating 50 Nite 2 systems as part of the current grant with EPA.

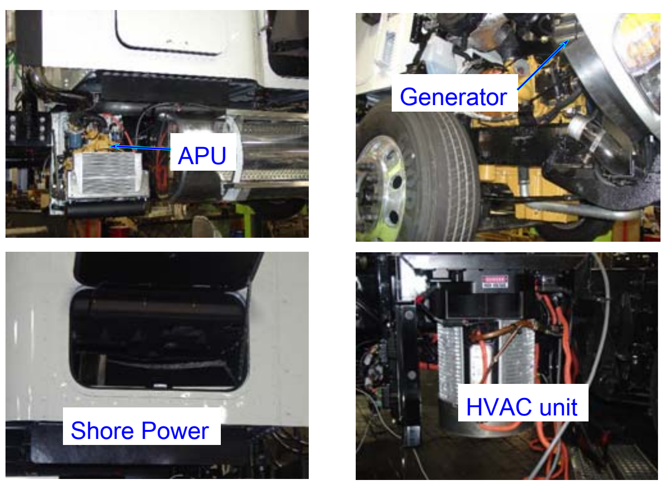
- Other Activities – Schneider has recently located a system from the Netherlands similar to the Bergstrom system, utilizing a 12 Volt system with a larger compressor that adds more capacity. Schneider added five of these systems to its summer 2007 tests. Schneider has also continued searching for an acceptable insulation package for the sleepers. The Freightliner "Extreme" package performs nicely and enhances the output of the battery system, however it is highly priced leading to no payback for the incremental additional capacity. Work is continuing with the OEM's to find a cost-effective solution, but it is very difficult as predominately only Schneider is actively pushing for this. Volvo appears to be putting some focus on insulation packages.

## Caterpillar, Inc.

The Caterpillar MorElectric™ technology system was originally developed in a joint DOE/Caterpillar project and was designed to reduce fuel consumption during on-highway truck operation and during rest periods when the truck normally idles. The MorElectric system consists of an auxiliary power unit (APU); a heating, ventilating, and air conditioning (HVAC) unit; and a high-efficiency generator that replaces the alternator (Figures 1 and 2). The electrically driven HVAC unit eliminates the need for an engine-driven air conditioning compressor, supplying 24,000 Btu/hr cooling, exhibiting high reliability and durability, and promising up to 2% fuel savings.

**Figure 1. Caterpillar MorElectric™ System**


**Figure 2. Caterpillar MorElectric™ Component Photos**




During rest periods, the same HVAC unit can be powered by the APU, using only 0.2 gallons per hour of fuel instead of the electrical power coming from the engine-mounted generator. The belt driven generator is high efficiency (79-83% versus 40-55% for an alternator) and can achieve up to a 1% fuel savings. The generator allows the A/C compressor to be removed from the engine, is highly reliable, and demonstrates excellent output (7.5 kW versus 2.3 kW) over its operating range. The HVAC system also can be plugged in at truck stops that have electrical service, thereby eliminating all diesel fuel consumption. The MorElectric™ System and APU option is expected to provide a total fuel economy improvement of up to 8% (2% on road and 6% idle reduction) compared to conventional HVAC systems, and the shore power option can provide up to 10% (2% on road and 8% idle reduction) improvement in fuel economy.

A two-piece HVAC design was used to minimize vehicle modifications and to address weight distribution issues. Use of the standard one-piece HVAC unit would have required relocation of one of the truck fuel tanks, changing the truck weight distribution and reducing trailer payload capacity. To keep the standard tank configuration and minimize truck cab modification, the design team decided to split the HVAC function with air handling done by the standard production fans, ducting, and water heat exchangers.

### *DOE Idle Reduction Demonstration*

Caterpillar Inc. formed a team with truck manufacturer International, and Illinois-based truckload and flatbed common and contract carrier Cox Transfer.  The 100-truck fleet for Cox Transfer idles approximately 677 hours/truck per year.  For this project, Cox Transfer ordered 10 new trucks from International.  Five of the trucks are serving as test vehicles, the other five as a control group.  For the first truck (see Figure 3), International installed the MorElectric™ system at its truck engineering center in Fort Wayne, Indiana; for the remaining four trucks, the MorElectric™ systems were installed at International's assembly plant in Chatham, Ontario, Canada.

**Figure 3.  Caterpillar MorElectric™ Test Truck**


This project started in October 2003 and Caterpillar began data collection from the test trucks in the Fall 2004, with all trucks operational since January 2005.  Fuel, operation, and maintenance data were collected regularly from the test and control trucks for direct comparison. Data items such as fuel and oil consumption, preventive maintenance, and repairs will be used to quantify operating costs. Engine and vehicle maintenance data was collected in addition to idle reduction system maintenance data to quantify any effects the MorElectric™ system may have on reducing truck maintenance from less engine idling.

### *Summary of Preliminary Results*

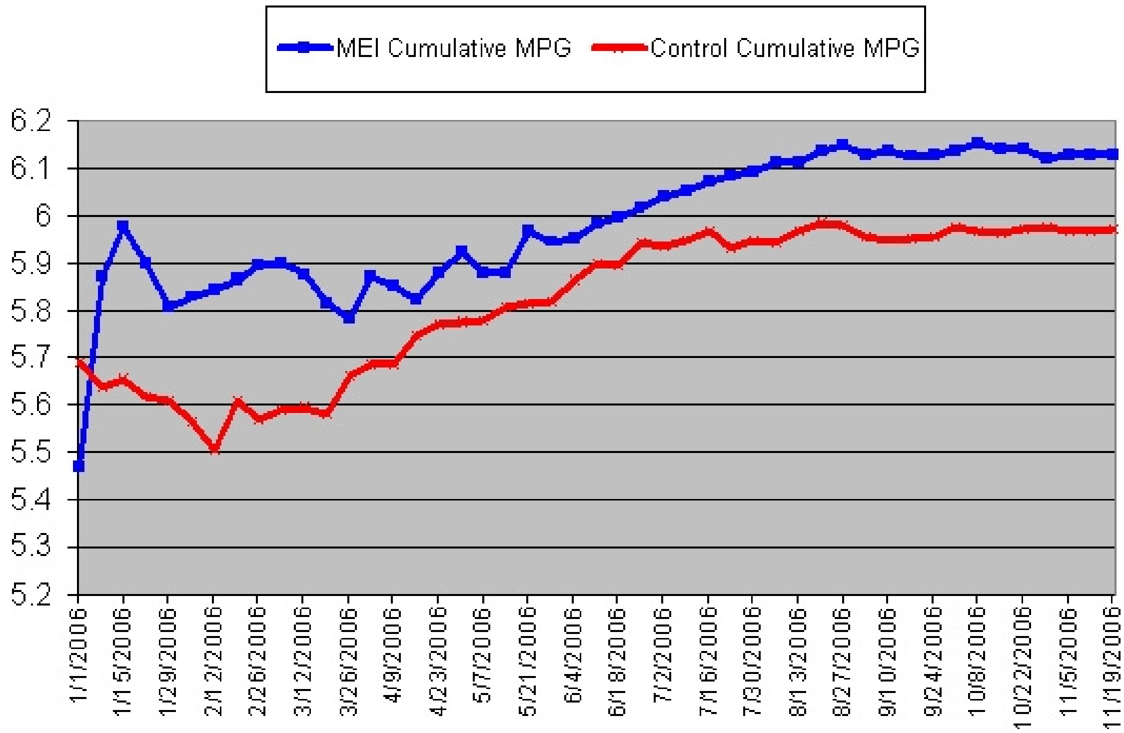
Overall driver acceptance of the MorElectric™ Technology is promising, with air conditioning capacity being very good. Initial system problems caused some negative feedback, but they have been corrected. Results from the driver survey are not yet available.

Table 1 below presents the truck usage summary for the MorElectric™ demonstration through December 2006. As shown, the MorElectric™ trucks are idling 13% of the time versus 27% for control vehicles. The MorElectric™ System does not require main engine idling to keep the engine from having cold start problems even in the coldest weather, because the APU shares coolant with the main engine. Therefore the 13% idling level is largely indicative of idling during loading and unloading conditions and while in traffic. The MorElectric™ fleet is demonstrating a 0.14 MPG improvement over the control vehicles based on fuel receipts through the end of 2006, which is equivalent to approximately 400 gallons of diesel fuel saved per truck per year. Figure 4 represents the cumulative MPG over the program life for the control and MEI fleet. This data is based on fuel receipts which includes APU fuel used while idling by the MEI fleet. As a result, actual on-road MPG will be higher. The control trucks have logged more total mileage than the MorElectric™ trucks due to some system problems on the demonstration trucks early in the demonstration. However, since July 2005 the MorElectric™ trucks have matched the control trucks in accumulated mileage, demonstrating the robustness of MorElectric™ technology.

**Table 1: Preliminary Results for the Caterpillar MorElectric™ Truck Demonstration**

| | MEI System | Control System |
|---|---|---|
| Total Mileage | 877,920 | 1,044,374 |
| High Mileage Truck | 232,946 | 225,221 |
| Engine Hours | 19,080 | 26,918 |
| High Engine Hours | 4,512 | 6,060 |
| APU Hours | 10,364 | n/a |
| Mileage/Week Since 1/10/05 | 8,504 | n/a |
| Mileage/Week Since 1/4/04 | n/a | 9,063 |
| % Idle Time | 13.0% | 26.7% |

**Figure 4: MEI vs. Control Truck Weekly & Cumulative MPG**




## Espar Heater Systems

Espar Heater Systems was awarded the third DOE idle reduction project in Fall 2004 to demonstrate combined cab heating and cooling systems in Class 8 trucks and conduct performance monitoring to demonstrate the potential fuel savings and emissions reductions that can be achieved during normal commercial operation. Engine operating and idling hours along with the operating hours of the idle reduction technologies was monitored over the course of the 24-month time span, and compared to non-retrofitted trucks to determine subsequent fuel savings and emissions reductions. Maintenance requirements for the idle reduction technologies will be determined.

Equipment installation was completed in May 2004, including installation of Bergstrom air conditioners and Espar bunk heaters as a combination package in 20 trucks (see Figure 5), and Thermo King Tripac auxiliary power units (see Figure 6) to provide heating, cooling, and accessory power into an additional 5 trucks. The 25 demonstration trucks and 20 baseline control trucks are being provided and operated by Walmart with International as the participating truck manufacturer.

**Figure 5. Espar and Bergstrom Idle Reduction Technologies**

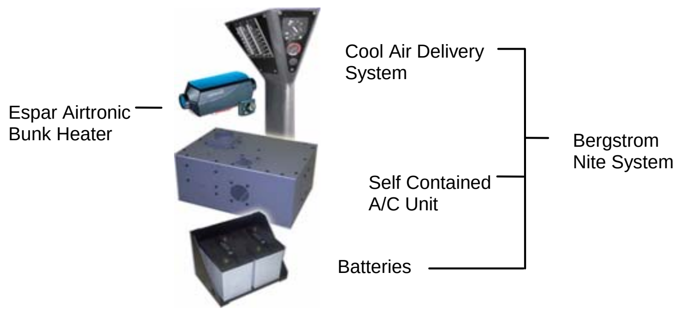



**Figure 6. Thermo King Tripac APU**


Table 2 provides the results of Espar's idle reduction technology demonstration. Through the data download in December 2006, the 25 demonstration trucks logged 17,140 hours of Espar Airtronic heater usage and 23,068 hours of Tripac usage. Through the data download in March 2006, 20 demonstration trucks logged 9,944 hours of Nite System air conditioning usage. The trucks with the Nite System were subsequently refitted with Tripacs after the March 2006 download. The test trucks average idle time, as of December 2006, is 11.75 %. The test trucks averaged a fuel economy of 7.24 MPG (Nite System originally) and 7.28 (Tripac originally) compared to the benchmark Walmart truck fuel economy of 7.01 MPG in 2005. This equates to a 3 – 4% fuel economy improvement.

**Table 2. Results of Espar Demonstration**

| | Data Download March 2006 | Data Download December 2006 |
|---|---|---|
| Heater (25 trucks) (hrs) | 13,001 | 17,140 |
| A/C (20 trucks) (hrs) | 9,944 | N/A |
| Tripac (hrs) | 3,784 | 23,068 |
| Average Idle Time (%) | 16.75 | 11.75 |
| Miles per Gallon<br>• Benchmark Trucks (7.01 in 2005)<br>• Test Trucks<br>o Nite System Originally<br>o Tripac Originally | <br>N/A<br><br>7.17<br>7.28 | <br>N/A<br><br>7.24<br>7.28 |

## International Truck and Engine Corporation

Through the "Factory-Installed Idle Reduction System for International Sleeper Trucks" project, International Truck and Engine Corporation is completing engineering development activities for the integration of on-board idle reduction technology into heavy trucks as an OEM, factory-installed equipment option. In 2005-2006, International was successful in developing, testing, factory releasing, and manufacturing idle reduction systems for International's 9000 series sleeper trucks (Figure 7). Five field test evaluation vehicles with idle reduction systems were built in July and September 2006 and delivered to customers. The five fleet evaluation vehicles will be monitored for fuel economy and idle time through 2007. In addition, deliveries of production orders for the factory-released system began in October 2006, providing for immediate fuel economy and emissions savings beyond the original five-truck evaluation. Two OEM options have been released: a Cold-Climate version and a Hot and Cold Climate version. International received 59 orders for the factory-installed idle reduction system for delivery in 2006, in addition to the five units for the field test program.

The idle reduction systems consist of four elements; an APU, electric air conditioner, cab and engine heater, and improved cab insulation. These systems must be offered at an affordable price that provides an economic incentive for truck owners to purchase and use idle reduction equipment at an operating cost savings. During the project timeframe of August 2005 – July 2007, the scope of work includes:

1. Development of idle reduction system and subsystem requirements
2. Design, fabrication, and testing of selected APUs and an electric heating, ventilation, and air conditioning (HVAC) unit to demonstrate component and system capability
3. Installation and testing of the developed systems and improved insulation as a prototype system in a pre-production pilot truck
4. Installation and field testing of the idle reduction system in five custom-ordered vehicles, allowing for hot and cold season testing to gain customer acceptance

**Figure 7. 9400 Wal-Mart Truck with First Factory-Installed Idle Reduction System**

***Project Progress***

International's program is divided into 7 phases: Specifications and Supplier Selection, Water Cooled APU Development, Air Cooled APU Development, Electric HVAC Development, Truck Integration, Fleet Installation, Fleet Evaluation, and Project Management and Reporting.

*Specifications and Supplier Selection*

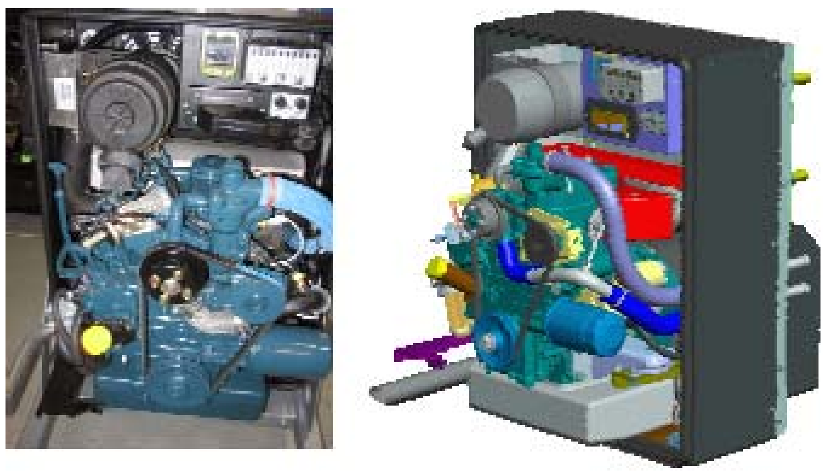
The first task for the idle reduction program was for International Truck to develop specifications for the diesel APU and electric HVAC subsystem, and this was completed in 2005. Solicitations for competitive bidding were sent to six APU manufacturers and three HVAC suppliers. In

December 2005, Mechron was selected for the APU system, based upon both cost and delivery schedule. In March 2006, Mechron was also selected as the primary source for the HVAC system, based upon cost and cooling performance.

*Water-Cooled Diesel APU Development*

The APU is a diesel generator that generates up to six kilowatts of electricity in utility format (12VAC, 60Hz). The 120VAC output of the generator is wired into the sleeper cab to provide power for the heating and air conditioning unit, as well as power to appliances plugged into the sleeper's 3-prong outlets. The APU also includes a 14 Volt battery charger to provide power to run truck loads and recharge the truck's batteries. Mechron made design changes to their APU (Figure 8), adapted from their existing CCS Lightning product, in order to accommodate International's truck and to improve ease of manufacturability.

**Figure 8. Mechron Water-Cooled APU**



By March 2006, International and Mechron had completed an APU frame-rail layout for the 9200 trucks. International performed FEA analysis to determine that the mounting system was adequate for the APU. The APU is built upon a Kubota engine that has been demonstrated to meet the 10,000 hours of life required. The APU meets EPA tier II emissions, and will be capable of meeting EPA tier IV emissions in 2008. However, additional APU development will be required to meet California's no idle regulation 13CFR 2423 released in October 2006.

To provide engine cooling for the APU, the APU was plumbed into the main engine's radiator cooling system. Mechron conducted testing on International trucks with both Caterpillar and Cummins engines to assure that the 9000 truck's main radiator was sufficient to reject the heat from the APU coolant. It was determined through this testing that an electric fan was not necessary on the condenser in order to cool the engine.

In April 2006, auxiliary ports for the APU's new fuel taps were released. In order to avoid allowing the APU to run the truck out of fuel at a stop, the APU fuel tank feed design will prevent draining of the fuel level below 25% of full capacity. To assure that the APU and main engine do not run simultaneously, a solution was developed for using a "main engine running" signal for the APU interlock. Installations for 9400 and 9900 models were completed by June 2006.

Also in June 2006, an "APU Test Stand" (Figure 9) was completed by Mechron and delivered to International for integration testing of the APU system and HVAC system without additional test trucks.  This test stand was very useful in rapid prototyping of the idle reduction system for the 2007 ProStar Truck.

**Figure 9.  Mechron APU Test Stand**

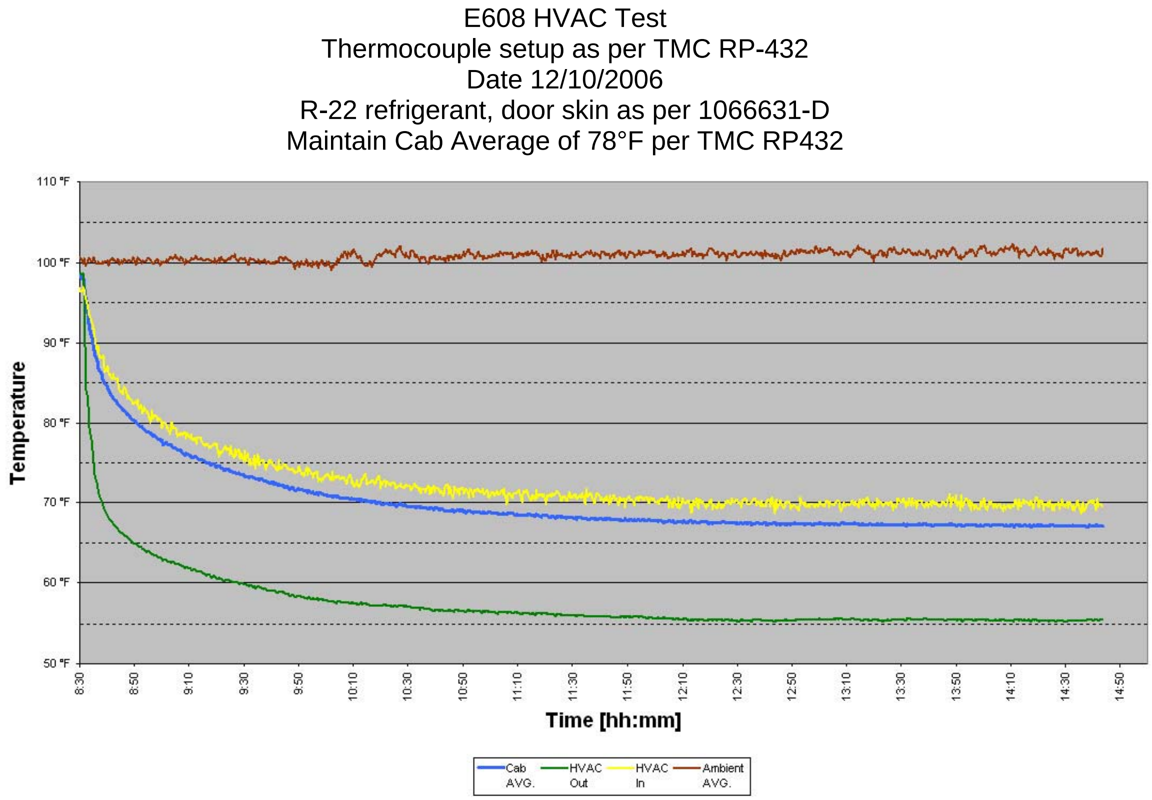

*Air-Cooled Diesel APU Development*

In parallel with the water-cooled APU, an air-cooled APU concept was developed.  International used a survey to identify several air-cooled diesel engines that were less expensive than water-cooled alternatives and that met Tier IV emissions.  However, no alternative was found to meet the required engine life for an engine in an APU for the sleeper application.

*Electric HVAC Development*

At the beginning of the idle reduction project, International considered and evaluated electric air conditioning based upon 12 Volt DC and 120 Volt AC HVAC compressors.  The 12 Volt DC system was desirable for compatibility with the truck’s 12 Volt battery system while the 120 Volt AC system was desirable for shore power and hotel loads.  Bergstrom developed 12 Volt DC and 120 Volt AC versions of their “NITE” bunk HVAC system, and in February 2006 completed testing of their A/C systems in International’s E608 sleeper truck.  Based upon the measured cooling output and temperatures, the 12 Volt DC HVAC system was determined to be inadequate per the Truck Maintenance Council’s (TMC) recommended practice RP432 (Figure 10).  At 10,000 BTU, the 120 Volt AC system output provided much higher cooling output and was more acceptable to drivers.

**Figure 10. Temperature Test Results of HVAC Test**




International developed and evaluated sleeper insulation options, including improved insulation in the bunk curtain and the bunk floor. Test results showed that the insulated curtain resulted in a significant impact on the amount of energy required to maintain the sleeper bunk temperature. The Insulated Curtain release 60288A for both the low-roof and skyrise Pro sleepers was completed in March 2006. The floor insulation also made a small improvement, but the cost of the floor insulation was not cost effective. During this portion of the HVAC system development, important feedback was received from drivers regarding their comfort from the air conditioner and the sleeper curtain. Although the sleeper curtain provides energy savings, many drivers or married driver teams prefer to keep the curtain open in order to have more space available. Based upon this input, the HVAC system output was specified and designed to provide sleeper comfort with the curtain open. Another challenge during the HVAC system development was developing an air delivery system that would adequately circulate air in the sleeper cabin. Several iterations of a footlocker were fabricated and tested before an optimum solution was found (Figure 11). A third challenge during the development of the HVAC system involved the condenser air flow. Several iterations were made on the louvered air vent and air-flow patterns to optimize intake and exhaust air flow, as well as condenser heat exchanger.

**Figure 11. Bunk HVAC and Air Ducts**

For trucks operating in cooler northern climates, International developed a “heat only” idle reduction system based upon a coolant heater system. The coolant heater was chosen to provide heat both to the driver for comfort and to the main engine for cold start-ability. The coolant heater was able to be frame-rail-mounted, and did not require any diesel fuel to be plumbed up to the cab. Tests of coolant heaters from two suppliers demonstrated the system easily met the TMC’s RP-432 specification of 68º F. In February 2006, all body effects for the No Idle Heating option were released. Because the coolant heater system requires an electric blower fan and electric water pump to operate for 10 hours, the system was released with additional 12 Volt batteries and a larger 12 Volt alternator. In June 2006, battery testing was completed to evaluate 6- and 8-battery packs supplying power to the coolant heater module.

*Truck Integration*

Truck Integration began in February 2006, when prototype test vehicle E608 was retrofitted with the first iteration of the idle reduction system. A second system was installed into a “show truck” in early March and presented at the Mid-America Truck Show at the end of March 2006 (Figure 12). Design integration with the truck primarily involved routing and clipping of the wiring between the APU and HVAC components. Mechron developed a bunk-mounted APU and HVAC controller. The electrical team completed the harness layout for the 9400 model. In order to release the idle reduction system on the 9200 and 9900 models and variations, Mahindra Engineering Design & Development Co. LTD. (MEDDCL) was contracted to support the large amount of wiring harness drawing creation. The balance of the release work was completed by September 2006.

**Figure 12. Mid-America Show Truck with Idle Reduction System, APU and HVAC Units**

In May 2006, the Mechron APU was adapted for the 2007 ProStar. A prototype system was installed onto 2007 ProStar validation vehicle P475 and delivered to Wal-Mart for evaluation.

*Fleet Installation*

Preparation for the factory release and fleet installation began in March 2006, when a factory review of the idle reduction systems was held at the Chatham plant. Plant facilitation planning was completed. At the request of the Chatham assembly plant personnel, APU and HVAC samples were delivered for the plant to practice assembling the idle reduction system and to provide feedback for improving the design for manufacturing. By March 2006, sales order feature codes were released for the idle reduction system and were introduced at the Mid-America Truck Show.

- 12WTK - APU and Power Distribution
- 16UZV - Auxiliary Electric HVAC
- 16VRU – Coolant Heater System
- 08MBE - Auxiliary Battery Box for CHS

Following the announcement, orders were received from Wal-Mart, Ryder Truck, and USA Truck for five APU systems. In June 2006, the first pilot build of the coolant heater system was completed (Figure 13), and an assembly trial "buck build" to practice on-line assembly of the APU idle reduction system was completed. In July 2006, the first saleable fleet evaluation truck with factory-installed idle reduction system was successfully built. Body, chassis and electrical engineering were present at Chatham to support the build. In August 2006, fleet trucks #2 and #3 were built followed by the completion of trucks #4 and #5 in September 2006. This rounded out the fleet of five evaluation trucks.

**Figure 13. Coolant Heater System and Installation at Chatham**

*Fleet Evaluation*

In April 2006, Telematics monitoring equipment was ordered and received, in preparation for the fleet evaluation. A Telematics account and monitoring website were prepared for fleet truck monitoring. After the sleeper trucks were completed at the plant, the trucks were transferred to the Way-con truck modification center, where the Telematics units were installed into the fleet evaluation trucks. Sensors were installed to measure ambient temperature, cab temperature, and

APU run time.  The Telematics “back-office” portal was established, and data was successfully collected on truck #1 in August 2006.

*Plans for 2007*

International plans to have all five field test units in service by March 2007 and conduct a driver survey later in the Spring. In 2007, additional platforms will be considered for the release of the factory installed APU. Engine software will be implemented for a 5-minute idle shut-off timer for the 2008 California Air Resources Board (CARB) no-idle rule. International will also be pursuing a 2008 California emissions-compliant APU system.

## Status of Other AVTA Idle Reduction Activities

**CoolCab**

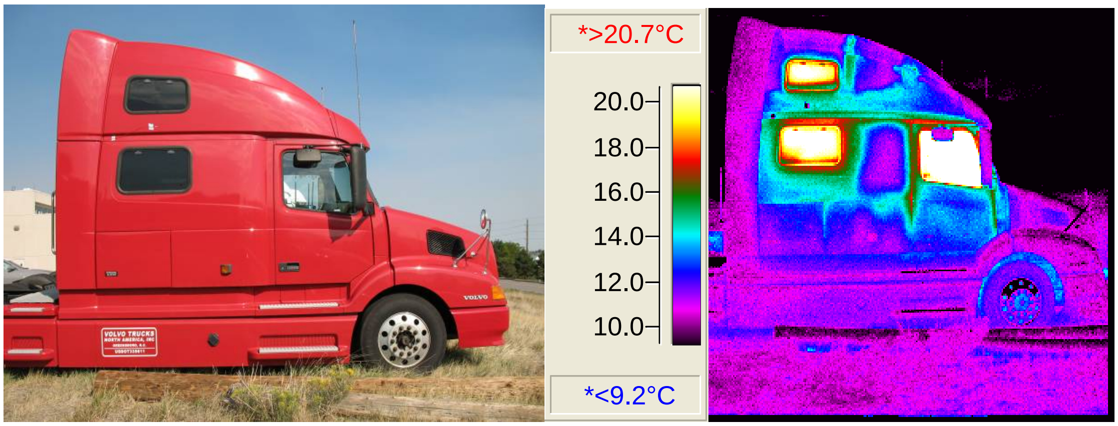
Results from the idle reduction demonstration projects have identified key issues with truck cab insulation that warrant further investigation.  Drivers complained of heat penetrating the cab walls, causing discomfort and reducing the effectiveness of the cooling equipment, most noticeable on sunny days.  This insulation issue was identified as needing further research and development at the National Idling Reduction Planning Conference in Albany, NY in May 2004. Manufacturers claim that improving insulation and reducing the cooling or heating load can substantially decrease the size, cost, and weight of their idle reduction technologies.  The DOE/AVTA team is conducting an activity to apply past experience with light-duty vehicle interior thermal management to heavy-duty truck tractor cabs.  Labeled “*CoolCab*,” this effort uses a “systems approach” to investigate thermal loads on the vehicle, effective delivery methods, and efficient equipment.  The initial work done on the CoolCab project was on Freightliner trucks in conjunction with Schneider National and concluded in FY2005.

*Continued Testing*

Volvo Trucks, a manufacturer of over-the-road truck tractors, expressed interest in improving cab insulation to help reduce idling and overall fuel consumption.  In 2006, Volvo leased a truck to the National Renewable Energy Laboratory (NREL) to help investigate potential reductions in truck cab thermal load as part of the CoolCab project.  Indoor and outdoor testing of the Volvo tractor began in July 2006 and concluded in October 2006.  Testing began with the establishment of a baseline for typical truck cab insulation.  Using an NREL-owned Freightliner Century Class tractor for reference, UA tests were performed to quantify heat transfer rates in both the Volvo and Freightliner tractors. UA is the overall heat transfer coefficient for a given area. For CoolCab, it is the value calculated to quantify heat transfer in the truck cab. "R-value" is calculated from UA for a known surface area. Simple modifications (insulating windows, applying a sleeper isolation curtain, etc.) were made to the Volvo tractor to help understand heat loss paths, using tools such as infrared imaging and heat flux gauges.  The evaluation also included daytime heat soak tests to help quantify solar gains.  Interior temperatures were measured in both trucks with and without window insulation applied to understand the effects of the glass areas.

As of early September 2006, baseline testing, including UA tests of both trucks and several preliminary soak test runs, was completed.  Data has been compiled from the test runs for evaluation and analysis.  Early data analysis shows less heat loss (less power required to maintain temperature set-point) from the Volvo cab than the Freightliner.  However, preliminary data from the soak tests revealed a higher temperature rise (greater solar load) in the Volvo cab.  Modified UA and soak tests, with sleeper curtain and window insulation applied, were completed.  Some initial infrared images of the truck cab exteriors were taken to examine heat loss. Using the set up from the UA tests and applying the same outdoor test conditions, images were taken of the truck cabs at night to eliminate solar effects. Interiors were heated to 40º C (104º F) with an ambient temperature of 13º C (55º F). Figure 14 shows the passenger side of the Volvo.

**Figure 14. Volvo Passenger Side Thermal Image**




Initial examination of this thermal image revealed elevated temperatures around door and window seams and at what appeared to be a seam at the upper roof. These elevated exterior temperatures (about 6º C) indicate areas of higher heat loss than the surrounding cab surfaces. The higher heat loss areas, or "hot spots," will be further investigated with images to be taken on the interior cab surfaces and physical inspection of insulation and seals in these areas. Infrared images of the interiors of both trucks and images comparing the two trucks have been taken. Results of the modified UA and soak tests, as well as the infrared images, will be published at the end of 2007, after conducting further testing with another manufacturer's cab.

*Future Plans*

Discussions continue with Volvo about the availability of the Model 770 tractor for continued testing, including evaluating the performance of an on-board electric air conditioning and upgraded insulation systems. Volvo also has interest in the potential to share cost in developing a model to help evaluate the effects of different insulation materials or strategies. It is anticipated that these discussions will result in a joint development project within CoolCab. In the meantime, testing on the Volvo truck will continue with the intention of quantifying truck cab heat loss and identifying potential areas to reduce heating and cooling loads and fuel use, and to improve overall driver comfort.

## Summary

Diesel fuel-fired cab heaters have clearly been shown to be fully viable from a performance and operational standpoint, as well as cost effective. There is no need for further demonstration of diesel fuel-fired heating technologies. The advantage of idle reduction technologies that provide air conditioning (A/C) in heavy duty trucks is less clear cut. Upgraded versions of phase change and battery powered A/C systems have demonstrated improved performance in very warm temperatures for extended periods. However, retrofitting these technologies is still often difficult and the economics have not been proven highly advantageous. Driver impressions of idle reduction A/C units have generally been very positive. Full function idle reduction systems, which have combined heating and A/C functions, have demonstrated 2 to 4 percent overall fuel economy improvements above control vehicles equipped with no idle reduction system or basic engine on/off systems. Industry is continuing to evaluate and number of full function idle reduction systems.

In 2005, Federal legislation designated the Environmental Protection Agency and the Department of Transportation as the lead agencies for heavy duty truck idle reduction. No additional Department of Energy supported idle reduction demonstration activities are recommended at this time.

## Other Idle Reduction Activities within the U. S. Government

### Clean Cities

DOE's Clean Cities (http://www.eere.energy.gov/cleancities/) is a part of Clean Cities and a deployment activity within DOE's FreedomCar and Vehicle Technologies (FCVT) Program (http://www.eere.energy.gov/vehiclesandfuels/) to advance the economic, environmental, and energy security of the United States by supporting local decisions to adopt practices that contribute to the reduction of petroleum consumption in the transportation sector. Since its inception in 1993, Clean Cities has grown to over 80 coalitions and 4,800 stakeholders across the country, placed close to 1 million alternative fuel vehicles (AFVs) on the road, and displaced over 1 billion gallons of gasoline. In 2004 alone, Clean Cities displaced 237 million gallons of gasoline through the use of alternative fuels, AFVs, idle reduction technologies, fuel economy measures, and hybrid vehicles. Clean Cities idle reduction strategies include: idle reduction technologies education; niche market workshops; outreach documents; special project grants; and national/regional goal establishment and tracking.

DOE's State Energy Program (SEP) (see www.eere.energy.gov/state_energy_program) is a part of Clean Cities and provides funding to states for renewable energy and energy efficiency projects. Through a competitive solicitation, DOE's Office of Energy Efficiency and Renewable Energy (EERE) awards these projects annually to state energy offices. Funding for the projects comes from EERE technology programs and is managed by SEP.
http://www.eere.energy.gov/state_energy_program/project_brief_detail.cfm/pb_id=996

Through the 2006 SEP Clean Cities Special Projects solicitation, Clean Cities funded the following projects for idle reduction technologies:

- DOE Secretary Samuel W. Bodman announced $8.6 million for 16 projects to expand the use of alternative transportation fuels. Combined with funding from the participants, more than $25 million will be invested in the nation's alternative fuel infrastructure. The grants are part of the Clean Cities program and were selected under three topic areas, including Refueling Infrastructure for E85 and Alternative Fuels; Incremental Cost for Alternative Fuel Vehicles; and Idle Reduction Training and Awareness for School Districts. (http://www.eere.energy.gov/cleancities/progs/afdc/ddown.cgi?idle/WHATS_NEW/646/1/0)
- Shurepower and IdleAire received more than $5.5 million in grants to install idle reduction equipment in North Texas. Administered by the North Central Texas Council of Governments (NCTCOG), the grants are part of the Texas Emissions Reduction Plan

(TERP), a comprehensive set of incentive programs aimed at improving air quality. All together, the units are expected to displace more than 231 tons of emissions per year. (http://www.eere.energy.gov/cleancities/ccn/archive/ccn_10_2.html)

- Salt Lake City Clean Cities Coalition in Salt Lake City, UT received $100,000 to create and disseminate a model idle-reduction program that can be easily replicated by school districts across the country to help them reduce petroleum consumption, save on fuel costs, minimize harmful emissions, and protect children's health. (http://www.eere.energy.gov/cleancities/solicitations_applications.html)

- The Association of Central Oklahoma Governments in Oklahoma City, OK was awarded $50,242 to conduct idle education training and awareness for school districts in central Oklahoma. The project will address the development and demonstration of techniques to reduce fuel usage and harmful emissions; demonstration of the benefits of idling policies; and publishing and presentation of project results. These results include best practices and fuel savings realized; training of transportation directors; bus drivers and key communicators; and dissemination of results to all Oklahoma school districts and school districts nationwide. (http://www.eere.energy.gov/cleancities/solicitations_applications.html)

- In 2005, three SEP grants were dedicated to heavy-duty vehicle idle reduction projects. New Mexico was awarded $100,000 to test a Pony Pack auxiliary power unit on a fleet of heavy-duty vehicles. California received a grant to assist with a shorepower truck idling project. New York was funded to help install, operate, and maintain a 50-pedestal truck stop electrification (TSE) facility at the Petro Stopping Center in Waterloo, New York. The shorepower TSE system at this 50-acre truck stop provides grid electricity to stationary, long-haul trucks for the operation of on-board HVAC units and in-cab conveniences such as telephone, television, and Internet access. These grants were jointly funded with DOE's Advanced Vehicle Testing Activity in the FreedomCAR & Vehicle Technologies Program.

- Clean Cities awarded $100,000 in 2004 to the New York State Energy Research and Development Authority, the American Transportation Research Institute, Shurepower LLC, the Waterloo Travel Center, the NYS Genesee Region Clean Communities, and the Clean Communities of Central New York to accelerate the development and national deployment of truck stop electrification (TSE) infrastructure by addressing the well-known and long-established barriers to implementation. Specifically, this project sought to advance marine-style, shorepower TSE systems that provide grid electricity to stationary, long-haul trucks for the operation of on-board heating, ventilation, and air-conditioning units, block heaters, and in-cab convenience appliances.

- In 2004, the Arkansas Energy Office partnered with IdleAire Technologies Corporation to reduce truck idling in West Memphis, Arkansas. IdleAire, based in Knoxville, Tennessee, makes and sells idle reduction devices that are typically installed at truck stops.

- The Science, Technology and Energy Division of the Alabama Department of Economic and Community Affairs, the Applied Research Center of Alabama, and IdleAire partnered in 2004 to demonstrate truck stop electrification service. IdleAire modules were installed at the Petro Truck Stop on Interstate Highway 20 between Birmingham and Tuscaloosa.

## State Technologies Advancement Collaborative (STAC) Solicitation Grants

The State Technologies Advancement Collaborative (STAC) (http://www.stacenergy.org/) was formed by an agreement between DOE, the National Association of State Energy Officials, and the Association of State Energy Research and Technology Transfer Institutions. STAC allows states, territories and the Federal Government to better collaborate and move forward on energy research, development, demonstration, and deployment projects using an innovative project selection and funding process.

There are currently no solicitations open under the STAC program. Since STAC did not receive a congressional appropriation for FY06, no future solicitations have been planned to-date. However, the South Carolina Energy Office received $1.5 million in competitive federal grant funding to install idle reduction systems at three truck stops in 2004. The Advanced Travel Center Electrification (ATE) from IdleAire Technologies were installed in 150 parking spaces in the three truck facilities along the I-85 corridor in South Carolina, North Carolina, and Georgia. The grant came from DOE-sponsored State Technology Advancement Collaborative (STAC), which is managed by the National Association of State Energy Offices (NASEO).

## EPA SmartWay Transport Partnership

The SmartWay$^{SM}$ Transport Partnership (http://www.epa.gov/smartway/index.htm) is a voluntary collaboration between EPA (http://www.epa.gov/) and the freight industry, designed to increase energy efficiency while significantly reducing greenhouse gases and air pollution. In 2003, EPA launched the National Transportation Idle Free Corridors project in Atlanta, GA. The objective of this project is to eliminate all unnecessary long-duration truck and locomotive idling at strategic points along major transportation corridors. This will be achieved by studying, evaluating, and deploying technologies and strategies for trucks, locomotives, truck parking facilities (see interstate highway maps [http://www.epa.gov/smartway/idle-tsemap.htm]), rail yards, and other idling locations. To implement idle reduction projects in a successful and cost-effective manner, EPA works with key partners and stakeholders, including state/local air quality planners, transportation and energy officials; idle reduction technology manufacturers; trucking fleets and railroad companies; truck stop owners and operators; environmental and community organizations; and other groups interested in reducing idling.

- In October 2006, EPA recognized 24 winners of the 2006 SmartWay Excellence Awards, held at the American Trucking Association's annual conference in Grapevine, Texas. The recipients were trucking companies selected as national leaders that exemplify superior environmental excellence. Wal-Mart, one of the awardees, is one of only two companies to make commitments as both a SmartWay Carrier and a SmartWay Shipper. By investing in idle reduction technologies, advanced aerodynamics, speed controls, and tire improvements, Wal-Mart is reducing 670,000 tons of $CO_2$ and saving over 60 million gallons of diesel fuel annually. http://www.epa.gov/oms/smartway/documents/2006awards.pdf
- In October 2006, SmartWay announced a $300,000 grant to the North Central Texas Council of Governments (NCTCOG), a voluntary association of local governments, to evaluate SmartWay technologies with trucking companies. Energy- and emissions-saving technologies such as an engine idle reduction technology, low rolling resistance tires, improved aerodynamics, and exhaust after-treatment devices will be combined into "SmartWay Upgrade Kits."

(http://yosemite.epa.gov/opa/admpress.nsf/4d84d5d9a719de8c85257018005467c2/50167c009d5044e4852571ff0054ff43!OpenDocument)

- An EPA SmartWay Transport Partnership award of $500,000 was announced in April 2006, highlighting a 2.5-year partnership between Volvo and the North Carolina Solar Center—at North Carolina State University (NCSU)—to demonstrate idle reduction technologies. NCSU's strategy involves installing platforms on the trucks for mounting mobile idle reduction technologies (MIRTs). The North Carolina Solar Center is sponsored by the U.S. Department of Energy, the North Carolina Department of Administration's State Energy Office, and the North Carolina Solar Center Foundation, and is operated by the College of Engineering at NCSU. (http://www.ncsc.ncsu.edu/news/news_story.cfm?ID=240).

- In November 2006, SmartWay announced a new loan initiative for the trucking industry. Smartway is collaborating with several lenders to make loans available to small trucking companies to help pay for technologies that will save fuel and money while reducing pollution. Participating lenders will provide quick approval and affordable monthly payments. Small trucking firms can borrow from $5,000 to $25,000, with no collateral, an easy on-line or telephone application, and flexible loan terms. (http://yosemite.epa.gov/opa/admpress.nsf/7c02ca8c86062a0f85257018004118a6/3e718f93846151a4852572260062b7e2!OpenDocument)

### Other Initiatives:

- In January 2006, EPA announced the availability of $3 million in grant monies (up to 12 grants ranging from $50,000 to $500,000) for projects that demonstrate new, innovative or experimental approaches to reducing diesel emissions on the West Coast. The grant program is part of the highly successful West Coast Collaborative, which has awarded more than $2.6 million in grants for 28 projects since 2004. (http://yosemite.epa.gov/opa/admpress.nsf/4d84d5d9a719de8c85257018005467c2/95d71b3ccf75a946852571000070d4f9!OpenDocument)

- In March 2006, North Carolina Mobile Source Emission Grants Program announced awards: the Division of Air Quality (DAQ) of the North Carolina Department of Environment and Natural Resources awarded $799,511 for 16 projects in 14 counties in the State. Two of these projects are for idling reduction: $8,889 for idling reduction equipment for the Carolina Coastal Railway, and $60,000 for an idling reduction program and equipment for the Charlotte/Mecklenburg school district.

  The Mobile Source Emission Grants program is funded by a 1/64-cent per gallon tax on gasoline sold in North Carolina. It awards grants for projects and equipment that limit air pollution from cars, trucks, and other motor vehicles. The program has awarded 88 grants totaling $6.44 million statewide since 1995. (http://www1.eere.energy.gov/vehiclesandfuels/pdfs/newsletters/mar06_network_news.pdf)

- In May 2006, the EPA made $1.5 million available for clean diesel projects, soliciting applications under two national clean diesel grant programs. According to the agency, eligible projects under the Voluntary Diesel Retrofit Program and the Clean School Bus USA Program may include, but are not limited to, diesel emissions-reductions solutions, such as add-on pollution control technology, engine replacement, idle-reduction technologies or strategies, or cleaner fuel use. All projects must benefit the air quality in the geographic regions that include Puerto Rico and the Virgin Islands. (http://www.eere.energy.gov/cleancities/progs/afdc/ddown.cgi?idle/WHATS_NEW/587/1/0)

- In May 2006, EPA-Region 4, as part of the Southeast Diesel Collaborative, announced the availability of $100,000 in grant monies (up to 3 grants ranging from $25,000 to $75,000) for projects that demonstrate new, innovative or experimental approaches to reducing diesel emissions within the Southeast. (http://yosemite.epa.gov/opa/admpress.nsf/7c02ca8c86062a0f85257018004118a6/d3dc5e346aabe7b98525717f00727e1d!OpenDocument)
- In September 2006, EPA awarded the state of New Jersey $2.1 million to fight diesel pollution encompassing 4 distinct initiatives:
    - Truckers' Challenge: On-board Idle Reduction Devices ($750,000)—an innovative trucking industry endeavor to fund the purchase of alternative energy sources and equipment to reduce idling and help truckers save on fuel costs. New Jersey's Department of Environmental Protection will work with the EPA and a New Jersey based trucking association that represents short haul motor carriers to fund the purchase of auxiliary power units or bunk heaters.
    - Idle-Free Corridor: NJ Turnpike Truck Stop Electrification Project ($1,000,000)—this project will expand the infrastructure for truck stop electrification in New Jersey by electrifying parking spaces at a truck stop along the NJ Turnpike. Trucks that utilize this technology will avoid the emissions and fuel costs associated with idling their engines when parked for long durations.
    - Diesel Risk Reduction Project: Analysis of In-Cabin School Bus Emissions ($215,000)—this study will determine how effective retrofits are in reducing fine particle pollution on the inside of school buses. The results of the analysis will provide scientific direction for an upcoming legislated statewide mandatory retrofit program for certain diesel vehicles, including school buses.
    - Idling Minimization Outreach Project ($135,000)—this outreach campaign will discourage unnecessary idling of engines throughout New Jersey, particularly targeting the trucking industry. The outreach campaign will, for the first time, focus on idling transit buses, and personal cars, at the State's numerous tourist attractions. The campaign will also train New Jersey police on how to effectively enforce the state's three minute limit for engine idling.

  (http://yosemite.epa.gov/opa/admpress.nsf/7c02ca8c86062a0f85257018004118a6/7c3309b33a632ed5852571f00054d79f!OpenDocument)