SHOREPOWER™ TECHNOLOGIES

Interstate Electrification Improvement Project Final Report

Shorepower Technologies

For:
U.S. Department of Energy
National Energy Technology Lab

July 2015

STEP
Shorepower Truck Electrification Project

F I N A L R E P O R T

Project Title: Recovery Act – Interstate Electrification Improvement Project
Cooperative Agreement Number: DE-EE0002613
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Executive Summary

The Interstate Electrification Improvement Project, publicly known as the Shorepower Truck Electrification Project (STEP), started in May 2011 and ended in March 2015. The project grant was awarded by the Department of Energy's Vehicles Technology Office in the amount of $22.2 million. It had three overarching missions:

1. Reduce the idling of Class 8 tractors when parked at truck stops, to reduce diesel fuel consumption and thus U.S. dependence on foreign petroleum;
2. Stimulate job creation and economic activity as part of the American Reinvestment and Recovery Act of 2009;
3. Reduce greenhouse gas emissions (GHG) from diesel combustion and the carbon footprint of the truck transportation industry.

The project design was straightforward. First, build fifty Truck Stop Electrification (TSE) facilities in truck stop parking lots across the country so trucks could plug-in to 110V, 220V, or 480VAC, and shut down the engine instead of idling. These facilities were strategically located at fifty truck stops along major U.S. Interstates with heavy truck traffic. Approximately 1,350 connection points were installed, including 150 high-voltage electric standby Transport Refrigeration Unit (eTRU) plugs--eTRUs are capable of plugging in to shore power[1] to cool the refrigerated trailer for loads such as produce, meats and ice cream.

Second, the project provided financial incentives on idle reduction equipment to 5,000 trucks in the form of rebates, to install equipment compatible with shore power. This equipment enables drivers to shut down the main engine when parked, to heat or cool their cab, charge batteries, or use other household appliances without idling—a common practice that uses approximately 1 gallon of diesel per hour. The rebate recipients were intended to be the first fleets to plug into Shorepower to save diesel fuel and ensure there is significant population of shore power capable trucks. This two part project was designed to complement each other by providing: 1) the infrastructure to plug into and 2) the on-board equipment capable of plugging into the infrastructure.

This project generated the largest dataset to date on shore power TSE utilization and use patterns, providing: insight into driver behavior and acceptance; evidence of cost savings; experience with system operations and management; and data for guiding future development of shore power, whether as a private enterprise or a publicly-subsidized service for meeting air quality goals.

[1] *"Shore power" is the commonly used term for providing vehicles with grid based AC electric power for hotel loads while parked.*

Findings

The findings showed that TSE reduces fuel use, fuel costs, engine wear, and noise. The data and customer feedback confirmed that TSE is desirable and affordable, and the service earned many devoted customers. The drawbacks: too few TSE facilities to meet the need; limited truck parking spaces (which discouraged non-customers from leaving TSE parking spaces open for plug-in customers); lack of driver awareness of the service; dependence on truck stop staff to promote the service; and lack of interest on the part of national truck fleets due to limited availability. Data analysis yielded the following:

- Users: The majority of regular customers were independent owner-operators. Fleet drivers were occasional users. At least one fleet is known to have actively trained their company drivers to use shore power when available. Some truck stops experience year-round use by recreational vehicles (RVs), who consider shore power a superior option in route to a destination site.

- Rebate recipients were intended to be the first trucks to plug in at the Shorepower facilities, but records show that very few rebate recipients actually plugged in at Shorepower facilities during the project.

- Power appears to be primarily used for temperature control, heating and cooling. This corroborates results of a 2003 article in Bulk Transporter: "Most Fleets Express Strong Support for Truck Stop Shore Power, Survey Says."

  According to Brian Lawrence, heavy-duty truck segment manager for Xantrex, "The comments in this survey show a pent-up demand by people in the industry," he said. *A total of 93% of all survey respondents said they wanted shore power to operate their heating and air-conditioning units."*

- As measured in hours, peak use of shore power is in the winter months between November and March. The next highest use period is in the summer months of July through September.

- Lowest shore power use is in April, with another drop in the month of September. This is likely because ambient temperatures are mild in spring and fall.

- How drivers used shore power:
  - The average power session is twelve hours and takes place between 6 pm and 6 am local time.
  - Saturday and Sunday are the days when most customers use shore power.
  - The average draw is one kilowatt (kW) or one kilowatt-hour (kWh) per hour.
  - Most use occurs between ambient temperatures of 30° F to 85° F.

- Approximately two-thirds of customers order power by phone and through the www.shorepowerconnect.com website; the remaining activate power through an onsite payment kiosk.

- The $1.00 per hour cost of cab power in the DOE installations represents the lowest cost cab power alternative for twelve hour sessions as compared with other options: engine idling, use of a generator or auxiliary power unit (APU), and rates charged by other TSE providers.

  $1.08 /hour – Shorepower TSE (cost plus set-up charge)
  $1.33 /hour – APU with no load (fuel plus maintenance)
  $1.49 /hour – APU under load (fuel plus maintenance)
  $1.85 /hour – IdleAir TSE
  $4.01 /hour – Diesel engine idling (fuel plus maintenance)

- The study identified four criteria for the ideal truck stop locations for shore power installations:
  - The owner/manager is committed to sustainability and takes personal 'ownership' of the service.
  - Good interior and exterior signage;
  - Ample parking of one hundred or more spaces, which meet the needs of regular customers, but is not overcrowded, so there are parking spaces available for drivers who arrive later in the evening;
  - The site is well-managed in general: clean and well-stocked; a variety of amenities; staff who are responsive to customers and speak with drivers about shore power.

- Truck stop ownership types (large national franchises to small "mom and pop" independents) were not found to be a major factor driving utilization.

- Climate extremes and location or population density (rural, urban) were also not found to be major factors driving utilization.

- Environmental benefits from the project in the study period:
  - GHG reduction = 800 metric tons CO_2
  - Diesel displaced = 79,126 gallons

Economic stimulus

Truck stop electrification development: $10,243,879.

- Construction costs: $4,844,774
- Operations & Maintenance: $5,399,135 (Shorepower staff, supplies, management, operations, maintenance, repair, outreach)

Idle reduction equipment rebate program: $39,676,205

- Rebates distributed: $9,976,205 towards the purchase and installation of EPA-approved idle reduction equipment, which generated 66,268 full time labor hours
- Cost share, $29.7 million - the amount contributed by independent truck owners and fleets to purchase and install idle-reduction equipment

Shorepower Technologies cost share: $262,917

Cascade Sierra Solutions overhead: $6,935,056

- Labor, office, administrative, marketing

Conclusions

The Interstate Electrification Improvement Project met all the grant objectives: stimulating the economy by returning 250% of the original grant monies; reducing diesel fuel consumption and exhaust emissions; adding 66,268 FTE labor hours to the economy; and doubling the number of truck stop electrification sites in the nation. The stimulus had a ripple effect within the trucking industry which continues. During the project period, major truck manufacturers such as Daimler-Freightliner began installing idle reduction equipment as standard on their production models. The idle reduction equipment manufacturers (of APUs and eTRUs) increased their sales, improved their technology, set up brokers, and increased sales staff. Fleets installed private electrification installations in their yards and staging areas.

Shore power is now a more common term in the trucking industry (and no longer only associated with marine vessels). It is a well-known alternative power source that's cheaper than idling, and tangible—not a concept or experiment. Industry spokespeople state it's "only a matter of time" before shore power is available everywhere, and they "see it coming."

Lessons learned

The 50 sites added by this project are an insufficient number to serve the long haul trucking industry and earn enough to support an enterprise without heavy education and outreach efforts. Further, some of the sites did not fit the profile of an ideal TSE site. Sites were originally selected for diversity in order to discover this ideal profile rather than cherry-picking for income potential.

Most of the trucking fleets that received rebates did not fully embrace TSE in spite of substantial cost savings. Had they participated (by plugging into Shorepower), utilization would have been much higher. Most fleet owners and managers who were contacted stated they did not track where their drivers parked and didn't know if they used shore power or not. Those that did track their vehicles said there

were too few sites along preferred routes, or no open parking spots at the power pedestals. Fleet drivers were not allowed to drive an extra distance to find a TSE site. A successful nationwide TSE system should be designed around the needs of large carriers.

Lack of open parking spaces next to power pedestals was a very significant barrier to TSE. Users of crowded truck stops will not leave a space open for a customer because they may not get any other space otherwise. Sites with consistent utilization always had adequate parking for overnight customers. Limited truck parking is a serious national problem that is challenging to solve, however, options are being considered at the time of this report: reserved paid parking at the power outlets; an idle-free zone at the connection points that is enforced; and parking priority given to major fleets and regular customers. Existing customers state they are willing to pay between $12 and $25 per night for a reserved space at a power pedestal.

Users effusively loved shore power. Many reported they talked with their fellow drivers about it and recruited customers on their own. An "ambassador kit" was created for TSE enthusiasts, with brochures, maps, and bumper stickers to give to fellow drivers. One truck owner *voluntarily* put large decals advertising Shorepower Technologies on his cab.

Operationally, a remote power vendor (such as Shorepower) depends on the reliability of multiple other services at the TSE site: the local power utility, internet service provider (ISP), truck stop staff, and availability of nearby technical contractors. In rural areas, the ISP was often unreliable. Inclement weather was also factor for reliability. The main challenge was ensuring 24/7 support from truck stop staff because this depended on the [already time-constrained] management.

From interviews with managers and/or owners of truck stops with high Shorepower utilization, it was learned that they had a personal commitment to the system. Different reasons were offered. It was seen as an amenity that drew loyal customers—a way to compete with the truck stop across the street. It was seen as a win-win opportunity all around, ensuring clean air and lower costs for customers. Several had strong interest in environmental protection, or conversely, in preventing additional environmental regulations.

Recommendations

Strategically expand TSE sites

It is estimated that there should be at least another 200 well-sited facilities to meet the operational needs of the truck drivers and fleets, and reach the critical mass needed to foster widespread adoption by large fleets. Future study might determine the best strategy for expansion:

- Concentrate sites on a very busy corridor and space them 100 to 150 miles apart, or
- Space sites no more than 500 mile intervals on Interstates nationwide, along routes used by large trucking fleets.

Select sites based on criteria in the Findings

1. The site owner or manager is committed to idle reduction or TSE or both.
2. The site is well-managed in general.
3. TSE is supported like any other amenity at the truck stop: adequate internal and external signage, a "no idling" or "shore power use only" designation; reserved parking in the Shorepower parking area.
4. The parking lot is over 100 spaces in size, but is not overcrowded.

Engage truck stop owners upfront

Determine if they embrace TSE as an important amenity, and if they are willing to support it with staff time and marketing materials. This includes ongoing staff training, adding adequate interior and exterior directional signage, and promoting the shore power service in company literature and websites.

Tie locations to where rebate fleet visits

A similar project conducted in the future, should coordinate the fleets with the locations (truck stops) where they stop, to ensure they will plug in. Additionally, perhaps the rebate amount could be tied to the level of plug in time.

Guarantee customer access to power receptacles

Shore power users want assured access and claim they are willing to pay for it. Further investigate the practicality and cost of reserved parking or idle-free zones at the shore power installation.

Include electric power for passenger vehicles

Co-locate other vehicle electrification options in the motor vehicle parking area at travel centers, for use by passenger electric vehicles (EVs) and RVs. RV and EV drivers are already using shore power at truck stops and this could help offset infrastructure costs while waiting for larger market adoption.

Site in locations other than truck stops

Identify the cost-benefits of a TSE installation at rest areas, public and private warehouses, distribution centers, staging areas, ports and multimodal centers, and other sites where trucks park while waiting for loading or unloading.

Consider the goods being hauled

Prior to siting, identify the goods hauled in a given region or corridor. If there's high tonnage in fresh produce for example, then 480V AC power should be available for eTRU units for refrigerated trailers, like the Carrier Vector. If most tonnage is in grain, than eTRU connections are not as important. This approach may draw a closer look when seeking support from fleets specializing in certain shipments, as well as the shippers they haul for. A SmartWay™-certified fleet, and a shipper that's minding their carbon footprint, will be interested in shore power for meeting their environmental goals.

Consider unique situations

On an interstate that passes through a large urban area, select sites located near the city limits on opposite sides of the city. Drivers can choose to avoid rush hour traffic when arriving or departing an area in either direction. Departures from a truck stop occur between 4 am and 8 am, and arrivals begin between 3 pm and 8 pm—both within the dreaded rush hour time frame.

Continually improve the service

TSE providers will need to sustain the same high standard of service as any power utility—100% uptime and stability—requiring rapid response to failures and ongoing maintenance. A smart phone app is essential, as are multiple payment options (cash, credit, debit, all fleet and fuel cards, PayPal, etc.).

Connect shore power use to other benefits

Thinking outside the box: In some regions of the nation, onsite photovoltaic installations can augment the grid for shore power. This will become another 'green' selling point for SmartWay™-certified operators. Fleets and TSE sites might negotiate reduced health care costs for employees because reduced idling means reduced carbon monoxide, particulate matter, and nitrogen gases or NOx compounds, which are shown to cause lung cancer. Lab tests have shown these gases are found in the truck cab as well as in the ambient air of the parking lot.

Rethink the business model for TSE

Most TSE systems are currently owned by the TSE provider, but in order to spread capital costs, the provider could co-own a system with the truck stop, or simply manage the system for a fee or percent of revenue.

Introduction

The Interstate Electrification Improvement project, publically known as the Shorepower Truck Electrification Project (STEP) was funded by the U.S. Department of Energy through the American Recovery and Reinvestment Act (ARRA). Two partners initially collaborated on this effort to develop shore power electrified parking spots at truck stops, commonly known as Truck Stop Electrification (TSE): Cascade Sierra Solutions (CSS) as the lead recipient (primary contractor), and Shorepower Technologies ("Shorepower") as the subcontractor. The project timeline is in the Appendix.

Project Objectives

STEP focused on reducing U.S. dependence on foreign oil imports by reducing engine idling of heavy duty Class 8 sleeper trucks. STEP was intended to accelerate the reduction of diesel fuel consumption and associated emissions and greenhouse gases by:

1. Implementing transportation electrification infrastructure at fifty truck stops along major interstate corridors which was completed by July 31, 2013.
2. Offer financial incentives towards the purchase and installation of equipment upgrades that allow truck drivers to use electric power during rest periods instead of idling of their main engines. Idle reduction equipment purchases were incentivized with ~20% rebates on purchase and installation costs. $9,976,205 in equipment rebates were distributed and installed by April 13, 2013.

Project tasks

a. Test, operate, and maintain the Shorepower system and collect utilization data. These activities were sustained continuously during the study period: January 1, 2013 through February 28, 2015.
b. Accelerate the adoption of shore power to reduce idling, and draw the trucking industry toward greater use of electric power. Conduct sufficient outreach to independent owner-operators, fleet drivers and management, and the fifty selected truck stops with electric power installations. These activities were sustained continuously during the study period.
c. Monitor and analyze data on the system and utilization in collaboration with the National Renewable Energy Laboratory (NREL) throughout the study period.
d. Produce quarterly and annual reports. Conduct technical briefings and presentations. Completed quarterly.
e. Complete final report in June 2015.

Overarching Goals

Stimulate jobs and economic activity for industry segments. These stakeholders received business activity from this grant: idle-reduction equipment manufacturers, equipment dealers and installers,

independent truck owners and fleet owners, truck stops, the shore power service provider, and multiple construction subcontractors in 30 states.

Drive widespread acceptance and use of shore power. And concomitantly, drive widespread acceptance of other idling alternatives, energy efficient practices, and air quality improvement practices.

Drive truck manufacturers' installation of idle-reduction equipment and shore power compatibility as standard on all new vehicles (e.g. Daimler-Freightliner, PACCAR, and Volvo).

Drive growth in production capacity for diesel and battery APU equipment (e.g. Dynasys and IdleFree). Drive equipment improvements and price reduction in shore power capable APUs.

Drive growth in shore power installations, to include private warehouses, distribution centers, fleet yards, and receiving docks, travel centers, etc. Drive installations for other fleets that routinely idle (municipal fleets, construction fleets, ambulances, short haul or drayage fleets, school buses).

Attain long-term profitability for shore power providers, and financially benefit the electric utility, the truck stop, and the user.

Partners

- National Renewable Energy Lab (NREL)
- Owner Operator and Independent Driver Association (OOIDA)
- New York State Energy Research and Development Authority (NYSERDA)
- Truck/Equipment manufacturers (sample)
  - Carrier Transicold
  - Hodyon, Dynasys
  - IdleFree
- Truck Fleets (sample)
  - Witte Brothers, MO
  - Werner Enterprises, NE
  - Gulick Trucking, WA
  - NFI, NJ
  - Mesilla Valley Transportation, TX
- Truck Stops (sample):
  - Pilot/Flying J – national franchise
  - Sapp Bros – regional franchise
  - Russell's – independent

Methodology

The STEP project had three main programs areas. The first was for expanding truck stop electrification (TSE) by constructing and operating Shorepower electrified parking spaces at 50 truck stops in diverse locations in the U.S. The project included collecting data on utilization for a period of two years. This program activity was developed and implemented by Shorepower Technologies, including education and outreach to potential users. Cascade Sierra Solutions (CSS) assisted with construction management and educational activities within the industry.

The second program area was for managing a rebate program to incentivize the purchase of idle-reduction equipment for trucks, such as auxiliary power units (APUs), which required the inclusion of "shore power compatibly." This enabled equipment to be plugged-in to shore power when it is available. The rebate program was developed and managed by CSS, which had prior experience with a similar rebate program for an EPA SmartWay™ grant.

The third program area was a study of TSE utilization that involved a partnership with the National Renewable Energy Laboratories (NREL) in Golden, Colorado. The study was for identifying use patterns and gauging the potential for widespread acceptance and use. All three organizations shaped the study and selected data sets for analysis. Shorepower set up the data collection reports, and CSS and NREL began statistical analysis and created quarterly reports on the data. When CSS closed in May 2014 and the grant was novated to Shorepower, Shorepower continued the partnership with NREL.

Development of the National TSE Network

Shorepower created selection criteria for identifying suitable truck stops, and built and commissioned the shore power installations. This included the design, manufacture, and testing of all components in the system: the power pedestal, the computer kiosk and operating system, the software, and the communications system. Shorepower subcontracted with EC Construction, a specialist in electric power facility construction, who constructed the Shorepower facilities along with regional subcontractors.

FIGURE 1

Power pedestal

Pedestal installation

Payment kiosk

Site suitability was assessed by Shorepower and EC staff (a subcontractor) based on site visits. Criteria used are in Table 1.

TABLE 1 – Site selection criteria		
Parking	**Primary Customer Base**	**Permitting Complexity**
Total parking spaces: _____	+Long haul	+Easy
Average overnight trucks: ____	_ Light Duty	Medium
Amenities	Other	_ Difficult
+Banking	**Location**	**Customer Makeup**
+Convenience store (C-store)	+On primary corridor*	Fleets
+Drivers' lounge	On secondary corridor*	Owner Operators
+Laundry	Miles away from corridor:_____	Other
+Load finding service	**Access to Power Supply**	**Access to Communications**
+Lodging, onsite or nearby	+Easy	+Cable
+Maintenance/repair services	Medium	+Internet
+Restaurant – fast food	_ Difficult	_ None
+Restaurant – sit down	**Affinity Program****	**Potential NEPA Issues?**
+RV parking allowed	+Yes	_ Yes
+Scales	No	+No
+Security	**Website**	**Paid Lot?**
+Shipping	+Yes	_ Yes
+Showers	No	+No
+Truck wash	**Parking Type**	**Facility**
+Wi-Fi	+Perimeter	New construction
Lot type and composition	Center/island	Retrofit
+Paved	**Signage**	**Idle free Zone**
Gravel	+Excellent	+Yes
_ Dirt	Fair	No
Owner Commitment to Project	_ Poor	
+High		
Medium		
_ Low		

*I-5, I-95, I-80, I-90, I-10, I-20

**The existence of rewards based on points earned from purchases

+ Increases site suitability

_ Reduces site suitability

Selection criteria

- Good site locations had factors that indirectly promoted the use of electric power. These could be local anti-idling regulations; a regional culture or ownership with an interest in environmental issues or in reducing petroleum use; and regulations that were enforced.

- Truck stop (host site) management interest in TSE was quite important. As the people who met customers face to face, successful outreach relied on host site staff to a large degree. They needed to keep brochures and maps on hand and displayed, order new ones, post or install signs, and assist customers with questions. They could also implement or allow a "no idling" zone at the power pedestals, or Shorepower-only parking. Both of these could promote steady use of shore power.

- Sites were amenable to a hard, dedicated installation, which meant a willingness to sign a contract to commit to multiple years' access, and provide general maintenance around the installation. Practical factors such as utility location and the complexity of permitting also drove selection, as well the availability of experienced local subcontractors.

- Collectively, site diversity was important for satisfying national (DOE) and research goals.
  - Geographic locations were dispersed throughout the country so that multiple states benefitted from the investment in local business.
  - Truck stops were not in close proximity so as to avoid competing with each other.
  - Sites were located in different climates, hot or cold or temperate, so as to gauge climate impacts on utilization.
  - Sites, as businesses, were diverse by size, ownership (national franchise, regional franchise, and independent, in areas of varying economic and traffic 'density' (urban, suburban, and rural) and with different mixes of amenities.
  - Customers needed to be diverse, and represent independent owner operators and salaried drivers of company fleets.

- The jurisdiction held the potential for public-private partnerships, or other opportunities to leverage funds from other sources to pay for portions of site development (cost share).

Construction

The names of potential truck stop businesses were initially drawn from online databases and guides used by truck drivers to select places to stay, which listed lot size, amenities, and the availability of Wi-Fi for example. Of the selections, a total of 150 truck stops were visited to assess interest and suitability. This larger number, greater than the 50 required in the Statement of Project Objectives (SOPO), was chosen with the understanding that many sites would be found unsuitable or unwilling to sign a multi-year contract. Truck stops that were eliminated had issues such as gambling ties or small lot size, or

which were poorly managed. The latter may have been dirty and unkempt, had untrained staff, or other undesirable qualities.

Construction of sites was planned with a site drawing designating pedestal and power panel locations and the utility location. Contractor bids and permitting followed, and permitting and approval protocol varied substantially across locations. After construction, sites were inspected and tested (e.g. voltages, signal strength, kiosk computer function, etc.) Once commissioned, a Grand Opening was scheduled.

Equipment design and manufacture

System design, from computer, to pedestal, to power panels, had to be heavy duty and weather proof to function outdoors in very hot, cold or wet conditions. The pedestals and power panel had to be protected to prevent impact from trucks backing into a parking spot. Other services were planned such as cable TV and Wi-Fi, but were implemented on a limited basis due to availability and technical complexity. Cable TV is not generally technically complex, but most carriers have gone to a digital only format that requires a set top box to get a signal. Since the providers and hardware differ from location to location, it was not feasible to implement cable TV at most locations. Drivers would need access to each provider's set top box. Additionally, some providers went to a digital only signal during the project. Rural locations often had very poor internet service and/or low bandwidth; therefore, offering Wi-Fi was not technically feasible or the service was already offered (for free or paid) by the site.

Regular maintenance and upgrades

From the start, Shorepower established regular contact and good working relationships with all host sites. Ongoing maintenance and repair required cooperation and responsiveness from staff. All sites were regularly visited and new or upgraded components and firmware installed. Software was continually being refined and uploaded to site computers.

Rebate Program

The rebate program was designed to get 5,000 vehicles on the road with onboard equipment that could use shore power when available, the intent was to provide a ready pool of 5,000 customers and collect data on their use patterns. In the application for a rebate, the applicant provided information such as his/her typical routes, stops, vocation, and truck age and type. The types of data collected are in the Methodologies section of the Appendix. It was also intended to stimulate the economy by leveraging investment in new idle reduction equipment, and supporting full time jobs for original equipment manufacturers (OEM) and mechanics who installed the equipment.

At the outset of the study, outreach and education were focused on fleets and fleet managers, though any truck owner could apply. It was logical that fleet trucks would readily use shore power since they had a greater incentive to plug in because they had the most to gain in cost savings.

Cascade Sierra Solutions (CSS) managed the rebate program, which incentivized the purchase of SmartWay™-certified equipment. Rebate amounts were $5,000 towards the purchase of an eTRU, and up to $2000 (eventually lowered to $1600) towards the purchase of an APU (battery or diesel powered) or evaporative cooler. The rebated equipment was required to have an optional feature that enabled it to be plugged in to shore power. CSS advertised the availability of rebates in multiple industry media outlets.

All onboard equipment was required to have a shore power-capable option, which allows it to be plugged into shore power. Recipients signed an agreement requiring them to use Shorepower at one of the Shorepower sites by a deadline of May 2014, or a year after the last rebate was awarded.

Data collected in this study cannot determine if any TSE plug-in event was a choice over an onboard APU if one was installed. Drivers were not required to use shore power if they were parked in front of a pedestal, but rebate recipients agreed to plug in when possible.

The application process had three main goals:

1. Appropriately manage public funds and prevent fraud;
2. Collect data on trucks, vocations, routes, and parking preferences among other metrics. The purpose was for tracking the driving patterns of characterized vehicles, and quantifying where and how much they used Shorepower services.
3. Obtain a commitment to use shore power at the Shorepower sites.

Application forms were available online, via email, or paper copy, and at any of CSS' truck equipment showrooms in the U.S, mostly along the I-5 Corridor: Seattle WA, Portland OR, Medford OR, Sacramento CA, Fontana CA, and Dallas TX (in partnership with North Texas Council of Governments). In time, equipment dealers began providing these application forms to customers and assisting them with completion.

Applicants' truck information included the VIN, proof of ownership, equipment type purchased, and other metrics for characterizing the study population, such as: annual mileage, % time spent idling, most-used corridors, and whether other efficiency equipment was desired or already onboard, such as low rolling resistance tires.

To prevent fraudulent requests, the customer received the rebate as a deduction from the invoice after the equipment had been installed. The installer then provided CSS a copy of the paid invoice, and received a reimbursement check in the rebate amount. This resulted in a paper trail that verified that the specific equipment (including serial number) was installed on the applicant's truck.

Connection Kits

In addition to rebates, CSS was responsible for distributing 1,050 Phillips and Phillips Temro connection kits free of charge. These kits included wiring and parts needed to install a power receptacle (inlet) on

the outside of a truck cab that was wired to outlets inside the cab when it was plugged into shore power (see **Figure 2).** It was presumed at the time that kit installation would also generate additional full-time hours for mechanics.

The kits were originally sent to host sites to give to customers and to fleets to install on their vehicles. To receive a kit, the applicant completed an application form and supplied a copy of the truck's cab registration card.

Phillips Connection Kit
FIGURE 2

Both means of distribution (to host sites and to fleets) posed potential issues. The arrangement could not track whether or not the kits were actually distributed or installed. Starting in 2014, this was modified. Kits were retrieved from host sites and fleets, and targeted exclusively to independent owner operators. The assumption was that independent owners operators were more sensitive to costs, had more control over where they could stop overnight, and could install the kits on their own or have them installed by a mechanic. Kits were made available on the Shorepower website, at driver appreciation events, at truck shows, and through the Owner Operator Independent Drivers Association (OOIDA).

Data sets

Because the data was being drawn from at least 5,000 vehicles, and because it was comprehensive and well-documented, it offered the opportunity to evaluate diverse aspects of TSE--from seasonal use patterns, to parking patterns, idle reduction equipment use, to the evaluation of ideal host sites. The study period officially began on January 1, 2013 and ended on February 28, 2015

Data for findings was drawn from:
Rebate database - drivers and fleets submitted data on rebate applications
Shorepower System database – data collected whenever the Shorepower system was used
Interviews, feedback, user and host site comments and communications

TABLE 2 – Data collected on Shorepower utilization			
Time	**Location**	**Utilization**	**Booking**
Start date	Site name	Length of event (hours)	Payment type
Start time (UTC)	Address, zip	KWH used	Booking source:
End date		Service selection:	Web
End time (UTC)	**Customer**	120V 20A	Kiosk
	Name	120V 30A	Phone
Other	Username	208V 30A	Cost
CSS ID (rebated veh.)*	User ID	480V 30A	Applied discounts

**In order to track trucks with rebated equipment, all truck owners were required to input a 5 digit number or CSS STEP ID when they ordered power.*

Rebate data from CSS **(Table 3)** was collected from truck registration cards and installation invoices, and self-reported on rebate applications.

TABLE 3 – Data collected from rebate applications		
Applicant	**Truck/trailer**	**Vocation**
Name, address, contact info	VIN	Reefer (refrigerated trailer)
Company, license, state	Make, model, year	Flatbed
Owner or lessee	Gross vehicle weight	Dry van
Name/address of carrier	Engine make, model, HP	Curtain van
Number of vehicles owned	Plate number, state	Liquid Tanker
	Truck/trailer reg. no., state	Heavy haul
Truck usage	Current mileage	Customized
MPG		Bulk hauler
Annual miles driven	**Rebate equipment**	Car/auto hauler
Annual fuel usage	eTRU, transport refrigeration	Other
Est. annual idle time (hours, %)	APU – battery or diesel	
	Cold plate	**Travel pattern**
Census	Battery HVAC	Preferred corridors
US citizen, woman/minority	Other technology	Preferred parking area

Qualitative data

Scripted interviews were conducted with rebate recipients: three independent owner-operators and six fleets of different sizes. Interviews included specific and open-ended questions about the use of idle reduction technologies, attitudes about alternative fuels, interest in reserved parking, and plans for efficiency upgrades. The scripts are shown in the Methodologies section of the Appendix.

Unscripted interviews were conducted with over 100 existing Shorepower customers, which elicited good comments and feedback on shore power. Many elected to become an ad hoc ambassador for Shorepower and provide brochures and information to fellow drivers.

During the course of this project, both CSS and Shorepower had the opportunity to interact with hundreds or drivers and fleet personnel at all levels. In some cases, trusting relationships developed due to a mutual interest in the overall success of truck stop electrification. This report draws upon information and experience that also serves to corroborate the results in this report's findings.

Research was conducted to predict a "tipping point," when market acceptance and purchase/use of alternative fuels such as shore power start generating enough income to support a viable business. Information was drawn from historical news and data on the chronological periods between the promulgation of a new 'green' service or product, and widespread adoption of the service or purchase of the product. The examples chosen were the introduction and eventual widespread acceptance of: organic food, certified sustainable wood products, and compact fluorescent bulbs.

Data analysis

Data analysis was initially undertaken by both CSS and NREL. CSS organized both the rebate data and "cleaned" the Shorepower data feed for NREL. NREL produced a semiannual report on the project which was posted on their website. Along the way, CSS periodically presented operations data to the DOE VTO in quarterly project reports. After CSS dissolved and the grant was novated to Shorepower, Shorepower continued this work in partnership with NREL.

Analysis of the data appears in the Findings section, but several constants were developed to complete these calculations which were drawn from the following:

- Rebate data was used to characterize an Average Truck and establish annual mileage, annual idle time, and miles per gallon.
- Shorepower data was used to establish 24 hour, day of the week, and seasonal utilization patterns, and the duration of plug in events, among others to calculate cost savings and cost comparisons.
- Diesel price per gallon was drawn from the U.S. Energy Information Administration (EIA) chart: "Data, Petroleum and other Liquids", and averaged for the period Nov 2012 through Feb 2015.

Other figures for analyzing data, such as the fuel consumption rates of trucks at idle and APUs with a load, were corroborated with data from multiple sources, including published research, published information from manufacturers and trucking industry papers, and personal communication with OEMs and drivers.

Education and Outreach

Shorepower and Cascade Sierra Solutions promulgated news about TSE and its benefits to multiple audiences, each focusing on different audiences. This was not mutually exclusive however--there was overlap.

Cascade Sierra Solutions

CSS promoted Shorepower and published the availability of equipment rebates with two organizations in the trucking industry. The ATA (American Trucking Associations) and OOIDA (Owner Operator and Independent Driver Association) informed their members via online newsletters and articles. CSS staff also conducted outreach by attending and presenting at industry conferences and trucking shows, where they distributed articles on STEP, Shorepower promotional materials and the 2010 Green Trucking Guide.

Shorepower Technologies

Shorepower engaged in several different strategies depending on the audience.

Drivers

Traditional marketing strategies were aimed at drivers, which included social media like Facebook, email newsletters, retail materials (brochures, maps), and the company website. Training videos were created, and sent via email or via links to YouTube.

Other driver outreach efforts included:

- Free power giveaways, examples: ten free hours for the first time user; half off after 10 hours.
- XM Radio interview and ads
- Truckers Report trucking forum
- The OOIDA newsletter, which also promoted the free connection kits
- Driver to driver contact via an "Ambassador" program. Interested drivers were supplied with brochures and maps to give to follow drivers in the lot.

Truck stops

- Ongoing contact was maintained with general managers and staff. Each host truck stop was assigned an account manager who replenished retail materials, recruited a truck stop staff person to be the main contact for Shorepower, and trained staff.
- A detailed marketing handbook called the "Success Kit" was provided, which offered ideas and practices for marketing and serving customers. A sample page is in the Methodologies section of the Appendix.

- Accessories to foster the use of Shorepower were suggested or provided for the convenience store or "C-store" including: 110V AC powered appliances (ceramic heaters, coffeemakers, etc.); heavy duty extension cords; and power strips.
- Engaging with National Association of Truck Stop Owners (www.natso.com)

The commercial trucking industry:

- Along with Cascade Sierra Solutions, Shorepower participated in dozens of media events and interviews, and facilitated over 200 magazine articles for industry publications. They also co-advertised with original equipment manufacturers (OEM) such as Carrier Transicold.
- Mainstream, news stories in mainstream media. Shorepower was also given several business awards that gave it exposure in sustainability and alternative energy circles.

Salient messages

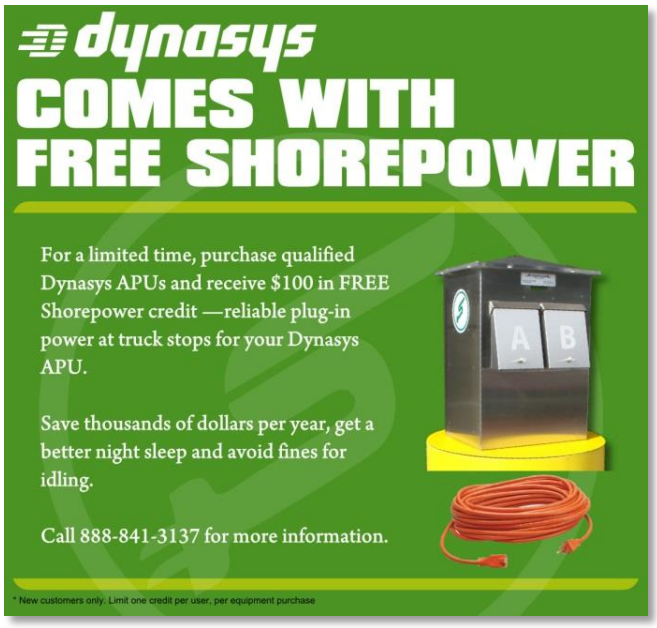
For driver and fleet audiences, the most salient outreach message promoted the substantial cost savings from using shore power over engine idling. Higher-than-ever diesel prices and an economic recession drew attention to the fuel cost savings aspect, along with savings accrued from reduced engine wear and maintenance. Cost benefit analyses were included in all educational and outreach materials.

Other messages focused on the health benefits of clean air and sleep quality that resulted when engines were shut down. Shorepower partnered with the American Sleep Apnea Association to communicate the sleep benefits of a quiet engine and a reliable 110V power for use with CPAP machines to aid with sleep apnea.

Health benefits were presented to fleet audiences as an incentive for driver retention. The reduction of U.S. dependence on foreign oil was another salient message embraced by truckers during a period when national security concerns were high. While environmental benefits were substantial, these messages were deemphasized for driver and fleet audiences due to negative perceptions that environmental programs resulted in unwanted regulations.

A different tack was taken with truck stop owners and managers. The financial incentives for providing shore power were not high, even though Shorepower paid a percent of sales revenue back to the site. Instead, shore power was presented as an amenity which, like free Wi-Fi, will eventually be expected by all customers. It also attracts customers that used shore power that may make other purchases from the convenience store.

Other outreach was made to: rebate recipients, truck stop guides, and companies with point rewards programs. These were offered for customers of Pilot/Flying J truck stops, buyers of AMBEST lubricants and service center mechanical work, and OEMs such as Dynasys, Figure 3.



Promotional ad offering free shore power to buyers of Hodyon's Dynasys APU

Figure 3

For the driver audience: Marketing tools common to the trucking industry were used for outreach and education directly to drivers: brochures with location maps, indoor retail signage, outdoor signage at truck entrances to lots, and directional signage to the installation in the lot. Booths were set up at Grand Opening events (of a new Shorepower installation), Driver Appreciation events (Mercer Town), and national truck shows such as the Mid-America Trucking Show. Promotional discounts and free power were offered to encourage drivers to give the service a try. Social media such as a Facebook account and a blog were set-up and updated. Shorepower ads were placed on ((XM)) satellite radio station 700 WLW, "America's Truckin' Network," which is popular with truck drivers.

Drivers who already used shore power were encouraged to talk to other drivers about it. They were asked if they wanted brochures and other items to share, and many agreed to do this. Talk among fellow drivers is an effective 'grapevine' approach and engages the trucking culture's active participation in daily dialogue amongst its members as immortalized by the CB radio—the earliest form of social media.

For the fleet audience: Visibility within the trucking industry at large was created through over 200 articles and interviews in media consumed by fleets and manufacturers. Presentations to fleet managers on the project were conducted by both Shorepower and Cascade Sierra Solutions' staff at industry trade association conferences such as the large Mid-America Truck Show (MATS), trucking's Technology and Maintenance Council (TMC), the Green Truck Conference, and the North American Council of Freight Executives (NACFE).

Cascade Sierra Solutions

CSS emphasized industry-wide communications, which were directed at large national fleets, industry associations, and research institutions. In addition to presentations described in the above paragraph, CSS presented at American Trucking Associations' conferences, the Carbon War Room, and state trucking associations in Oregon and Texas. CSS had prior experience educating the trucking industry on energy efficiency and environmental protection because they worked under a previous grant from the Environmental Protection Agency (EPA). One outcome of this was the 2010 "Green Trucking Guide," which featured information about products and services (such as shore power) aimed at fuel efficiency: aerodynamic modifications, low rolling resistance tires, and automatic tire inflation systems, among many others. Their EPA grant work also resulted in relationships with upper levels of the truck transportation industry, such as with Daimler-Freightliner, Mesilla Valley Transportation, and Werner.

CSS contributed many articles about its work on the STEP grant. Industry periodicals included Fleet Owner Magazine, Overdrive, Trucker's Report, and Landlines. Like Shorepower, health benefits were promoted; CSS highlighted the negative impacts Particulate Matter (PM) produced by burning diesel.

There were other audiences that could have been reached regarding idle reduction and shore power, but the time-invested was considered too costly or too long. These included large shippers like 'big box' retailers. As significant buyers of freight services, these companies had leverage over vendor practices. Many were already EPA SmartWay™-certified, thus likely to prioritize purchases from 'green' businesses. Another audience could have been renewable and alternative energy advocacy organizations, but their transportation energy focus was almost exclusively on passenger vehicles.

CSS ceased operation a year and a half before the project ended. It was subsequently novated to Shorepower Technologies for completion, which continued operations and maintenance, and data collection and analysis for the final report.

Findings

The first portion of this section presents the findings drawn from the TSE development project; the second portion presents the findings from the rebate program. When possible, the study findings are compared with published information to corroborate the quality of the data. If there was no published literature, further investigation was done by gathering information from individuals in the trucking industry or from case studies.

Findings from this study are somewhat different from what was anticipated over a decade ago when TSE was first being explored as an idle reduction option.

Original Assumption	Finding
The data on the rebate fleet of 4,265 trucks with idle reduction technology was intended to measure which owners and vocations used shore power; identify preferences for shore power between diesel APU and battery HVAC owners; and identify preferred truck stops.	Tracking the rebate fleets depended solely on the driver, who was required to input a code known as the STEP Vehicle ID, associated with their rebated truck upon booking power. However, it was possible to book a session without the STEP ID so that a guest (non-rebate customer) could use the service too. Rebate recipients may not have been entering the STEP ID. It was easy to forget, lost or deemed unnecessary/inconvenient. Without the STEP ID, there was no way to accurately track who was using Shorepower, and with what equipment on board.
Rebate recipients would use shore power because they had the modifications needed on their truck and it was less expensive.	Many fleets claimed they could not get to Shorepower sites because their routes had no installations. It was reported that the rebate was often used to upgrade trucks at a discount. Rebates stimulated the trucking industry and reduced idling, but not necessarily the use of shore power. Many APU owners reported they never needed shore power. They believed they were saving the same amount on fuel costs as they would be if using shore power. An APU dealer confirmed this was the belief at the time, and it was communicated to buyers

There would be steady growth in use, and seasonal utilization patterns would vary based on ambient temperature. Booking start time would occur in the early evening.	Moderate, but not steady growth has been achieved. Seasonal variation based on ambient temperature is validated in the data. Booking start time in the early evening is validated.
Fifty sites nationwide would be sufficient to establish steady bookings and become financially viable for private business.	Study results are unclear, but input from drivers and fleets dictate that more sites are necessary. There is overwhelming evidence that more sites are required for widespread adoption. Analysis of the sites defined criteria for locations that would see steady use.
Highest utilization would occur in summer and winter, with the greatest peak in the summer.	Highest utilization did occur in the summer and winter. Summer utilization was expected to be the highest, but onboard electric air conditioning units are more expensive than portable space heaters. However, many users adapted portable air conditioners, originally designed for home use, for use in their trucks.
The substantial savings over fuel costs would be a strong incentive to seek out and use shore power when possible.	This is true according to hundreds of repeat customers. Owner operators and fleet drivers report that they would use shore power if they could. To a much lesser degree, clean air, lower noise, and reduced wear on the engine were also reported as incentives.
Owner-operators claim that the primary barriers facing idle reduction technologies are cost; "cost is by far the biggest barrier with more than half of owner-operators and fleets reporting it as the number-one barrier to implementation."*	Cost does not appear to be the issue for shore power, since the upfront cost is relatively low. Repeat shore power users are primarily owner-operators who did not purchase idle-reduction equipment with a rebate. They consistently report that access to the pedestals is a primary barrier, on par with the overall lack of shore power-equipped sites.
Fleet managers claimed that cost was a barrier, but added, "Lack of driver education, training, and receptiveness to idle reduction	It appears that driver receptiveness may not be the issue. Fleet drivers' (at TSE sites) often commented to both CSS and Shorepower staff that their

technologies constitutes the second largest barrier category... In fact, this issue ranked as the number-one barrier by 32% of respondents." *	company did not promote idle reduction, even when diesel prices were around $4.00 per gallon. This study did not examine why so many fleets did not address idle reduction. Fleet driver comments may point to lack of fleet receptiveness instead or simply a lack of awareness among the fleet managers. This issue may also be related to the overall number of TSE equipped sites. Fleets say more locations are needed for fleet-wide adoption.
Fleet use of shore power will drive the market, and eventually result in shore power becoming widely available.	Many fleets are interested in TSE, but they aren't driving the market because they don't have enough sites on their routes. Increased fleet use and more locations would drive widespread use.
Fleets need a payback period of two years for idle reduction equipment upgrades.	Shore power use requires very little upfront investment, particularly for winter heating. A $25 portable space heater can get most drivers through the winter. Air conditioning can be more costly, but dedicated truck units are available for under $2,000. Most manufacturers such as Daimler-Freightliner and Volvo offer shore power equipment on standard models.

*National Renewable Energy Labs, "Idle Reduction Technology Demonstration Plan NREL/TP-540-34872 Sept 2003

The NREL 2003 study above couldn't have anticipated the constellation of events that impacted the idle-reduction goals of this project. The economy was in a recession, which reduced investment in upgrades; there was competition among multiple cheaper fuel alternatives (CNG, propane, hybrid engines); and there were cheaper aftermarket truck modifications that reduced fuel use, such as trailer skirts, aerodynamic mods such as trailer tails, and low rolling resistance tires.

Utilization

Figure 4 was created by the National Renewable Energy Labs (NREL) and depicts KWH used at the project locations. Sites with high total KWHs may either be heavily used or an older site with a longer period in service. Construction started May 2011, and the 50th site was completed July 2013.

FIGURE 4 – KWH used between Jan 1 2013 and Feb 28, 2015

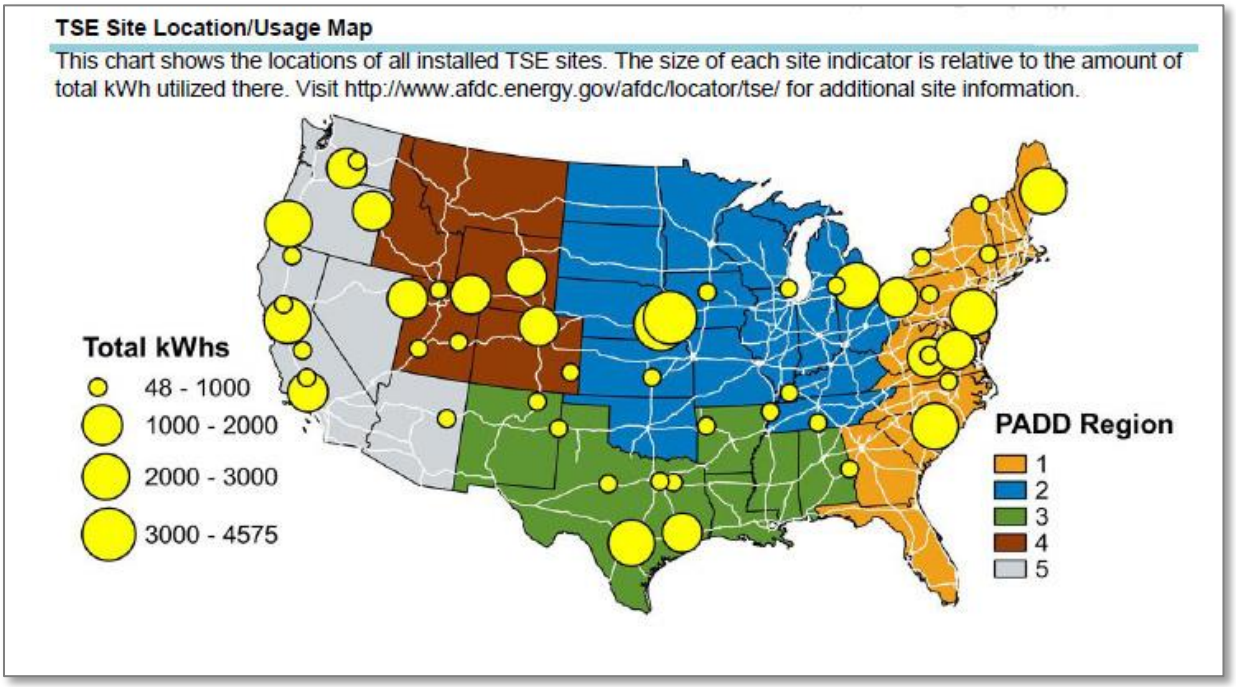


Figure 4: PADD Regions (Petroleum Administration for Defense Districts) were established by the Energy Information Administration to enable regional analysis of petroleum use.

In Figure 5, booked hours are paid-for hours. Data collected in this study cannot determine if any booked event was a choice over using an onboard APU or battery HVAC system, or any other system.

FIGURE 5 – Hours booked between Jan 1 2013 and Feb 28, 2015 (NREL)

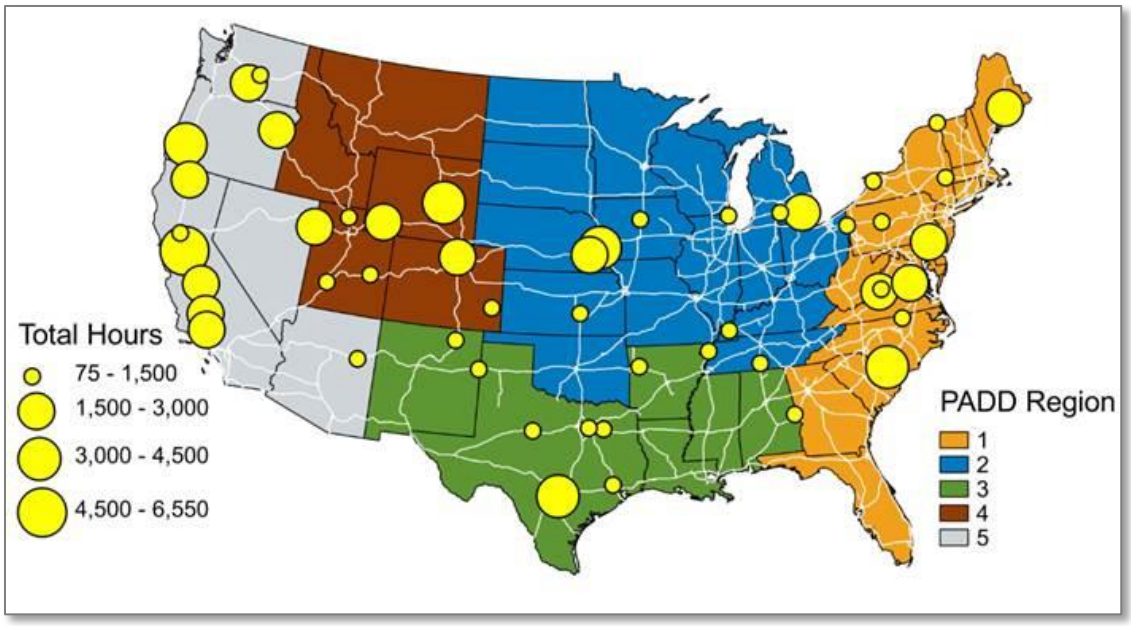
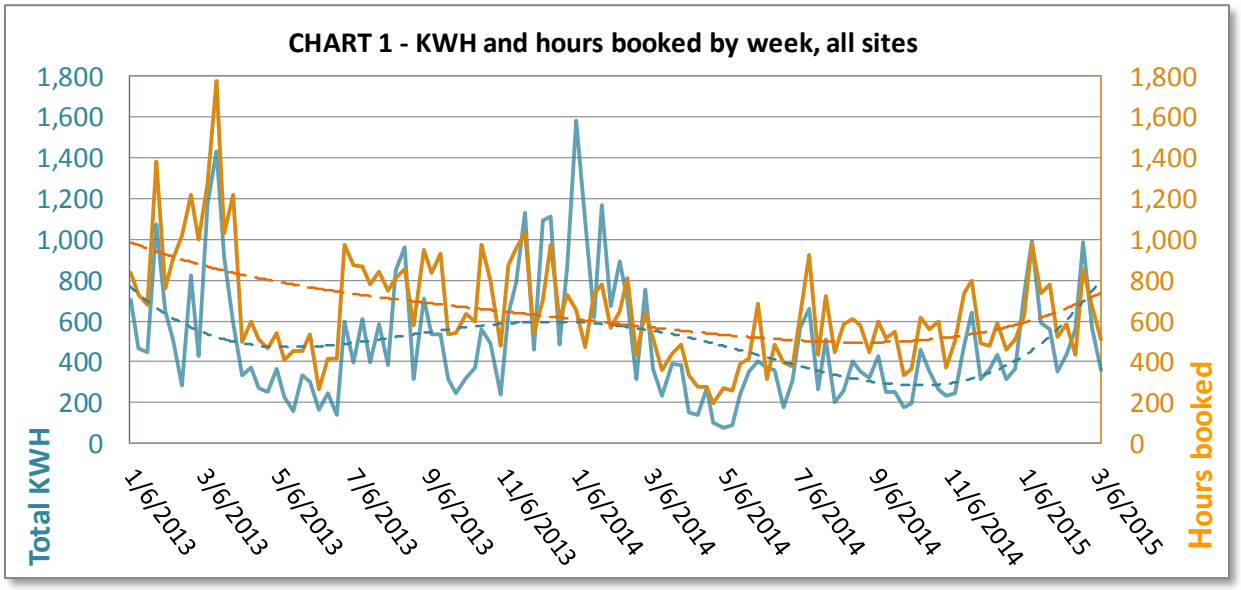


CHART 1 - KWH usage and hours booked by week. A seasonal pattern is evident. Booked hours are uncharacteristically high early in 2014 which reflects free power promotions.



Utilization is lowest during mild spring temperatures, followed by increasing use in summer and a brief dip in fall. The highest use is in winter, most likely for cab heating and engine block heaters. Given the necessity of air conditioning, summer utilization is not as high as expected. Most cab air conditioners are operated by the engine and not designed to use standard 110V AC power. Drivers will idle to keep cool in the summer unless they have battery HVAC, access to off board AC, or standalone air conditioners with shore power connections such as roof top or back wall units. Some drivers creatively mount off-the-shelf window units (made for small apartments) to run with shore power.

CHART 2 - Power use and hours booked by day of week (NREL), all sites

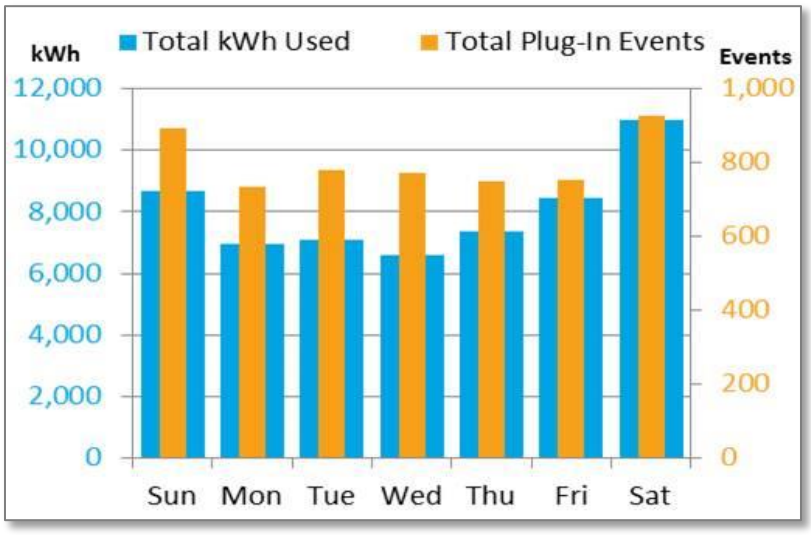
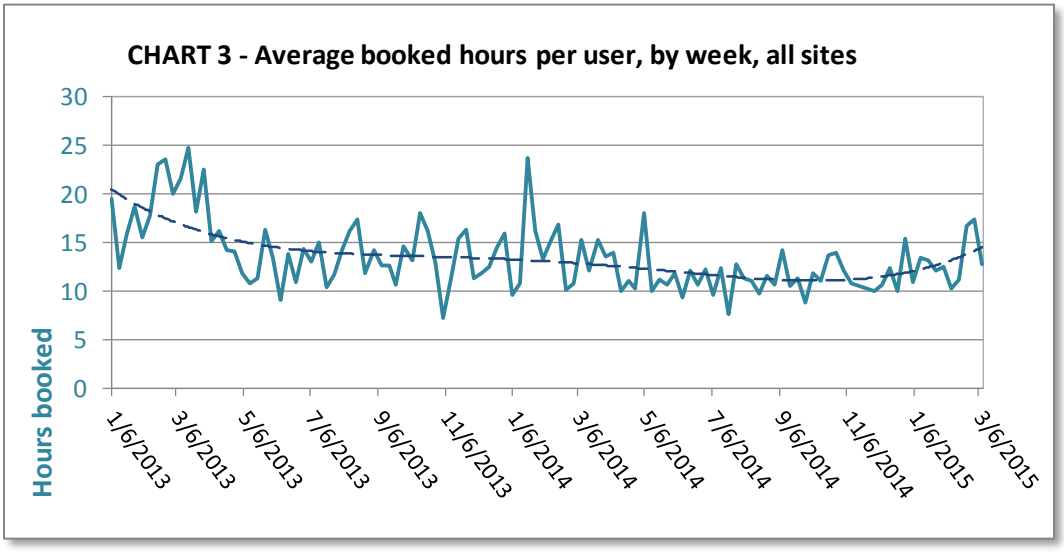
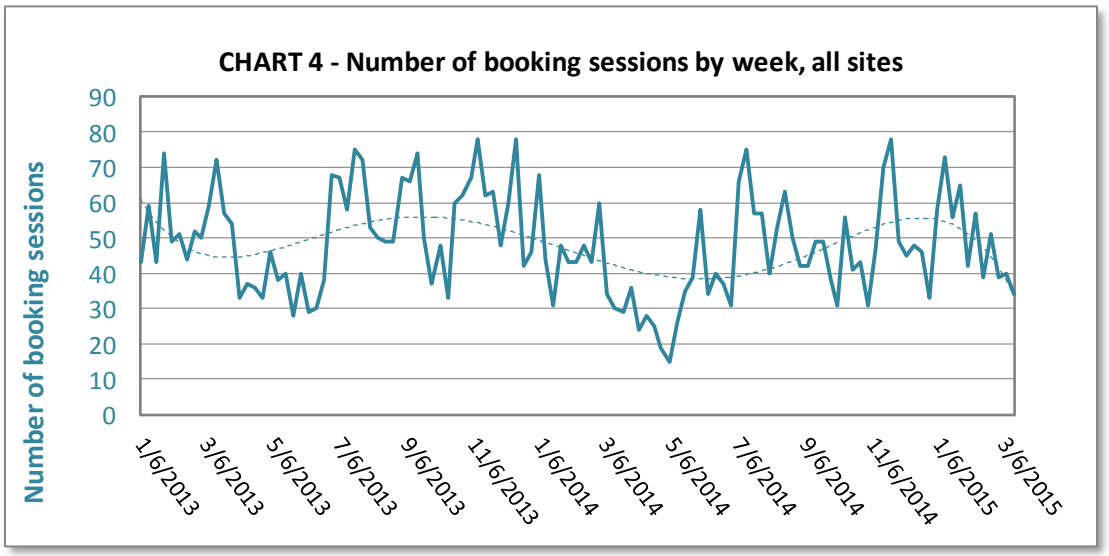


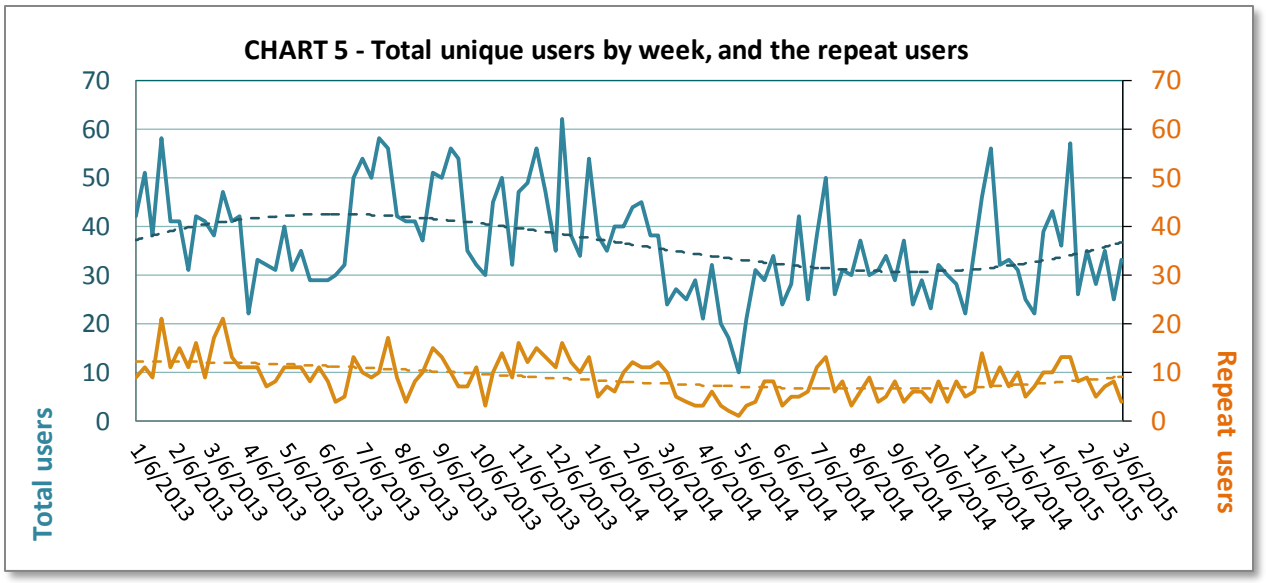
Chart 2 shows that peak utilization occurs on weekend days.



The average duration of plug-in events is greater than the 10-hour mandated rest period by Hours of Service rules during the study period. It was assumed that drivers departed soon after 10 hours, but drivers are required to "reset" their hours every week with a 34 hour rest period. The "34 hour reset" and longer weekend stays increased the average over 10 hours. The average duration was higher in the early months due to free promotional hours. When the promotional hours in the first half of 2013 are eliminated, average booking time is 12.6 hours.

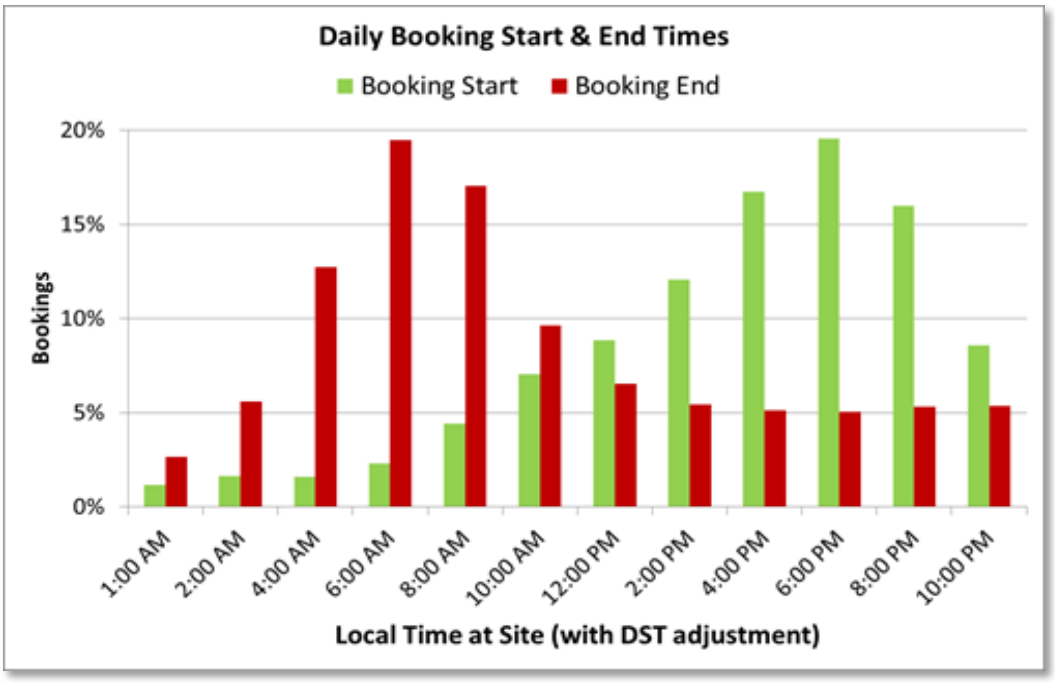


A seasonal pattern is evident.



The number of users who book two or more times in one week is fairly consistent over time. Note: the dip in April 2014 coincided with a system change to a new server.

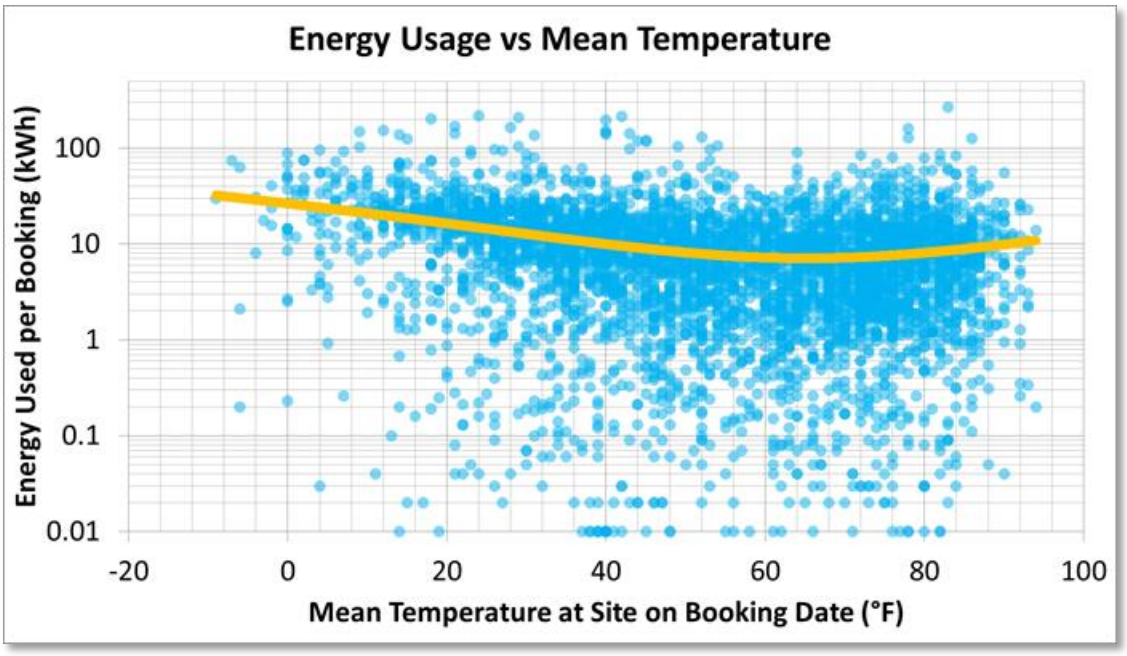
CHART 6 - Daily Booking Start and End Times (NREL)



The 6:00 pm to 6:00 am peaks corroborate the finding that the majority of bookings are 12 hours in length. The majority of users on any given day are plugged in overnight when most people like to sleep.

Effects of temperature on utilization

CHART 7 – Mean ambient temperature when a booking is created (NREL)



Although the curve is somewhat subtle, energy use is clearly higher as temperatures deviate from the human comfort zone. Energy use is lowest at approximately 65 degrees F.

A negligible number of eTRU connections were used at the STEP throughout the project, but they would have used significantly more energy than a standard cab power connection. Less than 10% of full sized refrigerated trailers are electric standby capable. Those that do have electric standby connections are plugged in at their home base, rather than at truck stops. eTRU connections at truck stops are not a short term revenue producer, but a long term enabler for maximizing plug in time and fuel efficiency.

Users

Despite efforts to promote the use of shore power to fleets, the mainstay users of shore power are primarily independent owner operators, most of whom own a single truck. Both fleets and owner operators are aware of idle reduction initiatives and benefits of idle reduction. Shorepower conducted formal interviews with both user types who received rebates to uncover the reasons behind this finding.

Interviews and feedback

Owner operators

During the course of business, conversations between Shorepower staff and owner operators elicited these general comments:

- **Shore power is not available** everywhere; many expressed a wish for more sites where they travel, which included multiple recommendations.
- **Downtime** is frustrating for all parties. Many of the sites are located in remote areas with weak or unreliable Internet service. Some sites experienced communication issues during the early part of the project, and customers may have been lost.
- **Parking problems** are serious and prevent the use of shore power. Examples given:
  - The lot is full and there is no parking available;
  - Shore power parking spots are taken by trucks that are not using the service and won't move;
  - Trucks must arrive in the afternoon to get a spot, before 3 pm or 4 pm, which is too early for many customers;
  - Many Shorepower pedestals are located in "prime" parking spots: close to the main building, in a quiet area or at the edge of the lot, which are preferred by drivers;
  - Although reservations can be taken with Shorepower's system, there are no barriers or means to ensure a Shorepower parking spot stays open for a user.
- Fleet drivers claim they have no incentive to use shore power or avoid idling because the fleet pays for the fuel. Some fleets have implemented "fuel incentives" that pay drivers for reducing idling and fuel waste, but they may not pay for the Shorepower service.
- Idling is a force of habit, and it's hard to make truckers change.
- The factory-installed air conditioner does not run on electric power, but is instead driven by an engine belt. Therefore, a separate electric air conditioner is needed to keep the cab cool while plugged into Shorepower. During the winter portable space heaters are cost effective and simple to implement.

Three independent owner operators who received rebated equipment participated in a scripted interview.

Owner 1

This driver owns a 2000 Freightliner auto hauler, and his rebate was for a Dynasys diesel APU. He has not used shore power. This owner believes that running his APU costs the same as using shore power; "$10 is $10." He also reported that it was difficult to find a parking spot at a Shorepower pedestal. He does not idle when parked in order to save money and reduce engine wear, and also because California has anti-idling regulations. He wants the option to reserve a parking space and will pay $12 a night. However, he disdained other off-board TSE technologies for blocking off parking spaces and disallowing all trucks from parking there. He has also researched other efficiency alternatives for his truck as a result of the project.

Owner 2

This driver owns a 2001 Freightliner dry van, and her rebate was for a TriPac-E battery HVAC system with electric standby. She has not used Shorepower, but has used IdleAir. She said she did not

know there were Shorepower pedestals installed at a truck stop where she regularly stays overnight; something discovered in this interview. She is unhappy with the TriPac-E because "It is always in the shop and it doesn't run enough hours (when I need it) anyway." She chose the battery system because "I have serious allergies and need AC and clean air to sleep." She prefers not to idle the main engine, but she has considered getting a new truck with a diesel APU because of her poor experience with the battery system.

Owner 3

This driver owns three 2004 International trucks customized for express freight delivery, and his three rebates were for Dynasys diesel APUs. This owner said he tried using shore power once, but the system was down. He does not expect any of his trucks to use shore power because they drive express delivery (day trips) and plug in at home. However, the owner said his rebates stimulated adding another Dynasys APU on a new truck. For efficiency and cost savings, he also considered trailer skirts. As to electric power in general, "It is superior when parked for cab power, charging batteries, and hotel loads. Propane and natural gas are not moving into the market fast enough." Lastly, he said transition to shore power may be hindered because, "Truckers are set in their ways."

Fleets

Fleets primarily chose to install battery HVAC systems, and 79% of the rebated fleets with more than 10 trucks purchased them. Batteries HVAC system can be more costly than diesel APUs, but the equipment may have appeared to offer better returns on investment, including lower fuel and maintenance costs (NREL 2003) than APUs, and zero air pollution. At the time when rebates were offered, APUs were often perceived as unreliable based on poor experiences with some models.

Fleets tended to fall into three categories regarding shore power. Some wanted their drivers to use the service as much as possible because it was clean and reduced their carbon footprint. These fleets were often SmartWay™-Certified. Some fleets did not care if their drivers used shore power because they were only interested in fuel cost reduction and regulatory compliance on existing trucks. Some used rebates to reduce the cost of new vehicles which were already ordered with the specified equipment.

Fleets have inherent operational limits that tend to prevent their drivers from using shore power.

- There are too few sites.
  - Routes usually cannot be changed to include truck stops with TSE.
  - Drivers are not allowed to drive out of their way to get to a Shorepower site because it wastes time and fuel.
- Driver training is required, but driver turnover makes training more difficult and costly.
- To ensure driver compliance with idle-reduction, fleets might use incentives and disincentives, but enforcement and management of these would incur additional costs.
- Many fleets do not track where drivers stay overnight. This is apparently not a concern.

Five fleets were interviewed. Here's a summary of the discussions.

Fleet 1 received rebates for 17 IdleFree Battery HVAC units and installed 11 connection kits.

The fleet manager had limited time for the interview when scheduled, but made these statements: "I do not know what the drivers are doing and don't keep track;" "Some had bad experiences early on finding available pedestals."

Fleet 2 received rebates for 37 Carrier TRU units and 45 NITE battery HVAC units, and installed 19 connection kits.

This fleet is very supportive of shore power because, "We must reduce our carbon footprint. Something has to be done in the next 5 years." The fleet manager said they have been adding trailer skirts, teaching shifting techniques to their drivers, and showing them how to save fuel. "We look at fuel economy, emissions, and economic efficiency altogether." His company has plans to put shore power in their yard and is looking for grant support to do so. Nonetheless, he stated, "I wouldn't have gotten (the equipment) if rebates weren't available."

The manager said they'd prefer to use shore power, however, "we cannot alter routes (to get to TSE sites) because we minimize miles travelled and don't allow our drivers to go further." He said, "I wish there were more shore power options available but, "our drivers have to get the load there on time." When asked about reserved parking, the manager said his company would like to have reserved parking at truck stops, and would "pencil out the costs seriously to see what we could afford."* He said this would help with driver comfort and driver shortage.

Fleet 3 received rebates for 8 NITE battery HVAC systems for flatbed trucks.

The manager stated that his company got batteries, "so that (drivers) would not have to plug in." He expected them to last 10 - 12 hours. He felt there was no need to do any more "green upgrades" on these eight trucks because "they are new and efficiency upgrades are all standard." In the future, this fleet has green investment plans for adding reduced rolling resistance tires or extra wide tires to their fleet. When asked about the benefit of rebates, he said, "The rebate program worked well, but the single biggest improvement in efficiency was less idling."

Fleet 4 received rebates for 10 Kidron cold plates for reefers, with electric standby.

The fleet owner was very happy with the rebates for his trucks. He said "We don't need shore power because we carry shore power with us. My trucks are out and back and plug in at home. We don't need to plug in or run a ThermoKing." Last, he said he "feels set" and has no other plans for green improvements to his fleet.

Fleet 5 received rebates for 25 Diamond Power APU units. *Unfortunately, this fleet opted to replace all of the Diamond Power units with a different brand APU because "they blew up left and right," according to the fleet manager.*

Initially, the fleet manager expressed that he thought it was cheaper to run the diesel APU than plugging into shore power. He believed his APUs consumes 1 cup of fuel per hour, and consequently believed the price of $1.00/hour for Shorepower is too high. However, independent studies show, diesel APUs can consume anywhere from 0.1 to over 0.5 gallons per hour according to truckingefficiency.org, depending on type and load. He also has fuel-fired heaters and inverters on board his trucks as additional power options. He said he encourages his drivers to use all the Shorepower sites in his state and to plug in; "Some do, but the majority doesn't." When asked about making reservations at truck stops he said they would more than likely do it, and added there needed to be a fee paid upfront to ensure the space is actually used or it is forfeited.

When asked about plans for making the fleet more 'green', he said that all trucks are SmartWay™-certified, and any new trucks will be also. His trucks have electronic cut-off switches that shut down the engine if it runs more than 10 minutes, and drivers are told to shut down an APU if it's not needed. His company tried using battery HVAC equipment, but batteries didn't work for them. "The air conditioner can't keep up in extra heat; (the batteries) only have 5 – 7 hours of life."

Truck stops

Other TSE studies over the past decade have sought input from fleets and independent drivers, yet truck stops are critical partners in any TSE development. They must provide permission to build on their land, extend staff time to communicate with and assist truck drivers, and actively reach out and market the services. Revenue from TSE is insignificant compared to other truck stop services, so it must be perceived as providing other value to customers or a competitive advantage.

Managers or owners of several TSE sites in this project were interviewed to capture their experiences and perceptions of their shore power system. These particular sites were selected because they were popular with shore power users. The intent was to elicit constructive feedback from those who'd given more thought to their system and to TSE in general. Interview questions are in the Methodologies section of the Appendix.

Summary from the truck stop perspective

According to truck stop owners and managers, TSE will find acceptance among truck stop owners, and it will expand because of evolving business needs not because of an interest in idle reduction and air quality. TSE is perceived as an amenity for customers that will make a truck stop more competitive than its neighbor. It also attracts a different type of customer, recreational vehicles (RVs), which is a selling point for some truck stops. Truck stop managers/owners predict that fleets, especially large national companies, will drive of TSE expansion once they learn about the savings and acquire trucks outfitted with TSE connections. Last, they said the most important hurdle to overcome now is simply the lack of driver knowledge about what TSE is, is how to use it and the potential for savings.

Truck stop interviews

Dysart's Service, Bangor. Maine (independently owned truck stop)

Tim Dysart, Owner and manager

Mr. Dysart said shore power use at his truck stop would be higher if three hurdles were overcome:

- He wants signage on the interstate (I-95) that includes mention of shore power availability. He said another truck stop nearby has their IdleAir facility advertised and it seems to help them attract customers. He also wanted advertising that communicated that shore power was "not just for trucks but RVs too… we get a lot in here."
- "It (downtime) was bad this winter when it was really cold." Most likely due to a wireless antenna that was covered by snow.
- Awareness of shore power: what it is, and how to use it. These are the most common questions drivers have. In this case, onsite dedicated personnel would help education and outreach efforts.

When asked if he thought idling was a problem he said yes. "We need to give people an option so they don't have to idle. (Shorepower Technologies) needs to go to fleets and tell them to make it easier for their drivers (by paying for their use of shore power). Fleets should also buy trucks with everything electric on board." If this happened, he said the future of TSE would be assured.

National franchise truck stop in Texas

General Manager

This manager said that the biggest hurdle to increasing shore power use was, "Getting fleets in the know, and that (shore power) is great for RV customers too. The word just needs to get out." To reinforce this, he said the most common question he gets from drivers about the pedestal installation is "What is it?" He recommended that parking spaces be marked, including on the pavement in front of the space, so it was easier for the driver to see. However, he said the company would need to be approached at a higher level for permission to mark spaces because it is not now allowed.

The manager said that idling was not a problem for his customers. As to idling's impact on air quality, he said that "we should move in the right direction for the environment on what we can control; that's definitely a position for truck stops." He said his site offers blended biodiesel as well as shore power for this reason, and he added, "Our role is to give the customer the option." He believes that environmental concerns will continue in America's future, but that "trucking will also want the least cost." When asked if parking could be reserved at shore power spots, he said his company was considering it but "manpower is the issue." It's an added cost that would need to be covered by fees.

When asked what he thought of the future of TSE, he responded that it was better; "It's going in this direction." As to the future of TSE at his site he said, "I want to diversity my place and have the

option (of shore power) here instead of across the street. At the end of the day, I want to make the customer happy and the company happy."

National franchise truck stop in the Southeast

General Manager

This manager said the biggest hurdle to shore power use is simply lack of knowledge. The most common question he gets is "What is it?" He said, "Educate the driver that it's available. If they use it once, it's easy." In this interview, the manager expressed some confusion himself about using shore power, and claimed that managers should be better educated also. Last, he expressed a desire for more Shorepower signs at his site: directional signs, entrance signs, interior signs, etc.

When asked if he thought idling was a problem and if truck stops have a role in reducing idling, he said, "It's really an EPA problem to reduce pollution, but I look at idling as a truck driver issue. The noise affects other drivers and makes it hard to sleep." Idle reduction is not the role of the truck stop, he stated. "It would be nice but it's not high on my list of priorities."

When asked about the future of TSE, this manager focused on the role of fleets and reserved parking. "I think (shore power) will spread when big fleets like Schneider and JB Hunt decide they want it. They are 80 – 85% of my business." He also said the company was expanding its existing reservation system, and commented that reserving spots at power pedestals was "a great idea." This manager said he was going to look into designated parking for shore power after having thought about it during the interview.

Independent truck stop in Western U.S.

Owner and manager

This owner said that TSE would not be widely adopted until fleets required their drivers to use it. He said he didn't know why they haven't figured out that the cost is cheaper than idling. "It's a great idea but I don't know why everyone hasn't jumped on the bandwagon." He intimated that his state had a regulatory attitude, and he anticipated "this Governor will someday require no idling, and then people will be scrambling for options." While he does not believe that truck stops have a responsibility for idle reduction, he believes that shore power is an option he should make available for customers.

"Shorepower is a little before its time. People always complain about costs, but here's something cheap and good for the ecology," he stated. He also said he would be glad to reserve spots for anyone who wanted to use shore power as long as they were a customer and not just someone looking for a place to park. He speculated he would need to get a staff person to put out cones and monitor the spot to ensure someone didn't take the cones or just drive over them.

The owner made some tangential comments about why he wanted the Shorepower system on his site and not another type of TSE (one that he complained required an expensive "erector set"

structure and a permanent lease). He said this limits his ability to be flexible with his property. He stated that the current lease is flexible and the system is more easily installed and expandable. The owner said he'd even thought about extending it into an adjacent lot and creating an RV park.

Parking reservations

Some truck stops have been reluctant to set-up a paid parking reservations service, though it is currently being reconsidered by all the major chains. Resistance arises from multiple concerns; it takes extra staff time; it may result in confrontation with some drivers; parking barriers may be damaged, stolen, or moved; and it is has been unpopular with some customers. However, interest in reserved parking was brought up by the owner-operators who were interviewed for this study. One was willing to pay $12, another was willing to pay $25. Regarding reservations:

"I would only be able to pay out of pocket if the site had superior services, plus a shore power plug-in available."

"I would be willing to update equipment to some sort of shore power if more stops offered it at a reasonable rate."

Rebates

Analysis of a baseline Average Truck

The 4,462 rebate applications included information provided by the applicant on their truck and operational quantities. This information was averaged, and the resulting figures were compared with published figures. (Published figures were drawn from traditional surveys as well as "rule of thumb" or commonly accepted figures discussed in trucking industry periodicals.)

TABLE 4 – Comparison of reported data with published data

Average Truck (reported figures)[2]	Published figures
2218 hours idling/year	2000 hours
6.4 mpg	6.6 mpg, at 80,000 pounds GVW[3]
19,122 gal/year	16,700 gal/year[2]
122,381 mi/year	100,000 mi/year
13.3% time idling per year	10% time idling

[2] Data reported by rebate recipients (n = 4462)

[3] NREL "Reducing Fuel Consumption through Semi-Automated Platooning with Class 8 Tractor Trailer Combinations", Control vehicle, (average truck 100,000 miles/year @ 6 mpg, 16,667 gal/year)

Average Truck calculations:

= 2550.7 gal/year while idling (2218 hr. x 1.15 GPH[4],[5],[6]) GPH = 1.15 gal/hour with load

= $9820.20/year fuel cost while idling engine w/load (HVAC), (2218 hr. x 1.15gal/hr. x $3.85/gal[7])

= $1835.70/year, maintenance cost while idling ($0.015/mile[8] x 122,381 mi/year)

= 13.3% time idling in a year ((2218 hours x 1.15 gal/hr.)/19,122 gal/year x 100%)

Assumptions for the study period: 1/1/13 through 2/28/15:

Diesel price average $3.85/gallon

Each plug-in event averaged 12 hours (see CHART 3)

Engine maintenance costs: $0.015/mi

APU fuel use and annual maintenance[9]

Diesel APU maintenance cost: $0.34/hour

APU fuel use/hour, high side is 0.30 gal/hr., low side is 0.26 gal/hour

Hourly costs of Idle Reduction Technologies (IRT):

Based on published data and on findings from this study, the hourly operating costs of idle-reduction technologies are compared with an idling tractor engine.

Hourly Costs of Idle Reduction Technologies

$4.01 /hour - Diesel engine, idling (fuel plus maintenance [1],[2],[3],[4])

$1.85 /hour – IdleAir TSE ("average" from IdleAir personnel)

$1.49 /hour – APU under load (AC, heat), (incl. fuel plus maintenance [1],[2],[4],[5],[6])

$1.33 /hour – APU, no load (includes fuel plus maintenance [1],[2],[4],[5],[6])

$1.08 /hour – Shorepower TSE (from website plus set-up fee for 12 hr. period

[4] Argonne National Labs, Linda Gaines, pers. comm., and her spreadsheets for calculating potential savings from reducing the amount of idle time of a Class 8 tractor

a. "Idling Reduction Savings Calculator" http://www.transportation.anl.gov/downloads/idling_worksheet.xls

b. "Idling Reduction Savings Calculator" Worksheet: http://www.transportation.anl.gov/pdfs/idling_worksheet.pdf

[5] Technology Maintenance Council *"Analysis of Costs from Idling and Parasitic Devices for Heavy Duty Trucks"* 2003, Technology & Maintenance Council, American Trucking Associations.

[6] Development of a NOx Verification Protocol and Actual Testing of Onboard Idle Reduction Technologies, Zeitsman, revised Jan 2012, p. 28, Texas Transportation Institute, College Station, TX

[7] U.S. Energy Information Administration: Data, Petroleum and other Liquids, average from Nov 2012 through Feb 2015.

[8] Shore power user case study: Annual maintenance/repair costs for Cat-15 650hp engine, running 163,000 mi/year, $0.015/mile

[9] APU dealer, pers. comm. and Shorepower customer case study

Annual APU maintenance costs	$675.00
Idle hours/year	2000
$/hour, fuel plus maintenance	$0.34

CHART 8 - Rebate recipients - Approximately half of all rebate recipients were owner operators with 3 or fewer trucks.

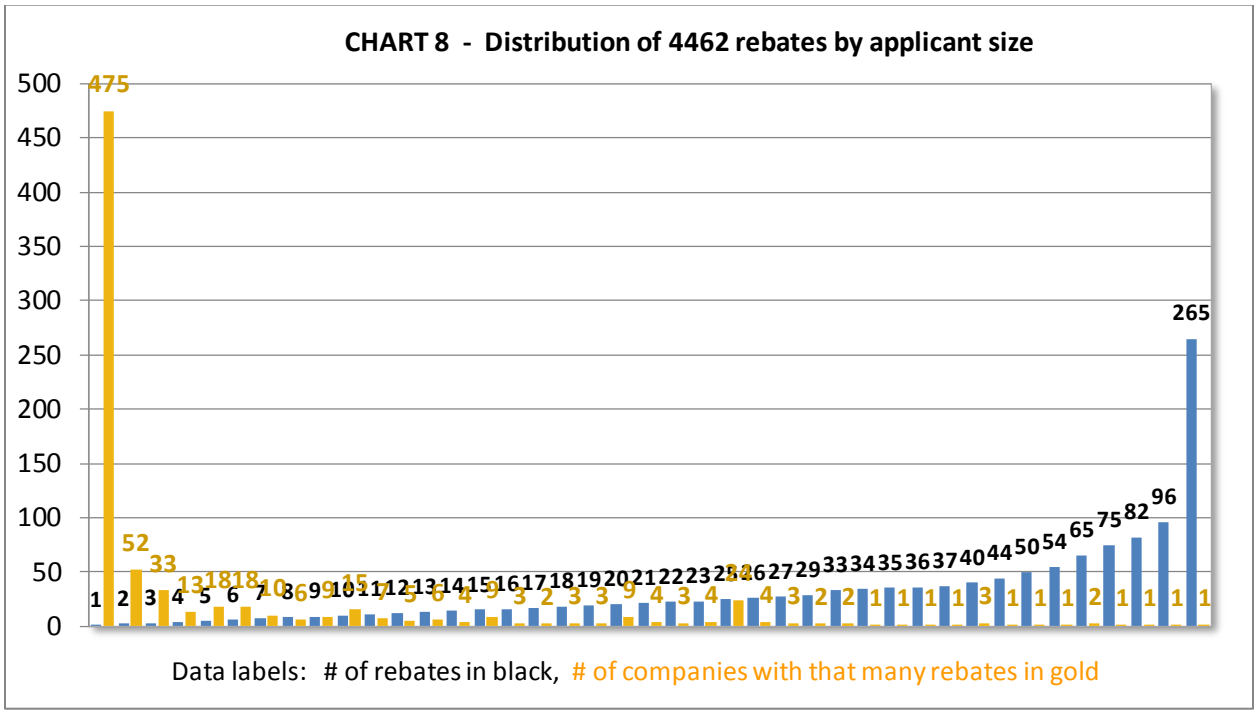
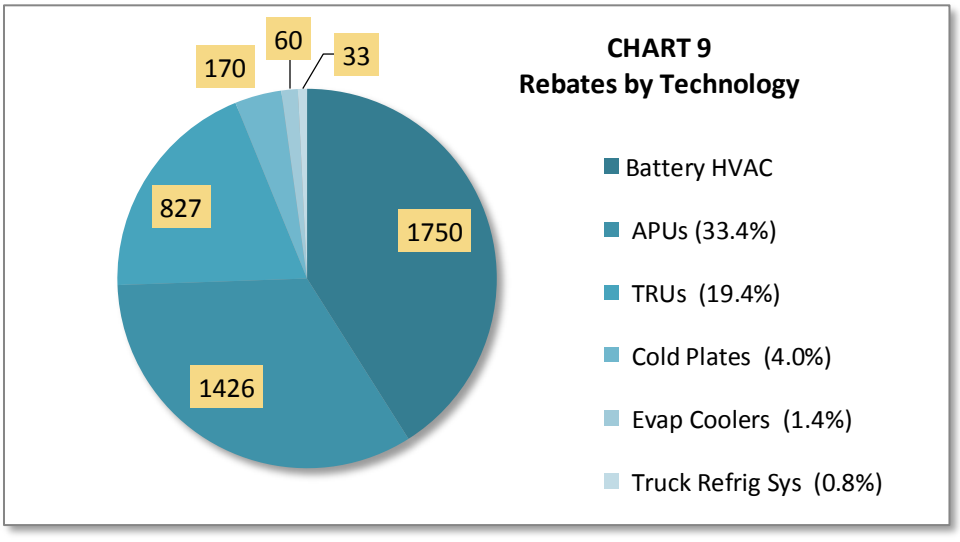
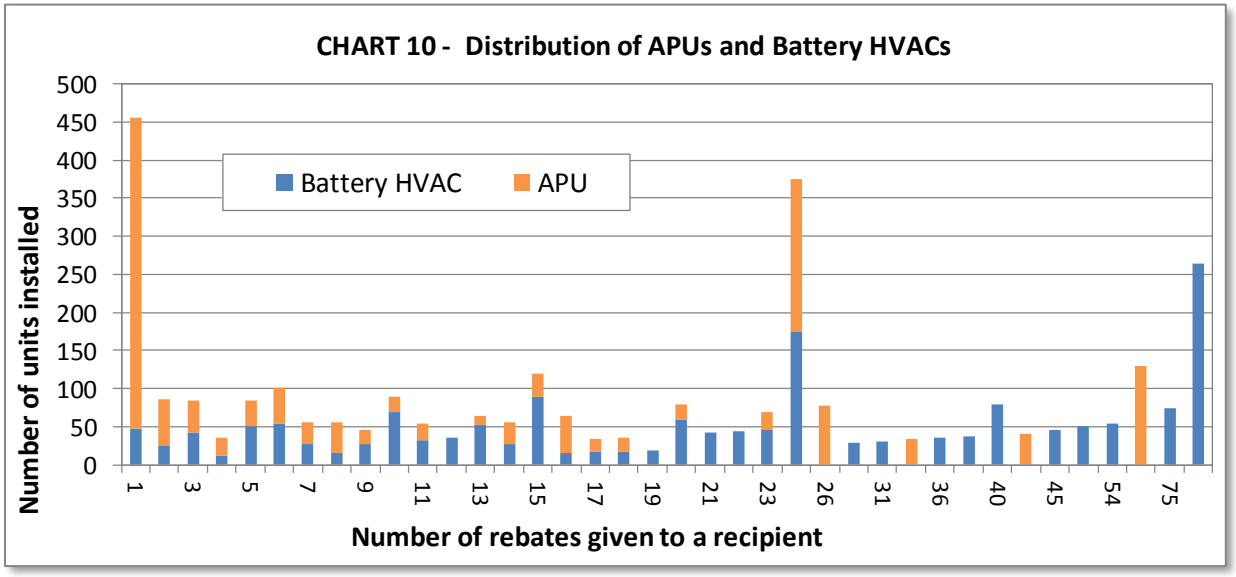


CHART 9

Of the equipment disposition, 38% of all rebates for APUs went to small owner operators (with 1 – 3 trucks), and 79% of all battery HVACs went to fleets of ≥10 trucks (average fleet size among recipients was 37 vehicles, median was 24).

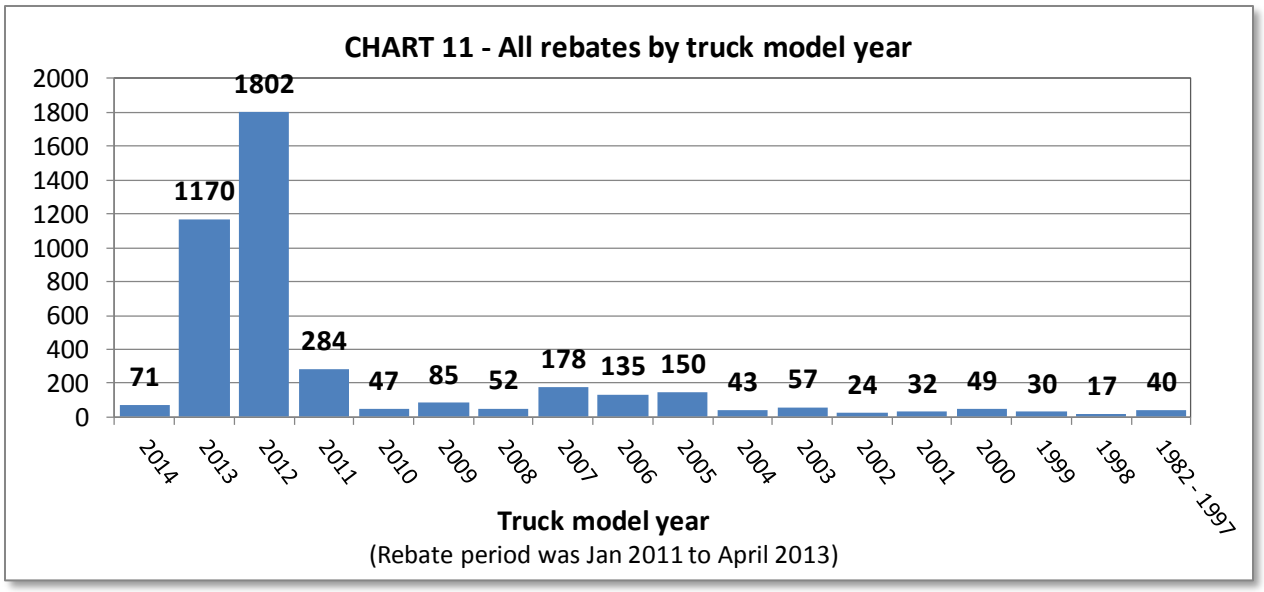


Most rebates were used to purchase two equipment types: battery HVACs and diesel APUs.

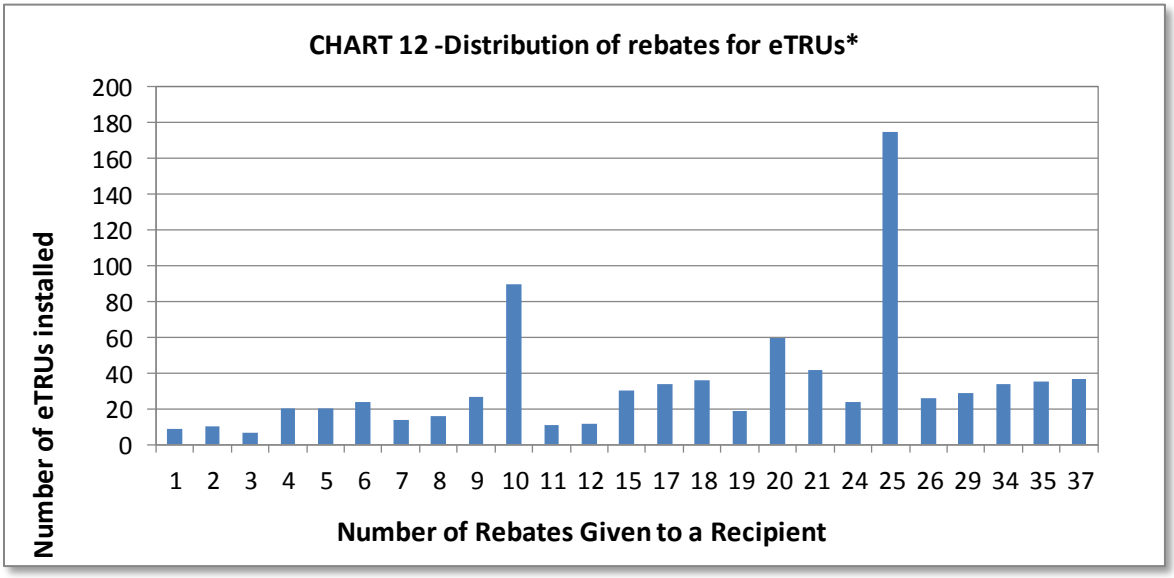


The noticeable spike at 25 represents seven companies who applied for 25 rebates each. This appears to be a preference for choosing blocks that are multiples of five. There are small spikes at 5 and 10 truck projects also. The same 25 rebate spike appears on CHART 12 depicting the distribution of eTRUs (electric Transportation Refrigeration Units).

Owner operators with APUs are not dependent on electric standby power even if it is available, but they nonetheless represent the “early adopters” and regular users of shore power. This may indicate that sensitivity to cost is higher. Conversely, fleet trucks’ battery systems benefit from standby power when battery capacity doesn’t meet the power demand in an average 12 hour event. Yet fleets have not adopted shore power for multiple other reasons, even though cost and reliability are clear benefits.



Rebate equipment was primarily installed on new trucks that would already have been CARB compliant (all post 2007 vehicles). It was originally assumed rebates would be used to bring pre-2007 trucks up to compliance (and there is an uptick in years 2005 – 2007). Instead, most rebate applications were for blocks of vehicles that had not yet been manufactured. This caused delays in funding and other complications because the applications required a VIN for each vehicle.



*eTRU = electric standby Transport Refrigeration Unit. These were primarily distributed to fleets of ≥10 vehicles.

Connection Kits

Connection kits (shown in Figure 2 above) are small wiring kits that include a convenience receptacle (inlet) to plug an extension cord into on the exterior of the vehicle. The inlet is wired to outlets in the cab to allow the driver to plug in appliances, just like at a home. Out of an original 1050 kits:

- 421 were distributed and fully documented with truck registration cards;
- 99 were distributed with partial documentation;
- 352 small owner-operators were recipients, usually with a single vehicle
- 9 fleets were recipients, and they installed kits in at least 69 of their trucks
- 53 can be shown to have been used

By the study end date, February 28, 2015, fifty were in Shorepower's inventory and continue to be distributed, and an unknown number were at fleets and truck stops that were: asked to return them, distributed them to drivers or continue to distribute them to drivers. It is known some were simply handed out without documentation prior to Shorepower taking over the project. After the end of the project, remaining kits were sent to OOIDA (Owner Operator, Independent Drivers Association) for distribution to their members.

Host sites

The truck stops with grant-funded Shorepower installations are very diverse in size, location, ownership, and amenities. This study benefitted from comparing the diverse sites to each other. A clear pattern of characteristics emerged that appear to indicate where future TSE installations may or may not be financially sustainable. A consequence of not "cherry picking" host sites for high utilization was that some of the sites did not experience sufficient revenue.

Economic stimulus

Truck stop electrification development: $10,243,879.

- Construction costs: $4,844,774
- Operations & Maintenance: $5,399,135 (Shorepower staff, supplies, management, operations, maintenance, repair, outreach)

Idle reduction equipment rebate program: $39,676,205

- Rebates distributed: $9,976,205 towards the purchase and installation of EPA-approved idle reduction equipment, which generated 66,268 full time labor hours
- Cost share, $29.7 million - the amount contributed by independent truck owners and fleets to purchase and install idle-reduction equipment

Shorepower Technologies cost share: $262,917

Cascade Sierra Solutions overhead: $6,935,056

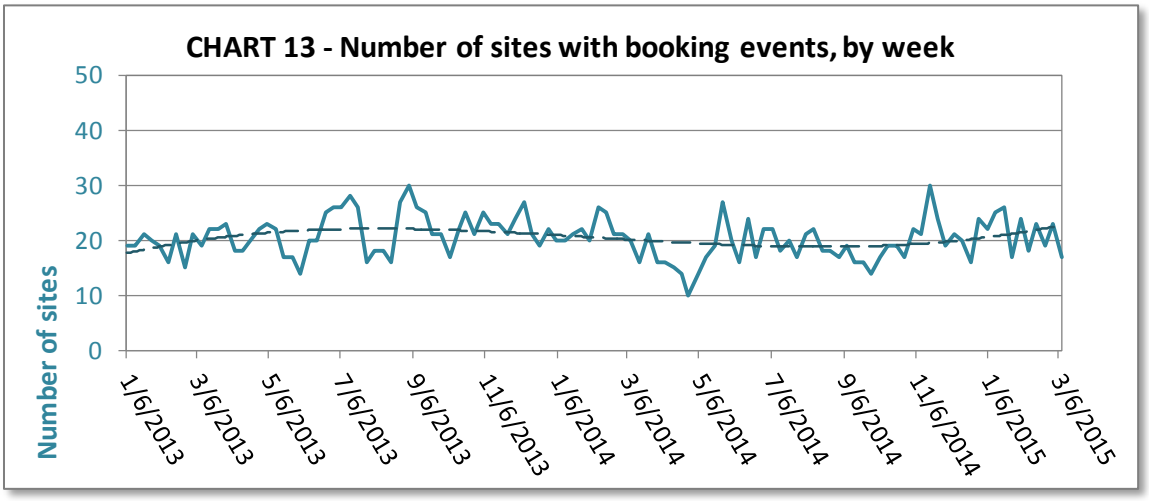
- Labor, office, administrative, marketing

Economic stimulus is measured by financial benefits directly to owners, and does not account for the "ripple effect" or secondary benefits to many other businesses. For both the TSE development project and the rebate project, other constituencies materially benefitted from this grant.

- Cascade Sierra Solutions' and Shorepower's staff
- EC, a construction and electrical contractor firm and the subcontractor that built the fifty shore power sites. Numerous local sub-subcontractors also worked on sites.
- Equipment manufacturers, such as: Carrier, IdleFree, ThermoKing, Hodyon, and Webasto.
- Equipment dealers such as: Champlain Peterbilt, NY; Landmark Trucks, TN; and Kenworth Sales, OR

Host sites

The truck stops with grant-funded Shorepower installations are very diverse in size, location, ownership, and amenities. This study benefitted from comparing the diverse sites to each other. A clear pattern of characteristics emerged that appear to indicate where future TSE installations may or may not be financially sustainable.



During some periods, only half of the DOE sites had hours-booked in any given week--a consequence of not "cherry picking" host sites for revenue potential.

There was also variation in how many hours were purchased at any one site, even accounting for seasonal variations. Among the Top 10 sites in terms of hours-booked, two types of utilization patterns were observed: 1. steady weekly bookings from multiple users; and 2. periodic bookings of a high number of hours from a small number or single user, often for multiple days.

Diverse characteristics of top 10 host sites

The ten sites with the highest hours-booked were diverse, which helped to narrow down the list of shared characteristics that point to criteria for selecting future TSE sites for use potential. Company size is not a key indicator of utilization potential. Steady earners among the 50 DOE sites include all owner types, large national franchises on major interstates with a host of amenities to small independent or mom-and-pop sites off the interstate with a popular local restaurant.

TABLE 5	No. of sites	Characteristic
Climate extremes:	9	Very hot summers
exceptional hot or cold seasons	4	Very cold winters
Ownership	6	National franchise
	2	Regional franchise
	2	Independent, "mom and pop"
Location:	4	Urban, suburban
Traffic density, population	6	Small town, rural

Characteristics of an ideal host site for shore power development

The site owner or manager is committed to idle reduction or TSE or both. Owners and managers at the best shore power sites expressed a belief that TSE is on its way and their customers will want and benefit from it. They also believe it is an amenity that gives them competitive advantage with the truck stop next door or nearby. With company commitment comes action: a point person is identified to answer customer questions, train employees on the system, and resupply brochures; the power pedestal site is mowed and weeded, and trash is removed; there is interior and exterior signage.

The host sites in this project with the highest shore power utilization had good signage:

- External: at the truck entrance, at the fuel island and a directional sign(s) in the lot. The signage was supplied free, but it was up to the host site to approve the number and location of the signs. Some designated spaces at the pedestals with "Shorepower Parking Only" or "No Idling" signs, or painted out "No Idling" zones.
- Internal: there was wall space for signs or maps, and brochures were visible and replenished.

The site is well managed in general: it is clean and well-stocked; it offers a variety of amenities; and staff are responsive to customers. Other than adding more new sites, on site personnel is perhaps the most important factor to attracting new users. Shorepower's long term business model is based on low operational costs; therefore, hiring full-time personnel for each site was not budgeted. However, due to high turnover it is difficult to keep the truck stop personnel trained; they also have many other duties that don't allow them to provide full attention to questions related to using Shorepower. Utilization would definitely benefit from dedicated Shorepower staff.

'Ample' parking: A 2006 Texas Transportation Institute (TTI) study (Zeitsman et al, Appendix) reported that that both Shorepower and IdleAir considered 75 spaces to be a minimum size, but this study found that sites with steady utilization had at least 100 spaces. Lot size is not the deciding factor however, but the number of vacant spaces at the power pedestals when the driver arrives. Lots in urban/suburban areas fill up quickly and pedestal spaces are usually full by 4 pm, but lots in less congested areas will have vacancies during the 4 pm – 6 pm time frame when most drivers plug in. As it turns out, many of the pedestal installations fill up quickly because they are the desirable spots; near the main building or located along the perimeter of the lot, often farthest from the entrance drive. Drivers have said this area is quiet, and trailers or exposed loads are safer from damage (such as for car carriers), and they claim they feel more comfortable with fewer neighbors.

Benefits to host sites

The revenue from TSE is low compared to other income streams at truck stops, but TSE might add to the suite of amenities that draws drivers to the same stop repeatedly. Feedback from Shorepower customers has highlighted additional benefits besides cost savings such as quiet sleep and clean healthy air. A TSE installation could become an amenity like Wi-Fi and many truck stops. Once enough are established, everyone else will need to meet customer expectations.

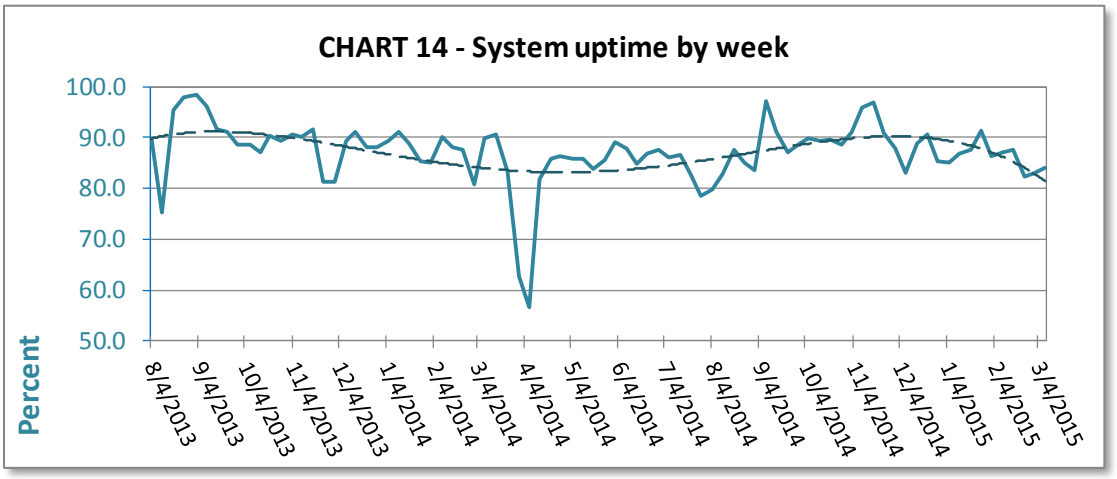
Other potential benefits should be investigated further:

- RV drivers also use shore power at truck stops. They report it is cheaper than a campground, and that truck stops are more accessible, and have more and better amenities. A couple of host sites are near or on the way to destinations popular with RV drivers and experience high utilization from them.
- Shorepower received inquiries from EV drivers who are interested in finding TSE locations in California to extend their range. This suggests co-locating EV charging stations in the auto lot at truck stops with TSE.

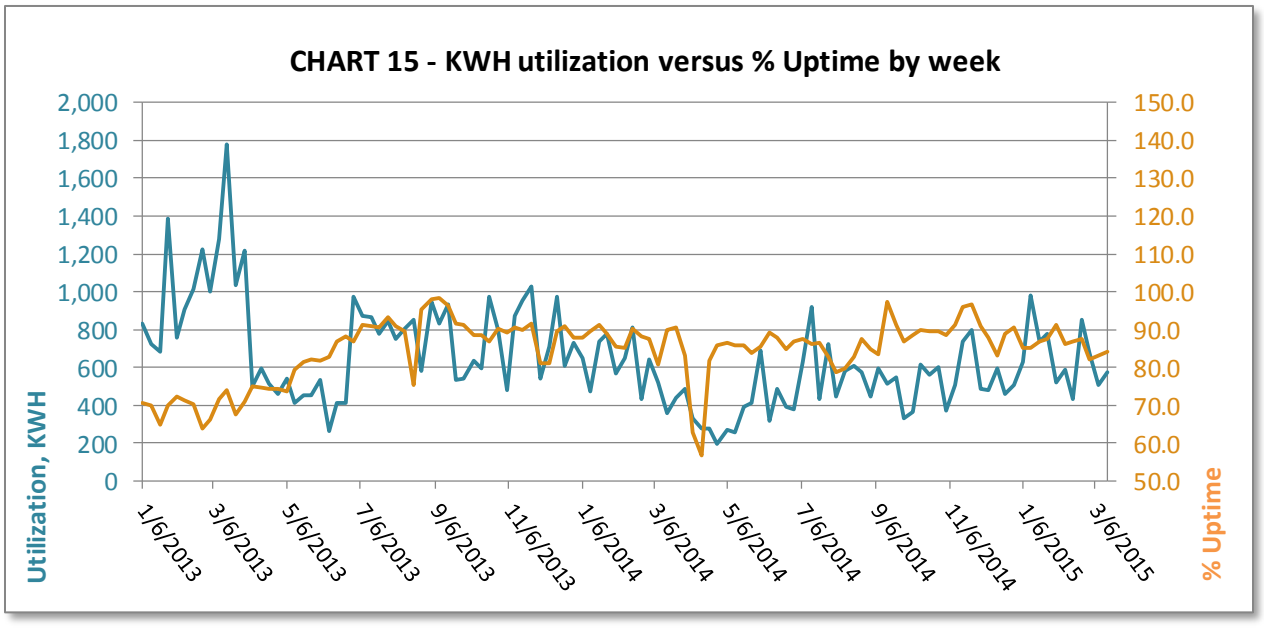
TSE System Operations and Maintenance

The TSE system originally developed by Shorepower started with 12 sites. These continued to be operated while new sites were being constructed. The complexity of building new sites and maintaining

them created technical challenges which may have impacted utilization. Yet these propelled important technical improvements. By late summer 2013, once all sites were completed and operational, many refinements and repairs had raised and stabilized system uptime.



Uptime is calculated by averaging all sites in the system. On any given week, usually 90% of the pedestals were operational; those that are 0% reduce the overall average. If nonoperational sites were excluded, uptime would fairly consistently be above 90%. The dip in April 2014 was related to third party hosted server issues. As a result, Shorepower moved to a more reliable server.



The "% Uptime" axis has been adjusted above 100% for visual reasons, to better reveal relationships.

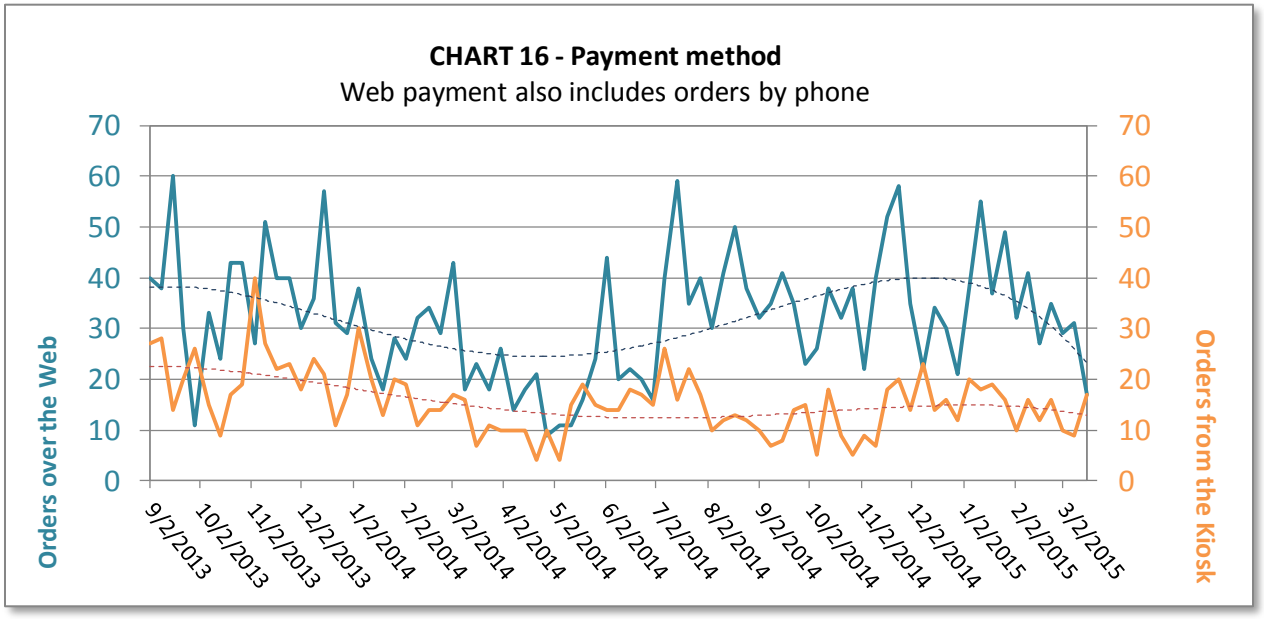
System uptime appears to influence the number of hours used per week, but the influence is not consistent. Seasonal utilization and power demand seem to have a greater influence. The server issues

in April 2014 coincided with an anticipated seasonal utilization drop in spring, so the correlation may not have been as dramatic.

Downtime resulted from lightening, trucks hitting equipment, and extremes of heat in the computer kiosk depending on where it is installed. Some outdoor kiosks were vandalized. Installations in rural areas had the majority of communication links challenges because the Internet Service Provider (ISP) itself was intermittent and unreliable.

One of the operational lessons from this project is that many system failures cannot possibly be anticipated. At one location, the construction of a new hotel next door to the host site blocked a wireless signal. An ant colony established itself in a power panel at another location, and shorted out the circuitry. Another site began construction to expand the parking lot without checking for underground cables, and cut Shorepower's power supply.

Payment methods



Drivers who booked shore power sessions preferred to do so via the website, www.shorepowerconnect.com, or via the toll free phone service. The answering service would make phone bookings on the web, but the majority of web bookings were made by drivers who used the website and not the phone. This fits a documented trend in trucker preferences for the use of technology to conduct business.

> *"The preferred mode of communication today was found to be the iPhone. Use of this device increased from 14% to 66% in just the past year. It was reported that 84% of drivers go online on a daily basis."*
> 2013 "King of the Road" survey by Atlas Van Lines (www.atlasvanlines.com)

Cash purchases were initially handled via sales of a gift card, but this was eventually minimized due to accounting complexities for the host site and the need for additional staff training, and because it was seen as extra work for the busy fuel desk. The biggest challenge with payment at the start of the project was fleet resistance to reimbursing company drivers who paid for shore power from their personal credit card. Fleet drivers often commented "it would save them (the company) money, but they're happy to pay for diesel." Comdata cards were eventually set-up for fleet accounts, which the driver could use for shore power expenses the same as fuel. This was widely desirable, but in reality is not highly utilized.

Education and outreach

Approach

> *"What is your main reason for reducing idling? "Save money on fuel", 71% "*[10]

It was hoped at the beginning of the education and outreach phase that high fuel prices would obviate the substantial cost savings from idle reduction and overcome resistance, so the strategy was to emphasize the monetary benefits over other benefits.

There were two challenges however. First, if a product has never been available before, it must overcome the inertia of habit and resistance to change. Truck drivers have *always* idled, even as fuel prices increased. Second, there was resistance to TSE because it had the gloss of environmentalism and regulation for some, and negative connotations in the trucking industry.

> *"…I will not pay for [TSE]. I am tired of companies [who convince] elected folks that everyone should be made to purchase their product because it's good for the environment".* [1]

Shorepower outreach

The company's outreach was originally aimed 80% at fleets (and rebate recipients) and 20% at owner-operators. As the project was underway, Shorepower reversed these percentages and focused outreach on owner operators because they were the majority of customers who booked with Shorepower. The most effective outreach to them was face-to face: Driver Appreciation Days, Grand Openings after completion of a new site, national trucking shows, and customers who were recruited to talk to fellow drivers. Drivers who were customers were quite effective at getting fellow owner operators to try shore power because it tends to be a peer to peer discussion rather than a sales pitch.

Shorepower's outreach efforts faced challenges.

[10] 2008 Washington State - Truck Parking Survey of truck drivers on Washington roads

- The time spent reaching out to fleets meant time lost reaching out directly to owner-operators. The message did not reach enough potential customers among owner operators during the project period.
- Several committed 'green' fleets were willing to try shore power, but the sites were not on their regular routes, and they wouldn't allow drivers to go out of their way to use shore power because it risked a late delivery. Drivers also have little incentive to plug in and save fuel since the fleet pays for it.
- There was a poor perception of TSE among some drivers that was based on negative past experiences. This derived from controversial practices of a previous TSE firm, such as blocking parking spaces to all but that company's customers. This is a challenging subject. Many drivers have difficulty finding parking, but TSE providers would like to reserve the parking for paying users. In the end, there is not ideal solution, until there is more available truck parking.
- The view of the pedestals is blocked by trucks, and the pedestals are usually in the far back of the parking lot. There is little opportunity to stumble upon or walk by them and be curious. Many times, we learned that customers and even truck stop staff were unaware that a shore power service was on site.

Cascade Sierra Solutions

CSS dissolved and went into receivership in February 2014. Subsequently, the project was novated (transferred) to Shorepower Technologies. The transfer of records and data was complete, but the transfer of project history, contacts, and established relationships was limited. The outcomes of CSS' education and outreach efforts are not addressed in this study.

Barriers

This project was not able to fully address the most-reported barriers to shore power use:

1. Too few sites;
2. Few sites on preferred routes;
3. Blocked access to power pedestals in the lot;
4. Inadequate face-to-face education and outreach efforts with the drivers that frequent stay at the truck stops with shore power installations.

Too few TSE sites

Nationwide, there are a total of 113 TSE sites in operation. In addition to the 62 sites operated by Shorepower, other sites are operated by IdleAir, AireDock, CabAire, and EnviroDock. By comparison, there are over 3000 truck stops in the U.S. (American Trucker, www.trucker.com), and TSE sites account for a tiny percentage. Major east-west routes in the Midwest and Mountain states have the fewest TSE facilities.

FIGURE 6

http://www.afdc.energy.gov/tse_locator/, U.S. DOE, Alternative Fuels Data Center

Truckers recognize the value of TSE compared with other options. In an article about the impact of anti-idling laws, Land Line Magazine authors articulated the need for more sites:

> *"Perhaps the least expensive idle-reduction equipment is wiring for truck stop electrification, but until there are tens of thousands of readily accessible parking spots, TSE without (onboard idle reduction equipment) is impractical."*
> Abelson, P; Jones, J; "Now who's blowing smoke?" Landline Line Magazine, Aug-Sep 2014

Not in optimum locations

As shown in **FIGURE 6** above, TSE sites are concentrated on the West Coast, and in the South and Eastern Seaboard. However, the majority of the 4462 rebate applicants did not identify major routes in these regions as their preferred routes. In the application, they ranked interstates they used with 1 being the most travelled and 5 being the least travelled, and identified the east-west interstates in the northern half of the country were I-90, I-80, and I-70, or the Midwest and Mountain states.

TABLE 6 – Where rebate applicants drive		
Overall Rank	Ranked 1st	Ranked 2nf
1	I-80	I-90
2	I-90	I-70
3	I-70	I-80
4	I-35	I-10
5	I-40	I-55

A national truck parking shortage

A January 2015 Wall Street Journal article covered the parking shortage problem.[11] "There aren't nearly enough legal, safe and well-lit parking places where truckers need them most. Meanwhile, safety regulators have increased enforcement of times that drivers must stop, park and rest. An informal Web survey in 2013 drew an outpouring of responses from nearly 4,000 truck drivers. Nearly 40% said it takes them, on average, an hour or more to find parking for the night. About 28% said they regularly or occasionally stay on freeway ramps; 52% said they pull up behind shopping centers, and 45% hunt for places like abandoned gas stations or vacant strip malls."

When desperation for parking leads drivers to unsafe, dangerous places, it is understandable that parking in a "Shorepower Only" space is not of concern. This shortage has been a problem for years. A 2008 survey of truckers in Washington State generated these results (n=473)[12]

How important is it for you to have truck parking along I-5, I-90, and/or I-82 in Washington State:

- "Very important", 62%;
- "Somewhat important," 10.3%

What are the major barriers you now face using existing parking on I-5, I-90, and I-82:

- "Overcrowded", 94.8%.

Electrified spaces are blocked by nonusers

Customers often expressed frustration that they couldn't access shore power pedestals because the spaces were blocked by other trucks or dropped trailers. Frustration was compounded if the drivers were not using shore power. Some reported asking drivers to move, and some did, or asking the general manager to get the driver to move. Truck stops are reluctant to offend or inconvenience customers, particularly if they made large fuel purchases.

Environmental benefits

GHG reduction and displacement of petroleum

From the formal study period beginning January 1 2013 through February 28, 2015:

- GHG reduction = **883.4 tons or 801.4 metric tonnes**
- Diesel displaced = **79,126 gallons**

This reduction in diesel greenhouse gas emissions derives from documented Shorepower booked hours only. A significant number of hours were not recorded when sites first came online and/or if communication to the server was lost, which sometimes happened during storms. Pedestals were

[11] "Too Many Trucks, Too Little Parking - New Rules Mandate Breaks, but Few Spots Are Being Built; Driver Deaths Cast Glare on Shortage", By Betsy Morris, Jan. 20, 2015

[12] Washington State Truck Parking Survey - Truck Driver Tabulation Report
There are a total of 473 responses FROM 03-Mar-2008 to 24-Mar-2008.

automatically put in “free” mode immediately after communication was lost. Power stayed on but the customer was not charged. Additionally, it is presumed the 4265 rebated units that were installed on trucks also resulted in additional GHG reduction, but usage data is not available. Calculations for GHG and diesel reduction are shown in the Findings section of the Appendix.

Conclusions

The STEP program confirmed that TSE is desirable and affordable for truck drivers, earning many devoted fans, but showed that deploying an additional fifty sites is insufficient to ensure that larger fleet customers can find and use TSE on a regular basis. There are more than 3,000 truck stops in the U.S. and less than 5% have some form of TSE or Shorepower. It is roughly estimated that there should be an additional 200 strategically placed installations to meet demand and build enough critical mass to reach a tipping point for mainstream adoption. The existing national TSE capacity, including that provided by other operators, does not meet the operational needs of nation-wide OTR truck traffic. That said, interest in TSE remains high and many industry insiders acknowledge it is only a matter of time before plug in technology becomes the norm.

> *"Shore power is the wave of the future",* fleet manager, anon;
> Idle Reduction Confidence Report, NACFE, 2014, p. 75

A case for expansion

From the truck stop perspective

Based on interviews with successful Shorepower host sites, there is strong interest in both serving the customer and in competing with nearby truck stops to attract customers. Host sites interviewed expressed a belief that TSE is on its way, that customers want it, and that offering shore power gives them a competitive advantage. In this early stage, the service may best be perceived as an amenity that will attract ancillary revenues in higher margin products such as food, drinks and accessories. A good analogy may be Wi-Fi at truck stops, which started as a paid service but is now often offered as a free amenity to attract customers.

> *"Jim Miller, owner of Ports to Plains Travel Plaza in Lamar, Colorado, said he sees truck stop electrification as a wave of the future.";*
> Eight Truckstops Join Network of Electric Plug-in Power Pedestals"**,** TruckingInfo.com (Heavy Duty Trucking), January 2013

From the driver, owner-operator perspective

Savings have now been documented and quantified for trucks that plug-in to shore power instead of idling. Customers have reported their preferences for quieter sleeping environments and better air quality. Many drivers started using shore power as a result of this project and will continue to use it for the foreseeable future.

From a fleet perspective

Adoption of battery systems is very high among fleets, and battery-equipped trucks with plug-in capability have strong customer potential because shore power can extend run times, especially for

battery HVAC systems. Battery capacity is not sufficient in all circumstances. There were reports during the course of this project that batteries didn't keep a cab air conditioned for a full 10 hour rest period. The 34 hour reset represents a greater challenge for battery systems that could be augmented with shore power.

CHART 17

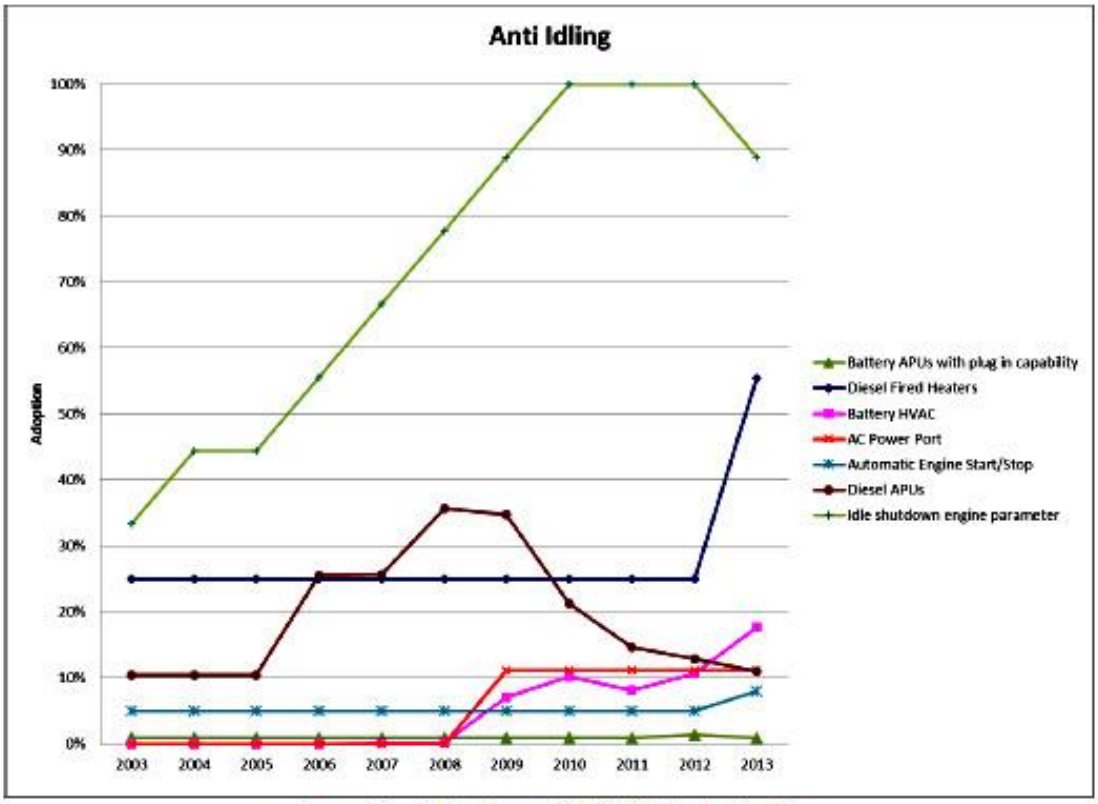


Figure 11: Adoption of Anti Idle Technologies

Technology adoption rate by major U.S. fleets.

2014 Fleet Fuel Efficiency Benchmark Study, NACFE, August 31, 2014, Jan Friesner and Mike Roethe –This paper also included adoption timelines for aerodynamic modifications for tractors and trailers, weight reduction, and component upgrades. Ninety-percent also adopted idle reduction consisting of engine shut off after a specified number of minutes.

Steps for increasing use of the system

Direct outreach to owner-operators needs to continue, and a marketing strategy revisited for outreach to owner-operators and fleets. If funds are raised to expand the network by 200 facilities, efforts should be focused on on-site marketing to owner-operators, early on and extend to fleets as the build out concludes. Large fleets need a larger network of facilities; therefore, it would not be efficient to market to fleets before most of the sites are completed. When working with truck stops, parking spaces must be clearly designated for users of shore power, but that can also include any truck that doesn't idle. Sites may decide to implement reserved parking and enforce them with clearly marked tow-away zones.

Current challenges

The industry focus has shifted from idle reduction to truck efficiency

The trucking industry expressed great interest in the option of TSE when STEP was announced in 2011 and injected millions of dollars into purchase of idle reduction equipment, yet the relative lack of infrastructure discouraged reliance on TSE as an idle reduction strategy.

If the results of the *2014 Fleet Fuel Efficiency Benchmark Study* (Freisner, Roethe 2014) represent the greater industry, major trucking companies and equipment manufacturers are now paying more attention to improving truck efficiency (mpg) when it is driving down the road, not parked. The upcoming heavy-duty truck fuel efficiency standards may also favor on-board fuel efficiency strategies, but it's important to recognize that some of these technologies have limitations. In particular, most on-board idle reduction technologies have limited capacity or consume petroleum. TSE can run indefinitely and produces little or no exhaust emissions or greenhouse gasses. Also, many on-board idle reduction technologies are compatible with shore power, making them a complementary strategy. New legislation to promote fuel efficiency should not favor any particular technology or solution. TSE should be included as an option to increasing fuel efficiency and decreasing petroleum consumption.

Fuel prices

Compared to the peak in 2008, the recent decline in the price of oil combined with accelerating economy has reduced the immediate financial need for improvements in efficiency or idle reduction, including TSE. However, global demand for petroleum is on an uptick and not expected to decrease in the long term. When prices rebound, demand for idle reduction technologies and TSE will increase relative to fuel prices.

Fleet drivers make the decision to idle or not, not the company

In formal interviews and informal discussions during the course of this project, Shorepower learned that fleets of all sizes often don't know where their drivers park overnight. An owner of one large national fleet said he encourages his drivers and teams to make this choice on their own, and simply incentivizes them with rewards for high average mpg. This behavioral approach may be worth investigating further.

Time to "Tipping Point" for TSE

It may be useful to compare the progress of TSE to other free market approaches to sustainability, or 'green' products and practices, and forecast when the all-important magical tipping point will arrive for TSE—when it is commonplace and people's behavior and choices change. The time period between the first introduction and initiative for the following green products, until they became widely adopted, took about 20 years. Each began in the same way: as an academic and government-funded studies that looked at the environmental implications of a practice, then worked their way through additional studies and projects to become bankable endeavors.

Industry	Time to reach tipping point (approx.)
Paper recycling and sales of post-consumer waste	23 years[13]
Lumber certification	20 years[14]
Compact fluorescent bulbs (CFLs)	21 - 25 years[15]

When did TSE start? The first on board shore power option was introduced by Volvo in 1996 on its VN models. The first TSE system manufacturers were IdleAir and Shorepower, which began in 2000. Assuming development capital needs are met, it is reasonable to anticipate that **TSE may come of age between ~2016 and 2020**. Why would TSE take so long to become widely available when savings are substantially more than those in each of the above 'green markets'? A 2014 study suggested that neither direct savings or personal motivation (the rightness of the idea) transformed industries, but ordinary concerns about financial risk:

> *"The findings from this exploratory survey study (n=1300) of factors affecting the acceptance of green products indicate that **consumers are more concerned with purchase risk than with product benefits**. Poor product performance/failure and risk of wasting money were rated most important factors. Peer acceptance and personalization were rated least important."*[16]

The outcome of a recent Department of Energy project may eventually erode concerns about purchase risk because it resolves one of the primary reasons for idling, air conditioning. Daimler-Freightliner designed the "SuperTruck" with electric-powered air conditioning. It is a proof-of-concept vehicle that may further open the route to viability for TSE.

"To a stock Cascadia tractor, engineers added "aerodynamic tweaks", a computerized powertrain management system, low rolling resistance tires, "*and electric subsystems for the power steering and air conditioning systems* (italics added)."[17]

[13] The Economist, June 7, 2007, "The Truth About Recycling"
[14] Forest Stewardship Council Report, 1994 – 2014
"US green building materials demand is forecast to increase 11 percent annually to $86.6 billion in 2017. Structural products (e.g. FSC-certified lumber) will grow the fastest." Freedonia Group Inc. 2013
[15] CFL Market Profile, U.S Department of Energy September, 2010
[16] (Drozdenko, Coclho, and Jensen, "Factors Affecting the Acceptance of Green Products", 2014)
[17] Hanley, Steven; "Daimler SuperTruck Doubles Fuel Economy To 12 MPG", http://gas2.org/2015/03/31/

Recommendations

"Advancements in the electrification of vehicles, as well as electricity-based idle reduction systems, improvements to battery techs, and other advanced components are emerging that may bolster battery HVAC and truck stop electrification. Electric-based idle reduction solutions could therefore be part of an overall sustainability strategy for the trucking industry in the long term."
"Idle Reduction Solutions Confidence Report July 2014"; NACFE, and Carbon War Room www.nacfe.org

The recommendations presented here are focused on the business aspects of TSE with the understanding that a national TSE system must be able to support expansion based on revenue. Capitalization cost is a major barrier; more investment investments must be made to reach the tipping point when TSE is considered an essential amenity.

"An overwhelming majority (88%) of fleets want truck stop electrification and (86%) would be willing to pay for it, according to a recent online survey of fleet managers and owner-operators."
"Most fleets express strong support for truck stop shore power, survey says", Jan. 1, 2003 | Bulk Transporter

Strategically expand TSE sites

It is estimated that there should be at least another 200 well-suited facilities to meet the operational needs of the truck drivers and fleets, and reach the critical mass needed to foster widespread adoption by large fleets. Future study might determine the best strategy for expansion:

- Concentrate sites on a very busy corridor and space them 100 to 150 miles apart, or
- Space sites no more than 500 mile intervals on Interstates nationwide, along routes used by large trucking fleets.
- Target locations where existing shore power users stop.

Select sites based on criteria in the Findings

The locations for new installations should be identified based on the criteria for ideal sites that are listed in the Findings, and the customers who use it, with a priority given to sites on with dedicated use by large fleets.

1. The site owner or manager is committed to idle reduction or TSE or both.
2. The site is well managed in general.
3. TSE is supported like any amenity: adequate internal and external signage, a "no idling" or "shore power use only" designation at the receptacles; reserved parking at the receptacles.
4. Site is not overcrowded and/or has the ability to reserve parking for TSE users
5. The site has an existing population of shore power compatible sleeper cabs that frequent the location.
6. The parking lot is over 100 spaces in size*

** Zeitsman J, Bubbosh P, Li, L, Bochner B, Villa JC, National Deployment Strategy for Truck Stop Electrification, Texas Transportation Institute, 2006*

It will be important to solicit information from large fleets about their preferences and interest. Truck stop investment in TSE onsite might be spurred by securing Letters of Interest from large fleets that are regular overnight customers. Increasing awareness of and need for TSE among fleets might be accelerated by initially focusing on EPA SmartWay™ trucking companies.

Engage truck stop owners upfront

Determine if they embrace TSE as an important amenity, and if they are willing to support it with staff time and marketing activities. This includes:

- Training new staff;
- Identifying one staff member to interact with the TSE provider on maintenance visits;
- Adding adequate interior and exterior signage, including directional signage;
- Demarking no-idling zones at the receptacles or limiting use to plug-in customers only;
- Providing 110V appliances for sale in the convenience store;
- Promoting the shore power service in company literature and websites.

Guarantee access

Shore power users want assured access and claim they are willing to pay for reserving a space (as some already do at TA/Petro stops). Reserved parking is worthwhile consideration for TSE, and the driver will still save money over idling. Establishing an idle-free or customer-only zone would be worthwhile, but this may need to be enforced.

Include electric power for passenger vehicles and future electric buses and trucks

A truck stop should consider including charging stations for all-electric vehicles (EVs) and RVs in the passenger vehicle parking lot. Electric power is a fuel choice that will experience increasing demand. EVs and RVs are already using shore power in truck parking lots when spaces are open, but this not advisable or workable at most truck stops. Although not common today, heavy-duty electric buses and trucks are being introduced to the market. With the grid based infrastructure in place, the shore power connections could be used for electric buses and trucks in the future. More than 30 sites have the higher powered eTRU connections for refrigerated trailers. This power level is sufficient to fast-charge batteries.

Incorporate other sites

Rest areas have always been popular for long haul drivers and anecdotal research suggests some drivers would rather park at rest areas and avoid truck stops due to overcrowded conditions, crime, and truck damage. Laws for non-commercialization at many state rest areas have previously inhibited development of TSE in these locations. It would be valuable to pass state-by-state waivers to allow parking lot receptacles for trucks and RVs, and capture a segment of the

driving population currently unserved, particularly in regions without full service truck stops. Waivers are possible—state transportation agencies currently provide them for vending machine operators for food and drink. TSE is simply vended power. This could be important to the long term success of TSE.

Trucks don't just park at truck stops. There many public and private distribution centers and warehouses, truck staging areas, ports and multimodal centers, and drop yards where a truck cab can be plugged-in for battery charging or temperature control without idling. Parking is temporary, yet trucks still need to idle for many hours waiting to be unloaded or loaded. Further study on the cost-benefits of parking electrification is merited here.

Future on-board equipment incentives

Future idle-reduction equipment incentives should include shore power compatibility that allows the equipment to operate on with electric power or the primary fuel; this give the operator more than one option. If diesel prices are high, it can be plugged in. If shore power is unavailable, it can run on diesel or batteries. Decreasing the number of cycles on the batteries will also extend the life of the batteries.

Future rebate programs designed to increase shore power utilization should require the use of TSE sites before receiving the rebate and/or link the use of shore power to the rebate value. This will ensure the fleets comply with the terms of the agreement. Also, rebate recipients should be selected based on their ability to access a shore power location. In other words, they should be prescreened to ensure they routinely visit existing TSE sites.

Consider the goods being hauled

Either approach must consider the dedicated routes of major fleets in that corridor or within that region, as well as the density of sites with respect to urban and rural areas. Market research should consider the goods distinct for that region or corridor. If there's high tonnage in fresh produce, then 480V AC power should be available for reefer eTRU units like the Carrier Vector. If most tonnage is in grain, than eTRU connections are not as important. This approach may draw a closer look when seeking support from fleets specializing in certain shipments, as well as the shippers they haul for. A SmartWay™-certified fleet, and a shipper that's minding their carbon footprint, will also be interested in shore power for meeting their environmental goals.

Consider unique situations

On an interstate that passes through an urban area, select sites located near the city limits on opposite sides of the city. Drivers can choose to avoid rush hour traffic when arriving or departing an area in either direction. Departures from a truck stop occur between 4 am and 8 am, and arrivals begin 12 hours later between 4 pm and 8 pm—both within the dreaded rush hour time frame.

Continually improve service

TSE providers, smart phone app, reliability, 100% uptime as reliable as utility itself, and rapid response to equipment failure, have payment options, cash, all fleet cards, PayPal, etc. It may be valuable to stay abreast solar technology to augment shore power some locations.

Connect shore power use to other benefits

Alternative energy programs

In some regions of the nation, onsite photovoltaic installations can augment the grid for shore power. This may become another 'green' selling point for SmartWay-certified operators.

Health care premiums

Reduced idling means reduced inhalation of carbon monoxide, particulate matter and nitrogen gases or NOx compounds, which are shown to cause cancer. Lab tests have shown that these gases are often found in the cab as well as in the ambient air of the parking lot.

> *"Men with the heaviest and most prolonged exposures (to diesel), such as railroad workers, heavy equipment operators, miners, and truck drivers, have been found to have higher lung cancer death rates than unexposed workers."*
> American Cancer Society Feb 2013

> *"This assessment also indicates that evidence for exacerbation of existing allergies and asthma symptoms is emerging"*
> EPA May 2002 Health Assessment Document for Diesel Engine Exhaust

Investigation is merited into health insurance policies with discounts for company health improvement measures. Documented use of shore power (or hours parked without idling) can be tied to an insurance premium discount for an owner-operator or fleet driver. There are multiple instances where improved worker health and safety lead to reduced health care premiums, such as for weight loss and smoking cessation. Non-smoking drivers and home owners already receive such discounts on auto and home insurance policies.

Earn carbon credits, reduce carbon taxes

Each 12-hour session using shore power when parked represents 0.12 metric tonnes of CO2, or one carbon credit (see calculations in the Appendix). If a truck idles while parked for the average reported 2218 hours, this works out to 22 carbon credits per truck per year. The market for carbon credits varies considerably depending on the market and legislative or regulatory actions. Price per credit has ranged from a high of $23/credit in early 2012 to a Q2 2015 price of $12.70/credit (California Carbon Allowance Futures). Carbon tax policy is under active discussion. Economic analysis of potential tax rates suggests the cost would be $24-$25 per credit* in 2015.

*Options and Considerations for a Federal Carbon Tax, Feb 2013, Center for Climate and Energy Solutions

Rethink the current business model for TSE

At this time, most TSE systems are owned by the provider, but in order to spread capital costs for construction of new systems, the provider could co-own a system with the truck stop, or simply manage a system for another owner for a fee or percent of revenue. Such a management service could include maintenance and repair, upgrades, billing, customer usage data, marketing, and reservation management.

TSE providers are joining forces

A not-for-profit group called TeamTSE.us has been developed to increase awareness and utilization of TSE throughout the US. Elements of our recommendations, particularly on the education and outreach front, may be carried by TeamTSE as resources are available. This group can help amplify the benefits of TSE and become a clearinghouse of information for investors and industry stakeholders.

Acknowledgements

Shorepower Technologies wishes to thank the many individuals and companies in the trucking industry who generously provided the information, advice, and constructive feedback that was used in this report. Your observations and insights helped us better understand the implications of the data, and develop realistic conclusions and practical recommendations.

Special thanks goes to the individuals who agreed to interviews used in this report: OOIDA, NYSERDA, Dave Magistrale, Newell Travel Center, Carrier, Pilot-Flying J, and Robert Prochaska at the National Renewable Energy Lab. Shorepower Technologies also wishes to thank its many dedicated customers who encouraged fellow drivers to use Shorepower.

APPENDIX

Introduction

Project Timeline

Project starts - May 2010
Rebate program starts – May 2011
Construction starts – June 2011
Formal study period starts – January 2013
Last rebates distributed – April 2013
Fiftieth truckstop completed – July 2013
Project novated to Shorepower – July 2014
Formal study period ends – February 2015
Final report submitted July 2015

Methodology

The following information was required of applicants seeking an equipment rebate. This was for characterizing or profiling users of shore power and tracking utilization patterns. The data is also a useful snapshot of the commercial fleet, and corroborates existing demographics. It also provided valuable information on preferred routes and preferred overnight parking spots.

Owner/Driver:

First Name, Last Name
Company, Address, Phone, Email
CDL License No. Exp. Date State in Which Licensed Vocation
U.S. Citizen? Minority-owned Business? Women-owned Business?
Date Submitted Step Id Idle Reduction Equipment? TRU? Install Cost Install Date
Invoice-Eqp Cost Labor Cost Total Cost Date
Rebate Amount Equip Model Serial No Invoice Date
Financed? Other Tech Installed?

Truck:

Vehicle Type Make Model Year GVW Current Mileage VIN State Registered
Engine HP Engine Make Year Fuel Usage Miles Traveled Current MPG
Estimated Idle Time Estimate Idle Percent of Engine Operation
Own/Lease Truck? Truck Lease Company Contact Address Phone
Own/Lease Trailer? Trailer Lease Company Contact Address Phone

Rank Preferred Routes:

R I90 R I95 R I25 R I80 R I75 R I5 R I70 R I65 R I40 R I55 R I10 R I35
Other Routes

Rank Preferred Overnight Locations:

Truck Stops	Staging Area	Rest Area	Empty Parking Lots	Loading Docks
Repair Facility	Fleet Terminal	Roadside	Other Stops	

Interviews with program participants

Fleet manager interview script:

The rebate program was intended to reduce truck idling and promote shore power. When you installed the idle-reduction equipment on your trucks, did your drivers plug-in to Shorepower or other electric source to avoid idling?

- ❑ No. What is the reason(s)?
- ❑ Yes: Great. Are your drivers required to use shore power when available? ❑ Yes ❑ No

Do you offer incentives? ❑ Yes ❑ No

Have your drivers altered routes or driving patterns to use plug-in power? ❑ Yes ❑ No ❑ unknown

Would your idle-reduction equipment be affordable if it didn't receive a rebate? ❑ Yes ❑ No

Which locations would be most useful to have electric power for your drivers if they wanted it?

❑ Interstates	❑ Near destination dock	❑ Near destination city
❑ Truck stops	❑ Rest stops	❑ Other locations?

Reserved parking spaces: Would your company consider a reservation service for guaranteed access to shore power?

- ❑ No
- ❑ Yes. If it's easy to set-up and schedule, would your company pay a small fee? ❑ Yes ❑ No

Do you have plans for purchasing new trucks or upgrading existing trucks for…? Please comment.

For energy efficiency?	❑ Yes	❑ No	❑ Not sure
For idle reduction?	❑ Yes	❑ No	❑ Not sure
Other?			

When is electrical power a superior energy alternative for the driver or your company?

Other than idle-reduction equipment on your trucks, what else would you do to reduce the use of diesel? And what would you need?

Do you have any comments or feedback on the rebate program and its goals of reducing idling by offering electric power service?

Independent owner-operator interview script

Since installing your (type of idle reduction equipment) have you used plug-in electric power such as Shorepower when parked?

If Yes: where did you use it?

If No: what is the reason(s) you have not plugged in?

Do you typically limit or avoid idling while parked?

If Yes, why:

❑ Save money ❑ Reduce noise ❑ Reduce engine wear ❑ Other?

❑ Health concerns ❑ Reduce pollution ❑ Reduce odor

If No, why not?

If you want to use shore power:

Which locations would be most useful to have it available? *Feel free to make recommendations.*

❑ Interstates ❑ Near destination city ❑ Rest stops

❑ Truck stops ❑ Destination Dock ❑ Other?

Have you ever altered your routes to use shore power? ❑ Yes ❑ No ❑ NA

If available, would you make a reservation for guaranteed parking space for shore power? ❑ Yes ❑ No

If yes, and if it's easy to set-up and schedule would you pay a fee? ❑ Yes ❑ No

Do you have plans for purchasing a new truck or upgrading your present truck for…?

❑ Energy efficiency ❑ Idle reduction ❑ Lower maintenance ❑ Other?

What are they?

When is electrical power a superior energy alternative for your business?

Other than installing idle-reduction equipment on your trucks, what else would you do to reduce diesel fuel, save money, and stay "green?" And what would you need?

<u>Truck stop manager interview script</u>

During the course of this project, we found there is indeed a demand for shore power, but too few truck stops have it to meet the need. Besides building more sites, what other hurdles must be cleared before shore power can become widely adopted?

What is the most frequently asked question from drivers?

The goal of installing shore power was to reduce diesel use by limiting truck idling.

Is idling a problem in your opinion?

Do you believe truck stops have a role to play in idle reduction?

Looking out into the future, what do you predict may happen with truck stop electrification?

At crowded truck stops, drivers who use shore power complain that spots are blocked by those who aren't using it. If your stop has too few spaces for the demand, are there plans to add spaces over all, or designate spaces for users only?

Drivers who use shore power tell us they would be interested in reserving and paying for a parking space so they could use shore power.

Would you stop consider designating reserved spaces at the shore power pedestals?

What would you need to implement this?

Please comment further on anything else you feel is important to truck stop electrification:

A sample page from the “Success Kit”, which was provided to truck stop management to aid them in promoting the shore power system on their site.

Consider creating a “no-idle” or “Shorepower-only” zone which may be marked on the pavement. We provide the Shorepower “S” paint stencil to you at no charge. Directing drivers to the plug-in stations and protecting spaces for drivers that want to plug in is a key to utilization.

SHOREPOWER TECHNOLOGIES

shorepower.com 503-892-7345

Calculations

GHG calculations

10.2 KWH average per event
0.81 KWH/hour = 10.2/12.6 average hours per event
1.08 gal displaced/hr. = 1.34 gal/KWH x 0.81 KWH/hr. (Fuel equivalent: - 1.34 gal displaced/KWH)
79,126.2 gal displaced = 1.08 gal/hr. x 73,265 hrs.
24.1 lbs. CO2/hour = 1.08 gal/hr. x 22.23 lbs. /gal (22.23 lbs. CO2 removed/gal diesel)
1,766,731 lbs. CO2 removed = 73,265 hours x 24.1 lbs./hr.
801.4 metric tons CO2 reduced= 1,766,731/2000 lb. /ton = 883.4 short tons = 883.4 x 0.907185 metric tonnes

- GHG reduction = 883.4 tons or 801.4 metric tonnes
- Diesel displaced = 79,126 gallons

Average Truck engine maintenance costs per year – based on reports from 5279 applicants for rebates and wiring adaptor kits. The results closely compared with reported annual maintenance costs provided by independent owner-operators.

2218 hrs. idling/year = Average of reported idling hours
13% time idling in a year, calculated
6.4 mpg = Average reported mpg
19,122 gal/year = Average reported annual fuel usage
122,381 mi/yr. = (6.4 x 19,122)
Engine maintenance: $0.025/mile (overhaul and oil change)
= $3060/year for annual engine maintenance = ($0.025 x 122,381 mi/yr.)

Calculations:
= 13.3% time idling in a year ((2218 hrs. x 1.15 gal/hr.)/19,122 gal/year x 100%)
= 2550.7 gal/yr. used while idling (2218 hr. x 1.15 gal/hr.)
= $9820.20/year fuel burned while idling, (2218 hr. x 1.15gal/hr. x $3.85/gal)
= 13.3% time idling in a year ((2218 hrs. x 1.15 gal/hr.)/19,122 gal/year x 100%)
= **$407 maintenance costs while engine idling** x ($3060 maint/year x .133 (% idle time))

References

Time to market for paper recycling, ~23 years
The Economist, June 7, 2007, "The Truth About Recycling"
1913 Am Inst. of Scrap Recycling

Efficiency is well underway with improved products
"Daimler SuperTruck Doubles Fuel Economy To 12 MPG"
Steven Hanley, http://gas2.org/2015/03/31/

To a stock Cascadia tractor, engineers added "aerodynamic tweaks", a computerized powertrain management system, low rolling resistance tires, "and electric *subsystems* for the power steering and air conditioning systems."

"AirFlow Trucks More Than Doubles Big Rig Fuel Economy"
Christopher Demorro, http://gas2.org/2014/01/07/
The Bullet Truck sports "a massive tapered nose and tire-hiding curtains;" uses LCD screens to replace electricity-hungry manual gauges; includes a hybrid air conditioning and power steering unit to reduce parasitic load; and video cameras replace the massive mirrors all semi-trucks currently require. That one change alone can result in a massive MPG gain."

Carbon credit benefits for truck stop and fleets

"TRANSPORTATION EFFICIENCY—Carbon Offsets from the transportation sector primarily focus on reducing emissions resulting from gasoline or diesel fuel used in fleet trucking operations. The two key strategies include truck idle reduction (where not required by law) such as with a truck-stop electrification project and efficiency upgrades to trucking equipment in order to improve fuel economy above prevailing regulated standards. In each case, reduced fuel consumption results in a reduction of greenhouse gas (GHG) emissions attributable to the strategy deployed."
See more at: http://www.b-e-f.org/learn/what-are-carbon-offsets/#sthash.tHl2hg7P.dpuf.
Bonneville Environmental Foundation www.b-e-f.org

Calculations:

1 carbon credit = 1 metric ton CO2 not released.
1 hour of Shorepower = ~1 gallons not burned
Since there are 22.23 lbs. CO2/gallon of diesel: 1 hour = 22.23 lb. CO2
Hours x 22.23 lbs. CO2 x 4.5359 x .001 = metric tonne
1 metric ton/(0.00045359 x 22.23) = 99 hours
1 carbon credit in 2015 = ~$12+/tonne (2015 figure)
Since sessions average 12 hours: **1 overnight session = .12 carbon credits = ~$1.30**