INSTALLATION AND ECONOMICS OF A SHOREPOWER FACILITY FOR LONG-HAUL TRUCKS

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ABSTRACT

Truck Stop Electrification (TSE) is currently being deployed to reduce heavy truck idling at truck stops and rest areas. Drivers of the nearly 500,000 long-haul trucks in the United States are required to rest for specific periods prescribed by the U.S. Department of Transportation's Hours of Service regulation. Idling increases fuel and maintenance costs, emissions, and noise. Recognizing these latter two concerns, local jurisdictions have developed regulations to restrict long-term idling. Several options exist to reduce idling; however, TSE demonstrates the potential for the largest pollutant and noise emissions reductions, the lowest operational cost to the driver and fleet, and the capability to displace the most petroleum. TSE supplies the driver with the cab heating or cooling and electrical requirements needed to maintain a satisfactory rest environment. A comparison between the currently available TSE systems was made and advantages of each listed. Issues surrounding the installation of a shorepower type TSE facility were illustrated and solutions proposed. Also, the economics for the installation of a shorepower TSE facility was presented and discussed. Shorepower TSE provides significant on-site emissions benefits over long-term idling. Additionally, the shorepower facility has a projected lower cost over other idle-reduction technologies, which provides users and facility owners an acceptable payback period. The information presented should be of interest to any organization looking to reduce long haul truck idling or long-term idling at freight terminals and warehouses.

KEYWORDS: anti-idling, truck stop electrification, shorepower

1. BACKGROUND

Truck engine idling is increasingly being recognized as a health and environmental problem and an energy use issue. Long-haul truck drivers typically idle their engines to heat or cool sleeper cab compartments, and to maintain vehicle battery charge while electrical appliances such as televisions, microwaves, coffee makers, and computers are in use. In colder climates, idling also keeps engine oil and fuel warm enough to prevent engine starting and operating problems.

According to a study conducted by Argonne National Laboratory (ANL), the average sleeper cab tractor idles for 1,830 hours annually, and consumes approximately one gallon of diesel fuel per hour; Stodolsky et al (2000). This extensive engine idling has drawbacks that include pollutant emissions, noise pollution, unnecessary fuel and maintenance costs, and driver discomfort. Key emissions attributed to diesel engine idling include; Tardif (1999) Lim (2002), Storey et al (2003):

Particulate matter (PM);
Oxides of nitrogen (NO_x);
Carbon dioxide (CO_2); and
Carbon monoxide (CO).

These exhaust emissions can affect driver health and job performance, which could negatively impact highway safety. Noise pollution generated by idling trucks can cause sleep loss, which can negate the targeted safety benefit of the new extended rest hours of the Federal truck driver Hours of Service regulation that took effect January 4, 2004; Federal Motor Carrier Safety Administration (2003). Noise pollution is especially problematic at large truck stops, where there may be hundreds of idling trucks; Woodruff (2003). Heavy truck engine idling can be virtually eliminated at TSE-equipped locations. TSE thus has the potential to improve environmental conditions at truck parking areas and the growing communities that surround them. This is especially a concern where U.S. Interstate highway corridors are heavily populated and have continuing concern with air quality non-attainment or maintenance issues.

Heavy truck idling is also attracting increased attention from state and municipal governments. Eighteen states and the District of Columbia now have anti-idling laws in place. Historically, drivers have viewed these regulations as punitive, and enforcement has been difficult due to a lack of alternatives. Gradual commercial market penetration of anti-idling devices and technologies promotes stricter enforcement and increased ticketing for idling violations. Legislation and enforcement, will in turn, encourages truck manufacturers, fleets, owner-operators, and drivers to consider alternatives to truck engine idling. A key factor in the move to anti-idling is the societal cost and benefit of the approach taken and its impact on the trucking industry, which is a key and growing element of the U.S. economy. Since TSE would allow the complete shut down of the truck diesel engine, quantitative air quality benefit factors have been developed and promulgated by the U.S. EPA that can now be used by air quality and transportation planning organizations in their air quality compliance efforts.

For purposes of distinction, TSE systems can be classified as "off-board" or "truck-board" depending on the location of the heating, ventilation, and air conditioning (HVAC) unit. The former is an external system that connects to the truck cab via a window or other access point.

An integrated off-board system consists primarily of an HVAC subsystem (heating/cooling/thermal transfer conduit) mounted off-board the tractor, usually on an overhead truss assembly. This system can also provide 120-Volt AC electrical power outlets as well as an entertainment package (i.e., Internet, telephone and cable television connections).

The latter system requires the combined use of truck-board equipment and facility power systems. It is referred to as shorepower since the electrical connection hardware on the sleeper cab and at the parking facility is very similar to that found at boat marinas. In fact, many of the component suppliers of shorepower TSE systems originated as marine suppliers, then transitioned into the Recreational Vehicle (RV) market, and are now embracing the commercial vehicle market. The shorepower system gives access to 120- or 240-Volt AC electrical power from a land-based electrical power source. Shorepower facilities can also supply cable television, Internet and phone connections.

2. TSE RESEARCH AND DEMONSTRATION

New York State has been leading the nation in Truck Stop Electrification and was the first state to install commercial TSE infrastructure; Perrot and Panich (2001), Perrot et al (2004). This includes the installation of the first three off-board TSE facilities, one with two years of operating data, and the design, installation and operation of the first prototype commercial shorepower facility, complete with a payment and control system, cable television, and communication interface. Installation of the first commercial shorepower facility in the United States was completed in May 2004. This facility is located in Wilton, NY, 30 miles north of Albany, NY. An early artist rendering of this system is shown in Figure 1. Figure 3 shows an example of the stationary TSE connection point hardware (“pedestals”). Further details and the advantages of this type of system are described in the paper. Of special note, the concept of a “no-idle zone” was also pioneered at this travel plaza.

3. SYSTEM DETAILS

New York State identified the opportunity to improve upon the commercial off-board TSE system and funded the development and deployment of a higher efficiency, lower-cost shorepower system. This led to the development of the Shurepower™ TSE system, the first integrated commercial shorepower TSE system to be introduced into the marketplace. This proprietary system includes a payment, operation, and control system to control services provided at the connection pedestals. Shurepower™ equipped parking berths are outfitted with a pedestal (Figure 3) that provides the connection points for the electrical and entertainment services. The pedestals are designed to accommodate a wide range of power requirements, including 20 ampere (A) - 120 volts AC (VAC), 30 A - 120 VAC, and 50 A - 240 VAC service. Since the market is in its infancy and standards have not yet been developed, several power connection options must be offered. The Shurepower™ design addresses the projected power requirements for cab power. The pedestals also have the appropriate connections for the bundled entertainment service (cable TV, Internet and phone) to make the driver’s rest period more relaxing and enjoyable. The vehicle accesses the service by using extension cable(s) to attach the vehicle electrical and entertainment wiring systems to the pedestal (Figure 2).

The kiosk and control system are centrally located in the parking area to make it convenient for the drivers to use. A small utility building/cabinet is installed adjacent to the kiosk to house the control PC and associated hardware, as well as provide environmental protection for the kiosk. The power and entertainment (cable TV, Internet, and phone) wiring are routed through the utility building, to allow for connections to the switching hardware (relays, network switches, etc.), and then continue on to each pedestal. Renderings of the kiosk and control building of a generic TSE installation are shown in Figure 2. Figure 4 provides a schematic of a generic facility to better understand the system layout.

Drivers initiate/terminate a session by using a single centralized kiosk user interface connected to a control system, allowing for unattended system access. This is an important feature since it eliminates the need for on-site personnel to assist with normal system operation. This design drastically reduces the system operation costs. The kiosk and control system were originally designed for unattended remote fueling stations, so the reliability and design are robust. In addition, this unit possesses many of the capabilities required for shorepower access and control. The kiosk unit includes a multi-line display, a keypad, a credit/debit card reader, and a receipt printer. The Shurepower™ kiosk required additional functionality and custom programming to accommodate the unique features needed by a shorepower TSE site.

To initiate/terminate service, drivers walk up to the kiosk and swipe their Shurepower™ member card encoded with their account information. The software authenticates the driver, requests their personal identification number, authorizes the financial transaction, and initiates a series of questions to determine which parking berth is being used, the type of service required (e.g. 20A/30A 120VAC or 50A/240VAC), length of stay, and other services desired (cable TV, Internet, phone). Once this process is completed, the kiosk initiates the session and switches on the power and entertainment jacks. The session is ended by the driver re-swiping the user card. The user's account is charged, and a receipt is printed. Future installations will continue to have a central kiosk, but will also include a wireless network connection (IEEE 802.11x) to allow drivers to perform these tasks from inside their trucks. This will allow drivers to initiate/terminate service and navigate the Internet without leaving their cab.

The control system uses a PC permanently connected to the Internet running proprietary software. The system interacts with the driver through the kiosk to perform the session initiation/termination procedure described above. The system acts on the user commands through an instrument control/data acquisition system that switches the power on/off via pedestal mounted power relays, activates the appropriate network port on a network switch, and records the power and energy usage on the PC from a pulse-type power meter installed in each pedestal. The power and energy data can be used for demand utilization and percent utilization studies to optimize the installation and for future installations. The control program is designed to automatically notify the system manager (e.g. property owner, truck stop manager-on duty) via email, phone, and/or pager in the event of a problem. The system can be remotely controlled or diagnosed by any authorized person with an Internet connection. This design will reduce service costs since software and hardware problems can be solved remotely without sending a technician to the site.

The initial Shurepower™ system design provides power for the truck cab only; however, system modifications can be integrated into the base system to accommodate electric-powered truck refrigeration units.

4. TSE SYSTEM COMPARISON

There are several fundamental differences between the shorepower (“truck-board”) and off-board approaches to TSE. Both approaches provide the truck with AC power, heated/cooled air systems, cable TV, Internet, and phone service. The differences come in the hardware required for operation, the initial costs (both for the driver and for the facility), the facility staffing costs, and the recurring hourly costs for using the services.

4.1. Off-Board TSE

The off-board TSE system is supported from an overhead truss assembly that requires a high capital investment and that may be visually intrusive to some observers. Each site requires a minimum of four weeks to install. The HVAC units are mounted on the truss assembly, with ducts delivering warm or cool air to the tractor cab. This allows minimal truck-mounted hardware alterations in the truck cab, but may allow high heat gains (or losses) through the duct and HVAC unit which are exposed to the outdoor ambient temperature.

Collisions with the bollards protecting the trusses and with the hanging units have been problematic increasing maintenance costs. Also, drivers have driven off with the units attached to their vehicles, activating the break-away system and disconnecting the head unit from the truss work.

The facility costs for off-board TSE installations are estimated to be over $23,000 per parking space, including the shared infrastructure such as control system, wiring, and electrical service, truss system, HVAC unit and duct system. The only initial cost for drivers is a $10 plastic template to mount the hardware in the vehicle window. The off-board TSE system requires on average 18 full-time support personnel per 100 spaces. These are mostly on-site personnel; however, it believed that a small fraction of this number is needed for overhead corporate support activities. This personnel requirement is necessary since knowledgeable staff are needed to assist truckers connect to the system to their trucks. The current design off-board TSE head units are relatively heavy and must be lifted and directed into a truck side window, which can require two individuals.

The hourly rates for the basic service including Internet, basic satellite TV, AC power, and heated/cooled air are $1.25 to $1.50. Additional entertainment services, such as additional TV channels or pay-per-view movies are available at an extra charge. Wireless internet service at the truck stop facility is an additional option which can be purchased at $1.25/hour, $3.00/day, or $70/year.

4.2. Shorepower TSE

Facility costs for shorepower systems are much lower than off-board systems, requiring relatively inexpensive power pedestals which are already mass marketed to the marina and RV markets, electrical service, and the control system, kiosk and utility shed. The cost per parking space is $3,500 - $6,000. The facility design is minimally obtrusive, requiring no large steel trusses or other hardware elements. As a result of the simpler design, construction can be completed in two weeks. The current system is designed to allow trucks to pull head in and back out. Concrete tractor wheel stops along with and the integrated bollard/pedestal design protects the pedestals from damage. The design and orientation of the pedestal ensures the extension cord used to connect the truck to the pedestal will pull out in the event the driver pulls away without disconnecting from the pedestal. Both of these features will decrease the unanticipated accidental damage to the hardware.

The full-service shorepower approach to TSE requires additional hardware on the vehicle to distribute the AC power throughout the cab. If tractors do not have a shorepower connection, the service can still be provided via wiring through the door jamb of the tractor. A better, long-term alternative is to upgrade the tractors with connection kits. The hardware can be as simple as a resistance heater for the cab and an engine block heater costing $150. High-end systems include an internal electric power distribution system with circuit breakers, a load management center, an AC electrically powered heating/ventilation and air conditioning unit, an inverter/battery charger, and AC convenience outlets installed in the cab. The hardware and installation of this system is $4,000 if installed as an aftermarket product. Costs for installation would decrease for Original Equipment Manufacturer (OEM) installations. Many truck manufacturers currently offer a shorepower option on new tractors. Shorepower systems can also be retrofitted to older vehicles to provide the same energy, environmental and cost benefits as OEM installations.

The trend of the trucking industry appears to be heading toward the “MorElectric Truck” systems in the quest to save energy by developing a more efficient over the road and parked vehicle. The “MorElectric Truck” will use an electric coolant pump, electric fuel pump, electric power steering pump, electric air conditioning compressor, and other smaller electrical accessories. It is anticipated that in the very near future, all tractor manufacturers will embrace and adopt many elements of this approach.

The hourly rate for shorepower service is $0.50 for basic 120 VAC power and $1.00 for 240 VAC service. Cable TV, internet, and phone are included as part of the service and are provided at no additional charge. Future installations will also have a wireless network connection (IEEE 802.11x) as a standard feature.

Table 1 provides a comparison between off-board and shorepower approaches to TSE.

5. ECONOMIC ANALYSIS

For idle-reducing technologies to be successful, the truck driver must be made aware of the long-term idling costs. Thus, the payback period for the shorepower-capable equipment has been investigated and was deemed acceptable based upon six variables. This paper defines these variables and the assumptions made to determine the payback period for the truck driver. Furthermore, to fully understand the economics of the shorepower facility operation, one must grasp the costs for installing the equipment at the truck parking areas. These costs have been separated into general utility and construction categories to signify the difference between the equipment and materials and construction activities. Because of a delay in construction, this paper looks only at the facility installation costs and compares these costs to other available TSE systems.

5.1. Payback Period for Truck Driver

For the truck operator, the payback period for the shorepower-capable equipment was the critical parameter for adoption of this technology and purchasing a complete truck-board shorepower package. The payback period is the amount of time required to pay for the truck-board equipment and TSE connection charges with savings from decreased diesel fuel and maintenance costs. By using a sensitivity analysis, the payback period was determined to be highly dependent upon six variables: (1) avoided diesel fuel cost; (2) avoided maintenance cost; (3) idling fuel consumption rate; (4) installed cost of shorepower package; (5) annual number of hours connected to shorepower to use the truck-board equipment; and (6) hourly service charge for shorepower services. Using industry accepted values for the first three variables (1) diesel fuel at $1.50 per gallon; (2) increased maintenance intervals plus additional wear and tear due to idling at $0.92 per hour (Tardif, 1999); (3) 1.0 gallons per hour consumed at idle; and projected costs and usage for the last three variables (4) $3,700 for an installed shorepower package; (5) using shorepower 1,800 hours per year; and (6) $1.00 per hour service charge for shorepower service, it was determined that a 17.4 month payback period could be attained by for the truck operator.

5.2. Detailed Shorepower Construction Costs – Wilton Travel Plaza

The construction costs for the Wilton shorepower project were based upon the construction drawings developed for the Wilton shorepower project, local labor, material, and equipment rates for adjusting the total direct cost. Table 2 summarizes these costs. Indirect costs such as permitting, engineering, and general contractor overhead and profit are based on a percentage of the direct cost as used in the construction industry.

The actual cost for the total facility installation was higher than shown in the summary table. Several items that will not be required in future installations were removed from this cost summary. These included: pavement and electrical connections, electrical redesign costs, and the need for a secondary survey because of other unrelated construction activity near the shorepower facility. Also, costs for research and development activities were also deleted from this cost.

Value-engineering efforts will reduce the significant over-design in the construction drawings as a second generation system is deployed. Economies of scale will also affect the cost per pedestal as it will be reduced as more TSE facilities are installed.

6. ISSUES

Several unanticipated issues arose to delay the deployment of the Shurepower™ TSE system. The installation of shorepower TSE requires proper planning to work with the local code officials to obtain permits for any site improvement activity or utility building construction. The Wilton shorepower project required frequent communication with the code officials to obtain permitting. Local code officials will be involved before subsequent shorepower project are planned and their schedules and deadlines known. This will ensure that critical dates are not missed and extended delays do not occur, which happened during the Wilton shorepower project.

Weather plays an important part in the installation of shorepower TSE. The current shorepower TSE design requires trenching and burying wire to deliver power to each pedestal. The trenching should be done during the construction season for the local area. This is necessary to complete the ground work prior to the ground hardening due to freezing conditions. In addition, if asphalt paving is required to cover up any trenching or to create any new parking spaces, this paving work must be performed while the local asphalt plants are open, which in the case of Wilton, NY, was not until late April.

Coordination and frequent communication with the utility companies is vital for any successful TSE installation. The landowner, or Truck Stop owner, must work together with the project engineer to identify an easement to the utilities and perform any necessary site preparations prior to installing a primary electrical service. For example, the Wilton Travel Plaza had leased land neighboring the Wilton shorepower project in the path for installing primary electrical service. This leased land was going to be graded, but not until after the Wilton shorepower was opened for commercial operation. Primary cable had to be routed around the perimeter of the leased land, since the local utility company would not allow primary cable to be buried in an area that was not within 6” of final grade. This extra primary cable added significantly to the installation cost. The shorepower project should be located as close as possible to the primary service location to reduce these costs. In addition, if installing secondary utility services like cable TV, Internet, or phone, all parties must be kept abreast of the project schedule early and often to allow for sufficient opportunity to schedule installation of the wiring and connection of service.

7. CONCLUSIONS

Shorepower TSE, now being commercially demonstrated in upstate New York, can provide significant on-site emissions benefits over long-term idling at a projected lower cost in all temperature extremes than other idle-reduction technologies. From preliminary projections, a significant decrease in energy use is expected. On-site emissions benefits for shorepower TSE are anticipated to be similar to the off-board TSE system. However, net emissions are expected to be slightly less since shorepower is a more energy efficient system. Data are now being collected to determine the actual emissions benefits of the shorepower system.

The reduced cost of shorepower facility construction and operation will provide users and facility owners an acceptable payback period compared to off-board systems. For this initial facility, installations costs were higher than expected due to unanticipated factors influencing the construction activities. The cost for shorepower TSE facility construction and installation is much lower than off-board TSE systems. With the current generation shorepower system design, the system cost is three times less than the estimated cost of an off-board TSE facility. With a second generation redesign, this cost advantage can improve to four and up to five times the estimated cost of the off-board TSE facility. These significant cost advantages permit the installation of many more commercial shorepower connection points than the off-board TSE system.

More data are required to confirm operational cost advantages of the shorepower design. To do this, operational data will continue to be collected from the Wilton Shurepower™ facility ensuring operation during all seasonal conditions to confirm the anticipated lower operational cost and energy use.

8. NOTICE

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Table 1: Comparison between shorepower and off-board TSE

		Shorepower TSE	Off-board TSE System
Infrastructure	Construction/Upgrades	Moderate	Extensive
	Aesthetic Impact	Minimal	Significant
	Actual Cost per Unit	$3,500 - $6,000+, depending on number of pedestals installed	$23,000 +
	Installation Period	2 weeks	4 weeks
	Maintenance & Operation	Low	Moderate
System	On-site Personnel	0	18 full-time per 100 spaces
	Difficulty of Installation	Low - simple plug-in	Moderate - may require 2 people to install
	Energy Use (per connection per hour)	0.5 kW to 4 kW	2.5 kW to 10+ kW: higher due to ducting losses, delivery issues, and overhead power requirements
	Service Cost per Hour	$0.50 for 120 VAC power to $1.00 for 240 VAC power	$1.25 to $1.50
	Environmental Impact	Both systems significantly reduce energy and emissions from diesel idling	
On-board	Engine & vehicle maintenance	Both systems significantly reduce engine maintenance requirements due to reduced idling	
	Fuel Savings	Both systems reduce diesel fuel consumption from idling by approximately 1 gallon per hour	
	Equipment Cost	$150 to $4000	$10 template

Table 2: Detailed construction costs for Wilton Travel Plaza shorepower facility

General Site, Utility Costs

Electric Service Upgrades - Primary Service feed to transformer (does not include primary 13.2 KV wire)	$	14,606
Shurepower™ Control System	$	33,426
Total Direct Costs, General	$	48,032
Electrical Distribution improvements between Transformer and pedestals	$	14,500
Communication Services	$	4,693
Power Pedestals	$	13,500
Parking Lot improvements	$	18,024
Total Direct Costs, Specific	$	50,717

General Site, Locality adjustment

Total Direct Cost, Unadjusted	$	98,749
Cost adjustment for location	$	(4,276)
Adjusted Total Direct Cost	$	94,473

Construction Costs

Total Construction-related Costs	$	45,347

Total Costs

Total TSE Shurepower™ Facility Cost	$	139,820
Cost per parking space	**$**	**7,768**

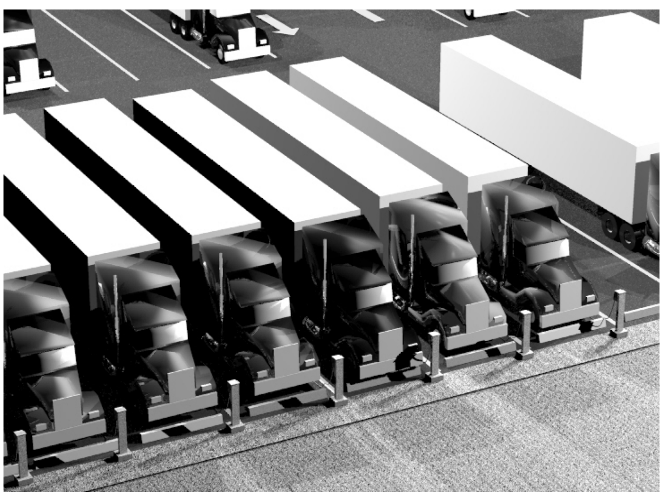

Figure 1: Artists rendering of Wilton Travel Plaza shorepower system

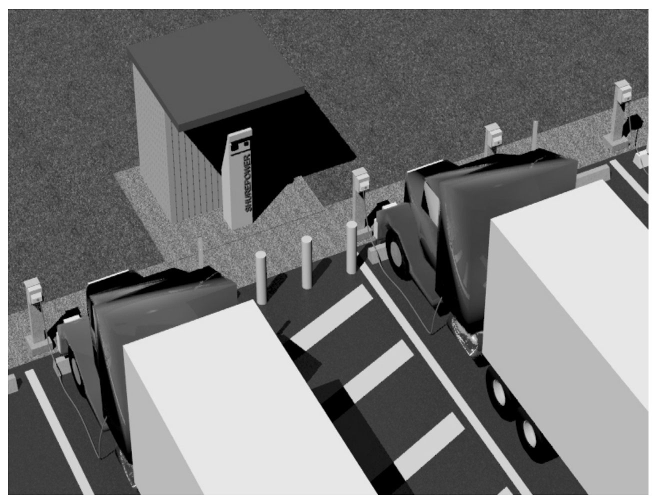

Figure 2: Shorepower control kiosk and control building

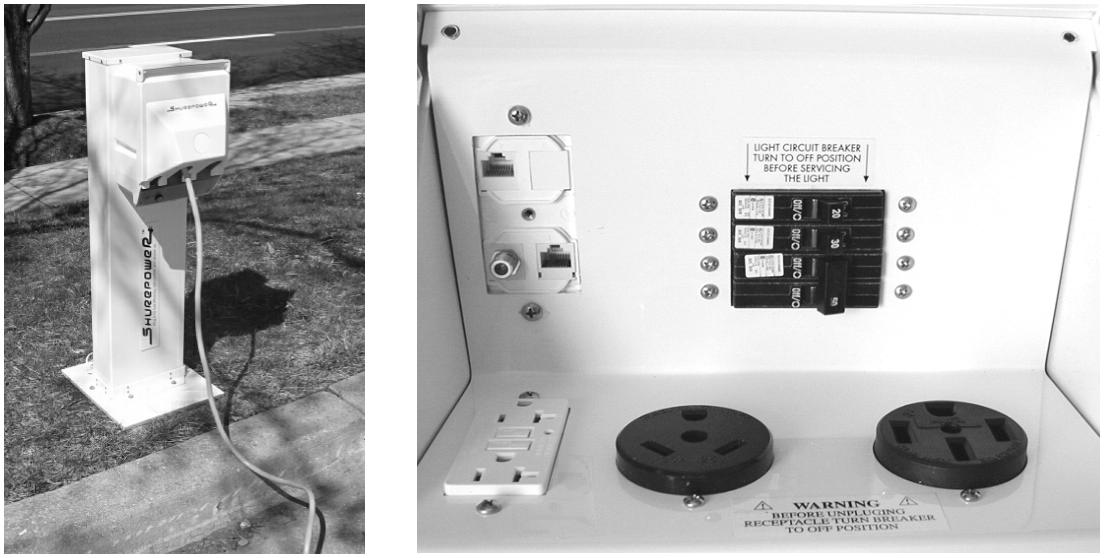

Figure 3: Shorepower pedestal with electrical, cable TV, Internet, and phone connections

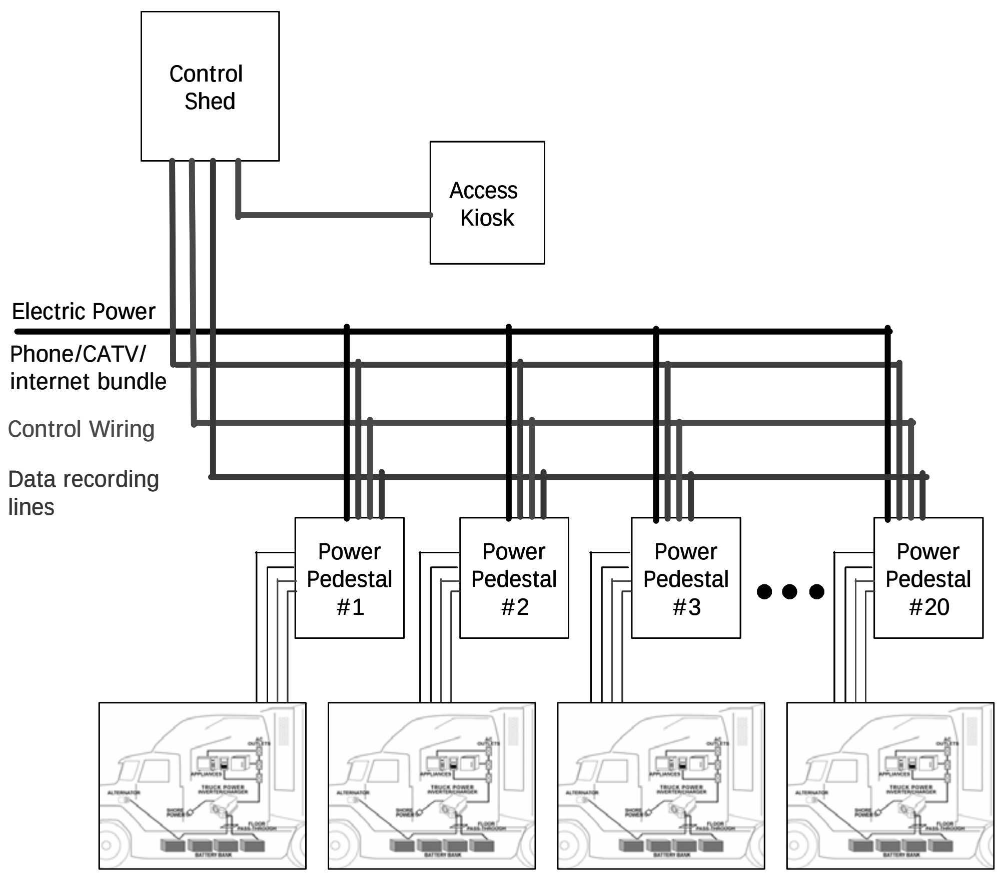

Figure 4: Shorepower TSE system diagram