TRUCK STOP ELECTRIFICATION AS A LONG-HAUL TRACTOR IDLING ALTERNATIVE

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NOTICE

ABSTRACT

Truck Stop Electrification (TSE) is an approach 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 must rest for specific periods prescribed by the U.S. Department of Transportation's Hours of Service regulation. Long-term idling is prevalent in the heavy truck sector to provide heating and cooling to the sleeper cab. However, idling increases fuel and maintenance costs, emissions, and noise. Recognizing this, local jurisdictions have developed regulations to restrict long-term idling. Popular options to reduce idling include auxiliary power units and fuel-fired heaters. Both have significant operational, environmental or cost disadvantages compared to TSE. TSE is the preferred approach to anti-idling because of zero on-site air emissions and minimal noise emissions. The paper reports on the path to the current state of the industry, ongoing TSE activities, and analysis of data collected from commercial TSE facilities to determine the technology's environmental impacts. The results indicate that TSE can significantly reduce on-site emissions as well as net airshed emissions.

BACKGROUND

Truck engine idling is increasingly recognized as an aesthetic and environmental problem across the United States. 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 and microwaves 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 (*1*). 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:

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

Idling promotes increased localized CO concentrations that can cause headaches, dizziness, and nausea, which can affect driver health and job performance. Noise pollution generated by idling trucks can cause sleep loss, which partially negates the targeted safety benefit of the new Federal truck driver hours-of-service regulation, which takes effect January 4, 2004 (*2*). Noise pollution is especially problematic at large truck stops, where there may be dozens of idling trucks. 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 in the communities that surround them.

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 (*3*). 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. Enforcement, in turn, encourages truck manufacturers, fleets, owner-operators, and drivers to consider alternatives to truck engine idling.

Available anti-idling options include auxiliary power units (APUs) that provide heating, cooling and electric power to the sleeper cab. However, these diesel engine-powered units are heavy and expensive, and also generate noise and pollution. In the future, fuel cell-powered APUs may become available. Fuel cells are more efficient, can use a variety of fuels, and have lower emissions than internal combustion engine APUs. Fuel cells; however, are heavier and significantly more expensive than their diesel-engine counterparts. Thermal storage for cab heating is also an option, but this approach is expensive, the equipment is heavy and cannot supply electric power to the sleeper cab. Inverters are also used as an idling alternative. Inverters convert 12-Volt direct current (DC) power from the truck's batteries to 120-Volt alternating current (AC) power for accessories and cab appliances. However, most inverters are not capable of supplying high-power-draw devices such as electric heaters and cab air conditioners for extended periods. Additional battery capacity is required to operate these devices for longer periods, adding weight to the tractor and increasing cost to the owner/operator.

One anti-idling option that addresses many truck operator, government, and citizen concerns is Truck Stop Electrification or TSE. TSE can be installed at truck stops, service plazas, or rest areas to provide electric power to a truck parking area. Truckers park, connect their trucks to a convenient power source, and use electricity. TSE allows truckers, without idling their engines, to operate on-board systems -- sleeper cab heating and cooling, microwave ovens, refrigerators, televisions (TV), telephones, personal computers, and other small appliances – while parked.

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

The combination use of truck-board and facility power systems is also frequently referred to as shorepower, since the hardware aboard the sleeper cab and at the parking facility is similar to that found at boat marinas. In fact, many of the component suppliers of shorepower TSE systems originated as marine suppliers, transitioned into the RV market, and are now embracing the commercial vehicle market. The shorepower system gives access to 120- or 240-Volt electrical power from a land-based electrical power source. This approach separates the electrical supply available at a parking facility from the accessory system installed in a tractor.

New York State is leading the nation in Truck Stop Electrification and was the first state to install commercial TSE infrastructure. This includes the installation of the first three off-board TSE facilities and the design and installation of the first prototype commercial shorepower facility, complete with credit card readers, cable television, and communication interface. In addition, New York State initiated the corridor approach to Truck Stop Electrification deployment and conducted the first Corridor TSE Workshop in June 2002. Targeted at the sixteen states along the I-95 corridor, this workshop quickly caught the attention of other interested groups. Inspired by New York's example, TSE activities are now underway on the I-35 (mid-western US north-south route) and I-5 corridors (western US north-south route).

NEW YORK STATE TRUCK STOP ELECTRIFICATION MARKET STUDY AND PRELIMINARY DESIGN REPORT

In January 2001, a detailed Truck Stop Electrification (TSE) market study and preliminary design report was completed (*4*). Niagara Mohawk, a National Grid USA company (NMNG), was instrumental in developing TSE as a significant, off-peak electricity market. NMNG spearheaded this activity to fully understand the potential of TSE as an additional method for using existing electric generation capacity, thus reducing overall electricity expenses to consumers. The New York State Energy Research and Development Authority (NYSERDA), whose mission is to use innovation and technology to solve some of New York's most difficult energy and environmental problems in ways that improve the State's economy, provided 50% cost-share for this TSE study.

The market study highlighted current TSE activities, and possible partners for TSE commercialization. A preliminary design was completed to estimate the cost of materials and labor required to install a shorepower facility at a commercial truck stop. The financial viability of shorepower TSE was analyzed and several conclusions were drawn.

TSE is a Promising Technology

TSE can be used as an effective approach to reducing long-haul truck idling. Shorepower systems requiring truck-board equipment are available from both the factory and from retrofit companies. In January 2001, all Class 8 sleeper cab original equipment manufacturers (OEMs) offered shorepower as an option for sleeper cab tractors. Moreover, the leading industry supplier of inverter/battery chargers offers customized kits for retrofitting major OEM sleeper cabs. These established industry offerings, backed by warranties and technical support, can accelerate the market penetration of shorepower-capable sleeper cabs.

Current Truck Parking is Insufficient

Recent United States Department of Transportation (USDOT) research on the non-commercial rest area needs of the industry shows the national shortage of parking is almost equal to the number of existing truck parking spaces. The same holds true in New York State. This shortfall provides the opportunity to install TSE in new and expanded truck parking and commercial truck stop facilities, reducing the cost of installation.

New York State Thruway (I-90) Corridor is Ideal for TSE Demonstration
In New York, several interstate roadways were investigated as TSE demonstration sites. Considering factors such as truck traffic, truck stop/rest area locations, and environmental conditions, it was determined that the Interstate 90 was the preferred roadway for a TSE demonstration. Interstate 90 runs the length of the state and is located near major U.S. cities. The highway is designated a Clean Corridor under the Clean Cities Program, and its NYSTA service areas are heavily used by trucks. In addition, NYSTA expressed interest in becoming a major partner in a TSE demonstration program. Moreover, the Syracuse metro area is classified as a carbon monoxide maintenance region by the U.S. Environmental Protection Agency. Thus, the Syracuse I-90 area was selected for the TSE demonstration.

Shorepower TSE is Financially Viable
A TSE shorepower facility installation can be engineered and installed at a cost that will provide a simple payback to the investor/owner in three years or less based solely on electrical supply. Revenue from other value-added services, such as cable TV, telephone and Internet service, will reduce the simple payback period. A business case can easily be made for the deployment of shorepower TSE.

Refrigerated Trailer Power Can Be Supplied at a Cost Premium
A TSE installation can also supply trailer refrigeration unit (TRU) standby power, albeit at a significant cost premium. The per-parking-space cost of providing TRU service is almost five times higher than sleeper-cab-only TSE. TRU electrical power usage and potential cash flow per parking space are also higher. However, very few long-haul TRUs are shorepower-capable, therefore TRU power was not deemed cost-effective.

Strategic Partnerships Can Be Developed
Strategic partnerships can be developed for a New York State TSE demonstration as well as commercial implementation of TSE. Government and private-sector organizations have expressed interest in a co-funded TSE demonstration on the I-90 corridor near Syracuse. The U.S. Department of Energy and U.S. Environmental Protection Agency have also indicated interest.

Based on the favorable findings from this comprehensive report, NYSERDA and NMNG formed a cooperative relationship with the New York State Thruway Authority (NYSTA) to fund the next phase of this activity, the first commercial demonstration of TSE infrastructure on the Interstate Highway System.

NEW YORK INTERSTATE 90 TSE DEMONSTRATION

Two off-board TSE demonstration sites were constructed on the New York State Thruway (I-90) east of Syracuse, New York. The first, at the DeWitt Service Area on the eastbound side of I-90, was completed for commercial operation in June 2002. The second site was completed in April 2003 at the Chittenango Service Area on westbound I-90 (Figure 1). Development time and modifications to the original design delayed installation of the facilities; however, both are now fully functional.

The off-board system installed at the Syracuse TSE facilities includes heating, cooling, AC electrical outlets, and touch screen monitor with Internet access, and phone and cable television connections. The HVAC system is mounted atop an overhead truss assembly where all the wiring and ductwork originates. The ductwork and wiring drop down in a protective, flexible shield which supports the integrated computer service console. The service console is connected to the tractor through the passenger-side door window by a mounting template. Templates for most tractors can be purchased at the TSE facilities for $10. An automated card reader mounted on each service console charges $1.25 per hour for registered fleets and $1.50 per hour to others for basic services. The primary advantage of the off-board system is that it requires no additional on-board componentry for use in the tractor. Internet service can be accessed through the touch screen (or other user-supplied computer equipment); however, use of the telephone service requires the user's own phone.

The DeWitt Service Area facility, with 21 TSE-equipped spaces, has been functional for over one year, encountering all seasonal climatic variations typical of the Syracuse area. The off-board system has performed well in this climate, apart from an occasional complaint regarding heating performance when temperatures dropped below freezing. Syracuse summers are characteristically mild, but the winter months are normally colder than the U.S. average. Much of the conditioned air remains in the front of the cab since the system is typically mounted in the passenger side door window. Manufacturers of this system are addressing this issue and may add insulation to the ducting or install a diverter to direct more conditioned air to the bunk area of the sleeper cab.

More recently, 24 off-board TSE units were installed at the Chittenango Service Area. This system is nearly identical to that at the DeWitt Service Area, offering the same basic services. It is expected that utilization will increase as more facilities install TSE and truckers become aware of its benefits.

The utilization and environmental benefits of the two demonstration sites have been recorded since the inception of the DeWitt Service Area TSE facility. Utilization data are being collected to determine the number of users and hours each user is connected to the system. Based on these numbers, fuel savings, end user costs, and environmental benefits can be estimated. A comprehensive report will be published after twelve months of data have been collected from both demonstration sites.

The average heavy-duty tractor consumes approximately one gallon of diesel fuel for each hour spent idling. At an average cost of $1.70 per gallon, this can total thousands of dollars per year for an individual truck and into the millions for large fleets. Additionally, service and maintenance costs are directly proportional to the hours an engine idles. LP Tardif & Associates Inc. found that an additional $0.92 is spent on service, maintenance and repairs for every hour the truck spends idling *(5)*. Combined with fuel costs, it costs operators over $2.50 for each hour of idling.

The average electrical energy consumption of each truck is estimated from the total energy consumption of the facility. Utilization hours are divided by the total energy use to determine the average consumption of each truck. The estimated consumption of each truck is higher than the actual value because it includes background energy used by facility support equipment. These loads include office HVAC, lights, computer, television, radio, security equipment and power tools that may used for repair and maintenance of the system.

Emission benefits are also based on hourly system utilization. Emission factors were derived from a cooperative study between the U.S. Environmental Protection Agency (*6*) and Oak Ridge National Laboratory (*7*). A wide range of truck models and years were emission tested in the Aberdeen Test Center's climate-controlled chamber at several temperatures. The results were averaged to formulate hourly emissions factors. These factors are used to estimate the total emissions displaced through use of the off-board TSE system. Analysis includes hydrocarbons (HC), NO_x, CO_2, CO, and PM.

Both Syracuse TSE sites were determined to be great demonstration sites due to the high traffic volume on I-90 and their proximity to major U.S. and Canadian cities. However, facilities with over a hundred parking spaces are better suited for this type of system due to high initial investment and infrastructure costs. The Syracuse TSE facilities are rest areas with fewer than 30 parking spaces, as compared to fully equipped truck stops that offer services such as truck scales, showers and maintenance facilities. For this reason, many of the trucks that stop at the two Syracuse TSE facilities stay only for short periods. Larger truck stops typically accommodate over a hundred tractor-trailers and provide all services the trucker may need. These larger truck stops sustain a larger proportion of overnight occupants and therefore may see higher TSE utilization.

In cooperation with Northeast States for Coordinated Air Use Management (NESCAUM), ambient air quality impacts are being assessed at the Chittenango Service Area. Elemental black carbon (BC), an indicator of PM, will be measured during four distinct periods to determine the airshed emission benefits of using TSE. The BC sampling method employs two Magee Scientific Aethalometers; the first is located on-site at the Chittenango Service Area and the second is located upwind at the Poolsbrook Picnic Area of the Old Erie Canal State Historic Park. The Poolsbrook site was selected to acquire background BC levels for comparison. The Poolsbrook Picnic Area is approximately four miles southwest of the Chittenango Service Area in a serene environment with relatively low vehicle traffic. Background BC levels will be subtracted from on-site levels to determine the total amount of BC created by idling trucks. Levels of PM, CO, and NO_x can be estimated based on the BC concentration.

The first BC readings were taken in October 2002 before the installation of the off-board TSE system and established a baseline emission level. BC was monitored again during the first three weeks in May 2003 when the TSE system was operational. This period was selected as a moderate temperature operational period. The third (summer) sampling took place in September 2003 for the high temperature period and the fourth and final (winter) sampling period is scheduled for December 2003. It should be noted that sampling periods were restricted due to equipment availability; however, data will be analyzed and reclassified into high, moderate and low temperature categories. Noise levels at the Chittenango Service Area are being recorded continuously until the final BC monitoring period is completed. Baseline BC levels will then be compared to the TSE operational monitoring periods. Ignoring seasonal and microclimatic variables, it is expected that BC and noise levels will decrease as TSE utilization increases.

NEW YORK INTERSTATE 87 NORTHWAY SHOREPOWER TSE DEMONSTRATION

A two-phase fleet demonstration of shorepower TSE is being sponsored by NYSERDA, New York State Department of Transportation (NYSDOT), and Oak Ridge National Laboratory (ORNL). The first phase involved recruiting a U.S.-based heavy-duty truck fleet that frequents the New York Interstate 87 (I-87) Adirondack Northway, identifying an appropriate truck stop on the Northway for a shorepower TSE installation, establishing a truck-board equipment package for retrofitting one Class 8 sleeper cab, producing one shorepower-capable prototype truck, and developing a preliminary shorepower infrastructure design. The second phase entails retrofitting up to 19 additional heavy-duty sleeper cabs, installing a shorepower TSE system at the selected facility, and collecting and analyzing utilization, operational, and environmental data for a one-year period.

On-Board Shorepower System

KLLM Transport Services was selected as the Phase 1 retrofit participant. A suite of equipment was selected to enable the demonstration vehicle to become shorepower capable. The shorepower TSE system consists of electrical connection hardware on-board the truck, and a stationary pedestal that houses electrical power connections. An exterior-grade wire harness connects the two subsystems. The on-board hardware uses components from industry leaders of truck-board power technology. Equipment selected for the retrofit included an Intellitec (division of General Dynamics) Smart Energy Management System (EMS), a Cab Comfort (division of Dometic Corporation) HVAC system, Phillips & Temro wire kits and receptacles, and a Xantrex inverter/charger. This truck-board suite of equipment was specified to operate on multiple current and voltage levels (120 Volt/20A up to 240 Volt/50A), to ensure flexibility as shorepower standards are finalized. The equipment specified for this truck-board shorepower system was selected to enable the development of a standard kit for future retrofit and possible OEM tractor installations.

Shorepower Facility

The stationary shorepower infrastructure will be installed in a dedicated “No Idle Zone” at Wilton Travel Plaza 30 miles north of Albany, New York. This facility will consist of 20 RV-style power pedestals manufactured by Marina Power and Lighting, Inc., as presented in Figure 2. The pedestals will be equipped with AC electrical power, cable TV, Internet, and telephone service connections as displayed in Figure 3. One pedestal will be provided for each of the 20 parking spaces. Two available voltage/current configurations are available on each pedestal. The first is a single 240-Volt/50A receptacle, the second combines two 120-Volt/20A receptacles and one 120-Volt/30A receptacle. To promote shorepower utilization, the wiring will accommodate trucks with either type of system.

A payment system will be placed in the center of the 20 shorepower parking berths for easy access. Customers will swipe a member or credit card and enter the number of the parking space they wish to activate. The control and billing kiosk unit controls and monitors power flow to each pedestal. The kiosk is manufactured by InfoNet Technology Corporation (division of FAMA Group), and is based on an existing model designed to control fuel pumps for unattended fueling. The interface is identical to those on commercial gasoline pumps, and incorporates a card reader, receipt printer, keypad, and display screen. The kiosk has Internet connectivity that enables remote diagnostics, monitoring, and collection of driver transaction and real-time power use data. This will help determine whether system power capacity will require modification in future site installations. Figure 4 illustrates how these shorepower TSE components are integrated to form a functional system.

RESULTS

An estimated 15,500 gallons of fuel have been saved through use of the two off-board TSE facilities in the Syracuse, New York region. This represents a savings of over $25,000 to drivers and fleet owners. Overall savings including service and maintenance costs, and the cost of the TSE service, are included in Table 1. TSE service costs are based on hours of use and do not reflect actual revenue. It is important to note that many hours were provided to customers as a complimentary service to promote system use. Emissions benefits from system use were calculated using the method described previously and are also shown in Table 1. Table 1 summarizes the overall utilization, energy consumption, average temperatures and benefits of both the Chittenango and DeWitt Service Area TSE systems.

To calculate the cost of idling at the two Syracuse, NY demonstration facilities, regional fuel prices must be used. Due to higher state fuel taxes, diesel fuel costs more in New York State. Weekly surveys are taken at both facilities and averaged monthly to determine the fuel costs at both locations. To estimate the overall cost of using the off-board TSE system, the cost of the TSE services is subtracted from the sum of average monthly diesel fuel, maintenance and repair costs, as shown in the example below:

$1.70 (fuel) + $0.92 (maintenance) - $1.50 (Cost for TSE service) = $1.12 (Net savings per hour of use)

In this example, the fleet or truck owner saves $1.12 for every hour of avoided idling while connected to the TSE system.

Emission benefits from the use of the TSE systems are based on total hours of use and emission factors derived from the ORNL/EPA study *(6, 7)*. Preliminary estimates indicate that approximately 60 kilograms of PM, 2400 kilograms of NOx, 1200 kilograms of CO, 700 kilograms of HC, and nearly 150,000 kilograms of CO_2 have been displaced as a result of trucks shutting down their engines and connecting to one of the two off-board TSE systems installed in the Syracuse region.

Energy demand is directly proportional to the ambient temperature at the TSE service area. Figure 5 shows the trends at the DeWitt Service Area since July 2002. Peak demand occurred in the winter months, driven by high heating loads. The warmest month on record (July 2002) also showed a sharp increase in average energy use due to high cooling loads. Months of mild temperature required little sleeper cab heating or cooling and energy consumption was therefore minimal. Figure 6 shows the expected power consumption of an individual truck based on the ambient temperature. All calculated per-truck power values are slightly higher than actual consumption numbers because they include energy used by on-site personnel. Previous studies indicate that shorepower systems will require less than half the power required by the off-board system *(4)*. Infrastructure power requirements and losses for a shorepower system will be minimal compared to the off-board system.

Utilization has been fairly consistent since the inception of the two facilities. *Hours of Use* (Figure 5) and *Facility Utilization* (Figure 7) have remained relatively constant. *Facility Utilization* is determined by dividing the number of daily users at each facility by the number of parking spaces; 100% *Facility Utilization* occurs when there are equal numbers of users and TSE-equipped parking spaces on a given day. The percentage of *Repeat Clients* (Figure 7) has steadily increased, indicating customers are satisfied with the services offered by the off-board system. Another indicator of satisfaction is the *Berth Utilization* trend line in Figure 7. *Berth Utilization* is the average visit duration divided by 8 hours; 100% Berth utilization occurs when the average length of stay is eight hours. Longer stays indicate the customer is comfortable with the service and used the system for more than a short trial period.

Figure 8 shows the utilization trend by day of week. Utilization of the TSE system corresponds to the number of trucks on the road making deliveries. Truck traffic is typically higher early in the week, tapering off toward the weekend. Beginning Sunday, utilization ramps up for weekday deliveries. Peak utilization typically occurs on Tuesday or Wednesday.

All data, with the exception of Table 1, are based on the DeWitt Service Area TSE facility. Final results and analysis will be performed on the Chittenango TSE facility and Wilton Travel Plaza shorepower facility at the conclusion of the demonstration periods.

Overall TSE usage is expected to increase as fleets and drivers realize the benefits of reducing long-term idling. The ‘bottom-line’ for the trucking industry is to increase profits and lower costs. This, from the industry’s perspective, is the strongest argument for using TSE facilities. From the governmental and societal perspective, the environmental benefits may best represent the positive impact of TSE. Energy suppliers may also benefit from a large shift in idling trends. TSE utilization is highest at night when most truckers prefer to rest. Energy demand from TSE use thus corresponds to a traditional off-peak period. This will enable energy suppliers to increase profits by using baseload power generation. Future analysis of peak use trends will enable verification of the off-peak use theory.

CONCLUSIONS

Based on the data obtained so far, off-board TSE has shown to be an effective approach to reducing long-haul truck idling. Preliminary results indicate that localized air emissions are reduced. Final conclusions regarding local environmental impacts must await the results of an ongoing environmental assessment of off-board TSE technology at the New York State Thruway's Chittenango Service Area. This assessment is expected to be complete in February 2004. However, conclusions can be drawn from data indicating a substantial decrease in diesel fuel use and emissions based on emission factors published by the U.S. Environmental Protection Agency and Oak Ridge National Laboratory. Significant maintenance cost reductions have also been estimated from L.P. Tardif data and data collected on TSE use at the New York State Thruway's DeWitt and Chittenango Service Areas.

Shorepower TSE, now being commercially demonstrated in upstate New York, can also provide significant on-site emissions benefits over long-term idling at a lower cost than off-board systems. From preliminary projections, a significant decrease in energy use is expected. Also, 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 beginning to be collected to determine the actual emissions benefits of the shorepower system. It is projected that, based on the reduced costs of installing shorepower, both on-site and truck-board equipment will provide users and facility owners an acceptable payback period. Data will be collected for the 12-month demonstration period operating in all climatic conditions to prove all preliminary assumptions.

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LIST OF TABLES AND FIGURES

Tables

Figures

Table 1 - DeWitt Data Summary Report

Date	Total Utilization hours	Average Per Space Utilization hours	Average Duration Per Visit hours	Berth Utilization of 8 hrs[1] %	Facility[2] Utilization %	Total Users #	Repeat Rate[3] %	Energy Use kWh	Average Power per Truck kW	Energy Cost[4] $	Diesel[5] Fuel Saved Gallons	Trucker's Costs: Fuel Cost Savings[6] $	Trucker's Costs: Engine & Maint.Cost[7] $	Trucker's Costs: TSE Service Cost[8] $	Trucker's Costs: Overall Savings $	Direct Emission Reduction[9]: PM kg	Direct Emission Reduction[9]: NOx kg	Direct Emission Reduction[9]: CO kg	Direct Emission Reduction[9]: HC kg	Direct Emission Reduction[9]: CO2 kg	Daily Average Temp F
Jul 2002 Total	1631	77.7	6.3	78.4%	39.9%	260	13.8%	4840	3.0	$614	1631	$2,447	$1,501	$2,447	$1,501	6.4	251	127	72	15458	74.2
Aug 2002 Total	998	47.5	5.2	65.0%	29.5%	192	14.6%	3330	3.3	$434	998	$1,497	$918	$1,497	$918	3.9	154	77	44	9457	72.7
Sep 2002 Total	871	41.5	4.4	54.5%	31.7%	200	26.0%	3565	4.1	$525	871	$1,300	$802	$1,307	$795	3.4	134	68	38	8256	66.9
Oct 2002 Total	1266	60.3	5.2	64.6%	37.6%	245	26.5%	4611	3.6	$837	1266	$1,899	$1,165	$1,899	$1,165	4.9	195	98	56	11994	50.5
Nov 2002 Total	1471	70.1	7.4	92.0%	31.7%	200	30.0%	5121	3.5	$956	1471	$2,294	$1,354	$2,207	$1,441	5.7	227	114	65	13943	41.1
Dec 2002 Total	1289	61.4	7.5	93.1%	26.6%	173	34.7%	6045	4.7	$988	1289	$2,010	$1,186	$1,934	$1,262	5.0	199	100	57	12216	29.4
Jan 2003 Total	1147	54.6	6.9	86.4%	25.5%	166	42.8%	6457	5.6	$820	1147	$1,891	$1,055	$1,720	$1,226	4.5	177	89	50	10867	21.0
Feb 2003 Total	1462	69.6	8.7	108.8%	28.6%	168	47.6%	6406	4.4	$889	1462	$2,704	$1,345	$2,193	$1,857	5.7	225	113	64	13852	31.5
Mar 2003 Total	1271	60.5	7.9	98.7%	24.7%	161	39.8%	5631	4.4	$1,085	1271	$2,479	$1,170	$1,907	$1,742	5.0	196	99	56	12047	36.5
Apr 2003Total	1283	61.1	8.0	99.6%	25.6%	161	37.9%	4,357	3.4	$988	1283	$2,310	$1,181	$1,925	$1,566	5.0	198	100	56	12161	46.0
May 2003 Total	1152	54.8	7.7	96.0%	23.0%	150	44.0%	2,889	2.5	$559	1152	$2,038	$1,059	$1,727	$1,370	4.5	177	89	51	10912	58.6
June 2003 Total	1076	51.3	6.9	86.8%	24.6%	155	45.8%	2,826	2.6	$438	1076	$1,787	$990	$1,615	$1,163	4.2	166	84	47	10200	65.2
1-Year Total	14918	710.4	6.8	85.3%	29.1%	2231	33.6%	56078	3.8	$9,133	14918	$24,656	$13,725	$22,377	$16,003	58.2	2297	1158	656	141364	49.5

Notes:

[1]Berth Utilization equals Average Duration per Visit divided by 8 hours. 100% Berth Utilization occurs when the Average Duration per visit is exactly 8 hours.

[2]Facility Utilization is calculated by dividing Total Users by the number of berths per facility. 100% Facility Utilization equals an average of one user per parking space per day.

[3]Percentage of customers who have used the service previously.

[4]Energy rates are based on monthly energy bills and include any demand surcharge.

[5]Based on an average fuel consumption of 1.0 gallon per hour.

[6]Based on average monthly Diesel fuel cost per gallon at the Dewitt Service Area.

[7]Service and maintenance costs are estimated at $0.92 per hour of idling, from ANTARES TSE Market Study.

[8]TSE Service Costs are based on the non-discounted hourly rate of $1.50 per hour.

[9]Average hourly emission factors are from the EPA - Oak Ridge National Laboratory Heavy-Duty Diesel Idling Study.

FIGURE 1 DeWitt Service Area (top) and Chittenango Service Area (bottom) off-board TSE facilities.

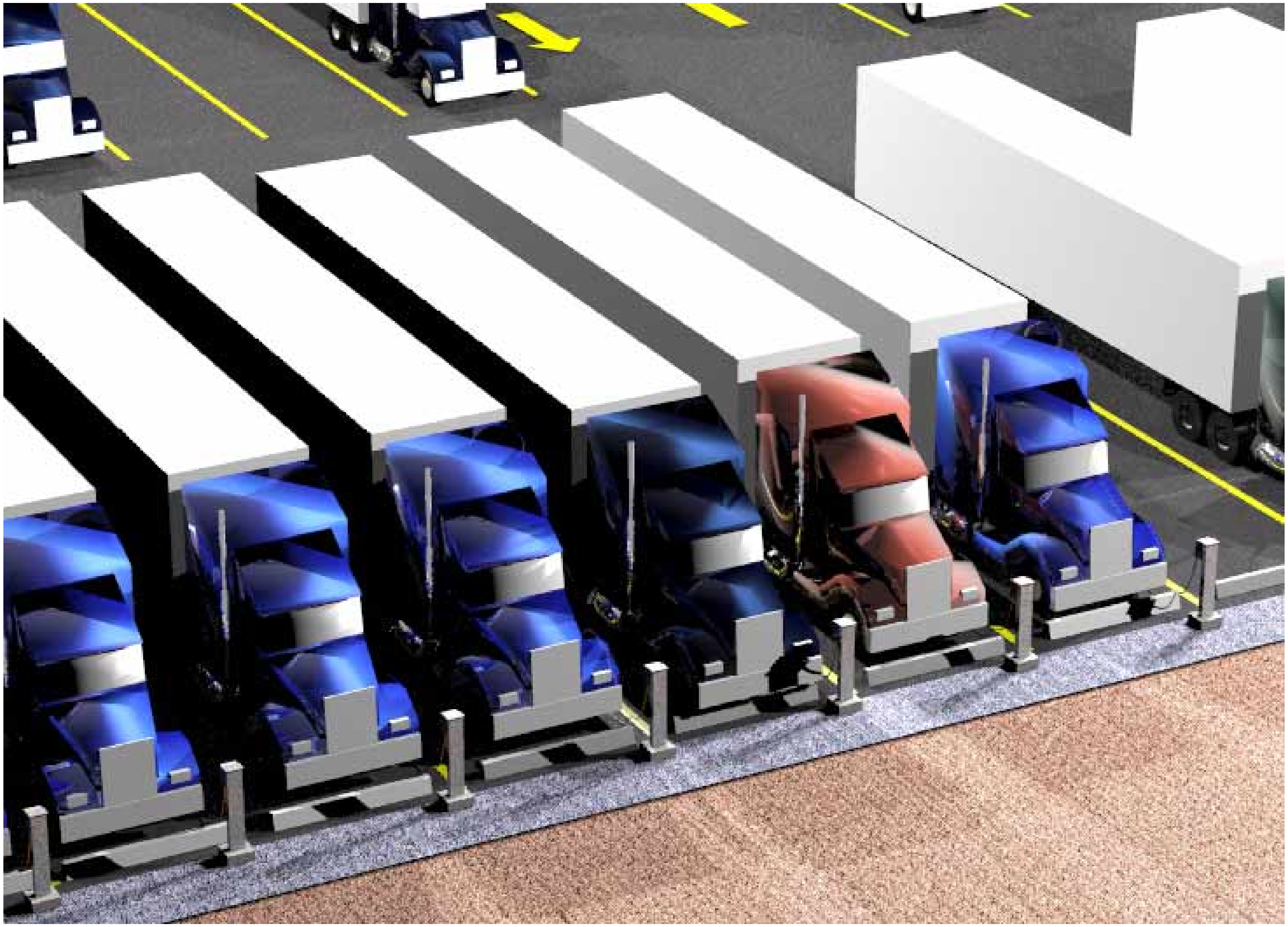

FIGURE 2 Artist's rendering of Wilton Travel Plaza shorepower system.

FIGURE 3 Shorepower pedestal with electrical, cable TV, Internet, and phone connections.

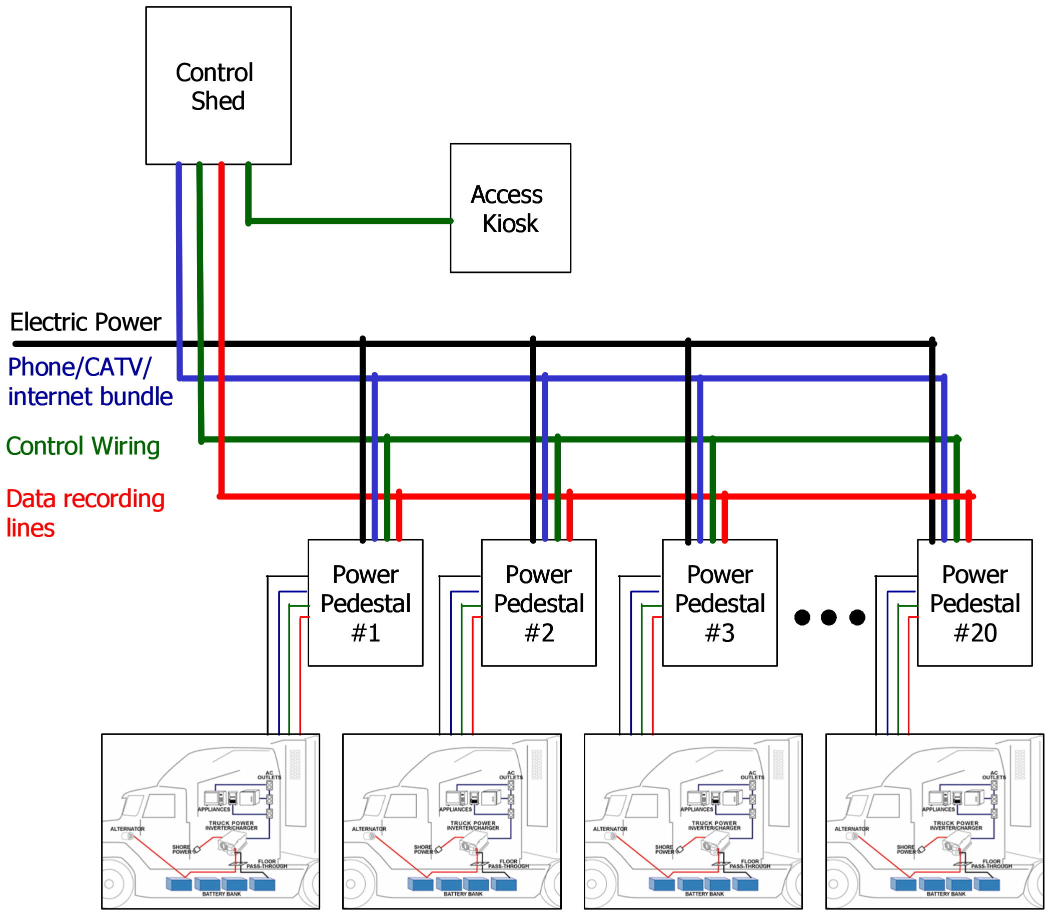

FIGURE 4 Shorepower TSE system diagram.

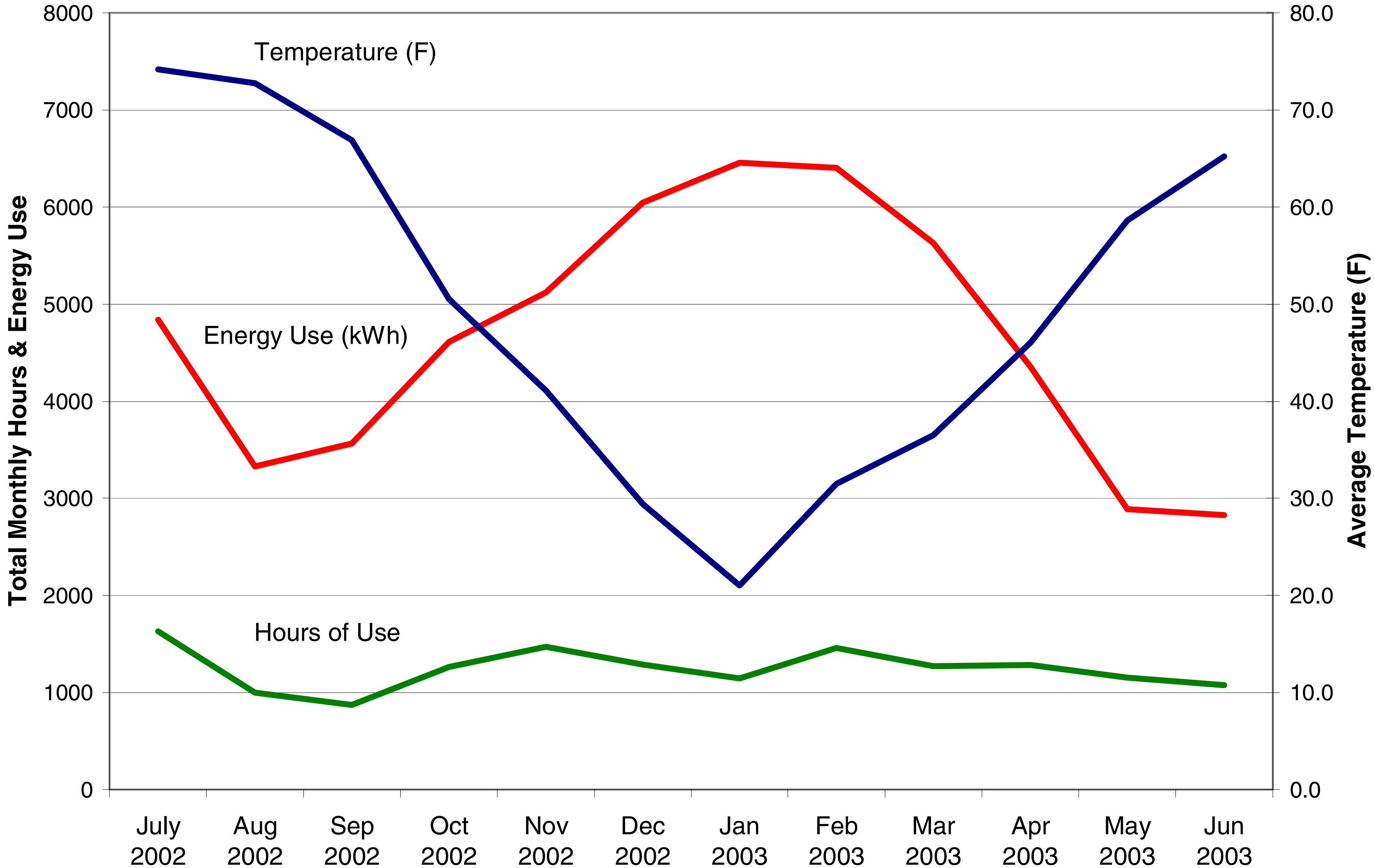

FIGURE 5 DeWitt monthly average temperature, energy, and hours of use.

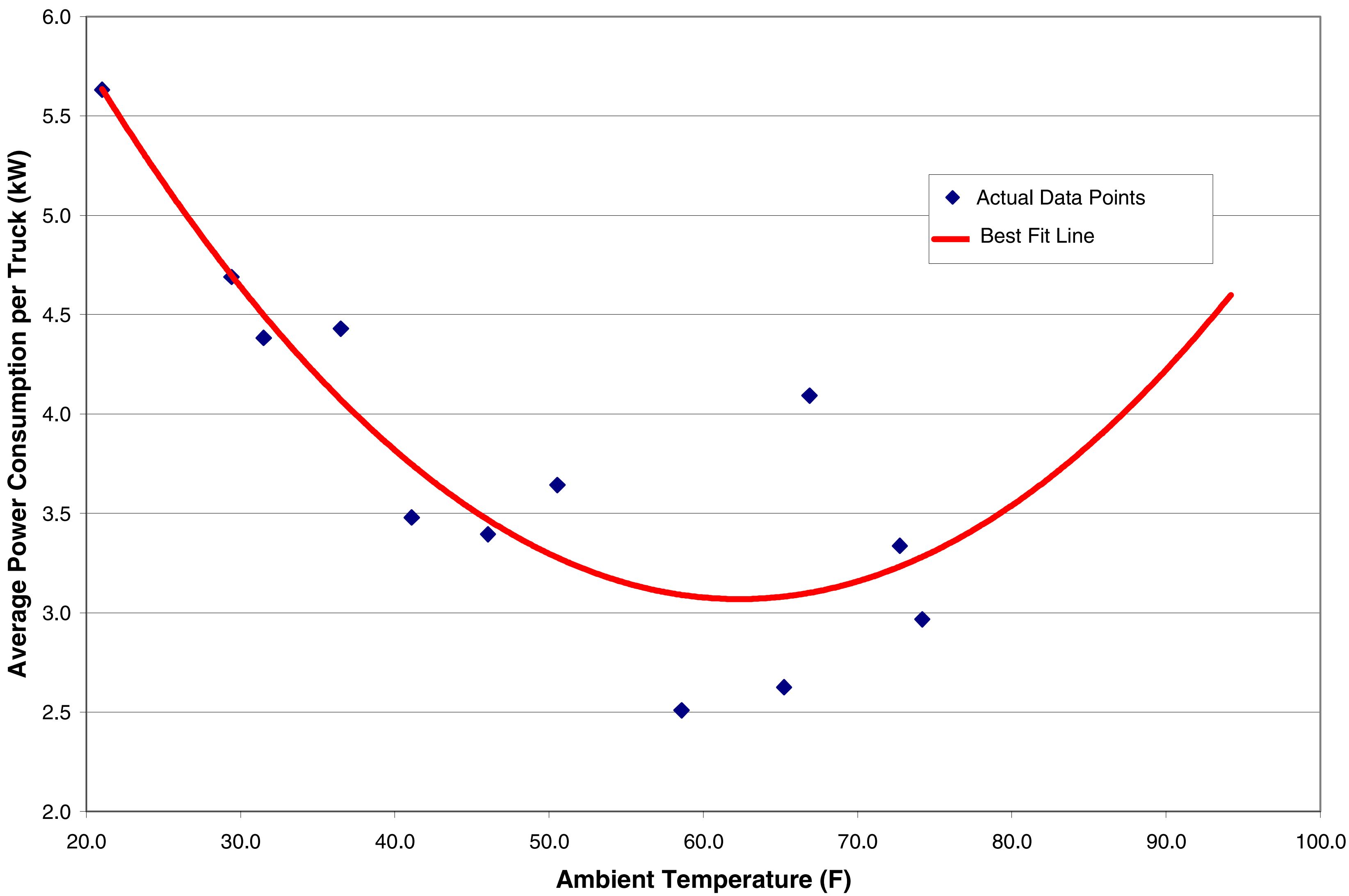

FIGURE 6 Average power consumption from July 2002 to June 2003.

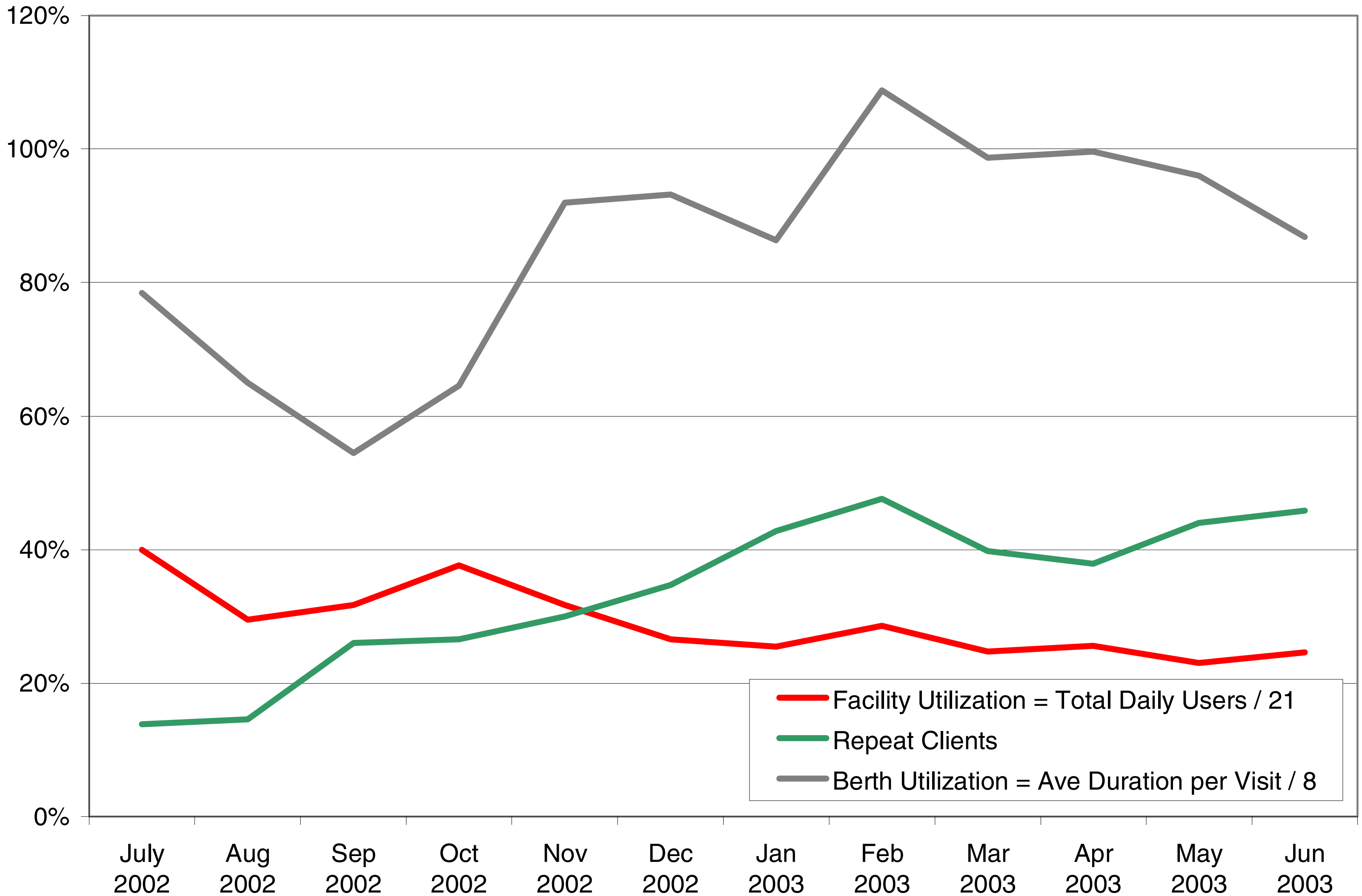

FIGURE 7 DeWitt TSE monthly utilization.

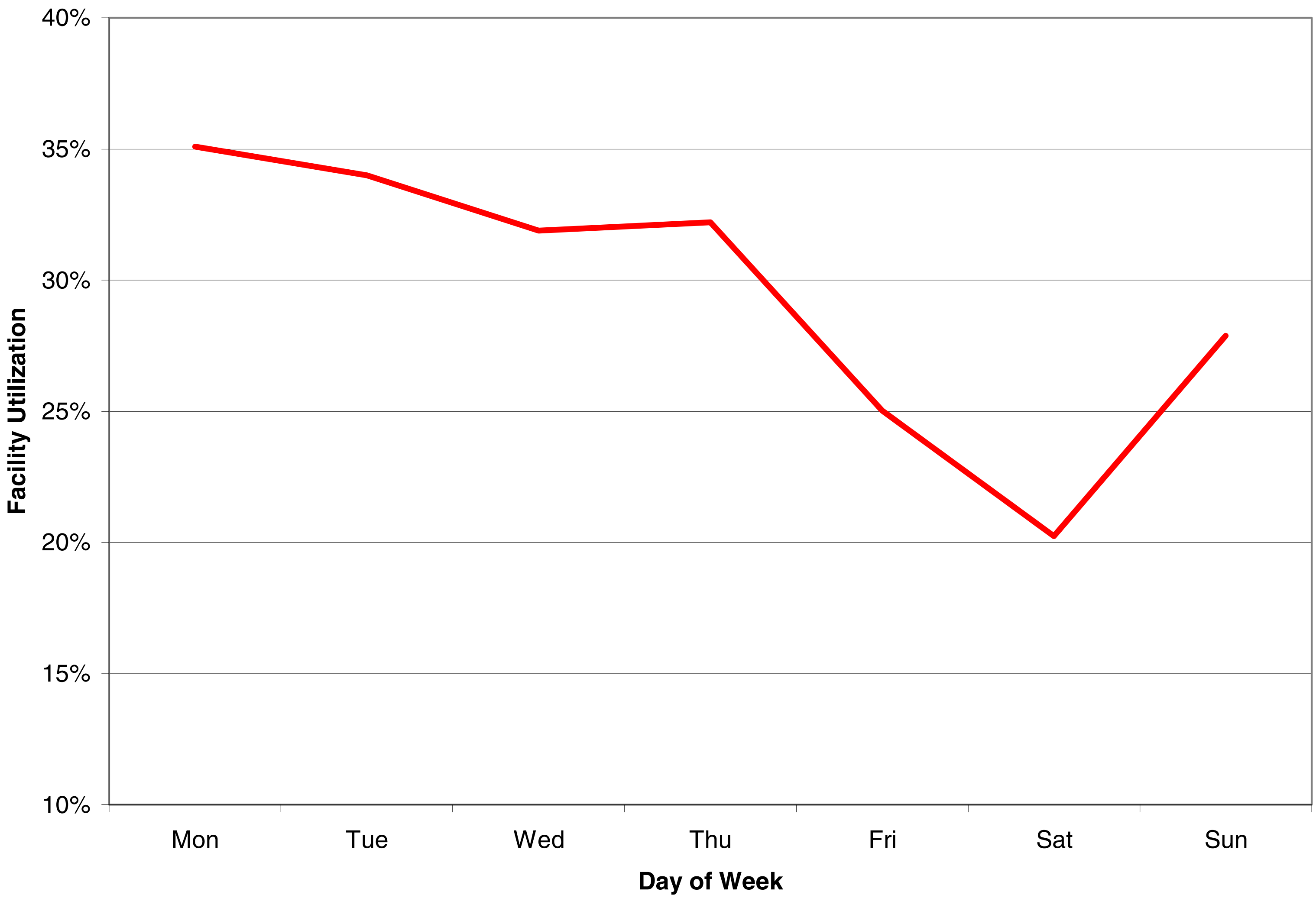

FIGURE 8 Average DeWitt TSE facility utilization by day of week (July 2002 – June 2003).