CONFIDENCE REPORT: IDLE-REDUCTION SOLUTIONS

ABSTRACT

This report documents the confidence that North American Class 8 trucking should have in pursuing Idle Reduction Solutions. The study team engaged the entire industry in the data that is presented here. Thanks to all of those who contributed to this important work.

Trucking Efficiency

Trucking Efficiency is a joint effort between NACFE and the Carbon War Room to double the freight efficiency of North American goods movement by 2016 through the elimination of market barriers to information, demand and supply.

Confidence Report on Idle-Reduction Solutions

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Executive Summary of Confidence Report

The fuel costs faced by the tractor-trailer industry have been swiftly and steadily rising over the past decade. By 2012 diesel fuel costs reached $0.64 per mile, costing the industry more per annum than the combined costs of wages and benefits for the drivers. This recent surge in fuel prices has reshaped the economics of trucking, and the industry is in need of solutions if it is to stay profitable.

Fortunately, a myriad of technologies which show strong potential for achieving cost-effective gains in fuel efficiency for Class 8 trucks are readily available on the market today. Unfortunately, the industry's uptake of such technologies has been stymied by a multitude of barriers. Central among those barriers is a lack of data about the true performance gains offered by these technologies, and, what's more, a lack of confidence in the data that does publically exist today. In order to overcome those barriers and facilitate the industry's trust in and adoption of the most promising fuel-efficiency technologies, the North American Council for Freight Efficiency (NACFE) has partnered with the Carbon War Room (CWR) to form the Trucking Efficiency Operation. The Operation's work has begun with a series of Confidence Reports, of which this report on idle-reduction options is the third.

Focusing specifically on sleeper tractors pulling trailers, this report finds that each year fleets in the United States use around 3 billion gallons of diesel (approximately 8% of total fuel burned) while idling, and more importantly that two-thirds of that idling time could have been reasonably avoided using currently available technologies – **meaning that 2 billion gallons of diesel were unnecessarily burned in the last year alone, costing the industry approximately $8 billion in fuel and generating over 20.3 million tonnes (Mt) of CO_2 emissions.** Put in perspective, 20.3 Mt of CO_2 is the approximate amount released by the electrical consumption of nearly 2.8 million North American homes for an entire year - more households than the entire state of Washington. Put in perspective, in order to absorb those 16 Mt of CO_2 and prevent them from contributing to climate change, more than 413 million trees would need to grow for an entire decade.

But reducing idling is no easy matter, as drivers do not idly (pun intended) idle their engines – idling is required in various circumstances in order for drivers to keep their trucks operating smoothly, not to mention for them to stay safe on the roads and maintain a healthy and comfortable working environment, especially as their trucks double as their homes on many of their multi-day shifts.

This Confidence Report details the key reasons for idling, as well as the main forces incentivizing idle-reduction efforts in the trucking industry today.

This Confidence Report details the key reasons for idling, as well as the main forces incentivizing idle-reduction efforts in the trucking industry today. One example is new 'Hours of Service' regulations, which include mandatory driver rest periods lasting 34 to 48 hours and are causing fleets to search for idle-reduction solutions that provide heating, cooling, and electric power for extended periods of time without jeopardizing engine performance.

Besides allowing fleets to save fuel and meet regulatory requirements while reducing their greenhouse gas emissions, other benefits of carefully implemented idle-reduction efforts include improved driver satisfaction, productivity, and safety, lower maintenance costs, reduced truck and engine wear, improved community air quality, and reduced noise pollution.

Unlike other options for increasing the fuel efficiency of Class 8 trucks, idling as a source of inefficiency can be addressed via a variety of methods, and as such a very diverse array of idle-reduction technologies are found on the market today. Given that, this Confidence Report does not provide one overarching figure for the fuel savings that a fleet will likely achieve by pursuing idle reduction. Rather, the report finds that this variety of options currently poses one major barrier to the adoption of such systems by the industry today, as fleets struggle to determine which technology will best meet their needs, and how best to implement an overall idle-reduction strategy.

The core objective of this Confidence Report, therefore, is to provide the leadership of fleets with a comprehensive overview of proven idle-reduction technologies and a comparative analysis of those systems (i.e. the pros and cons of each), along with best practices for adoption. Note that the Trucking Efficiency Operation is a vendor-agnostic organization, and therefore compares among the various types of systems, and not among individual brands or vendors of such systems. Specification sheets for 40 different vendors are included in an appendix to the report, though the Trucking Efficiency Operation has not independently evaluated any of the information contained therein.

Technologies Considered

This Confidence Report defines nine key categories of idle-reduction, reviewing a total of nineteen specific options within those. Each technology category is distinguished by the energy source that it relies on, and by whether the technologies within it are installed on-board a truck itself or constructed off-board, such as at a truck stop. The technologies considered in this report are:

1. Fuel-Operated Heaters

- **1.1. Fuel-Operated Air Heaters (also known as Diesel-Fired Heaters or Bunk Heaters):** Burn diesel fuel to heat the sleeper air.
- **1.2. Fuel-Operated Coolant Heaters (also known as Diesel-Fired Water, Coolant, or Engine Heaters):** Burn diesel fuel to warm the coolant to the engine and main HVAC system.

2. Auxiliary Power Units (APUs)

- **2.1. Diesel APUs:** Small diesel engine to generate power for the sleeper cooling, heating and hotel loads.
- **2.2. Battery HVAC [also known as Battery APUs or Battery EPUs (Electric Power Unit)]:** Sleeper cooling and ventilation system powered by a separate set of deep cycle batteries. Batteries are recharged by a larger alternator when the main engine is running.
- **2.3. Thermal Storage Systems:** Refrigerate a thermal storage material while the main engine is running to cool the sleeper while the engine is turned off.

3. Automatic Engine Start/Stop Systems (also known simply as Auto Start/Stops)

Turn the main diesel engine on and off as required to provide heating and cooling for the sleeper as well as charge the batteries and maintain engine temperatures for ease of starting.

4. Vehicle Electrification

4.1. Inverters & Battery Chargers: Inverters use DC power stored in the truck batteries to create AC power similar to a household outlet. Battery chargers essentially do the opposite by using AC power to charge the DC batteries. These two technologies are most commonly deployed together as a single package of an inverter with an integrated battery charger, though sometimes they are adopted by themselves.

4.2. Solar Energy Capture: Solar energy is captured and turned into DC power for storage in the batteries or immediate use by the electrical system.

5. Truck Stop Electrification

An active, off-board system that uses a "snorkel," as an energy source and delivers heated or cooled air through the cab window along with AC power, internet, and potentially cable TV. These systems require no adjustments to the truck itself.

6. Off-board AC Power (also known as shore power)

These systems combine elements of both vehicle and truck stop electrification, as they require both AC wiring and power ports to be installed inside the sleeper as well as infrastructure to be deployed for an external AC power source.

7. Driver / Vehicle Behavior Controls

7.1. Electronic Engine Idle Parameters: Establish boundaries of operation for the main engine such as idle time-out limits and external temperatures boundaries that when exceeded will allow unlimited idling.

7.2. Driver Training: Train drivers to optimize their idling and control operational costs.

7.3. Driver Incentives: Monitor vehicle data and driver behavior to provide rewards for idle reduction.

8. Additional Vehicle Systems

8.1. Additional Cab Insulation: Extra barrier(s) between the inside of the vehicle and the external climate. A passive system.

8.2. Light-Color Paint: Painting the exterior of the vehicle a lighter color will conserve thermal energy and maintain temperatures inside the cab. A passive system.

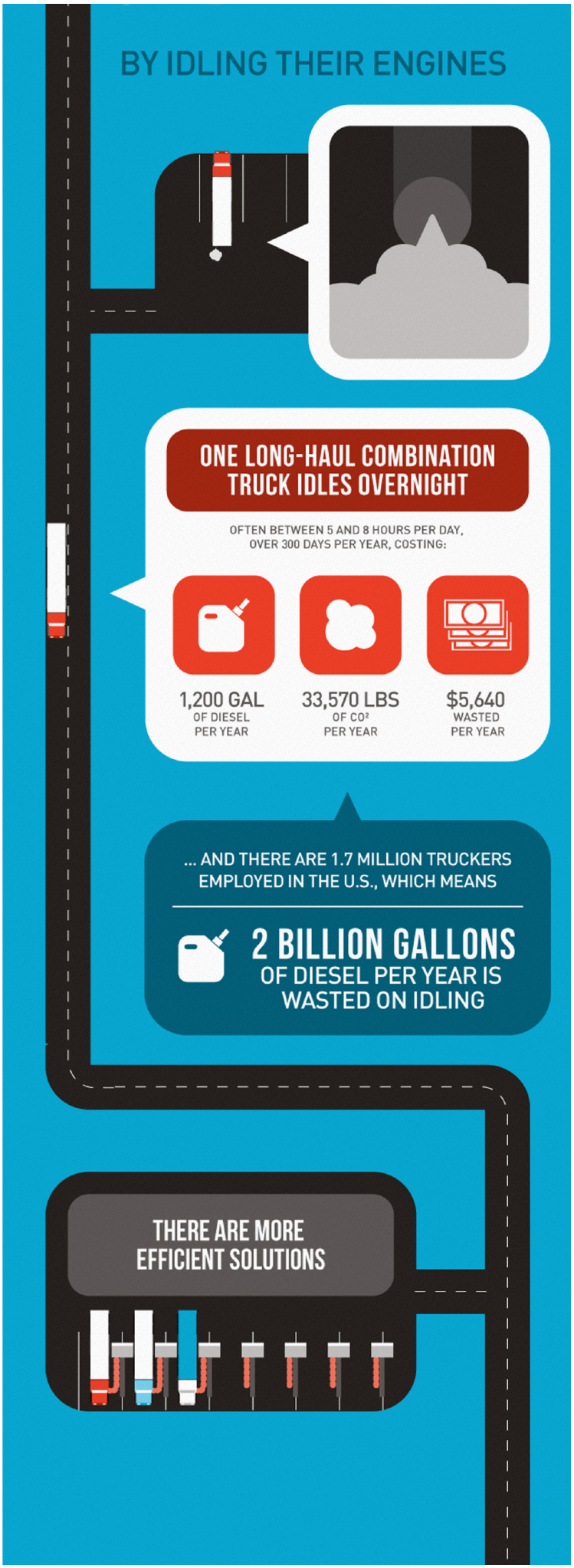
8.3. Additional CPAP Battery: An extra battery to power a CPAP for sleep apnea or other needs.

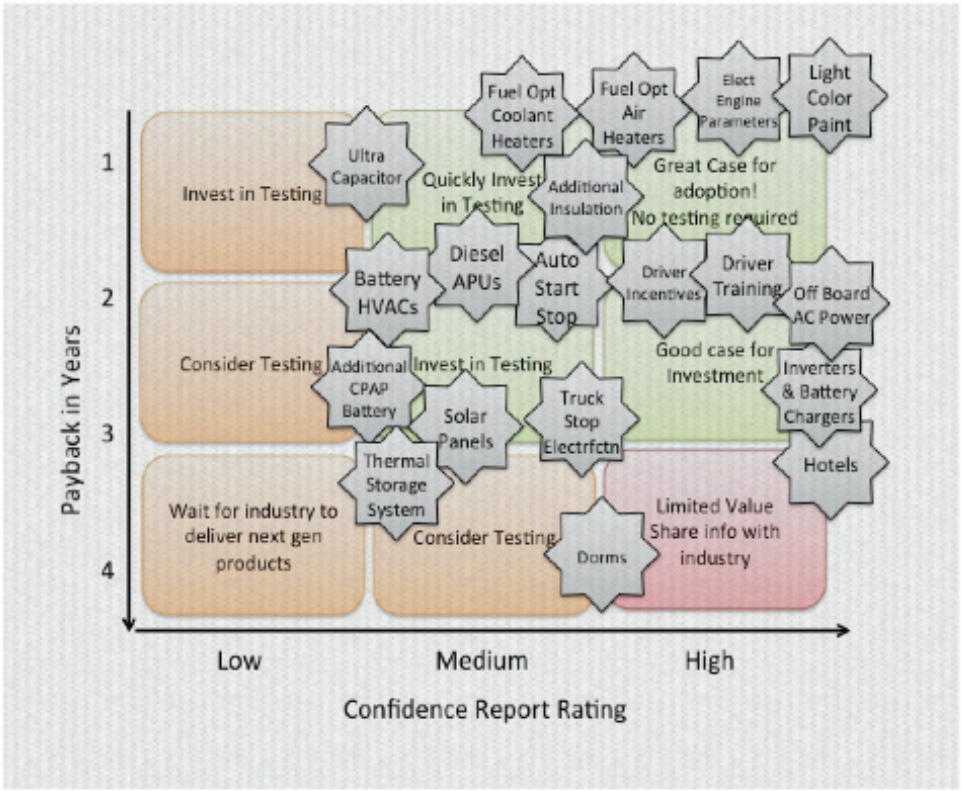
8.4. Ultracapacitor Starting Systems: High power density ultracapacitor strictly for starting the engine.

9. Sleeping Quarters

9.1. Hotels: provide sleeping quarters and amenities outside of the sleeper cab

9.2. Dormitories: provide sleeping quarters and amenities outside of the sleeper cab





The comparative review of these nineteen technologies is summarized in the above matrix, which indicates how confident the Trucking Efficiency study team is in the investment case for a given option.

As mentioned, a lack of clarity around the many options available is a major barrier to the adoption of idle-reduction technologies. By considering such a disparate group of systems in one report, Trucking Efficiency hopes to take the first step in addressing this barrier. Idle-reduction technology providers could also take action to overcome this barrier by standardizing some of the terms that they use to discuss their technologies, and generally becoming more fluent themselves with all of the options available, so as to improve and better tailor their individual value proposition to specific clients.

Combining Idle-Reduction Solutions for Greater Success

In the course of conducting research into these nineteen individual technologies, Trucking Efficiency found that early-adopting fleets were enjoying the greatest successes by adopting one of a few combinations of idle-reduction solutions. This adds complexity to the decision-making process on idle-reduction, which is a barrier to their adoption, and so to address this barrier the Confidence Report explores the most common and most promising combinations of technologies and gives some insights into which technology packages would be most appropriate for which types of fleets.

The best solution will depend on factors including the availability of capital, driver needs, the climate/weather in which the truck operates, and the consistency of a truck's stops and predictability of its parking spaces.

The report finds that simple and quick actions, though smaller in their impacts, can and should be implemented first, such as simply improving the insulation of a cab to better regulate internal temperature. On the other hand, certain solutions like hotels and CPAP batteries should be considered as backups to a fleet's primary idle-reduction solution, which might likely be an APU or fuel operated heater.

Insights from Stakeholder Conversations

This insight into successful fleet behavior and the promising results presented by adopting a combination of idle-reduction technologies was generated in the course of another main feature of the report – stakeholder interviews. Trucking Efficiency spoke with OEMs, fleets, and owner-operators on their experiences with idl r to trust that they have improved.

In addition, the interviews found that more idle-reduction solutions need to be available directly through the truck Original Equipment Manufacturers (OEMs), as fleets are seeking proven integrated solutions, and find that OEM solutions are the most attractive choice as they have been vetted, validated and warrantied by the manufacturer.

Stakeholder interviewers also identified the fact that the use of terms such as "anti-idle" or "zero idle" by technology vendors, fleet managers, and policy makers may backfire on idle reduction efforts in the form of driver resistance to them (hence the term "idle reduction" is preferred by this report), as eliminating idling entirely is an unrealistic demand for the industry today and one which fails to recognize the human needs of sleeper-cab drivers to maintain comfortable working conditions. A key finding of the Confidence Report overall is that the opinions, preferences, and knowledge of drivers are crucial to both the decision to install an idle-reduction technology and to the successful implementation of the chosen technology.

Comparing Options

The final major insight from this research is that the industry desires a holistic payback calculator that can compare multiple solutions interacting on the same vehicle. Unfortunately, the task of creating such a tool is extremely complicated, perhaps impossible, as some idle-reduction systems run when the vehicle is turned off (diesel APU), some consume additional energy while the vehicle is rolling down the road (battery HVAC and thermal storage), some operate sporadically as required (automatic engine start/stop), and some are completely passive (paint color, insulation, etc.). Plus, many fleets lack comprehensive data on the idling behavior of their drivers, and even the best data from one year may be very different from the next, say if an especially hot summer occurs.

However, fleets can use this Confidence Report as an initial decision-making tool by considering which of the various idle-

+ Initial Purchase Costs

+ Initial Installation & Training Costs

+ Operational Costs (diesel fuel, shore power time…)

+ Maintenance Costs (PM, filters, repairs…)

- Idling Fuel Costs

- Main Engine Maintenance Costs

- Resale Value

- Intangible Benefits (driver turnover, sustainability…)

= True Benefit of Idle Reduction System(s)

reduction options detailed in it are relevant to or replicable in their own operations. Specifically to this end, and in light of the fact that most fleets have already adopted some sort of idle-reduction techniques, the report includes a section of "If-Then" decision-making tables which fleets can use to assist in their consideration of alternative technologies for improving on the main system they already have in use, or in converting to a different system entirely. These tables ask fleets which problems they currently face in their idle-reduction efforts, and make some suggestions for steps to take based on those self-identified challenges. For example, if a fleet currently uses diesel APUs, but finds that its idling costs in the winter are too high, one suggestion of the report is to add thermal window curtains to the cab, or perhaps add a fuel operated heater.

Though lacking the ability to create a one-size-fits-all Payback Calculator for idle-reduction technologies as previous Confidence Reports have included, Trucking Efficiency recognizes that commercial trucking decision-making is driven by payback, and so any technology assessment must include both benefits and consequences. However many technology vendors speak only about the benefits of their products, while fleets are often much more vocal about their negative experiences than their positive ones. To overcome this barrier of a lack of comprehensive information on the pros and cons of idle-reduction technologies, this Confidence Report documents all of the factors that need to be analyzed and offset to complete a total operations review. In the above chart, the plus signs (+) add costs and the minus signs (-) reduce them.

Overall, Trucking Efficiency is highly confident that pursuing an idle reduction strategy should offer significant fuel-efficiency gains, and moreover that it is today a requirement for operating a fleet given the regulations of a majority of geographies in the United States.

Looking to the Future

Looking forward, the Confidence Report finds that the emerging 'smart' energy grid and the ever-increasing penetration of renewables into the North American energy mix should be exploited by idle-reduction efforts. 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 truckstop electrification. Electric-based idle reduction solutions could therefore be part of an overall sustainability strategy for the trucking industry in the long term.

In sum, it is the hope of the Trucking Efficiency Operation that this report will catalyze significant new interest in idle-reduction technologies as a method for the industry to profitably increase its fuel efficiency and obtain other benefits for truck drivers as well as the environment. Trucking Efficiency is always seeking to expand the data or case studies that we can provide to the industry. We invite you to share with us your own experiences with idle-reduction systems – whether you have adopted them already, are considering doing so, or have chosen not to pursue them at this time.

About Operation Trucking Efficiency

Operation Trucking Efficiency is a joint effort between NACFE and the Carbon War Room to double the freight efficiency of North American goods movement by 2016 through the elimination of market barriers to information, demand and supply.

Worldwide, the heavy-duty freight trucks emit 1.6 gigatons of CO_2 emissions annually – 5.5% of society's total greenhouse gas emissions. These emissions are the result of the trucking sector's dependence on petroleum-based fuels. From a global perspective, truck manufacturing is a growth market which will likely see up to 33 million new units built by 2015. But this growth, though profitable, could result in massive increases in trucking's emissions – unless the trucking sector improves its fuel efficiency as fast as it expands.

With fuel prices continuing to rise, the adoption of efficiency technologies by all classes of trucks and fleets offers significant cost-savings to the sector while reducing emissions. For example, for a typical heavy-duty truck in the United States, a 5% reduction in fuel-use gained through improved efficiency offers yearly savings of over $4,000. Technologies capable of conferring such gains are relatively cheap to implement and widely available on the market. Many have the potential to be retrofitted onto existing trucks.

But in spite of the potential cost savings, even the most promising of these technologies are not yet being widely adopted by the North American trucking industry. Operation Trucking Efficiency finds that the following market barriers are responsible for this:

- **Lack of Confidence in the Data on Efficiency Technologies** – New technologies abound, but fleet owners lack cross-comparable, credible, and widely-available data proving their potential performances. Often the only existing data are producer claims, which fleets view with skepticism. Fleets worry that savings will be less than promised, and that technologies will negatively impact their operations.

- **Information is Not Shared** – When fleets do independently test a technology, the tests are expensive and time-consuming, leading to 18-month average implementation times and low purchase quantities. Fleets tend to test in parallel, rather than sharing their test results or otherwise collaborating in obtaining performance data, resulting in an unnecessary duplication of cost and effort.

This Confidence Report series from Operation Trucking Efficiency was born out of not only the identification of these barriers and several others, but also conversations with the industry, which made it clear that the elimination of these barriers requires a credible and independent source of information on fuel efficiency technologies and their applications. The Confidence Reports aim to deliver the first such source on the market today.

In order to generate confidence in the performance claims of efficiency technologies, Operation Trucking Efficiency, via these reports, is gathering and centralizing the multitude of existing sources of data about the performance results of different technology options when employed in a variety of vehicle models and duty cycles, and making all of that data openly accessible and more cross-comparable. Furthermore, we are assessing the credibility of the available data, and providing an industry-standardized ranking of confidence in performance results, including return on investment and efficiency gains.

Operation Trucking Efficiency welcomes outside views and new partners in our efforts to help accelerate the adoption of profitable, emission-reducing trucking technologies.

To engage with the Trucking Efficiency Operation, please contact Trucking Efficiency Operation Lead Mike Roeth at:

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About the Carbon War Room

The Carbon War Room is a global nonprofit, founded by Sir Richard Branson and a team of like-minded entrepreneurs, that accelerates the adoption of business solutions that reduce carbon emissions at gigaton scale and advance the low-carbon economy. The organization focuses on solutions that can be realized using proven technologies under current policy landscapes.

The Carbon War Room identifies and works in sectors where emissions can be reduced profitably, and where there are barriers preventing greater adoption of low-carbon solutions. Within these sectors, we launch Operations and collaborate with the sectors' stakeholders. The War Room's current Operations include Maritime Shipping Efficiency, Building Efficiency, Renewable Jet Fuels, Smart Island Economies, and Trucking Efficiency.

For more information, please visit www.carbonwarroom.com.

About NACFE

The North American Council for Freight Efficiency will drive the development and adoption of efficiency-enhancing, environmentally-beneficial, and cost- effective technologies, services, and methodologies in the North American freight industry by establishing and communicating credible and performance-based benefits. The Council is an effort of fleets, manufacturers, vehicle builders and other government and non-government organizations coming together to improve North American goods movement.

For more information, please visit www.nacfe.org.

1 Introduction

This Confidence Report forms part of the continued work of Operation Trucking Efficiency, a joint initiative from the North American Council for Freight Efficiency (NACFE) and the Carbon War Room (CWR), highlighting the potential of fuel-efficiency technologies and practices in over-the-road goods movement.

The fuel costs faced by the tractor-trailer industry have been swiftly and steadily rising over the past decade (Figure 1). By 2012, as Figure 2 shows, fuel costs had reached $0.641 per mile, surpassing even the costs for the driver (wages plus benefits).

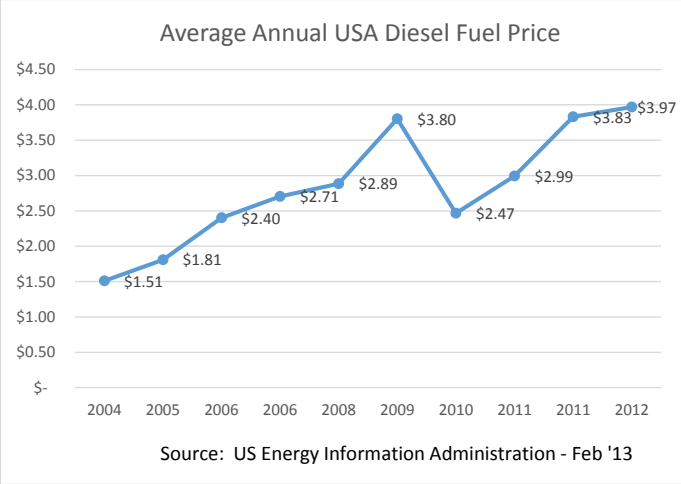


Figure 1: US Annual Diesel Fuel Prices

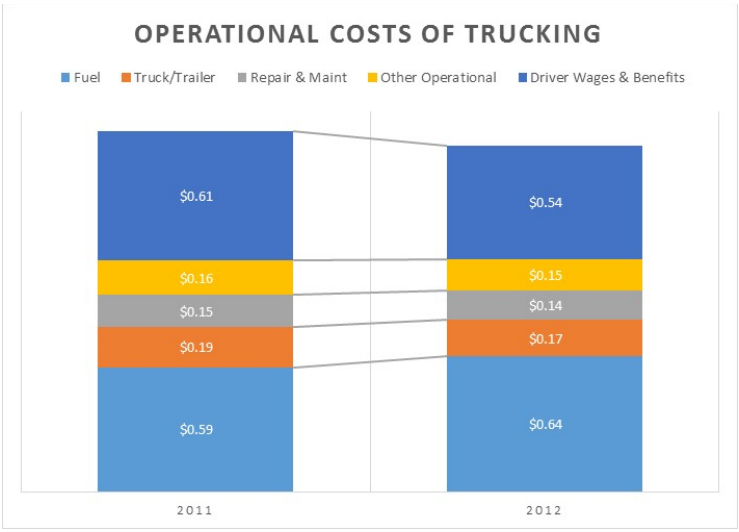


Figure 2: Trucking Operational Cost

Source: American Transportation Research Institute 2012. Operational Costs of Trucking.

Investment into proven technologies and practices that allow a truck or fleet to increase their fuel efficiency – meaning that they can do the same amount of business while spending less on fuel – is a hugely promising option for the industry in light of this trend.

To understand, and thereby better facilitate uptake of such technologies, NACFE conducts an annual review, "the Fleet Fuel Study," of the industry-wide adoption rates of over 60 fuel-efficiency technologies currently available for Class 8 tractors and trailers. This work, available on the www.nacfe.org website, has been called "The most comprehensive study of Class 8 fuel efficiency adoption ever conducted." (Truck News, 2012)

Figure 3: NACFE Fuel Study Participating Fleets

In February 2013, NACFE completed an annual update of that study which included, for the first time in any study ever, additional research into the use of fuel-efficiency products and practices by ten of the largest, most data-driven fleets (Figure 3). Those fleets represent both regional and long-haul tractors and trailers, in both dry goods and refrigerated cargo movement, and boast a combined inventory of 41,000 tractors and 125,000 trailers. The 2013 study reviewed a decade of those ten fleets' specific experience with the 60-plus technologies. Each fleet shared the percentage of their new purchases of tractors and trailers that included any of the technologies. They also shared 10-years-worth of annual fuel economy data for the trucks in their fleet. With these two pieces of information, which will be updated each year for future reports, NACFE is able to generate insights into the following trends with the industry:

- Adoption curves for each of the sixty-plus technologies, indicating which technologies have the steepest adoption rates, which are being adopted steadily but slowly, and which are not being purchased at all. These curves also show how uniformly (or not) fleets are acting in their adoption patterns. Figure 4, for example, shows the results of the Fleet Fuel Study for five of the various technologies on idle reduction covered in this Confidence Report.
- Identification among the various fleets of the innovators, early-majority, late-majority, and even laggards, in new technology adoption as described specifically in the report.
- Comparison of technology adoption rates to overall fuel efficiency.

The overriding take-away from the Fleet Fuel Study is that fleets are enjoying dramatic improvements in their fuel efficiency by adopting any combination of the various technologies surveyed - saving about $5,700 per tractor per year in fuel costs compared with a fleet who has not invested in any efficiency technologies.

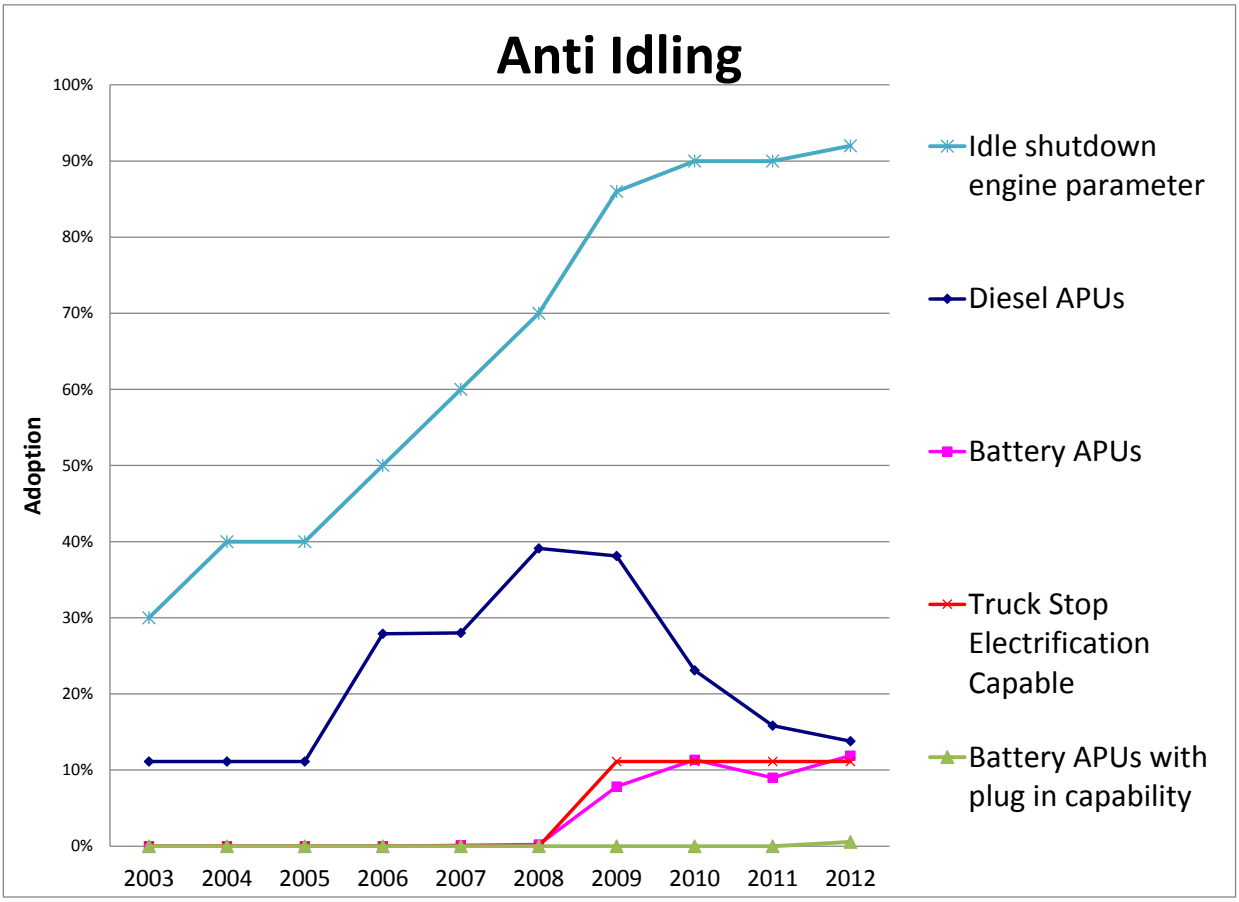


Figure 4: Idle Reduction Adoption

1.1 Operation Trucking Efficiency's Confidence Reports

NACFE's Fleet Fuel Studies provide useful insights into adoption trends in the industry, as well as into the specific practices of different major fleets. NACFE hopes that this information alone could spur additional investments, particularly by fleets that may be lagging behind the overall industry when it comes to certain widely adopted technologies. However, in the course of conducting the studies, it became clear that some technologies are still only being adopted by the most progressive or innovative fleets in spite of their showing strong potential for achieving cost-effective gains in fuel efficiency. In order to facilitate the wider industry's trust in and adoption of such technologies, NACFE and the CWR formed Operation Trucking Efficiency, and began this series of reports, called "Confidence Reports," which will take an in-depth look at those most-promising but least-adopted technologies one-by-one.

Idle-reduction systems are one such technology set that shows limited initial adoption rates in spite of promising results, and therefore meets Trucking Efficiency's criteria for being a class of technologies to investigate further. Specifically, the NACFE Technical Advisory Committee (TAC) found that these technologies deserved additional research due to the fact that some fleets have been successfully

lowering their idling costs by adopting such systems, while others are struggling to obtain consistent improvements in their efforts to reduce idling and increase fuel economy.

This Confidence Report was produced in order to confirm or refute common perceptions of the benefits and challenges of idle-reduction systems, and generally to provide more information on them to the industry. This exploration of idle-reduction systems is the third in Trucking Efficiency's series of Confidence Reports, the first of which was released in August of 2013 on Tire Pressure Systems, followed by a report on 6x2 Axles published in January of 2014.

Confidence Reports provide a concise introduction to a promising category of fuel-efficiency technologies, covering the key details of their applications, benefits, and variables. The reports are produced via a data mining process that both combs public information and collects otherwise-private information (which is shared with Trucking Efficiency for the purpose of the reports), in order to centralize an unparalleled range of testing data and case studies on a given technology set. The information gathered in each Confidence Report will typically include:

- Technology Suppliers' Bench Tests – For instance, predicting fuel economy
- Fleet-Reported Case Studies – Data and best practices
- Trucking Original Equipment Manufacturers (OEMs) – How the technology performs in engineering testing, as well as their plans for product introduction and ramp up
- Public Reports/Test/Data, press information, etc.

The core objective of this Confidence Report is to provide the leadership of fleets with a comprehensive overview of the proven options for idle reduction, as well as an indication of some emerging opportunities.

Additional objectives include:

- Understand the options and technologies which allow for the reduction of idling and are currently available to North American trucking operations
- Understand the history of the development of idle-reduction systems
- Work with the industry to detail the fuel efficiency performance of the technology
- Document both the benefits and adverse consequence of adoption, and outline best practices
- Provide guides to decision making on the best idle-reduction technologies for individual fleets to consider, depending on those fleets' specific needs or practices
- Report an industry-wide 'level of confidence' that end-users can have in both the existing data and the actual gains they will enjoy by adopting a given technology

Although this Confidence Report was requested by fleet management personnel, they are not the sole intended audience. For example, it is highly likely that there are suppliers of idle-reduction systems that are not fully aware of how some sister systems discussed in this report could make a significant

difference in the operation and payback of their core system. Nor is everyone involved in the creation and enforcement of idle-restriction legislations as well versed in the realities of the operation of a sleeper tractor. Finally, idle reduction is a frequent topic in the transportation media, and this report should add to that discussion.

2 Methodology

Trucking Efficiency's approach to Confidence Reports, illustrated in Figure 5, is centered on the recruitment of an unbiased team of trucking experts who will conduct the actual research. For this idle-reduction study the core team included:

- David Schaller, Program Manager and Key Technical Lead, Schaller LLC
- Denise Rondini, Program Specialist and former industry magazine editor.
- Rob Swim, Program Specialist and former industry marketing executive.
- Sue Slick, Senior Researcher, NACFE

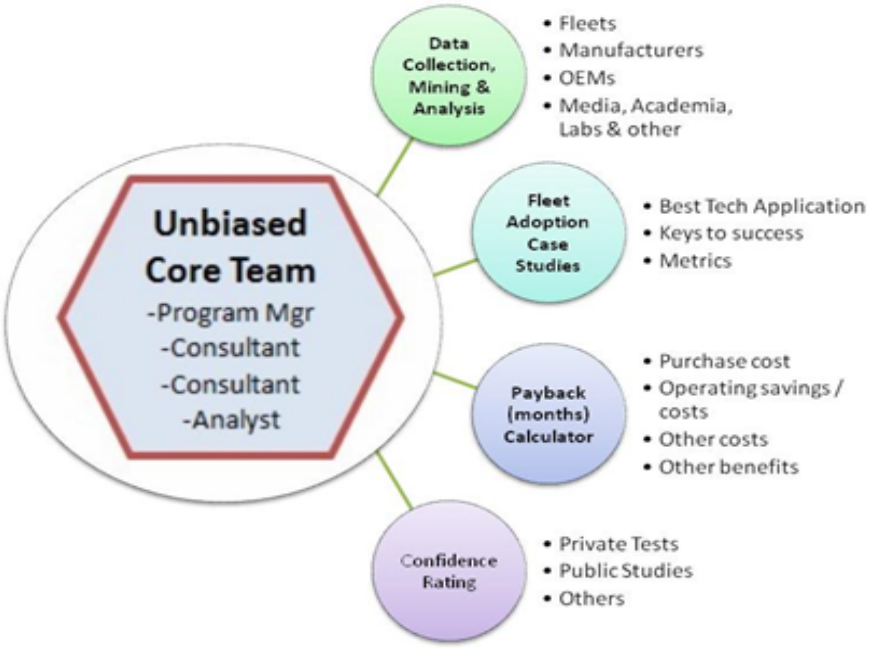


Figure 5: Approach to Confidence Reports

In June 2013, NACFE began a preliminary study of the technologies available to limit the engine idling of Class 8 highway sleeper tractors in North America. The NACFE Technical Advisory Committee, via Operation Trucking Efficiency, commissioned this report in July 2013, and the study team named above began actively working on it in August of that year. The study team began by conducting a literature review, in order to identify and categorize the general types of systems used to reduce idling in sleeper tractors, as well as online research into the specific idle-reduction systems that are currently commercially available. These first two steps identified nine categories and 19 technology types within those, as well as multiple unique suppliers of idle-reduction technologies. The team also found that the business of supplying idle-reduction systems to Class 8 sleeper tractors is quite dynamic, with players entering and exiting the market on a regular basis.

In the process of categorizing the idle-reduction options available on the market today, it became clear to the study team that there is significant confusion or lack of consistency around the terminology used for idle-reduction systems. This report uses a consistent set of titles or terms throughout, and makes note of instances where competing terms are commonly used.

The following steps were then involved in completing this Confidence Report:

- Key suppliers of various idle-reduction technologies were identified and interviewed in-depth about their products' costs, capabilities, specifications, features, market penetration, warranty, etc.
- Product summary sheets were developed for each of the 40 idle-reduction technologies.
- Fleets, OEMs, and industry suppliers participated in roundtable discussions about idle-reduction challenges at a NACFE-sponsored workshop during the October 2013 High-Efficiency Truck Users Forum (better known as HTUF).
- As part of a CK Commercial Vehicle Research project, a small sample of directors and vice presidents of maintenance at heavy-duty fleets were asked questions about their fleet's idling practices. The results largely validated some of the study team's initial findings.
- Representatives from a truck OEM, the media, and a non-profit research laboratory were used to test early findings and conclusions.
- Executives at 10 for-hire truckload carriers were interviewed to learn more about the idle-reduction technologies in use at their fleets, and their experience and satisfaction with those technologies.
- A survey was sent to The Michelin Fleet Forum, an online community of 200+ members, ranging from owner-operators to fleet managers of small to mid-sized trucking companies. A total of 55 members of The Michelin Fleet Forum responded to the survey, sharing information about what idling means to them, the idling challenges they face, the idle-reduction technologies they use today, and their satisfaction with those technologies.
- A similar survey focused on owner-operators and owners of small fleets was sent to all members of Kevin Rutherford's Let's Talk truckers' forum and 148 responses were received.
- A matrix was developed from survey responses to map the interactions between multiple idle-reduction systems when applied in tandem, and the benefits available from such a strategy. Common fleet-level idle-reduction strategies were determined from this matrix.
- Truck OEMs were interviewed about their efforts at idle-reduction system integration, including which systems are available from their factories on the production line and which are installed at post-production modification centers.
- Finally, perspectives on future idle-reduction systems including cab sealing, humidity control, solar, battery development, etc., were collected and summarized.

Trucking Efficiency also used major truck conferences to obtain additional data and perspectives from manufacturers, end users, and tractor OEMs, including the 2014 Technology & Maintenance Council exhibition in Nashville, and the 2014 Mid-America Trucking Show in Louisville.

2.1 Primary Study Questions

A series of primary study questions were created to help guide the study team's effort:

- What idle-reduction technologies are currently (or soon-to-be) available on the market, and what distinguishes each of them?
- How widely have the various idle-reduction systems been adopted to date, and with what level of success?
- How successfully are fleets using these technologies to reduce the percentage of time spent idling?
- What confusion regarding these technologies may be a barrier to wider adoption?
- What other challenges are current adopters facing with these technologies, and how are they overcoming them?
- What paybacks are adopting fleets experiencing?
- What were the experiences of the very early adopters?
- Why did some fleets switch from one idle-reduction system or approach to another?
- What forces are driving increased use of idle-reduction systems?

3 Background on Idle-Reduction

3.1 Why Idle?

Not every reader of this report will be a member of the trucking industry itself, making it worth exploring why sleeper trucks idle in the first place. The world has almost certainly been idling its diesel engines since shortly after Rudolf Diesel first invented this version of an internal combustion engine in the 1890s. Why? First of all, restarting a diesel engine in cold temperatures is much easier if the engine oil is already warm and therefore at a lower viscosity, and idling also prevents the cold-weather gelling of diesel fuel. Second, the introduction of sleeper berths into the trucking industry meant truck drivers needed a controlled indoor climate while the truck was parked in all manner of weather conditions. Idling is used by some drivers of sleeper cabs to simply provide white noise and a gentle vibration as they attempt to get some rest in the middle of a truck stop parking lot, with vehicles pulling in and out around them all night. Third, over the past two decades, the growth in personal electronic usage among off-duty drivers has placed additional loads on truck batteries, given the use of gaming devices, cell phones, and laptops in sleeper cabs. Driver health is also causing an uptick in personal electronic usage, as the average driver is now over the age of 50, and 22.8% of drivers are overweight while an additional 68.9% are obese (American Journal of Industrial Medicine 2013). These demographics have created at least two additional loads on batteries – one being a wider use of refrigerators in cabs to allow for the storage of healthier food such as fresh fruits and vegetables, and the other being use of CPAP machines to provide quality rest for drivers suffering from sleep apnea.[1]

This growth in the use of the battery to power driver electronics is behind what is perhaps the most compelling reason for idling – engaging the alternator – in order to keep a truck's batteries charged to a level sufficient for restarting the vehicle.

Also inherent to the trucking industry is idling in queues, for example while waiting in line for a dock to open, or for an inspection, especially at border crossings. Finally, a few unique instances within the trucking industry create a need for continuous idling, to supply needs such as in-transport heat to warm liquid bulk trailers. However these applications are the exception and not the rule.

Based on conversations with the industry, this study team breaks the aforementioned reasons for idling behavior into eight specific instances (Figure 6):

1. Cooling the cab/sleeper
2. Heating the cab/sleeper
3. Maintaining battery charge

[1] According to the website for the National Registry of Certified Medical Examiners (https://www.nrcmetrainingonline.com/hot-topics/37-obstructive-sleep-apnea-osa-its-effects-on-commercial-truck-drivers), about 70% of people with a BMI over 35 have Obstructive Sleep Apnea which results in cessation of breathing while sleeping. Sleep quality is critically important to truck driving, as the Large Truck Crash Causation Study published by the FMCSA in 2007 found that 13 % of large truck accidents involved driver fatigue.

4. Powering electronic devices for driver comfort
5. Keeping the engine warm for 'startability'
6. Preventing diesel fuel from gelling
7. Queuing (waiting for a dock spot or custom)
8. Vocation or application requirements
9. Engine white noise and vibration

Figure 6: Reasons to Idle a Sleeper Tractor

This Confidence Report focuses on just five of these reasons for idling in terms of the "benefits" that fleets would seek to obtain from any idle-reduction technology they might adopt. The five benefits considered in this report, wherein a technology is employed to meet these needs instead of the idling of the truck's engine, are:

1. Cab heat
2. Cab cooling
3. Battery charge (maintaining a charge in the truck engine battery)
4. Hotel loads (TV, refrigerator, microwave, game station, CPAP, fan, laptop, electric blanket, cell phone charger, etc.)
5. Engine heat (keeping the engine warm)

3.2 Why Minimize Idling?

Just as the trucking industry had been idling since the invention of diesel engines, the diesel fuel that those engines consume had long been abundant and inexpensive, while environmental concerns or regulations around the use of that fuel were few. Some efforts at limiting idling behavior did come from the trucking industry in attempts to save fuel costs and minimize engine wear. Also, occasionally, citizens would protest the noise or smell of idling vehicles, and create "no idle zones" in their areas.

But over the past two decades, operating with goals or under mandates to cut or eliminate truck idling across North America has become the norm for the industry. Several rounds of EPA-mandated emission controls have substantially lowered allowed levels of truck emissions, as well as requiring Diesel Particulate Filters (DPFs) and Selective Catalytic Reduction (SCR) systems. Local restrictions on idling have also increased exponentially, creating a patchwork of regulations, all of them stricter than what the industry faced in the past.

Not only are government regulations intensifying; still more recently the trucking industry has been impacted by an increased awareness of sustainability among general society and within the industry itself. For example, freight customers are now asking large fleets to provide documentation of their sustainability effort and results. This incentivizes both serious advances in the adoption of

environmentally-friendly technologies and practices, as well as less helpful attempts that can only be deemed "green washing."[2]

In another example of these shifting attitudes, renewable energy has entered idling discussions of late, as the continued development of renewable energy technologies has created an opportunity to use renewables to support sleeper trucks while they are stationary, allowing the diesel engines to be turned off almost entirely.

Concurrent with this increase in the importance placed on sustainability, the trucking industry has struggled to adapt to an unprecedented volatility in the price of diesel fuel – volatility which moreover has occurred within a larger trend of steady and substantial increases in the average price of that fuel.

All of these factors combine to put substantial pressure on the trucking industry to reduce or even end the idling of engines. Figure 7 lists the current factors motivating the industry to curb idling.

1. Fuel costs
2. Reduce emissions and meet environmental regulations
3. Reduce maintenance costs by reducing engine wear
4. Minimize noise and fumes

Figure 7: Current Pressures to Reduce Idling

But reducing idling, especially given all the reasons that cause idling in the first place, has been a challenge for the trucking industry. The American Transportation Research Institute (ATRI) conducts an annual industry survey to determine the top 10 issues generally facing the transportation system. The latest of these 'Top 10' lists was released in October 2013, and is show in Figure 8:

1	**Hours of Service (HOS) Regulations**		**6**	**Truck Parking Availability**
2	Compliance, Safety, Accountability (CSA)		**7**	**Driver Retention**
3	**Driver Shortages**		**8**	**Fuel Issues and Fuel Prices**
4	Economy		9	Congestion and Traffic Bottlenecks
5	Electronic On-Board Recorder Mandate		**10**	**Driver Health and Wellness**

Figure 8: ATRI's 2013 Top 10 Trucking Industry Issues

The bold-faced items in Figure 8, numbers 1, 3, 6, 7, 8, and 10, all come to bear on any efforts to reduce idling in sleeper cabs. Only one of them, concern over rising fuel prices, is a motivator for actually

[2] In the trucking industry, green washing commonly takes the form of a fleet's using of some cutting-edge systems on just a few vehicles, with the intent both of system validation but perhaps more so of achieving beneficial media exposure without making any real commitments to increasing their sustainability.

reducing idling. The other five all increase the pressure to idle. For example, the top issue is the Hours of Service Regulation, which went into effect July 1, 2013 and includes a mandatory "restart" that calls for a period without driving to occur at least once a week which lasts at least 34 hours and includes two stretches of time between 1am and 5am. Depending on when a driver pulls over to begin such a restart, it could actually be nearly 48 hours long, if the regulations are to be met. These longer rest periods necessitate an increase in engine idling, both to keep the truck's batteries charged and to keep the drivers comfortable. The regulations also cause greater waiting times for open parking spaces, since any given space is now being used for longer stops (leading to issue #6).

Finally, the driver shortage, driver retention, and driver health issues, #3, #7, and #10, all serve to give drivers more leverage over the industry and therefore a greater voice in determining which features are or are not included on their vehicles – and while this is wholly positive for the drivers it poses a challenge to idle-reduction efforts. And keeping drivers happy is actually good for the whole society, as the need to take care of the driver and ensure they are able to sleep properly was demonstrated in a 2007 Large Truck Crash Causation Study by the US DOT, wherein 13% of all crashes where found to involve driver fatigue. (Starr 2013).

3.3 Current State of Idling

Most industry stakeholders, including fleets, technical trade associations, systems suppliers, original equipment manufacturers, and government administrators, agree that the idling of truck engines should be minimized, as doing so is best for the fleets' profitability as well as for the environment. However the commonly-used term for efforts at doing so – "anti-idling" – implies that there should be no idling at all. But given that the occupants of a truck require a comfortable place to obtain quality sleep, on top of the fact that it is reasonable to expect the vehicle to restart upon command, some level of idling is absolutely required for the foreseeable future, this report therefore proposes the use of the term "idle-reduction" in speaking about these technologies, as opposed to "anti-idling."

Various surveys provide different numbers on how many tractors have some sort of idle-control devices installed presently, as there is no standard definition of such a device. For example, virtually all electronically-controlled diesel engines today have programmable parameters to control idle speeds, idle times before shutoff, and temperatures under which idling is allowed. As these systems have been in production for over 20 years the vast majority of vehicles in operation are now equipped with them. A main feature of such systems today is to control idle speeds, as the actual rate of diesel fuel used while idling depends on the engine as well as the engine speed during idle, per Figure 9 published by Cummins:

Engine Speed (Revs Per Minute)	Average Fuel Consumption
650 RPM	~ 0.5 gallons/hour
1,000 RPM	~ 1.0 gallons/hour
1,200 RPM	~ 1.5 gallons/hour

Figure 9: Fuel Consumption relative to Engine Idle Speed

Although this table makes the argument for idling at lower speeds to save fuel, the Technology & Maintenance Council (TMC) of the American Trucking Associations (ATA), in their "Recommended Practice 1108: Analysis of Costs from Idling and Parasitic Devices for Heavy Duty Trucks," demonstrated that running at lower speeds creates additional wear on the engine's internal parts compared to driving at highway speeds, so overall cost savings will not depend on engine speed alone, and therefore these electronic engine parameters, by far the most common technologies today, may not be truly optimizing a fleets idle behavior.

A plethora of newer idle-reduction systems now on the market and covered in this Confidence Report have much lower rates of adoption, yet they are capable of reducing idling significantly below current averages. Assuming that the survey work for this Confidence Report is accurate, fleets in the United States average, at best, about 10% of a truck's time spent idling. When combined with statistics on the size of the trucking industry in the United States published by the ATA (ATA, 2013) – such as 3,000,000 registered Class 8 tractors, 37,000,000,000 gallons of diesel fuel consumed per year, 9,200,000,000 tons of freight per year moved by truck, and over 137.2 billion miles logged by Classes 6 through 8 of trucks in 2011 – the study team finds that, in order to operate their sleeper tractors, fleets in the United States use 3 billion gallons of diesel while idling, approximately 8% of the total fuel burned (Sustainable America, 2014).

As mentioned, some of that idling is realistically unavoidable, but the study team finds that two-thirds of it is in fact profitably and realistically avoidable today – meaning that 2 billion gallons of diesel were unnecessarily burned (Figure 10) –

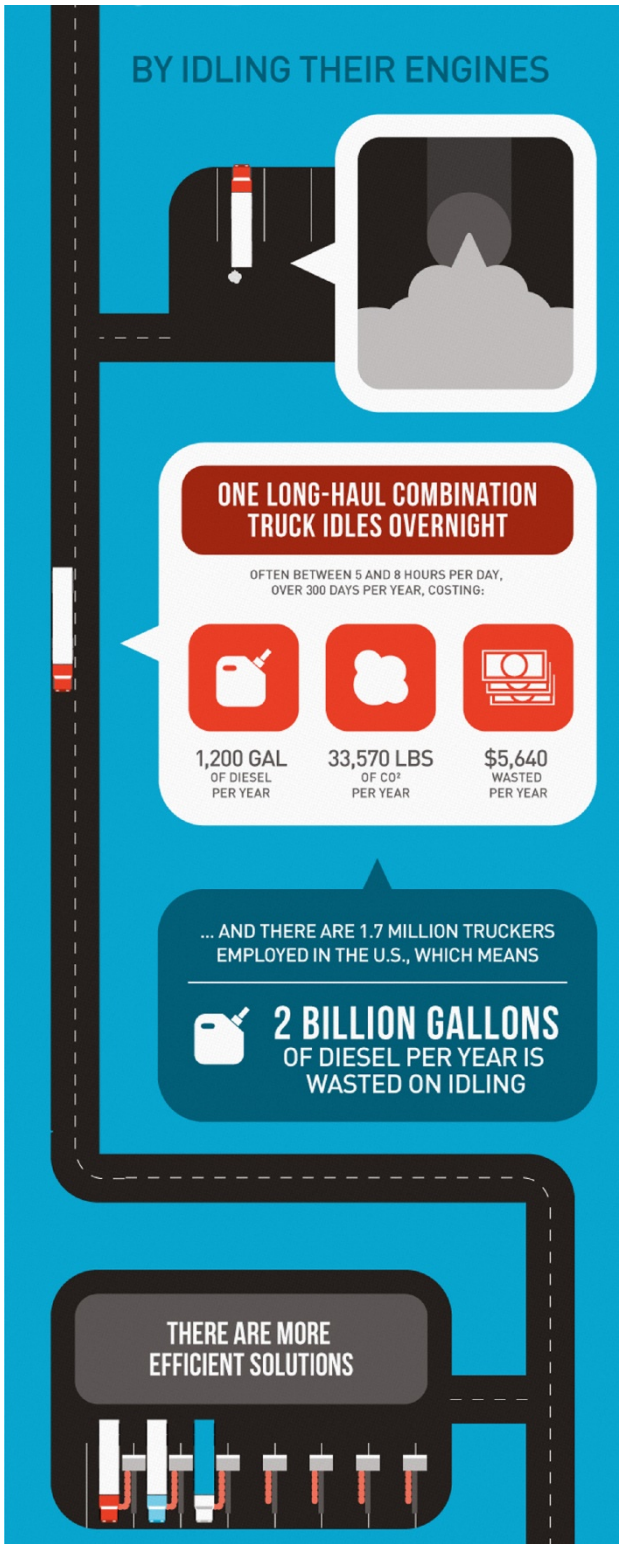


Figure 10: How the Trucking Industry Can Save Billions of Gallons of Fuel Per Year, Courtesy of Sustainable America

costing the industry approximately $8 billion in fuel and generating over 20.3 million tonnes (Mt) of CO_2 emissions. Put in perspective, 20.3 Mt of CO_2 is the approximate amount released by the electrical consumption of nearly 2.8 million North American homes for an entire year - more households than the entire state of Washington. Assuming that the average tanker trailer can hold 200 barrels (8,400 gallons) of diesel, the industry is allowing nearly 240,000 trailer loads of diesel to go to waste. That many tractor-tanker combination vehicles, placed bumper-to-bumper, would stretch across the country, from Los Angeles, California to Charleston, South Carolina.

3.4 Current Regulatory Landscape Governing the Idling of Heavy Vehicles

3.4.1 Government Idling Regulations

No single, blanket federal regulation covers the idling of Class 8 trucks in the United States or Canada. Instead, a multitude of different idling regulations, which determine maximum idling time, fines, and exemptions, exist across the country, and they vary widely – by state, county, and even municipality. Permitted idle times range from zero to 20 minutes, with first-time fines ranging from $25 up to $500, and maximum penalties up to $25,000 or even imprisonment. Typical exemptions from such rules for idling include under certain traffic or weather conditions, for queuing, in the event of mechanical difficulties, and for safety reasons. By-and-large, the strictest idling regulations in the country are found in California, and as many fleets have trucks that must pass through that state, so-called CARB regulations (California Air Resources Board) are

often used as the benchmark standard nationwide.

2008 brought the introduction of "Clean Idle Stickers" issued by CARB, which signified that a given engine installation meets the CARB requirements for extended idling. These holographic serial numbered oval stickers are applied by the truck OEM to the driver's side of the hood. The sticker indicates that the engine for the given vehicle meets the more stringent nitrogen oxide idling emissions standard and allows idling beyond the 5 minute limitations in California.

Figure 11: CARB "Clean Idle" sticker with serial number

In the end the burden is on fleets and drivers to fully understand and comply with the regulations on idling within a specific geographical area. Some information is available from various sources, including:

- ATRI publishes a monthly compendium of state, county, and local no-idle regulations. See: http://www.atri-online.org/research/idling/ATRI_Idling_Compendium.pdf
- Clean Cities, a U.S. Department of Energy (DOE) agency, also has information on engine idling laws and ordinances in a database called Idlebase. See: http://www1.eere.energy.gov/cleancities/
- The Alternative Fuels Data Center provides information on federal, regional, state, and local laws with an interactive map of all the states. See: www.adfc.energy.gov/laws
- The U.S. Environmental Protection Agency's (EPA) covers regulations and compliance information via its SmartWay publications. See: http://www.epa.gov/smartway/

3.4.2 Federal Excise Tax (FET) Exemptions for Idle-Reduction Systems

One federal statute that does cover idle-reduction nationwide serves to incentivize the purchase of idle-reduction technologies, as qualified on-board idle-reduction devices are exempt from the Federal Excise Tax imposed on the retail sale of heavy-duty highway trucks. The exemption also applies to the installation of qualified equipment on vehicles after the vehicles have been placed into service. For a list of eligible products and additional information about product exemption eligibility criteria, see the U.S. EPA's SmartWay Technology Program Federal Excise Tax Exemption website. The exemption applies to equipment that was determined by the Administrator of the EPA, in consultation with the Secretary of Energy and the Secretary of Transportation, to reduce the idling of tractors at a motor vehicle rest stop or other location where such vehicles are either temporarily parked or to remain stationary. Only

equipment sold on or after October 4, 2008, is eligible. For more information, see IRS Publication 510 and the instructions for IRS Form 720, which are available on the IRS Forms and Publications website. (Reference 26 U.S. Code 4053)

3.4.3 Status of Weight Exemption for Idle-Reduction Systems

One disincentive to the adoption of idle-reduction devices is that they can add weight to a truck. The Energy Policy Act of 2005 allowed for a national 400-pound exemption for the additional weight of idling reduction technology on heavy-duty vehicles. On October 1, 2012, "Moving Ahead for Progress in the 21st Century" (MAP-21) became law, increasing this weight allowance from 400 lb. to 550 lb. Each state can adopt this exemption at its own discretion. Not all states have the same weight allowances nor do they have the measurement and enforcement laws or policies. The best source for information about weight allowances is the previously mentioned monthly newsletter from ATRI. Their website also helps identify, by state, the status of weight exemption for idling reduction technologies. See:

http://www.atri-online.org/research/idling/ATRI_Idling_Compendium.pdf

3.4.4 Government Grants for Idle-Reduction Systems

Unlike for some emission-reducing or otherwise "green" transportation products like diesel electric hybrids, there have been few federal, regional, state, or even local grants or other types of monetary support for idle-reduction technologies. One exception was the Shorepower Truck Electrification Project (STEP) funded by the U.S. DOE. Between 2011 and 2013, Shorepower Technologies and the non-profit Cascade Sierra Solutions worked together to install one type of idle-reduction technology covered in this report, AC electrical power pedestals (which are referred to as "off-board AC power" in this report) at truck stops, and also to provide rebates of up to 20% for the purchase of other types of technologies also discussed here, including diesel APUs with electrical standby, battery HVACs, and thermal storage systems. This program has already concluded, and it resulted in 50 truck stops (primarily along the I-5 interstate corridor between California and Washington) receiving off-board AC power capabilities.

A few government agencies currently provide similar grants and funding to offset the cost of idle-reduction technologies. The total dollar amount available for these projects is relatively small though, and the disbursement of such funds is currently few and far between. This report will not delve into the particulars of seeking such money today. The best source of information for identifying possible grants or funding for idle-reduction is the U.S. DOE's Vehicle Technologies Office, which publishes the "National Idling Reduction Network News" on a monthly basis. This publication includes a compendium of regional, state, and local funding sources, as well as the idle-reduction regulations governing those areas. Also listed are upcoming industry events, meetings, and shows that could be relevant to idle-reduction efforts, along with manufacturers' news, and updates on pending government regulations. The website is:

http://www1.eere.energy.gov/vehiclesandfuels/resources/fcvt_national_idling.html

4 Idle-Reduction Systems

This chapter will share a deep dive description of the various idle reduction technologies including such items as an overview, their benefits and challenges, comparison to other solutions and some recommendations for adoption. Technical details for each specific technology supplier that was interviewed and the products considered in the course of completing this report are found in Appendix B. That appendix contains a page for each of the individual systems that were reviewed through manufacturers' interviews as part of this report. This report would not have been possible without the support of those companies in the form of the information and specific data on the solutions they provided to the study team. There are, without a doubt, more suppliers of these systems in the industry, but it was not possible to review them all within the time and budget constraints of the project.

The nine categories and 19 technologies considered in this report are:

1. **Fuel-Operated Heaters**
    - 1.1. **Fuel-Operated Air Heater:** (also known as Diesel-Fired Heaters or Bunk Heaters) Burn diesel fuel to heat the sleeper air.
    - 1.2. **Fuel-Operated Coolant Heater:** (also known as Diesel-Fired Water, Coolant, or Engine Heaters) Burn diesel fuel to warm the coolant to the engine and the main HVAC system.
2. **Auxiliary Power Units (APUs)**
    - 2.1. **Diesel APUs**: Small diesel engine to generate power for the sleeper cooling, heating and hotel loads.
    - 2.2. **Battery HVAC**: (also known as Battery APUs or Battery EPUs (Electric Power Unit)) Sleeper cooling and ventilation system powered by a separate set of deep cycle batteries. Batteries are recharged by a larger alternator when the main engine is running.
    - 2.3. **Thermal Storage System**: Refrigerates a thermal storage material while the main engine is running to cool the sleeper while the engine is turned off.
3. **Automatic Engine Start/Stop System**: (also known as simply Auto Start/Stops) Turns the main diesel engine on and off as required. Some systems only monitor the battery's state-of-charge or engine temperature, while the fully featured versions will also monitor sleeper temperature to provide heating and cooling.
4. **Vehicle Electrification**
    - 4.1. **Inverters & Battery Chargers**: Inverters use DC power stored in the truck batteries to create AC power similar to a household outlet. Battery chargers essentially do the opposite by using AC power to charge the DC batteries. These two technologies are

most commonly deployed together as a single package of an inverter with an integrated battery charger, though sometimes they are adopted by themselves.

4.2. **Solar Energy Capture**: Solar energy is captured and turned into DC power for storage in the batteries or immediate use by the electrical system.

5. **Truck Stop Electrification**: An off-board system that uses HVAC, or a "snorkel," as an energy source and delivers heated or cooled air through the cab window along with AC power, Internet, and potentially cable TV. These systems require no adjustments to the truck itself, just an adapter to fit the "snorkel" to the door window.

6. **Off-board AC Power:** (also known as shore power) These systems combine elements of both vehicle and truck stop electrification, as they require both AC wiring and power ports to be installed inside the sleeper as well as infrastructure to be deployed for an external AC power source. Although this type of system is sometimes supplied by a company with the brand name of "Shorepower," the words "shore power" are frequently used in the industry simply to mean that there is a connector on the side of the vehicle to plug in a 120V AC power cord. Meanwhile this category is distinct from truck stop electrification as the external power source can be installed in other locations, such as a fleet's central parking lot.

7. **Driver / Vehicle Behavior Controls**

7.1. **Electronic Engine Idle Parameters**: Establish boundaries of operation for the main engine such as idle RPM limits and external temperatures boundaries that when exceeded will allow unlimited idling.

7.2. **Driver Training**: Train drivers to optimize their idling and control operational costs.

7.3. **Driver Incentives**: Monitor driver and vehicle behavior to provide rewards for idle reduction.

8. **Additional Vehicle Systems**

8.1. **Additional Cab Insulation**: Extra barrier(s) between the inside of the vehicle and the external climate.

8.2. **Light-Color Paint**: Painting the exterior of the vehicle a lighter color will conserve thermal energy and maintain temperatures inside the cab.

8.3. **Additional CPAP Battery**: An extra battery to power a CPAP for sleep apnea or other needs.

8.4. **Ultracapacitor Starting System**: High power density ultracapacitor strictly for starting the engine.

9. **Sleeping Quarters**

9.1. Hotels: provide sleeping quarters and amenities outside of the sleeper cab.

9.2. Dormitories: provide sleeping quarters and amenities outside of the sleeper cab.

4.1 History of Idle-Reduction Systems

The first device to help diesel-powered tractors avoid unnecessary idling was the electric block heater, created in the 1940s and designed to keep engine fluids warm, enabling better starting in cold weather conditions. Electric block heaters are a very basic technology, and have been so widely accepted in the 70 years since their introduction that they are not explored further in this Confidence Report.

In 1952, Webasto created fuel-operated heaters that functioned independently of the main engine for use in passenger cars and buses. At some point these technologies made the jump into the trucking industry and have been going strong ever since. Today, fuel-operated heater systems are capable of heating the cab's air as well as the engine fluids, and these systems are covered in this report.

Diesel auxiliary power unit (APUs), also covered here, have been in existence since World War I, and it is unclear when they were first used on a truck, as they have long been the preferred tool of truck owner/operators in need of more fully functioning sleeper amenities as they often lived in their trucks at nearly all times. Escalating fuel prices led to more large-scale adoption by fleets in the mid-2000s.

The considerable growth of diesel APUs lead to some quality issues in that industry, as demand was so high that diesel APU manufacturers and their supply base struggled to satisfy it. The resultant dip in diesel APU reliability stimulated the growth of a simplified battery-powered HVAC system (which is itself also a type of APU), covered here, that avoided the complexity and maintenance of the diesel APU.

The most common battery HVAC (Heating, Ventilation & Air Conditioning) system, the Bergstrom Nite system, hit the market in 2006. It further widened the selection of options available to combat excessive idling by providing a solution that didn't use any diesel fuel while providing cold air to the sleeper. These systems do, however, consume diesel fuel, because the larger alternators they require place a large load on the engine to charge their battery packs when the truck is being driven.

Inverters to provide AC power on trucks have a similar history to the various APUs. They were used in small quantities by those who liked to enhance the features of their vehicles. The growth of "personal electronics" throughout the 1980s and 1990s led to wider use of these devices, but most have been the personal property of the drivers and not installed with the oversight of fleet management. Factory installations by vehicle OEMs began in the 1990s. Inverters are considered in this report along with a complimentary technology, battery chargers.

The conversion to electronically controlled diesel engines began in the mid-1980s, with the introduction of programmable parameters that could monitor and control idling practices. These now include the exact idle RPM a fleet desires, the temperatures where idling is timer-controlled, and the temperatures that are considered so hot or cold that unlimited idling is acceptable.

The concept of an automatic diesel engine start/stop system was first introduced in 1990s. These began as add-on systems, but the patents were licensed to several diesel engine OEMs who integrated the

functionality into their engine control system. Both OEM-integrated and aftermarket add-on systems are still in use today, and as such are covered in this report.

The general usage of AC power for vehicles started with block heaters. It is difficult to say when the first clever driver started using AC power for other functions while stopped, but it probably started when the drivers where home for a few days and it was determined that plugging in household heating or air conditioning systems could get the vehicle to a comfortable temperature. This similar concept has long been used by boats and ships, creating the name "shore power," since the AC power was only available when your boat was in dock along the shore. This report discusses such systems under the terms "Vehicle Electrification" and "Off-board AC Power."

Volvo introduced shore power connections as a factory option with the VN model in 1996. The company Shorepower (a specific brand name and not to confused with these systems generally, which are also called "shore power") entered the picture in 2006, and initially provided AC power to test locations in New York.

The first Truck Stop Electrification system was introduced by IdleAire in 2000, promising not only 120 volt (V) AC power, but also HVAC, Internet, and cable TV. These systems are distinct from off-board AC power systems as they require greater investment in and construction of infrastructure, but little to no modifications to the truck itself. The benefits of such systems are obvious, but limited infrastructure/access to their portals has hampered initial acceptance. Some fleets also avoid the use of truck stops for security reasons, which prevents their vehicles from using this technology. Nevertheless the expansion of these systems continues today, with more of the recent installations in fleet-owned locations where vehicles are stopped most frequently such as at border crossings.

Most recently, 2008 brought the introduction of "Clean Idle Stickers" issued by CARB which signified that a given engine system met the CARB requirements for extended idling. This has since grown to have a separate sticker to indicate that a diesel APU has a DPF and meets more stringent requirements for California. These stickers allow drivers to idle the certified component beyond the 5 minute in California.

4.2 Key Features of Idle-Reduction Technologies

Idle-reduction technologies can be distinguished at a most basic level by the pathways by which they reduce the need for idling. Some of the systems are "active" in nature and provide a specific set of benefits to the vehicle and driver, while other idle-reduction methods are "passive" and simply work to minimize the need for the active systems. The wide range of options poses a challenge, or barrier, to the adoption of idle-reduction systems overall, in that each fleet must assess which of the potential benefits conferred by these systems they value the most, and therefore which type of system will allow them to best achieve those benefits.

"Passive" options covered in this report include: additional insulation, curtains, light-colored paint, and other simple tips such as parking in the shade and avoiding blacktop parking in the summer sun. "Active" systems are primarily distinguished among one another by the energy sources they use as alternatives to an idling engine. "Active" idle-reduction technologies today use one of five basic sources of energy, two that are on-board and three that are off-board, as shown in Figure 12:

Diesel Fuel	**On-board**
DC Power in Batteries (12V DC)	
AC Power in Electrical Lines (120V AC/shore power)	**Off-board**
Truck Stop Electrification (Heating/Cooling via a "Snorkel")	
Solar Energy	

Figure 12: Energy Sources of Active Idle-Reduction Systems

The matrix of "Active" systems, Figure 13, aligns the five main desired benefits that drivers require from idling or an idle-reduction technology with the above main sources of energy for those technologies, and then also shows the idle-reduction systems that can meet that specific benefit (solar is not included in this graphic).

BENEFITS	ON TRUCK ENERGY SOURCES		OFF TRUCK ENERGY SOURCES	
↓	DIESEL FUEL	BATTERIES (12 VDC)	120 VAC (shore power…)	OFF BOARD HVAC
CAB HEAT	Diesel APU	Battery HVAC (some)	Household Space Heater	Truck Stop Electrification
	Fuel Operated Air Heater			Hotel
	Fuel Operated Coolant Heater			Dorm
	Automatic Engine Start/Stop			
ENGINE HEAT	Diesel APU		Block Heater	
	Fuel Operated Coolant Heater			
	Automatic Engine Start/Stop			
CAB COOLING	Diesel APU	Battery HVAC	Electric Air Conditioning	Truck Stop Electrification
	Thermal Storage System			Hotel
	Automatic Engine Start/Stop			Dorm
BATTERY STATE OF CHARGE	Diesel APU		Inverter With Charger	
	Automatic Engine Start/Stop		Battery Charger	
HOTEL LOADS	Diesel APU	Inverters	AC Wiring	Hotel
		CPAP Battery	CPAP Battery	Dorm

Figure 13: Energy Sources vs. Provided Benefits Matrix

4.3 Detailed Overview of Idle-Reduction Technologies

This Confidence Report reviews the different types of idle-reduction technologies available on the market today, of which there are many. Specifically, this report divides the systems into nine categories, with a total of 19 technologies considered. Again, the technologies considered here are:

1. Fuel-Operated Heaters
    1.1. Fuel-Operated Air Heaters
    1.2. Fuel-Operated Coolant Heaters
2. Auxiliary Power Units (APUs)
    2.1. Diesel APUs
    2.2. Battery HVAC
    2.3. Thermal Storage Systems
3. Automatic Engine Start/Stop Systems
4. Vehicle Electrification
    4.1. Inverters & Battery Chargers
    4.2. Solar Energy Capture
5. Truck Stop Electrification
6. Off-board AC Power
7. Driver / Vehicle Behavior Controls
    7.1. Electronic Engine Idle Parameters
    7.2. Driver Training
    7.3. Driver Incentives
8. Additional Vehicle Systems
    8.1. Additional Cab Insulation
    8.2. Light-Color Paint
    8.3. Additional CPAP Battery
    8.4. Ultracapacitor Starting System
9. Sleeping Quarters
    9.1. Hotels
    9.2. Dormitories

Please note that any pricing shown anywhere in this report is the full Manufacturer Suggested Retail Price or manufacturer's list price. The trucking industry is known for discount pricing, but discounts can vary, so they were avoided for the purpose of this report.

4.3.1 Fuel-operated Heaters

Fuel-operated or diesel-fired heaters use diesel as a fuel and either provide heat to the sleeper cab (bunk or air heaters) or heat to the truck engine (water or coolant heaters). Both types of heaters can operate with the truck's engine turned off, thereby avoiding idling. These systems do not provide any cooling or AC electric power to the cab.

4.3.1.1 Fuel-operated Air Heaters (also known as Bunk Heaters)

Overview

Fuel-operated air heaters act like small furnaces, with a heating element and blower providing bunk (cab) heat either via direct ducting or via the truck's factory-installed HVAC ducting.

There are four primary manufacturers of fuel-operated air heaters, offering various models with a range of heating capacities – from 6800 to 13,600 Btu/hour. Fuel-operated air heaters draw from as little as 0.7 up to 11.2 amps of battery power while in use. Their maximum blower air flow ranges from around 40 to over 80 cubic feet/minute.

Components

Fuel-operated air heaters are about the size of a loaf of bread and weigh around 6-8 pounds. They are usually mounted under or behind the outside of the sleeper cab, with their fuel pumps plumbed directly from the truck's diesel fuel tank. They use the truck's main batteries as a source of electrical power to run their blowers.

Inside the cab these systems include a driver controller with on/off switch, temperature setting, and fan speed selector. Some controls have digital displays, which can sense the interior temperature, show the current time, and have timers for pre-setting temperature control prior to the driver entering the cab.

Advantages of Fuel-operated Air Heaters

Fuel-operated air heaters are relatively inexpensive to purchase and maintain, and installation is easy as it is usually under or behind the sleeper and does not require frame free space.

Fuel-operated air heaters are very fuel efficient, burning from as little as 0.02 to as much as only 0.13 gallons of fuel per hour. On average they will use around a gallon of fuel during a 24 hour period. One manufacturer recently introduced an air heater that runs on compressed natural gas (CNG). Moreover, they operate very quietly and produce minimal emissions.

Fuel-operated air heaters are available as factory installed options from all truck OEMs. They integrate nicely with other idle-reduction technologies, and therefore are often sold along with battery HVAC systems, thermal storage systems, or some diesel APUs. They are often also sold along with fuel-operated coolant heaters

Disadvantages of Fuel-operated Air Heaters

Fuel-operated air heaters are limited in their functionality as they only provide bunk heat and do not meet the idling needs of air conditioning or AC power for hotel loads, nor do they provide engine pre-heat. They use the truck's main engine batteries for their power, and therefore can drain those batteries over long periods of use. They do burn fuel to operate and emit exhaust in doing so.

Pricing

All truck OEMs offer some of the brands as factory-installed options. They can also be installed locally by their respective truck or heater dealers. Market prices for installed units range from $900 to $1500. Maintenance is minimal and includes flushing out the system and checking fuel lines, mechanical parts and electrical connections.

Warranties and Support

Standard warranties are 2 years and up to 2000 hours and service contracts are usually available for extended coverage.

Suppliers

Espar Airtronic, Airsnugger, Proheat Air, & Webasto Air Top

4.3.1.2 Fuel-operated Coolant Heater (also known as water or engine heaters)

Overview

These systems provide engine pre-heat without the need to idle the truck engine. Fuel-operated coolant heaters act like hot water furnaces, utilizing the truck's own supply of diesel fuel to produce the needed heat. Fuel and air are combined in the systems, generating heat in a combustion chamber. The heater's water-pump warms and circulates engine coolant throughout the truck engine's cooling system to transfer heat to the engine. This provides affordable engine pre-heating. Some higher Btu capacity models of fuel-operated coolant heaters also provide supplemental heating to the cab heater and defroster systems. Coolant heaters regulate the engine's coolant temperature by cycling the heater between various heat levels, depending upon ambient temperature, to maintain appropriate engine coolant heat. This eliminates truck engine cold starts and also the need for electrical engine plug-ins (like block heaters).

Various models with a wide range of heat outputs and control functionality are offered by four major manufacturers. Heat output ranges from 17,100 all the way up to 45,000 Btu/hour. Electrical consumption runs from to 1.9 to 7.5 amps.

Components

Fuel-operated coolant heaters are relatively compact and can be mounted under the hood near the engine or along the frame rail. They are plumbed to the truck's fuel tank and burn between 0.07 and 0.4 gallons of fuel per hour, depending upon the heat output required, the ambient air temperature and the controller setting. Most models weigh around 6 or 7 pounds.

Driver controls include an on/off switch and diagnostic codes, and most models offer a 7-day timer providing automatic start-up of the heater without the need for driver interface. Coolant heaters are often required in trucks operating in colder climates and sometimes sold in conjunction with fuel-operated air heaters or other idle-reduction solutions like diesel APUs, battery HVACs, or thermal storage systems.

Pricing

All truck OEMs offer some of the brands of fuel-operated coolant heaters as factory-installed options. They can also be installed locally by their respective truck or heater dealers. Market prices for installed systems range from $800 to $1000.

Warranties and Support

Maintenance is minimal and includes flushing out the system and checking fuel lines, mechanical parts and electrical connections. Standard warranties are usually 2 years / 2000 hours and service contracts are usually available for extended coverage.

Advantages of Fuel-operated Coolant Heaters

- Relatively inexpensive to purchase and maintain
- Eliminate truck engine cold starts
- Provide higher heating capacity than engine block heaters and no AC power electrical connection required
- Can be programmed for remote start-up without driver interface
- Pre-warmed engines deliver cab heat and defrost windows without needing engine warm up
- Can be used with diesel APU or battery HVAC system, and/or with Fuel-operated air heaters
- Warm engines produce fewer emissions upon start-up
- Available as a factory-installed options from all truck OEMs

Disadvantages of Fuel-operated Coolant Heaters

- Do not provide cab cooling
- In most cases, do not provide bunk heating
- Do not provide AC power for hotel loads
- Use fuel and create emissions

Suppliers

Espar Hydronic, Snugger, Proheat X45 & Webasto Thermo Top and DBW 2010

4.3.2 Auxiliary Power Units

Given that the tractor's main diesel engine is its primary power unit, any additional sources of energy are "auxiliary." Some of these units are diesel-powered, some are battery-powered, and some use thermally-stored energy for future use.

4.3.2.1 Diesel APUs

Overview

Diesel APUs can provide cooling, heating, and electrical power to the sleeper cab while the truck's engine is off. Note though that some diesel APUs on the market today provide heating and cooling and AC power, while others provide cooling and AC power only and use a fuel-operated air heater for cab heat. All diesel APUs also charge truck batteries and provide electrical power for a block heater. They burn between 0.1 and 0.5 gallons of fuel per hour depending on their design, the ambient temperature, the sleeper's insulation, and the resulting HVAC load, along with the AC power being generated. They utilize various brands of two- or three-cylinder water-cooled engines running on diesel from the truck's fuel tank. Engine power runs from 7 to 18 HP.

There are two basic types of diesel APUs relative to how electrical power is delivered to the cab. One type has a 4K or 6K watt generator providing AC power directly to the cab, while the other type generates electrical power with a 12V DC alternator that charges the truck's battery system, with an in-cab inverter providing 110V or 120V AC power to the cab.

In addition, some diesel APUs are closed systems (closed loop), that is, they are not plumbed into the truck engine's cooling system, while others are open systems (open loop) connected to the truck engine's cooling systems. Another differentiation among diesel APUs is whether the air conditioning condenser is mounted on the diesel APU itself (self-contained) or remotely mounted, (often called "split-system") usually on the outside back of the sleeper cab. Finally, some diesel APUs utilize the truck cab's existing air ducting, while some require supplement ducting. In any case, a complete assembly with power unit, evaporator, condenser, and connections weighs from about 400 up to 550 pounds.

Components

Basic components of a diesel APU are the power pack (with or without generator), evaporator assembly, and condenser/fan assembly. For cooling the systems also have an HVAC compressor, and an air conditioning condenser and fan assembly included. The power pack consists of the diesel engine, alternator, starter, radiator and fan, muffler and tail pipe, air filter, water filter, fuel filter, and electrical components. Diesel APU power packs are mounted inside a cabinet made of steel, aluminum, or stainless steel, which is secured to the truck frame via mounting hardware. The evaporator assembly with blower is usually mounted under the sleeper bunk. Fuel lines are plumbed to the truck's fuel tank and the diesel APU is wired to the truck's battery bank. The free space needed to install a diesel APU ranges from about 24 inches to 36 inches. Finally, the system's driver-operated control unit is mounted inside the sleeper cab.

Functionality

A diesel APU's engine has an alternator that provides power to the truck's batteries. This keeps the batteries charged to eliminate jump-starts, and also provides adequate power for the inverter in diesel APU models which do not utilize a generator. (These models usually include a larger capacity alternator, up to 150 amps.) In models with generators, the diesel APU's engine runs the generator which provides AC power to 110-120V outlets inside the sleeper cab for driver hotel loads. The diesel APU's engine also powers the air conditioning compressor which is connected to the evaporator and condenser assemblies to provide cooling. Cooling capacity runs from 12,000 to 20,000 Btus. Heat is provided via either heat-strips or coils, a heat pump, or one manufacturer uses a fuel-operated air heater that is integrated with its system. Heating capacity runs from 7500 to 18,000 Btus. Most diesel APUs can also power a truck engine block heater if a vehicle is so equipped. In open-loop systems, wherein the technology is plumbed into the truck engine cooling system, the running diesel APU can keep the truck engine warm, thus eliminating cold starts, while also serving as the radiator for the diesel APU engine. Other common functions include battery monitoring with automatic diesel APU start-up for battery charging, possible "limp home" capability should the truck engine's alternator fail, and auxiliary AC power source for running items like lights or tools outside of the sleeper.

Driver Controls

Diesel APU controllers are mounted inside the sleeper and are used to turn the unit on or off, switch between heat and cooling modes, and regulate fan speed. They can be touch screen, controlled by knobs or switches, or a combination of those. Most units have an hour meter to measure the diesel APU's run time. The displays also monitor battery charge condition, and some can display diagnostic codes and will facilitate diesel APU engine shut-down in conditions of high water temperature or low oil pressure. Some manufacturers provide maintenance reminders and the capability to program hour and day automatic diesel APU start-up times to provide pre-trip cab cooling or heating.

Generator vs. Inverter Models

Diesel APUs with generators provide 120V AC power directly to cab and do not depend on the truck's batteries for this power. They can provide maximum 'hotel loads' (hotel loads are anything the driver has running while the truck is parked such as a TV, refrigerator, microwave, game station, DVD player, CPAP, fan, laptop, electric blanket, cell phone charger, etc.) for power both inside and outside the cab without the need to purchase and install an inverter. A disadvantage of the generator-based diesel APU system is that you must run the diesel APU engine and generator for any AC power needs.

Inverter-based diesel APUs depend on the diesel APU's alternator to provide power to the DC truck batteries, which is then converted to AC power via an inverter inside the sleeper. Therefore, with the exception of HVAC needs, the only time the engines of inverter-based diesel APUs run is when the systems' batteries need to be recharged. Depending on hotel power needs it is possible that the truck batteries will need to be replaced more often, as may the diesel APU's alternator due to the increased charge and discharge cycles inherent in these systems. On the upside, this configuration of diesel APU is

usually lighter and less expensive to purchase than a generator-based system, and it typically uses less fuel and requires a bit less maintenance.

Other Options

Some diesel APU manufacturers offer 'shore power' 110/120V AC capabilities for diesel APU engine-off performance. One brand provides an optional air compressor to run pneumatic tools or supplement the truck or trailer air brake systems. Various compartment exterior finishes are available and one manufacturer offers a top of frame rail mounting when there is not enough free space on the side of the frame for mounting. Higher output heaters are available and higher capacity alternators are popular options. Diesel APU controllers have many options and can include LCD digital displays and remote diagnostics. Two diesel APU manufacturers offer CARB approved DPF (diesel particulate filters) systems.

Summary of Types of Diesel APUs

- APUs where AC electrical power comes from a generator
- APUs where AC electrical power comes from an inverter, via DC power from the truck batteries
- APUs that provide complete HVAC (both heating and cooling)
- APUs that provide cooling only and use a fuel-fired bunk heater for cab heat
- APUs that have an open system plumbed into the main truck engine to eliminate cold starts
- APUs that have a closed system and are not plumbed into the main truck engine

Advantages of Diesel APUs

Diesel APUs provide a complete solution for cab cooling, heating, AC power for hotel loads, and battery charging. Because they run on diesel, they can operate as long as the truck has fuel. This provides nearly an unlimited amount of time for cooling, heating, and AC power without the need to restart the truck engine. Diesel APUs are well suited for hot and cold temperature extremes with their high Btu capacities. In comparison, battery HVAC APU systems are limited to 6-10 hours of cooling before truck engine restart and battery recharging is required, and their hotel load AC power capabilities usually are less than their diesel-powered counterparts. Plus cold weather reduces battery capacity thus negatively affecting the hotel load AC power capabilities of such systems, while diesel APUs can avoid those issues. Battery HVAC systems also require optional fuel-operated air heaters to provide cab heat. Meanwhile, compared to automatic engine start/stop systems, diesel APUs provide significantly less main engine wear and open the opportunity to extend service intervals on the main engine.

Disadvantages of Diesel APUs

Diesel APUs are usually more expensive to purchase, install and maintain than other idle-reduction technologies. Compared to battery HVACs, for example, diesel APUs require periodic oil and filter changes (sometimes more frequently than the truck's normal maintenance cycle) and have more parts

and components to be maintained. Due to their mounting location, diesel APUs are exposed to road debris, salt and spray, and one must have adequate frame space to install a diesel APU. Plus, additional work is required at installation for an open-loop system. Diesel APUs do consume diesel fuel, and therefore they generate emissions and noise, while reducing fuel savings less than other idle-reduction technologies. Finally, some primarily urban municipalities have zoning restrictions against running a diesel APU. In California, for example, one may need to add an expensive diesel particulate filter to make a diesel APU compliant with that state's specific emission regulations.

Service and Maintenance

Of all the available idle reduction technologies, diesel APUs provide the most functionality but have the most components to maintain, and proper maintenance is necessary for optimal operation and long life. Most components are accessed inside the diesel APU power pack compartment via removable panels. Maintenance includes periodical inspection of belts, hoses, clamps, electrical connections, A/C refrigerant levels. Diesel APU engine manufacturers' recommendations for changing engine oil, oil filters, fuel filters, air filters vary from 500 to 2000 hours. Coolant and fuel lines, electrical lines and connections, alternators, compressors, evaporators, condensers, and generators also need to be inspected and maintained.

Warranties and Support

Diesel APU manufacturers provide standard parts-and-service warranties, and most offer optional service contracts. Warranties are stated in years and hours of operation, and the standard ones vary from 1 to 4 years and 1000 to 4000 hours for their diesel engines and related components. Warranty coverage on other components like compressors, generators, and HVAC assemblies are often different than published APU engine warranties. Factory-authorized dealer support varies widely by brand and is relative to number of locations, as some brands have locations in the US only but others can provide service in both Canada and the US. Dealers provide installation along with parts and service support. Some truck OEMs offer diesel APU accommodation packages and some even offer complete unit factory availability. Dealer installation times vary by brand and complexity of the system and usually run from one to two days. Most brands also offer financing and/or leasing.

Pricing

Installed prices vary widely, from around $8,000 up to $12,000, depending on generator or inverter models, diesel APU brand, closed- or open-loop systems, options specified, truck configurations (mounting implications), and local or OEM factory installation. Different diesel APU manufacturers offer different standard and optional warranty coverage and these factors also affect initial purchase price. The diesel APU may be FET exempt, per the information provided earlier in section 3.4.2 of this report.

Residual Values

Residual values depend upon the age and mileage of the truck and the number of hours the diesel APU has operated. Some fleets remove their diesel APUs at time of trade and install them on new trucks or

resell them as loose power units along with their components. Values may fluctuate based on options, brand, and type of diesel APU and market demand.

The following values assume the diesel APU provides heating, cooling and AC power to the cab and is in working condition:

- One major truck OEM residual value at time of trade (4 year old truck with 500K miles) is $750-1000
- NADA used truck values by model year: 2011=$1,225, 2010=$1,100, 2009=$975, 2008=$850, 2007=$725
- Truck Blue Book values by model year: 2011=$2,250, 2010=$1,300, 2009=$750

Recommendations and Best Practices

Diesel APUs are best suited for the following:

- Trucks operating in the south and southwest US where day and night temperatures are high
- Situations where a fleet needs to provide driver comfort over longer periods of time, such as to comply with the 34 hour HOS restart regulation
- When drivers need maximum AC power loads for multiple in-cab electronic devices
- When optimal driver satisfaction due to the multiple benefits of diesel APUs is of high importance
- When drivers have been trained how to properly operate this more complex solution
- When a fleet's maintenance shop can meet the required, often shorter, maintenance schedules of diesel APUs
- When the extra weight and frame space required for a diesel APU is not an issue

Suppliers

Acemco, Comfort Pro, Centramatic, Diamond Power Systems, Green APU, Go Green APU, Dynasys, Parks Industries HP2000, Pony Pack, Rigmaster, StarClass, Thermo King TriPac, Tridako & Willis

4.3.2.2 Battery HVAC

Overview

Battery-powered HVAC systems, often also called Battery APUs or Battery EPUs, are designed to provide climate control for sleeper cabs without having to idle the engine. Battery HVAC systems have been described as true zero-idle solutions since they do not use any type of engine while in operation. Some of these systems operate on 12V power generated from a bank of independent Group 31 Absorbed Glass Mat (AGM) batteries, using an inverter which converts 12V DC battery power into 115V AC power. Other units do not use inverters and simply operate on 12V DC power. Developments in lithium ion battery technology may change the type of batteries used in these systems in the future.

Many truck OEMs including Freightliner, Navistar, Kenworth and Peterbilt, offer battery HVAC systems as factory options. One battery HVAC manufacturer has a partnership with a company that offers a solar battery charging technology which uses solar panels to charge the battery HVAC unit's batteries.

Functionality

While a truck is running (driving), these systems capture energy produced by the main truck engine's alternator and store it in the AGM batteries. Later, when the truck's engine is turned off, the energy stored in the batteries can be used to power air conditioning, hotel loads, and, in some configurations, heating systems. The system's batteries can be recharged either by running the main engine to utilize the alternator or by plugging into off-board AC power (shore power.) Because of the extra load placed on the alternator by battery HVAC systems, trucks which have them installed will also need to have a larger alternator (185-amp minimum) installed. Many manufacturers recommend much larger alternators in the 270-amp to 320-amp range to ensure that the HVAC batteries get fully recharged before they are to be used again.

When the system is on, the inverter converts 12V DC energy that is stored in the AGM battery bank into 120V AC electricity. This provides the electricity needed to power electrical appliances like microwaves, televisions, computers, etc. Using an inverter-charger decreases the available run time for air conditioning systems especially when electrical hotel load devices are also being used.

Cooling capacity for the units varies from 4,600 to 10,000 Btu/hour, and cooling is influenced by a variety of factors including the size of the sleeper/cab, amount of insulation in the vehicle, size of windows, sun loading (when the sun itself heats up the interior of the cab), and exterior paint color, as well as the ambient temperature the vehicle is operating in. Most battery HVAC system manufacturers say their units can provide 8-10 hours of cooling capacity. Real-world results vary depending, as mentioned, on ambient temperature, whether the driver pre-cooled the vehicle and if the battery HVAC system is also being used to power electrical devices in the sleeper/cab while the truck engine is off.

When selecting a battery HVAC, fleets must remember that the higher the Btus the more energy or power it will take to run the unit, and therefore the less run-time that it will offer. Fleets should aim to purchase systems that will meet their cooling needs for 8-10 hours. To ensure adequate cooling time, many battery HVAC systems are able to run off AC current via an off-board AC power connection. AC current is more efficient than DC current, so more powerful air conditioners can be used for the amount of time needed by the driver. In order for battery HVAC systems to run on both DC and AC power, an inverter-charger needs to be included as part of the system. This adds some complexity, cost, and weight to the system. Battery HVAC systems that run only on DC power do not need inverter-chargers.

Components

Components necessary for a battery HVAC system are: deep-cycle batteries, high-performance alternator, DC-to-AC inverter, air conditioning components, and a controller/thermostat. Some models do not use inverters and operate solely on DC current. Many battery HVAC systems can be specified with optional heating from fuel-operated heaters.

The air conditioning units can be split or self-contained. With a split system, the condenser is located outside the sleeper/cab, while the evaporator/compressor is inside the sleeper/cab. In a self-contained unit, all components are located in a storage compartment or under the bunk. An additional battery box has to be installed to house the auxiliary batteries needed to operate the battery HVAC system. In some systems, batteries are tied together with the four main truck batteries and then connected to an inverter-charger. In other systems, the auxiliary batteries operate independently and some systems do not use inverter-chargers. When inverter-chargers are used they typically have a low voltage disconnect so the batteries will never run down below the recommended level. Some units feature inverter-chargers with battery management/automatic start technology that automatically restarts the truck's engine when the auxiliary batteries reach a pre-determined depth of discharge.

Advantages of Battery HVACs

Since they operate off of battery power, battery HVAC systems produce zero emissions while providing air conditioning or AC power for hotel loads.

Battery HVAC systems reduce the cost of fuel associated with idling to keep the driver cool or warm. Compared to automatic engine start/stop systems, battery HVACs cause significantly less main engine wear, thereby allowing fleets to extend their service intervals on the main engine.

Battery HVAC systems are less expensive than some other anti-idling options. Prices range from $4,500 to $6,000, not including the cost of an optional fuel-operated heater.

Battery HVAC systems are quieter than diesel APUs. They also have fewer moving parts (so less opportunity for malfunction) and require less maintenance training than diesel APUs. Overall battery HVACs have lower maintenance costs than diesel APUs.

Most battery HVAC systems have the option of operating off an off-board AC power connection. This will increase the operating time of the unit and will also recharge the batteries more cheaply than doing so with the engine alternator. Battery HVAC systems are easy for drivers to operate. Digital or rotational automotive-style controls provide automatic temperature control. The driver simply turns the switch to heating or air conditioning, and selects a fan speed and a desired temperature.

Disadvantages of Battery HVACs

Systems equipped with fuel-operated heaters will consume diesel fuel during heater operation as well as battery or AC power to run the heater fan. Additionally, battery HVACs are not a viable solution for the 34 consecutive hours of rest that is part of FMCSA's Hours of Service regulation without restarting the truck's main engine and running it for one to three hours. In most cases, however, the batteries of the battery HVAC system will simply be recharged while the truck is driving.

While manufacturers of battery HVACs claim 8-10 hours of cooling capacity, there is some concern that in extremely hot conditions there will not be enough battery power to keep the sleeper/cab cool enough for the driver.

The AGM batteries in these units do not last forever and will have to be replaced. Two years seems to be the average life expectancy of these batteries.

In total, including the required four deep-cycle AGM batteries, battery HVACs will add 400-500 pounds to the weight of the vehicle. This may become less of an issue in the future if other battery technology is developed.

Because of the increased load battery HVACs place on the charging system, trucks equipped with such battery HVACs need to have large capacity alternators. Cables of the proper size must also be used, and it is important that all connections be tightened properly for the system to operate.

The alternator for a battery HVAC system puts twice the load on the engine of a normal sleeper tractor's alternator. These higher capacity alternators pull between five and seven additional horsepower off the engine. Therefore, their use does cause a truck to consume more diesel fuel while driving, but lowers fuel use overall as they can reduce significant amounts of idling.

Service and Maintenance

Very little maintenance is associated with battery HVAC systems. The batteries need to be checked frequently for signs of corrosion and to make sure all electrical connections are tight. The air filter needs to be inspected regularly and cleaned as needed, in order to ensure good airflow across the evaporator. The air path between the return-air grill and the evaporator needs to be inspected to ensure it is not blocked. The condensate drain needs to be checked to ensure it is draining properly, and any clogs that are found need to be removed. Outside wires, cables, and refrigerant lines need to be checked for chafing. The filter on the evaporator needs to be cleaned periodically. Debris needs to be removed from the condenser. Battery HVAC manufacturers recommend that connection tightness be checked during normal preventive maintenance inspections to prevent voltage drops.

Obviously batteries wear out, and Group 31 AGM batteries are no different from other batteries in that regard. AGM batteries range in price from $180 to $260 each, and their typical life cycle is two years.

If refrigerant levels are low, service must be performed by an EPA-licensed HVAC technician using proper tools.

Warranties and Support

Battery HVACs that are purchased in the aftermarket take from 4-10 hours to install, depending on if they are air conditioning only or heating and air conditioning systems. Warranties vary from 2 years parts and labor to 1 year labor/2 year parts.

Pricing

The Manufacturer Suggested Retail Prices (note that MSRPs are not discounted) for battery HVACs is $4,500 to $6,000. With installation, system prices range from $8,500 to $8,800. Installation times are six to eight hours, including installation of the extra battery box, wiring the batteries, mounting the alternator, and mounting the unit itself. The price of the batteries themselves range from $180 to $260.

Optional fuel-operated heaters cost an additional approximately $700, as well as the fuel they consume to operate.

Recommendations and Best Practices

To get the most out of a battery HVAC, fleets should also spec extra cab/sleeper insulation. Meanwhile, drivers should pre-cool their trucks by running the vehicle's air conditioning on high while driving just prior to shutting the truck engine off and turning on the battery HVAC. Drivers also should pull the curtain between the cab and sleeper, use window shades, and park on concrete rather than dark asphalt if possible. Limiting hotel loads will also significantly extend the available cooling hours of a battery HVAC.

Battery HVAC Suppliers

Arctic Breeze, Bergstrom (NITE Plus and NITE Phoenix), Crosspoint Solutions (ClimaCab), Domestic, Idle Free Systems, Indel B, Kingtec & Thermo King TriPac e

OEM Systems

Freightliner ParkSmart (Bergstrom), Kenworth KIMS (Bergstrom), Mack (Idle Free), Navistar MaxxPower (Bergstrom), Peterbilt Smart Air (Bergstrom), Volvo (Idle Free)

4.3.2.3 Thermal Storage Systems

Overview

Thermal storage systems provide engine-off cab cooling through the use of cold energy storage. No additional batteries are required, as these draw power from the truck's four vehicle starting batteries. Therefore, their operation does not consume any fuel or generate any emissions. However thermal storage systems do not provide cab heat, nor do they aid in engine cold starts. Moreover, AC electrical power for hotel loads and battery charging requires the additional adoption of an off-board AC power system - thermal storage systems do not provide these options.

Components

Thermal storage systems have two major components. One, a refrigeration and cold storage assembly inside a compartment mounted to the truck's frame rail, and two, a heat exchanger (also called an air handler) with fans and a controller mounted on the back wall of the inside of the sleeper. Together these components weigh around 325 pounds. A vehicle alternator of at least 165-amp output is also required.

Functionality

Thermal storage systems produce cool air using thermal energy stored in a frozen graphite/water matrix. In 4-6 hours of normal driving, an electric refrigeration compressor freezes the water within the storage unit. When idle cooling is required, a pump circulates coolant through a storage core and then through a heat exchanger in the cab. Fans in the heat exchanger draw in warm bunk air past where it gives up its heat to the chilled mixture thus creating cool air, which is then blown back into the sleeper.

Cooling capacity is stated at 17,000 Btus, with power consumption during cooling at 3.5 – 10 amps. The driver can control fan speed and temperature. This system is CARB approved, creates zero emissions and can run from 8 – 10 hours under most ambient conditions on one charge without idling.

Service, Maintenance, and Warranties

Currently this system is only available from one supplier, as a dealer-installed aftermarket item. While in use, this system is virtually maintenance free with a standard warranty of 2 years.

Advantages of Thermal Storage Systems

These systems are quiet, and do not burn fuel or create emissions while in stationary cooling mode. Also, they do not require additional batteries like battery HVAC systems. Plus, thermal storage systems are virtually maintenance free. These systems are best for trucks which frequently operate in hot weather and therefore require cooling almost whenever the truck is stopped.

Disadvantages of Thermal Storage Systems

Unlike diesel APUs, thermal storage systems have limited cooling time, provide no electrical power for hotel loads and do not keep the truck engine coolant warm to aid in cold starts.

Overall, thermal storage systems are limited in their function, as they only provide cooling for the cab when the truck is stopped. To also obtain AC electrical power to the cab and truck battery charging without idling, they must be specified together with an off-board AC power system (shore power). To also obtain bunk heating without idling, a fuel-operated air heater would be required.

Thermal storage systems also require a larger truck alternator in order to provide cold storage unit charging while the truck is being driven. The larger alternator places an additional load on the engine at all times the vehicle is running, which in turn burns additional diesel fuel (again, not as much as is saved by not having to idle the engine for HVAC).

Suppliers

Webasto Blue Cool

4.3.3 Automatic Engine Start/Stop Systems

Overview

Automatic engine start/stop systems utilize the main diesel engine to provide a variety of features without requiring the truck's engine to idle continuously. These systems have a set of inputs to ensure that it is safe to start the engine without anyone at the controls, such as:

- Transmission Neutral Switch (not in gear)
- Parking Brake Set Switch (won't roll away)
- Hood Closed Switch (no one is under the hood doing checks or service)

Functionality

Once the engine is running the vehicle's HVAC systems will warm or cool the sleeper just as they would when the truck is driving down the road. Essentially the vehicle is still idling, keeping the engine warm and the batteries charged, but it is able to do so much more intelligently/efficiently, and automatically.

These systems can be used in very cold climates, for instance while a truck is in storage for a weekend or other down time, and offer very beneficial results, ensuring the vehicle will start when it is time to go back into freight-hauling operation. Automatic engine start/stop systems perform the work of both a block heater and battery charger without the need for the truck to be connected to outside power.

Types of Automatic Engine Start/Stop Systems

There are two different types of automatic engine start/stop systems, the most common being one that has a goal of maintaining a cab's interior temperature when the vehicle is occupied. These may also assist with keeping the engine warm and the batteries charged.

The newer and less common type of automatic engine start/stop system focuses solely on maintaining the batteries' state of charge. Given the growth in use of battery HVACs, combined with the new HOS restarts that last far longer than the 8 to 12 hours a battery HVAC can operate on one charge, this type of automatic engine start/stop system will probably grow in popularity, as they serve to recharge the battery HVAC system as it has drawn itself down. These will therefore enable battery HVACs to idle for longer than a single 8-10 hour window, allowing a driver to enjoy air conditioning continuously during an HOS restart. This type of automatic engine start/stop system is programmed to recognize the specific type of batteries being used by the battery HVAC system, and monitor their voltage, current draw, and temperature to provide optimal recharging patterns by comparing the inputs they receive to electronically stored battery-life models. It will typically require about 45 minutes of engine operation (which the automatic engine start/stop system will control) to fully recharge a battery HVAC system for an additional 8-10 hours of operation.

Currently, most of these automatic engine start/stop systems are aftermarket installed, but one OEM, Freightliner/Detroit, has integrated the feature into its engine controls and vehicle controls.

Advantages of Automatic Engine Start/Stop Systems The most obvious benefit of all automatic start/stop systems is that they add relatively little componentry and weight to the vehicle. Since they are controlling the main engine, they do not require additional HVAC components, batteries, or engines to accomplish their tasks.

If a vehicle is purchased with a California Air Resource Board (ARB) "Clean Idle" engine, it will have a serial numbered holographic sticker on the driver's side of the hood or driver's door. See Figure 11 for a photograph on this sticker. Such stickers allow automatic engine start/stop systems to be used without violating any idling regulations, provided that the vehicle wasn't also purchased with the tamperproof five-minute timer which does not allow any idling at all beyond that time limit.

Clean idle engines offer an integrated and clean solution which utilizes a few extra sensors to provide all of the desired HVAC and hotel load benefits while the vehicle is not moving. It may also be the solution

most preferred by fleet maintenance teams, given its simplicity/commonality of diagnostics, service and parts.

Disadvantages of Automatic Engine Start/Stop Systems

The initial automatic engine start/stop systems that came out about two decades ago were not well-liked by truck drivers. Whenever those systems started and stopped the main engine the noise and vibration could wake a sleeping driver. Some improvements have minimized this problem on newer systems, such as using the engine brake to create a more rapid and smooth engine shut-off than the cab rocking and engine sputtering which occurs during a normal shutoff.

Another drawback of these systems is that they do require idling the main engine, creating additional hours of wear on the main engine and loading of the DPF exhaust system.

Finally, it is not completely clear how various idle laws relate to some of the operational modes available with these systems. If the automatic engine start/stop system is charging the batteries or allowing a regeneration of the DPF system, it should be permissible to allow engine operation longer than the typical five minute maximum, similar to the rules which govern aspects of the electronic engine idle parameters technology class, and are detailed in that section.

Pricing and Warranties

MSRPs range from $1,500 to $2,500, and the warranties range from two years to a lifetime guarantee.

Recommendations and Best Practices

If your fleet is dissatisfied with the length of operation of your battery HVAC system, a battery monitoring and charging system such as that offered by automatic engine start/stop systems could be a desirable investment to extend operation.

For fleets that are challenged from a support aspect to keep diesel APUs systems in operation, the combination of a Clean Idle engine and an automated engine start/stop system could reduce that challenge.

Suppliers

Detroit Diesel Optimized Idle, EMI Temp-A-Start, IdleSmart & Vanner IdleWatch

4.3.4 Vehicle Electrification

This section of the report focuses on the use of AC power inside the sleeper cab. For the sake of this report we put the provision of AC power to the vehicle via off-board AC power, (aka shore power) into a separate section (including but not limited to the use of the power from the company named Shorepower). This section deals only with systems that are installed onto a vehicle, not systems which require both vehicle modifications and the construction of external powering infrastructure.

4.3.4.1 Inverters & Battery Chargers

Overview

Inverters are not necessarily an idle-reduction measure, as they are simply designed to convert 12V DC power into 120V AC power. But they have been included in this idle-reduction Confidence Report along with the battery chargers included in some models of inverters as one technology, due to their usage by many drivers to support the CPAP machines they require for quality sleep. Hotel loads such as a CPAP drain the truck's engine batteries, and as a battery charger connected to AC power can recharge the batteries using an inverter, this technology has significant potential to reduce idling. Although only a small fraction of sleeper tractors are built with an inverter at the factory, the majority of sleeper tractors have an inverter installed once they are put into use, as fleets or more commonly drivers chose to add them.

Selecting the best inverter for a given truck involves a variety of factors, including:

- AC Power Output Size
- Power Cleanliness (Pure Sine Wave versus Modified Sine Wave)
- Battery Charger (None, Integrated, or Separate)
- Reliability
- AC Wiring Backbone (Shore power capable, Quick Connect or hardwired)

The first factor, sizing an inverter, requires creating a list of what devices are expected to be operated in the sleeper cab while it is stopped, and moreover identifying which device will operate on the truck's 12V DC system and which will need to operate via the 120V AC power from the inverter. It should be noted that although 120V AC devices are more readily available and therefore usually less expensive than 12V DC devices, the ones on the market may not be designed for the vibration levels and temperature extremes seen in a truck sleeper. Small college dormitory style refrigerators, for example, are not typically designed for use inside a truck in 120V AC models – 12V DC versions are required for automotive and commercial truck applications.

A summary of common AC appliance loads is provided in Figure 14:

Approximate power requirements for commonly used electronics:

Example	Power in Watts	Example	Power in Watts
Computer System	200	Microwave Oven	1200
Power Drill	400	Large Vacuum	1200
Coffee Maker	900	Circular Saw	1500
Toaster	800	Blender/ Juicer	1000

Figure 14: Inverter Loads (Xantrex, 2010)

Types of Inverters & Battery Chargers

Inverters are made in two categories; pure sine wave and modified sine wave. These nomenclatures describe the 'cleanliness' of the AC power being created by the inverter. Pure sine wave inverters create

AC power that is similar to the power provided by the familiar wall outlets inside buildings. Modified sine wave inverters are more common in automotive applications, but they 'clip' the normally smooth AC power wave. While most electronic devices can be operated on a modified sine wave inverter, there are some that CANNOT be operated properly at all, notably some medical devices and computers, and other devices that will suffer shorter useful lives from operating on modified sine waves. Most relevant to the trucking industry when selecting an inverter is the CPAP machines used by many drivers. Most models of these devices are capable of functioning on a modified sine wave signal, but it is quite possible that a modified sine wave power source will shorten the life of the device. The cost differential between a pure sine wave inverter and the cheaper modified inverters has been decreasing, so it is worth considering making this additional investment up front and purchasing the pure sine wave inverters, given that they could save money on the lifespan of devices in the long term. Utilizing a pure sine wave inverter guarantees a cleaner power source for more sensitive devices that might not work or work as well with modified wave inverters.

Inverters drain a truck's batteries to generate AC power for the operation of electrical devices inside the cab while the truck's engine is turned off. Some models of inverters have integrated battery chargers, which essentially reverse the operation to charge the batteries whenever the vehicle is connected to 120V AC via a heavy-duty extension cord. This is beneficial to both battery state of charge and therefore the likelihood of restarting once the extension cord is removed. Because few driver installed inverters utilize a battery charger, some suppliers sell battery chargers that are not integrated into the inverter but can be installed in tandem with the inverter for the additional functionality. Use of off-board AC power and a battery charger can extend the life of the vehicle's batteries, which can offset the additional costs of the inverter and battery charger over time.

It should be noted that some tractor sleepers are wired for 120V AC use without an inverter, to enable ease of power use in off-board AC power or truck stop electrification situations. The external off-board AC power connecter is wired to the internal AC outlets so whenever the vehicle is plugging into off-board AC power all devices inside the sleeper on the AC power lines can have instant access to power. Obviously in this situation without an inverter, the instant that off-board AC power is removed, all AC devices inside the vehicle lose power.

Advantages of Inverters & Battery Chargers

An inverter alone can use DC power stored in batteries to provide 120V AC power to a wide range of devices including but not limited to CPAP machines, TVs, DVD/Blu-ray players, and gaming stations. If sized large enough they can also power an appliance such as a microwave. If a driver is confined to his or her sleeper for a 34 to 48 hour restart, the comforts of home become very important, and an inverter can provide those in a cost-effective manner without violating idle laws.

An even more beneficial system is an inverter with an optional battery charger and off-board AC power connection, as this configuration has the capability to charge the batteries and in most cases can bypass the inverter to allow off-board AC power (or any other 120V AC supply) to run all of the AC powered devices on the vehicle. Properly used, an inverter with a battery charger system can be beneficial not

only when the driver resting in the vehicle, but also could be plugged in when the driver is home, simply to maintain the truck's batteries in a fully charged state.

Disadvantages of Inverters & Battery Chargers

While a very small inverter can operate off a 12V DC power plug, most sleeper inverters need to be wired to the vehicle's batteries. Small inverters also have small power ratings which prevent them from being used for appliances and heavy AC loads. (Reference the power chart on the previous page)

The vehicle's AC wiring system is critical for safe operation of an inverter (and battery charger if so equipped). Failure to properly size, fuse and protect the wires from vibration and chaffing can result in fires, injuries, and even death. To insure a quality installation that is also straightforward for shop mechanics to service, most OEM inverter installations are done with polarized quick connect wiring systems. Similar wiring kits are available for aftermarket installation. Some inverter installations have the capability to automatically switch to off-board AC power operation when the vehicle is connected to a 120V AC power source. This is highly desirable to move the AC electrical loads from the inverter/truck battery system and place them on the external power source.

A truck sleeper will expose any device to a variety of vibration and temperature extremes during operation and storage. Many inverters on the market today were designed for less-demanding family needs, such as camping or tailgating excursions. These inverters are less robust and therefore less expensive – tempting but ultimately a poor choice for the trucking industry. It is recommended that an inverter for a truck sleeper be UL 458 approved to indicate that it is designed for truck applications.

Failure to properly install and operate an inverter can result in fire, property damage, injury and even death. At least one fleet manager is known to keep a photograph of a burned-out sleeper tractor on the wall as a reminder of the dangers of improper wiring.

Recommendations and Best Practices

Given the need and popularity of inverters, fleets need to establish polices on use of inverters in their vehicles. Such rules might cover such areas as:

1. Are drivers allowed to install their own inverters? (If yes, what modifications are drivers allowed to do? For instance, connections to the batteries?)
2. If drivers are allowed to connect directly to the vehicle's batteries, who has the responsibility to make sure the work was done properly including wire size, circuit protection and routing and clipping that prevent chaffing and shorting?
3. If the vehicle is equipped to be connected to off-board AC power, will the fleet reimburse drivers any portion of the off-board AC power charges?
4. For simplicity of service and diagnostics, does the fleet have one approved inverter system and installation method?

5. At the highest level, is it worth the extra vehicle battery life and reliability to order the sleeper from the OEM factory with the inverter, battery charger, polarized quick connect wiring system and off-board AC power connection point?

For this last question, doing so provides numerous benefits including a common system across the fleet, validated installation methods, complete system warranty, and maximum functionality for the drivers. Additionally if this system is used with off-board AC power when stopped or on weekends, it enhances battery life while reducing jump-start requests.

Suppliers

Phillips & Temro, Tundra, Vanner, Xantrex

4.3.4.2 On-Vehicle Solar Energy Capture

Overview

Many fleets have reported that their most significant barrier to idle-reduction are sunny and hot summer days. On-vehicle solar energy capture puts that sun to work to the advantage of the driver, thanks to roof-mounted solar panels. Those solar panels capture the energy from the sun and convert it to DC power that can run a battery HVAC system during the day, as well as recharge the HVAC batteries after they have been run down overnight.

Advantages of On-Vehicle Solar Energy Capture

Fleets using battery HVACs to provide summer cooling face a challenge of how to keep the HVAC batteries charged during the longer rest periods mandated by the new Hours of Service (HOS) rules. Conventional battery HVACs can provide cooling for at most 8-10 hours on a single charge. Roof-mounted solar panels offer a completely silent and cost-free source of energy, with which to either run the HVAC system directly or recharge the HVAC's battery. Daylight breaks, which are popular among drivers seeking to avoid daytime congestion, can be extended to at least 14 hours when on-vehicle solar energy capture provides most of the battery HVACs' power. Overnight breaks can also be extended with solar panels. Overall, on-vehicle solar energy capture reduces diesel fuel use and maintenance costs by offloading the engine and alternator charging load.

Early examples of these systems were fragile and inefficient, resulting in some current industry resistance or mistrust. However, new products have been ruggedized for the trucking industry and provide very attractive returns on investment and lease terms, due to higher efficiencies and lower panel costs.

Disadvantages of On-Vehicle Solar Energy Capture

Dirt on the solar panels can prevent these systems from operate at full efficiency, so they must be kept clean – luckily the panels are also truck-wash safe, and their polycarbonate covering has a low adhesion rate, so dirt easily washes off.

An additional concern for some customers is that the panel mounting location may limit the amount of surface area for fleet logos on the roof air fairing.

Suppliers

eNow

4.3.5 Truck Stop Electrification Systems

Overview

Truck stop electrification with HVAC, also referred to as an off-board idle reduction technology, is an attempt to bring not only 120V AC power to trucks at truck stops and rest areas, but to provide heating and air conditioning as well. A pedestal or overhead truss system serves as the infrastructure for these systems. A removable window adapter is inserted in the cab window and heating and air conditioning are pumped into the cab and sleeper through a hose in the adapter. Standard AC electric service is available both inside and outside the cab for powering things like microwave ovens, refrigerators, televisions, computers, and block heaters, etc. Some systems offer satellite television and Internet.

Depending on the system, drivers can pay with credit cards, fuel cards, or cash. Some systems operate using fresh air and others use recirculated air similar to a home heating/air conditioning system.

The heating and air conditioning are controlled by the driver, who can set both temperature and fan speed.

In addition to the stationary units, one manufacturer of truck stop electrification with HVAC offers a portable unit. It is most often used at a fleet terminal or distribution center and can be wheeled out to where the truck is so the driver can then hook up to it.

Although the product offered by the company Shorepower is considered a form of truck stop electrification, it is covered in the next section on off-board AC power, since it is one of many ways to get AC power to a stationary vehicle.

Advantages of Truck Stop Electrification Systems

There are a number of benefits to selecting truck stop electrification as a strategy to reduce idling:

- Low cost
- Easy to use
- Long running time
- Recharges batteries
- Quality of life

The cost to plug into a typical electrified parking space with HVAC is about $2 an hour, which is less expensive than idling or than other anti-idling options. Most suppliers offer fleet discounts or loyalty programs which reduces the cost per hour of use.

To operate the system all the driver needs is a window adapter that is provided by the TSE service provider and a way to pay for the service. Once the driver pays for the service and installs the window adapter, he can select whether he wants heat or air conditioning and he can plug in his in-sleeper electrical devices. He can use the outside outlet to plug into the block heater.

Unlike some other anti-idling solutions, there is no limit to the length of time a truck can have access to electric power from an electrified parking space.

The truck stop electrification with HVAC can also be used to keep the truck's batteries charged.

Truck stop electrification with HVAC brings the driver all the comforts of home. Heat and air conditioning can be used as long as needed to keep the driver warm or cold. Temperature will remain steady throughout the entire time the driver is using the system so he or she will not be awakened by temperature spikes. This will help ensure a good night's sleep, which is a key element to driver safety.

Disadvantages of Truck Stop Electrification Systems

While there are some positive features about truck stop electrification, there are also some concerns:

- Lack of coverage across the United States
- Limited number of electrified parking spaces at individual truck stops
- No policing of use of spots by drivers not using the service
- Issues with fit of window adapters
- Bad reputation because of previous experience
- Fleets don't reimburse drivers for the cost

The biggest obstacles to truck stop electrification with HVAC as the single solution to idling is lack of availability. One provider of truck stop electrification with HVAC said, "if we are not at 80% of the locations a fleet goes to, they need to use another option, like an APU, in order not to idle."

In addition to a limited number of truck stops and rest areas that have truck stop electrification with HVAC, there are a limited number of spots at each of these locations. Most providers of truck stop electrification with HVAC do not have staff on site to monitor usage so drivers who need a parking spot may pull into a spot that has been electrified, but will not use the service. To combat this, one provider of truck stop electrification with HVAC does have staff on site to manage the usage of their spots.

There are 75 different window configurations on today's heavy-duty trucks. Windows range in size from 17-inches wide to 43-inches wide. Some of the window adapters only come in one size leaving drivers to figure out how to fill in the gap. One provider has an adapter that it says seals the window no matter what size it is.

Perhaps one of the biggest negatives with truck stop electrification with HVAC was the exit of a major supplier, which left infrastructure in place that then became inoperable. The supplier has since re-entered the market under different ownership, but there is still some confusion in the marketplace and a "bad taste in the mouth" among some fleets that had previously relied on this supplier.

Many fleets are not reimbursing their drivers for use of electrified parking spaces, but do reimburse them for diesel fuel. This is a disincentive for a driver to use these systems as the payments for using truck stop electrification would come out of their own pockets.

Pricing

Usage price averages about $2 before fleet and loyalty discounts. There is little equipment cost to the fleet or driver associated with truck stop electrification with HVAC. Some providers have a $10 fee for the window unit; most offer it free. Truck stop electrification with HVAC uses no fuel to operate.

Suppliers

Convoy Solutions LLC (Idle Air), Craufurd Manufacturing LLC (Aire Dock), Enviro Dock (edock stationary, edock mobile), Truck Star Systems

4.3.6 Off-board AC Power (AC power ports + AC power distribution a.k.a. shore power)

This section considers the vehicle *and* infrastructure modifications required to use off-board AC power to meet the needs which otherwise cause idling. Using AC power inside the vehicle requires different wiring that the normal 12V DC wires, as well as the installation of power ports onto the truck. It also requires infrastructure in places where trucks might otherwise idle – also commonly called shore power. Many fleets and customers use AC power to reduce their idling already – running block heaters, hotel loads, battery chargers, battery HVAC systems and much more.

Overview

Options around AC power connections to a vehicle were one of the bigger points of confusion while creating this Confidence Report. For many years, the plug on the side of a sleeper was referred to by many as the "shore power plug" because it was similar to the so-named connection for a boat that allows a 120V AC extension cord to provide power to the vehicle. Now a company by the name of "Shorepower" (formerly Shurepower) is selling AC power distribution systems for truck stops and rest areas. Thus, the use of the term "shore power" has different connotations to different people, and this report uses the term "off-board AC power" to refer to these types of systems throughout, to avoid this confusion.

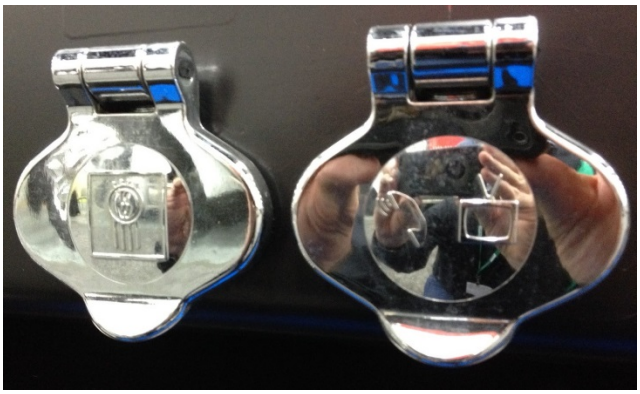


Figure 15: External connection ports for electricity and internet

For the sake of clarity in this section, we will refer to the connection as the "AC power port" because it doesn't have to be connected to any specific brand or vendor's infrastructure to function correctly – any 120V DC supply from a house, shop, barn, rest area or truck stop will serve.

Potential confusions can arise from multiple aspects of considering AC power ports:

1. Some vehicles have this port, but it is strictly for a block heater
2. Some vehicles have this port to supply an inverter/battery charger (and when such a truck is plugged in, its inverter can go into "by-pass mode" and allow the AC power to supply the truck's needs.)
3. Some vehicles use the AC power port to provide AC power into the sleeper without using an inverter or battery charger (essentially, this set up is simply running an extension cord into the sleeper.) (The case of inverters and chargers is handled in a previous section of this report, section 4.3.4.1.)
4. Some vehicles have this port to use AC electrical power to run the heater or air conditioning of their diesel or battery APU system. This is sometimes referred to as an electric hybrid system.

Some vehicles have two of these AC power ports, to meet the needs of both items 1 and 2, or items 1 and 3.

As mentioned in item 3 of the above list, it is possible to use an off-board AC power plug like an extension cord to the inside of the vehicle, to make AC power available inside the sleeper for any AC-powered device. The plug merely eliminates the challenge of running the extension cord through the door, luggage door or window, while also making the truck safer by avoiding a possible pinched wire.

Advantages of Off-Board AC Power

Bringing AC power to the sleeper from an off-board source saves the vehicle from depleting its batteries as well as avoids idling to create more power. This prevents any wear-and-tear on the vehicle's components, and burns zero diesel fuel.

Disadvantages of Off-Board AC Power

Some will argue that this off-board power is not necessarily that "green," because it could be coming from a coal-fired power plant.

Drivers must be taught proper use for any AC wiring on the vehicle. For instance, they should not overload the system using extension cords and receptacle splitters inside the vehicle.

Unlike a home's AC wiring, the wiring in a truck will be subjected to substantial vibration while the truck is moving, which can cause chaffing and shorting of wires. The AC wires must therefore be properly selected, routed, and clipped to be safe in the vehicle. The use of AC wires designed specifically for vehicles helps with this. Some of the leading AC wiring systems for trucks also use "quick-connect" connectors to simplify the wiring and prevent the possibility of altering the system with unsafe customization efforts.

Drivers may run into problems connecting their vehicle to their house, barn, or garage due to circuit protection. A block heater alone can draw up to 15 amps, which is typical circuit protection level for household wiring. So if a driver takes two extension cords and plugs both into the block heater and off-board AC power into their truck, they may overload the 15 amp circuit of their house, barn or garage, thus tripping the circuit breaker.

Pricing

AC wiring systems come in many variations making it difficult to show a range of prices.

Suppliers

Phillips and Temro, Shore Power

Other uses for electrification

Fleets are beginning to use electrification at their terminal locations and distribution centers. They are installing electric connections on their sites primarily to plug in block heaters to keep engines warm.

A major fleet recently installed truck stop electrification with HVAC at one of its terminals. The 24-space facility provides drivers with in-cab services that provide heating and air conditioning, Internet connectivity, television and 120V electrical service.

4.3.7 Driver / Vehicle Behavior Controls

How a driver manages their vehicle both while moving *and* while stationary has a huge impact on the fuel economy the vehicle will obtain. Fleets have options for motivating desired behavior or penalizing/preventing undesired behavior. This section will cover methods to monitor and control undesired behaviors via electronic controls, as well as options for training and incentivizing drivers to follow best practices, in order to obtain optimal reductions in idling.

4.3.7.1 Electronic Engine Idle Parameters

Overview

The introduction of electronic engine controls in the mid-1980s brought along controls for idling behaviors. Over time the list of programmable options has increased. Currently the list of idle settings has grown to look something like that depicted in Figure 16:

Parameter Summary Table:

Feature / Parameter	Range	Default
Idle Engine Speed - Parameter	500 - 800 rpm	600 rpm
Idle Shutdown - Feature Option	Enable/Disable	Disable
Idle Shutdown Timer - Parameter	2 - 1440 minutes	60 minutes
Idle Shutdown Manual Override - Feature Option	Enable/Disable	Disable
Idle Shutdown in PTO - Feature Option	Enable/Disable	Disable
Idle Shutdown Percentage PTO Load Override - Parameter	0 - 100 %	10 %
Idle Shutdown Ambient Air Temperature Override - Feature Option	Enable/Disable	Disable
Idle Shutdown Intermediate Ambient Air Temperature - Parameter	0 - 120 °F	60 °F
Idle Shutdown Hot Ambient Air Temperature - Parameter	0 - 120 °F	85 °F
Idle Shutdown Cold Ambient Air Temperature - Parameter	0 - 120 °F	30 °F
Idle Shutdown Hot Ambient Automatic Override - Feature Option	Enable/Disable	Disable
Idle Shutdown Manual Override Inhibit Zone - Feature Option	Enable/Disable	Disable

Figure 16: Sample Electronic Engine Idle Parameters

These parameters not only control the exact speed that an engine will idle, they set the idle timer length, and establish the boundaries for when idling is allowed for cold and hot temperature extremes. The exact parameter names, ranges and defaults differ between engine OEMs.

In our fleet survey work, many of the contacts knew that their vehicles used a setting to determine temperatures above and below which unlimited idling was allowed for temperature extremes. It was interesting to note that some did not know how the vehicle controlled such events, and moreover they wondered why the idle-reduction study team was asking about electronic engines – indicating that this set of technologies is often not considered as an idle-reduction option at all. The fleets surveyed generally had about 75°F as an upper limit, but at least one fleet raises this number when the vehicle has a battery HVAC on-board. The lower limit varied between -10°F and 25°F depending on the fleet.

Advantages of Electronic Engine Idle Parameters

Since such electronics on engines are now standard equipment, there is no cost for using them to control idling. The failure to use them for this purpose, however, could impose an opportunity cost. Fleets will benefit most by adjusting their temperature parameters to fit around the other idle-reduction technologies they may have selected. For example, fleets with fuel-operated air heaters may set significantly lower cold temperature limits for unlimited main engine idling, since the heater will serve to keep the driver warm in all but the most severe outdoor temperatures.

Disadvantages of Electronic Engine Idle Parameters

Security is always a concern, as modified electronic parameter settings can allow for operation outside of desired ranges. Although there are password protections to prevent such events, shop technicians with service tools and password privileges must know that they are not allowed to alter vehicle settings without management approval.

Pricing

These parameters are a basic part of every electronic engine and are no additional cost.

Legislative References

The engine timer controlled by the electronic engine system is referred to as an AES or Automatic Engine Shutoff in legal documentation. During our survey, fleets raised questions about when an engine timer (AES) could and should stop the engine. The provisions that allow an engine to idle beyond 5 minutes when using an Automatic Engine Shutoff are called out in the EPA standards at the following website (EPA, 2013):

http://www.epa.gov/otaq/climate/regs-heavy-duty.htm

Consult page 57424 section 1037.660. Or for the pdf:

http://www.gpo.gov/fdsys/pkg/FR-2011-09-15/pdf/2011-20740.pdf (page 320 of the pdf file)

4.3.7.2 Driver Training in Optimal Idle Reduction Techniques

Overview

The truck driver is an integral part of any idle-reduction initiative. Human intervention is needed to ensure that whichever technology is adopted is also being properly operated and maintained, and that the benefits of the system are being maximized. Fleets need to understand their drivers' needs for safety, comfort, and convenience and therefore how they will be using the idle-reduction technologies installed on their trucks. Driver education and follow-up training is key to this process, especially in today's world of high driver turnover.

First and foremost, drivers must know how to operate the system. Some fleets provide ongoing education via drivers' meeting, newsletters, emails, or videos downloaded directly to the truck via an on-board satellite system. Some systems are more complicated to operate than others, and some require drivers to periodically do minor maintenance checks while on the road.

Regardless of the system, drivers can help optimize the system's capabilities by following some general rules. For an example of simple best practices, here are some tips on how to optimize any system's cooling capabilities:

- Pre-cool the cab by running the AC before shutting your truck down for the night
- Park on concrete instead of asphalt

- When parking the truck, try to find a shaded area
- Make sure the cab's windshield is facing away from the sun
- Ensure all doors and windows are tightly closed
- Use a reflective covers for the windshield and windows
- Pull down shades and cover sleeper cab windows and skylight
- Fully and tightly close the bunk curtain
- Set the temperature and fan speed on the controller at a reasonable number
- Switch off heat-producing appliances inside the cab
- Turn off the HVAC system as soon as possible after waking up
- Only use the APU when it's truly needed – mainly when sleeping or sitting idle-free for long periods. Do not use the APU when fueling, eating, etc.
- Always plug into off-board AC power (if the truck is so equipped) whenever possible to keep powering up the truck's batteries (even when not using your APU)
- Be conservative with hotel power loads especially when maximum cooling is needed

Tips for maintaining an efficient idle-reduction system:

- Daily inspection of the system
    - Depending upon the type of system, for example with a diesel APU, you should check for leaks, and inspect oil level, fuel and refrigerant lines and connections, hoses, belts, electrical cables and connections
- Do not block the air flow between the return air flow duct and the evaporator
- Keep the condenser assembly clean and free of debris or obstructions
- Keep all high current electrical connections free of corrosion and cover them with a protective coating

4.3.7.3 Driver Incentives

Overview

Due to the high impact that drivers will have on idle reduction, many fleets have incentive systems to encourage drivers to be involved in reducing the fleets' fuel expenses, by sharing the savings between the truck owners and the drivers. These incentives may cover many different elements of fuel use, including a vehicle's speed, time spent in top gear, percent idle time, use of idle-reduction solutions, etc.

Incentives can include cash bonuses, other awards such as prizes (a few fleets have given a motorcycle away quarterly to the best drivers) and selecting merchandise from catalogs. Fleets should select

incentive programs and benefits that fit their driver demographics and characteristics, in order to ensure the biggest impact.

TMC Recommended Practice 1113, "Guidelines for Driver Incentive Programs" offers both suggestions on how to implement a program as well as some things to avoid, as they have been known to cause such efforts to fail.

4.3.8 Additional Vehicle Systems

The following section focuses on several technologies that are not frequently covered in discussions of idle reduction, but nevertheless can be very beneficial. Most of these sleeper tractor additions are passive, and can be used in conjunction with the previously discussed active idle-reduction systems, to attain even better levels of idle reduction. Chapter 8 of this Confidence Report will explore such combination systems in more depth.

4.3.8.1 Additional Cab Insulation

Overview

As with residential homes, additional insulation decreases the energy demanded by the heating and cooling systems. In a home, such improvements often mean double pane windows and extra insulation in the attic. For a sleeper truck they may include insulated bunk curtains, windshield curtains, and extra insulation installed by the truck OEM into the cab-in-white metal frame work and composite roof prior to the installation of the interior trim. Several truck OEMs offer optional "Artic Packages" that provide better insulation. Thermal imaging cameras have come down in price and are now readily available to visualize the heat transfer paths, making it possible to see insulation issues and opportunities, by viewing a heated cab on a cold day or a well-cooled cab on a hot day.

Advantages of Additional Cab Insulation

The National Renewable Energy Laboratory (NREL) has published the results of tests they conducted on sleeper cabs and insulation in conjunction with engineers at Volvo and Navistar. They used both live vehicle tests and computer simulation models to analyze the impacts of insulation on interior cab temperature. Examples of the findings include a 21% heating-load reduction through the use of a normal sleeper curtain to close off the bunk area, while the use of an insulated bunk curtain provided a 26% reduction. Meanwhile use of cab/sleeper window insulation (similar to the windshield sun blocker you can put in your car) can reduce the predicted cooling demands, without a sleeper curtain, by up to 34%. NREL also showed that by adding insulation to the walls, floor, roof and structural channels, up to a 36% reduction in heating load and a 34% reduction in cooling loads could be achieved.

Disadvantages of Additional Cab Insulation

Some fleets that were interviewed for this Confidence Report were strong advocates of extra sleeper insulation, while others were somewhat leery given that it is difficult to see and understand how much insulation was actually installed and how much more might be needed, since much of it is not visible. One of the simplest ways to see how well a sleeper cab is insulated is to look at it in a truck stop parking lot the morning after a light snow or heavy frost. A well-insulated vehicle will be evenly covered with frost or snow, while a vehicle that shows spots or stripes of paint through the snow is showing where insulation is lacking. For instance the stripes showing on a composite roof are most likely uninsulated roof reinforcements. The truck OEM must insulate inside these reinforcement before they are bonded to the roof during roof sub-assembly. The actual benefit of some portions of the insulation such as window insulation and bunk curtains are obviously dependent on driver use, but if the driver wants to have the bunk as cool as possible on challenging summer days, they will find significant benefit in using them properly.

4.3.8.2 Light-Colored Paint

Overview

Many fleets surveyed by the study team reported that their most significant idle-reduction challenges were on hot sunny days. Of all the idle-reduction technologies covered in this Confidence Report, this one is probably the most simple and straight forward, as the paint color of the outside of the cab and sleeper impact the heat loading the sun will cause in the interior of the vehicle. NREL conducted testing of sleeper cabs to determine the difference created by exterior paint color. NREL's testing reveled that a black vehicle requires 26.2% more energy to cool on a sunny summer day than the same baseline vehicle painted white. (Or stated another way, it requires 20.3% less energy to cool a white cab from a black cab as a baseline). Obviously black to white is the most drastic change, but for those fleets struggling to keep their sleepers as cool as many drivers would like, this information should not be ignored, as switching from any dark color to any lighter color will help, albeit to a lesser degree than the 26.2% gain available from moving from one extreme to the other.

Advantages of Light-Colored Paint

Lowering the heating load impact of exterior paint color lowers the energy required for cooling demands. Whether a truck is using battery power for a battery HVAC or diesel fuel for an APU, it will use less energy for cooling with a lighter-colored exterior paint. Changing the external color of the vehicle (at least the cab and sleeper portion) starts to pay back as soon as the vehicle is sitting in the sun on a warm day. For a battery HVAC equipped vehicle, a change in paint color can allow batteries to last longer, or potentially reduce the number of batteries required for the same level of cooling.

Unfortunately a darker paint color will not offer similar benefits in cold climates or winter operations. As sun hours and solar intensity for the United States and Canada are far less in the winter, the opportunities for solar heating are not the reverse of the light color in the summer scenario.

Disadvantages of Light-Colored Paint

Paint color can obviously have an impact on a fleet's well-established brand image. It can also have an impact on the resale value of a vehicle depending on the color selected. Outside of these two issues there are no other disadvantages to this simple change of specifications. Keep in mind that it is the color on the exterior of the cab and sleeper that make the most difference, so if a fleet still wants to use a darker color in its overall paint scheme, it is best to limit the dark color to the hood and chassis skirts.

Pricing

As long as the light-colored paint selected is a normal paint for the truck OEM, there should not be a cost or warranty impact to this change. This is the only idle reduction technology covered in this Confidence Report that has no cost, is available from all truck OEMs, and offers an instant return on investment!

4.3.8.3 Additional (Auxiliary) CPAP Battery

Overview

CPAP machines have become a significant discussion point in the United States transportation industry, including pilots and commercial truck drivers. These machines provide a constant humidified air pressure throughout the night, alleviating the discomfort and even danger of sleep apnea, but they consume energy the whole time. To relieve the truck's batteries from powering this "hotel load", an auxiliary battery is available that will power the CPAP machine through the night, and can be recharged by connecting it via a power cord to a 12V DC power plug. It will also recharge as the vehicle is driven.

Advantages of Additional CPAP Batteries

This system is likely the simplest solution for a fleet seeking to accommodate CPAP users, as it is small, simple, and installs in minutes. Its portability is appealing for fleets wherein drivers may utilize different vehicles from time to time. It may also be valuable to fleets as a backup system when a vehicle's primary idle-reduction system (APU, battery HVAC…) is out of order, since the fleet could loan out the CPAP battery and reclaim it once the primary system has been repaired.

Disadvantages of Additional CPAP Batteries

Drivers need to be trained that if they plug other devices beyond the CPAP into this unit (it has USB and 12V DC power ports as well) the battery will not stay charged as long.

Pricing & Warranties

The Manufacturer Suggested Retail Price (MSRP: not discounted) for the battery (with AC cord and neoprene carrying case) and DC power protector is $399.99. The standard warranty is one year.

Suppliers

AspectSolar

4.3.8.4 Ultracapacitor Starting Systems

Overview

When truck batteries are discharged there is often not enough power to start the truck engine. When the truck is in an engine-off state the batteries can be discharged from excessive hotel loads inside the cab, running battery-powered air conditioning or from long-term use of fuel-fired heaters. Truck inactivity and seasonal issues also affect battery condition. Drivers often want to idle their engines to minimize the risk of jump-starts caused by discharged batteries. One solution to this dilemma is to add an auxiliary battery (to aid in starting the engine) to the truck's existing engine starting battery pack.

One manufacturer offers an auxiliary starting battery called an Engine Start Module (ESM). The ESM integrates with the truck's 12V starting system (batteries, alternator, and starter), is easy to install and replaces one of the existing starting batteries. It uses ultracapacitor technology (rather than AGM or lead acid componentry) for energy storage and power delivery. The ESM also includes a self-contained DC-DC converter and controller electronics inside a polypropylene plastic case. Weighing around 20 pounds, the ESM provides 1800 Cold Cranking Amps (CCA) at every start based on a three second crank in temperatures ranging from minus 40°F to plus 149°F. Peak power is rated at 32.8 kW. The system fully recharges in less than 15 minutes.

Advantages of Ultracapacitor Starting Systems

With the ultracapacitor starting system installed, one need not idle the truck engine to keep the starting batteries charged. This saves fuel, reduces engine wear and tear and associated maintenance costs, and results in lower emissions. Reliable engine starts help fleets reduce the costs and downtime associated with jump-starts due to discharged batteries. Since they work in tandem with the truck's starting system, the ESM can help extend the usable life of the original truck starting batteries. This product is available as an aftermarket option from most truck OEM dealers. Prices range from $850 to $1,200 and installation time averages about 1 to 1.5 hours.

Manufacturer

Maxwell Technologies (distributed by Pana Pacific)

4.3.9 Sleeping Quarters

The most radical methods of reducing idling may be to get the driver out of the vehicle altogether. In developing this report, the study team encountered fleets that are already pursuing this strategy, which not only reduces idling but also makes it is possible to shift to day cabs and escape the cost, weight, and resale penalty of sleeper tractors. The use of a hotel or dormitory instead of staying in the truck sleeper seems to be becoming an increasingly viable option in the industry.

4.3.9.1 Hotels

Overview

If an HOS restart takes between 34 and 48 hours, using a gallon of $4 diesel fuel an hour to idle the truck creates an expense of $136 to $192 dollars for the restart period. Most of the fleets interviewed for this report had temperature boundaries (both high and low) within which unlimited idling was completely acceptable. Most anti-idling laws are written with similar temperature exceptions. So while it may not make sense to switch to day cabs and utilize hotels during the whole year, there are likely some situations where it does now make sense to get the driver out of the sleeper to avoid the cost of constant idling.

Advantages of Hotels

Going beyond the operational costs noted above, the drivers' quality of rest may be improved by getting out of the sleeper and into a room. Hotel rooms provide a private bathroom and shower, which is certainly more convenient and comfortable than getting out of the sleeper and crossing a truck stop parking lot to use the rest room. Most hotels have cable TV in every room and many now have free Wi-Fi. All rooms have electrical outlets for CPAP machines and recharging phones or laptops. Many hotels have additional amenities such as free coffee, a free breakfast, or an exercise room. Given the health challenges of today's truck driver, the use of an exercise room alone could be very beneficial during a restart.

Disadvantages of Hotels

Not all hotels can accommodate a 53-foot trailer and tractor, but there is now a service that provides a database of available hotels which offer truck parking.

Many drivers travel with pets, but not all hotels welcome pets, so this need must be explored on a case-by-case basis. The same holds true for the availability of 120V AC to allow extension cords to supply a parked vehicle with power for a block heater or off-board AC power.

Pricing

Annual memberships to the hotels for truckers cost $9.95 per year and include a discount of 15% to 20% off normal posted room rates.

4.3.9.2 Dormitories

Overview

The next step beyond hotels is the use of a custom-built dormitory. Dormitories are a significant capital expense and have only recently entered the picture in the United States. In other parts of the world such as South Africa, truck dealers have dormitories to house drivers while their vehicles are serviced. A major fleet in the United States recently built a facility that combines dormitory rooms with a driver training facility.

Advantages of Dormitories

Dormitories can be highly specified by the fleet to fit its needs. Rest rooms could be individualized or larger shared spaces similar to some college dormitories. The facility may be designed to house drivers while in training classes and include classroom space as well. The facility can house other medical examination needs as well as exercise and relaxation areas.

Disadvantages of Dormitories

A dormitory room may not be quite as large or have all the same amenities as a hotel room, while offering those amenities would be a significant cost to the fleet. The availability of 120V AC to allow extension cords to supply a parked vehicle with power for a block heater or off-board AC power must be explored on a case- by-case basis.

Pricing & Warranties

The price of custom-built dorm facilities is driven entirely by the size and content of the building. It would be reasonable to expect a multifunction facility capable of housing, food service, a training center, and driver wellness to reach into the $5- to $10-million dollar range.

5 Summary of Original Equipment Manufacturers' Perspectives

The Original Equipment Manufacturers (OEMs) of Class 8 sleeper tractors provide numerous options for idle reduction. As shown in the previous sections, there are dozens of suppliers of idle-reduction technologies, many of them offering numerous different idle-reduction solutions, so no single OEM is really capable of engineering, testing, sourcing, producing, and servicing the full range of available options. Instead, OEMs select a set system for each tractor and sleeper model line that they can validate and produce with a high degree of customer confidence. Some of these systems require considerable integration including frame rail space/mounting, fuel system connections, cooling system connections, battery cables, instrument panel wiring, sleeper control displays, as well as numerous sensors and controllers. Combined with all of the other complexity of sleeper sizes and tractor options it becomes a daunting challenge to manufacture with high quality. That is, if an idle-reduction system is difficult or complicated to install after a vehicle is built, it is also difficult to complete the necessary design-work and testing at an OEM.

Figure 17 maps the idle-reduction options covered in this report in terms of, generally, the degree of modification to a standard sleeper tractor that their installation requires – this is relevant both to OEMs and for retrofit installation on older vehicles.

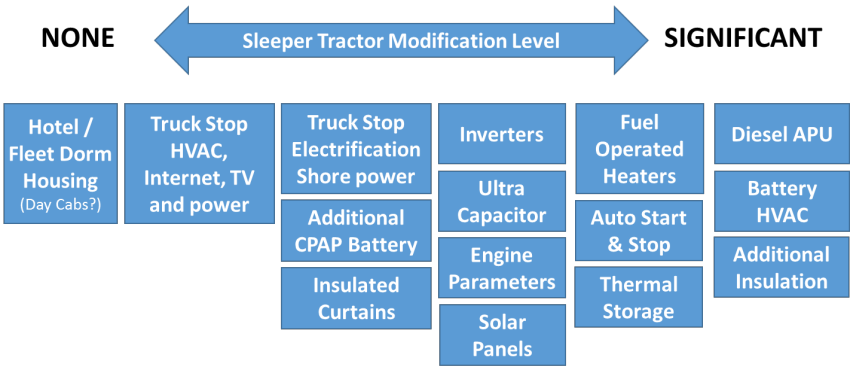


Figure 17: Levels of Vehicle Integration

Overall, different OEMs offer different idle reduction options, but some options are more commonly offered than others. For example, every OEM offers optional block heaters (not covered by this report.) All OEMs also offer fuel-operated heaters, as well as an optional AC power port to enable the vehicle to use off-board AC power, truck stop electrification systems, or other 120V AC power sources. Finally, every OEM offers electronic engine idle parameters – in fact these programmable features are now standard on every vehicle made across the industry.

None of the other technologies covered in this report are universally or uniformly offered by the OEMs, and none of the options come standard. The details of what is included in an overall idle-reduction package from an OEM vary, and can even vary between one OEM's different tractor models. Most OEMs offer passive idle-reduction options, mainly some form of extra cab insulation or optional bunk or windshield curtains, and in some cases these options become mandatory as part of a larger option package if the fleet or owner-operator is ordering a major idle-reduction system.

Meanwhile, only one OEM is offering a diesel APU as a factory-installed option. Some of the other OEMs have an option that provides a mounting location and some of the connections to enable a faster and easier installation of a diesel APU after the OEM production line.

With regards to the OEM-offered battery HVACs, the industry-leading supplier of those technologies has its products available from most OEMs, but this may not be obvious to fleets as the system has been rebranded by each OEM, so it is known by several different names. However, only two of the OEMs offer an option for the automatic start/stop system to recharge the batteries so the battery HVAC can be used longer than one charge.

Finally, the OEM interviews conducted for this Confidence Report found that the OEMs seem to be in general agreement that if a customer orders an inverter, it should be a powerful one with a battery charger built into the system. This means it will include an off-board AC power connection, so that every time the vehicle is plugged in the inverter will go into by-pass mode during which the external AC is powering the AC devices inside the sleeper as well as charging the batteries. Therefore if a fleet does chose to spec their new vehicle with inverters from their OEM, it would be wise to make sure that their drivers will be plugged in to off-board AC power whenever and wherever possible.

Not only do the OEMs offer different idle-reduction technologies but there is a range of different mechanisms by which such features can be specified, including:

1. Standard Equipment
2. Published Price Page Option (compatible with other systems as described)
3. Non-published Option (limited compatibility with other configurations and options)
4. Post-production Line OEM Upfit (Option or Specialty Center after the production line)
5. Dealer or Supplier Upfit
6. Optional factory line “accommodation packages,” (which ease the installation of a system outside of the factory.)

This concept of OEM accommodation kits is something that fleets and suppliers in the industry should pursue with their OEMs, as these would make post-production installation of idle-reduction technologies easier while also relieving the OEMs of the challenges of system validation/integration and allowing them to avoid warranty exposure over systems they don’t have the resources or funds to test. Such kits might, for instance, entail the completion of some frame drilling, or the installation of a sensor or two that is difficult to mount after production.

In any case, idle reduction systems will enjoy much wider rates of adoption if they are available from OEMs, and today many promising systems are not. Figure 18 documents which technologies are

available from which OEM at time of writing. The study team for this Confidence Report anticipates that this section of this report will become rapidly outdated, as the vehicle OEMs make more and more idle-reduction systems available and even standard.

	Freightliner	Western Star	Peterbilt	Kenworth	Volvo	Mack	International
Fuel Operated Heater	Espar	Webasto & Espar	Espar	Espar	Webasto	Webasto	Webasto & Espar
Additional Insulation	Optional	Optional	Optional	Optional	Optional	Not Available	Optional
Diesel APU	ThermoKing	Prep Kit for off-line APU install	Prep Kit for off-line APU install	Prep Kit for off-line APU install	Prep Kit for off-line APU install	Prep Kit for off-line APU install	Prep Kit for dealer APU install
Battery HVAC	ParkSmart (Bergstrom Nite)	Not Available	SmartAir (Bergstrom Nite)	K.I.M.S. (with extra insulation)	Prep Kit for off-line APU install	Off-line: Idle Free	MaxxPower (Bergstrom Nite)
Battery Management Start/Stop	Detroit Optimized Idle	Not Available	Not Available	Not Available	Not Available	Not Available	MaxxPower Option
Automatic Engine Start/Stop System	Detroit Optimized Idle	Detroit Optimized Idle	Not Available	Not Available	Not Available	Not Available	Not Available
Inverter & Battery Charger	Xantrex	Xantrex	Xantrex	Xantrex	Xantrex	Xantrex	Xantrex
Shorepower AC Connector	Optional	Optional	Optional	Optional	Optional	Optional	Optional
TSE AC Power	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible
TSE HVAC & AC Power	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible

Figure 18: Truck OEM High Level System Offerings (Subject to Change by OEMs)

6 Summary of Fleet Perspectives and Experiences

This chapter discusses the results of four different efforts by the study team to collect information, both qualitative and quantitative, from various sections of the trucking industry, all of which are end-users of the idle-reduction solutions described in this report.

6.1 Best Practices Study

As part of a CK Commercial Vehicle Research project, a small sample of directors and vice presidents of maintenance at heavy-duty fleets were asked a range of questions about their fleet's idling practices. The study team for this Confidence Report was able to include two questions on this survey.

Fleets who responded to the survey indicated they had the best results with fuel-operated heaters and extra cab/sleeper insulation, and were most dissatisfied with diesel APUs and battery HVACs. Figure 19 maps fleet satisfaction with a variety of the technologies discussed in this report.

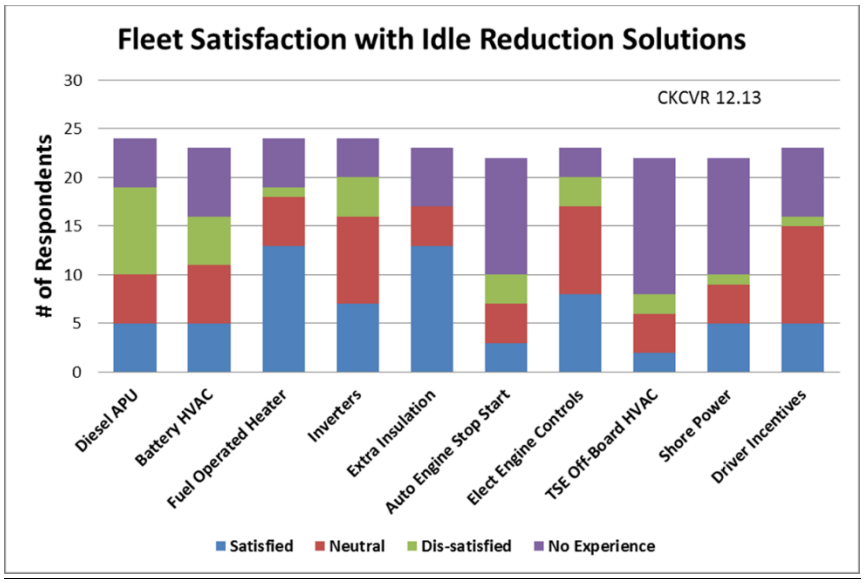


Figure 19: Fleet Satisfaction with Idle Reduction Technologies per CK Commercial Vehicle Research Survey

In addition to a reduction in their fuel costs associated with idling, fleets who responded to the survey indicated that payback and maintenance costs were two key additional factors that went into their decisions to add idle-reduction technology or technologies to their vehicles (Figure 20).

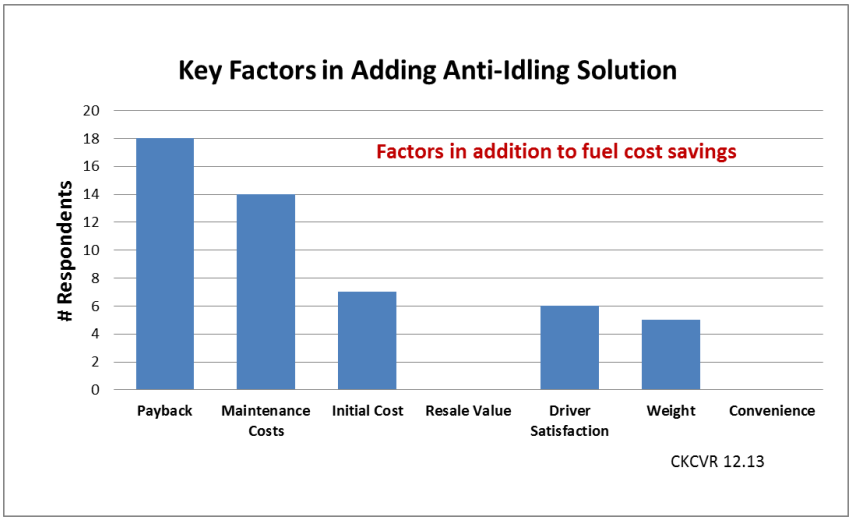


Figure 20: Key Factors in Selecting an Idle Reduction Solution per CK Commercial Vehicle Research Survey

6.2 Interviews with Large Fleets

Executives at 11 for-hire truckload carriers were personally interviewed by the study team over the telephone to learn more about the idle-reduction technologies presently in-use at their fleets, and their experience and satisfaction with those technologies. Fleet size for this segment ranges from 100 to 10,000 trucks.

When asked to describe what idle reduction meant to their operations, all 11 executives said that it had something to do with reducing fuel use – as one responded: "It simply means burning less fuel." However, several of them also indicated that driver comfort had to be factored into the equation.

These interviews found that there is no one technology currently being used by all 11 of these fleets to solve their idling issues, and moreover that most of the large fleets use a combination of technologies. For example, 10 of them are installing fuel-operated air heaters in their vehicles, and eight are using electronic engine parameters (and therefore many fleets are using these technologies simultaneously). Driver incentives, particularly those that involved driver pay, are also part of eight of these fleet's idle-reduction plans. Finally, diesel APUs, off-board AC power (shore power) and truck stop electrification were the least common technologies employed by this group of fleets. The full results are shown in Figure 21.

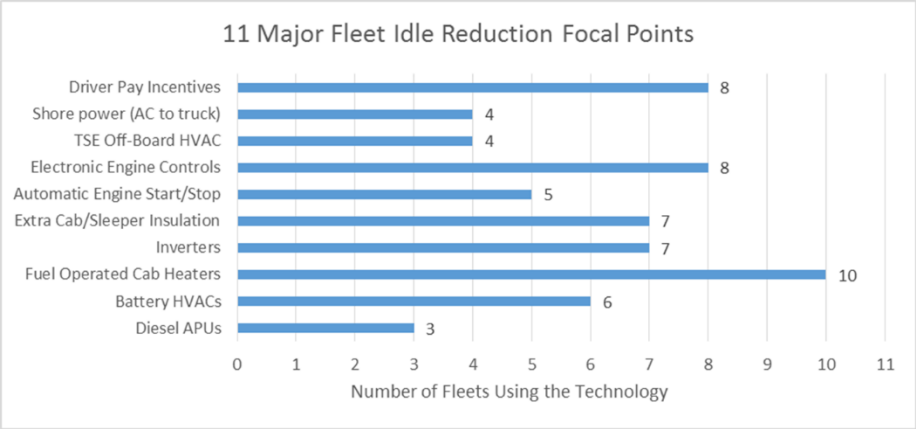


Figure 21: Major Fleet Use of Idle Reduction Technologies

A fuel-operated air heater was the technology that these large fleets found to be the single most beneficial in their idle-reduction efforts, followed closely by driver pay incentives. None of the other technologies rated very high in this area.

In addition to fuel savings, payback and driver satisfaction were major benefits that were important to these large fleets in choosing an idle-reduction strategy. One fleet executive put it succinctly: "Return on investment, it's how we run our business." But another fleet that has very low driver turnover (20%) said driver satisfaction was of key importance to their technology selection, given that the estimated cost to "find and bring a new driver on board is $15,000." And yet another fleet executive said, "Drivers are the name of the game in our business. There is a driver shortage and retention is extremely important so we can maintain our size if not grow a little."

Across the board, these fleet executives stated that they do not consider resale value, emission reductions, or compliance with idling regulations to be important benefits to be gained from the adoption of idle-reduction technologies. Most said they are not getting any more for vehicles equipped with idle-reduction technology when they resell or trade in their vehicles. While fleets recognized that emissions reduction was a side benefit of idle-reduction technology, it was not considered a motivating factor in their decision-making. And most fleets had very little experience with the enforcement of idling regulations, and as a result do not see such regulations as a major issue.

Six of the 11 fleets indicated that they have installed 120V off-board AC power sources into their parking lots, so that drivers can plug their vehicles in when they are at the fleet location. However, it is important to note that in most instances these are only being used to power block heaters, and not for driver comfort and convenience or the other causes of idling, which AC power can take care of.

Two-thirds of the large fleets interviewed said that they have seen their maintenance costs increase since introducing idle-reduction technologies into their operations. The main causes of these cost increases have been the replacement of batteries on battery HVACs, or the additional maintenance and servicing of the engine when a diesel APU is installed.

Recognizing the important role drivers play in the successful implementation of any idle-reduction strategy, all of the fleets executives that were interviewed indicated that they do some combination of addressing idle reduction during the recruiting process, providing training on how to use idle-reduction technology, seeking input from drivers on their satisfaction or dissatisfaction with the technologies, or providing drivers with incentives to reduce idling. Often these incentives are targeted to more than just idle reduction, but idle-time percentages are one of the key factors in many driver bonuses. One fleet executive said, "It's really about drivers' behavior – just getting the driver to turn off the engine when he doesn't need to run it." Another said, "It's always a challenge getting company drivers who don't have to buy their own fuel to be good corporate citizens and not waste fuel by idling too much."

While fleets say that drivers are key to their idle-reduction strategies, nine of the 11 fleets that were interviewed do not reimburse drivers when they plug into off-board AC power or truck stop electrification systems, provided their vehicles are equipped to do so. Drivers end up paying for the service themselves if they want to use these systems in those cases.

Fleet executives were also asked to share their idle-time percentages from 2011, 2012, and 2013. Idle percentages from 2011 ranged from 40% to 15% with an average of 22%. Idle percentages from 2012 ranged from 40% to 8.4% with an average of 19.96%. Idle percentages for 2013 ranged from 40% to 10.5% with an average of 20.27%. As Figure 22 shows, two fleets posted an increase in idling over this period, four enjoyed an annual decrease, and the remaining five had either basically stable or slightly fluctuating idle times.

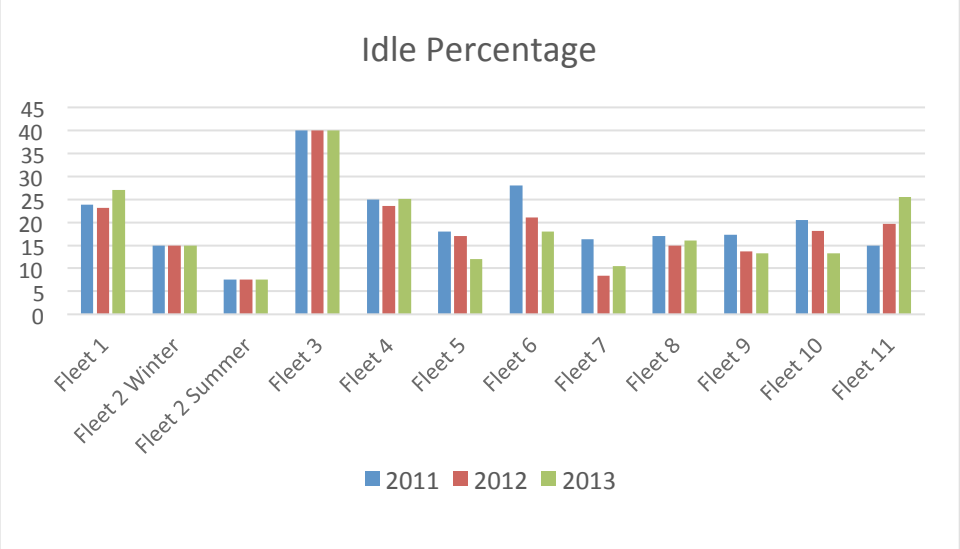


Figure 22: Large Fleet Idling Trends

All but one fleet reported goals for decreasing their overall idle-time percentages, with goals of under 10% most common and several fleets indicating they would like to see idle percentages under 5%.

Of the few fleets who said that any of their drivers had been fined for violating idling regulations, most indicated that those fines were issued in either California or New York City.

When asked about the impact of the new Hours of Service rules on their plans to invest in idle-reduction technologies, most of the fleets surveyed said they had not seen or experienced a big impact from the new rules. "I think indirectly it has [impacted us] with driver satisfaction, because of the amount of time off they are required to take. Indirectly, I think this has made [diesel] APUs more valuable than they were before," one fleet executive said. Another fleet executive said that they try to ensure that most restarts can occur while the driver is home. "I would say we get 90% to 95% of our drivers home on the weekends. That is a big goal not just because of idling, but because of quality of life. If drivers have to do their restarts on the road, we encourage them to stop somewhere where there is access to heating and air conditioning so they only have to idle the truck when they are sleeping." Still another said, "It will put more strain on our system. If they sit longer than there will be more hotel AC power loads, which means more battery wear."

At the conclusion of the interviews, the fleet executives were asked for any additional insights into idle reduction. Here are some of the key comments:

- "[Shore power] is the wave of the future, but currently there is not enough infrastructure."
- "I am always looking for a product that will require the least amount of driver interaction, something that is passive and does not require the driver to implement."
- "Team drivers can reduce idle percentages and save fuel. "
- "There is a side of me that wants to use diesel APUs, but there is a side of me that says that I want to try to be green. I feel if I would wash my hands of what I call EPUs, electrical power units [battery HVACs], and go back to diesel APUs, then the development of [an electric solution] would suffer. So I am more inclined to keep meeting with people who are trying to do things with battery power to try to push them in the direction of developing the technology to the next level."
- "I think the only thing that can really eliminate idle time is if we had a motel room available for every driver out there on the road. I don't know if that will ever come to fruition."
- "We used to hit guys hard on idle time. It was more punitive. Now with the incentive program that we put in place it is so tied to fuel economy, it is kind of like free money if they don't idle. If they choose to idle — we don't want them doing that — it is only coming out of their pockets."
- "We like the direction that battery systems are going, but they are too expensive right now. We are still spec'ing them though. Twenty to 25% of our trucks are CNG powered so obviously we can't use diesel APUs. We do have compressed natural gas heaters. It is a tougher problem to solve because compressed natural gas is cheaper so that means it is less expensive to idle your trucks."

6.3 Internet Fleet Survey

In conjunction with Michelin, NACFE and the study team surveyed the 200-plus members of Michelin's Fleet Forum to learn about which idle-reduction technologies they are using, to understand why they have chosen a specific idle-reduction technologies, and to determine which idle-reduction technologies these fleets find work best. The survey was available online to members of the Fleet Forum from January 17, 2014 until January 31, 2014. A total of 55 fleets responded to the survey.

Three-quarters of the survey respondents indicated that the primary causes of the idle-reduction challenges they face are 1) weather and 2) driver buy-in. One respondent summed up his challenges this way: "Our primary challenges are weather-related – how do we keep drivers cool enough in hot weather to get their rest, and how do we keep trucks running in cold weather while at the same time keeping idle time to a minimum."

When asked what idle-reduction technology they would install if they were to purchase a new truck with such options, fuel-operated air heaters (52.9%), extra sleeper/cab insulation (52.9%), and diesel APUs (51%) were the most cited. Other technologies ranked as follows: inverters and battery chargers (49%), electronic engine parameters (33.3%), off-board AC power (25.5%), driver incentives (23.5%), automatic start/stop systems (21.6%), battery HVACs (15.7%), and truck stop electrification (11.8%). Nearly 6% of the survey respondents indicated they would not spec any idle-reduction technology on new vehicles.

Survey respondents indicated that they were satisfied with a variety of idle-reduction products, but diesel APUs and fuel-operated air heaters were seen as the most beneficial, as highlighted in Figure 23. More than a third of the respondents said they found diesel APUs beneficial because they consume less energy than idling, allow the driver to rest alongside the road, and can power multiple devices/driver needs. More than a third of the respondents said fuel-operated air heaters are beneficial because they are reliable and inexpensive to operate.

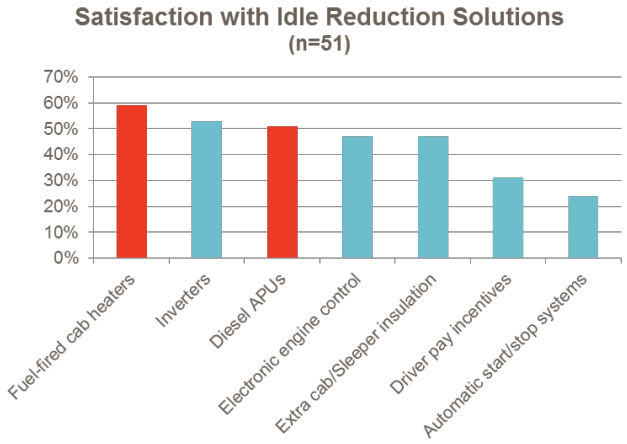


Figure 23: Satisfaction with Idle Reduction Solutions as presented by Communispace for Michelin

More than half of the respondents indicated they had no experience with battery HVACs, off-board AC power or truck stop electrification.

Most fleets that responded to this survey said they would like to see their idle-time percentage reach between 10% and 15%. The average idle percentage for fleets that have implemented one of the idle-reduction technologies profiled in this report dropped from 21% to 18% over the past three years.

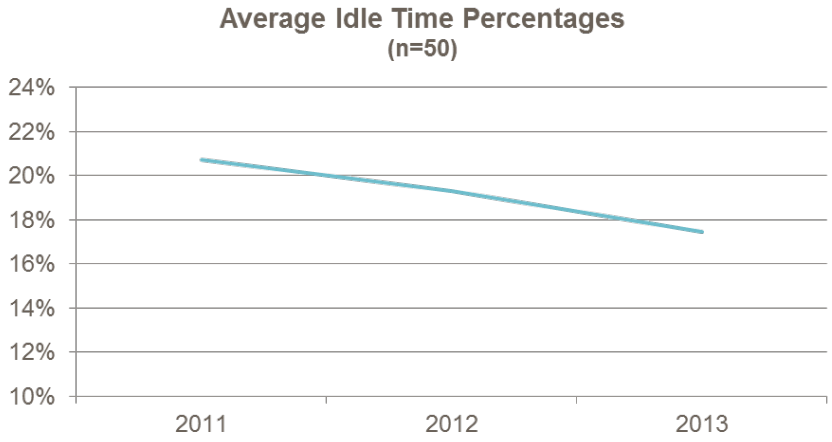


Figure 24: Average Idle Time Percentages as presented by Communispace for Michelin

Survey respondents acknowledge the importance of drivers in the successful use of idle reduction technology and as a result close to two-thirds provide training for drivers on how to reduce idle times. More than a third of the respondents provide incentives for drivers with lower idle percentages. One survey respondent said, "Drivers feel APUs are more convenient than other options. Happy drivers make happy management."

When asked if they reimburse drivers who use truck stop electrification, half the respondents indicated that they do not.

Despite the fact that there are idling restrictions in many states and municipalities, only a handful of survey respondents indicated that their drivers had been fined for violating idling laws.

In addition to fuel savings, survey respondents said driver retention and a reduction of engine wear and tear were the biggest benefits they received from using idle-reduction technologies.

Finally, after introducing idle-reduction technologies into their fleets, maintenance costs remained the same for 41% of respondents and decreased for 38%.

6.4 Internet Owner-Operator Survey

In conjunction with Kevin Rutherford's "Let's Talk" truckers' satellite radio forum, the study team for this Confidence Report sent a survey covering idle-reduction practices to owner-operators and small fleets. Of the 144 people who responded to the survey, the vast majority (82.6%) own five or fewer trucks. None of them owned more than 99 trucks.

When asked to define what idle reduction meant to their operations, here is a sampling of what they had to say:

- "It's a balance between saving fuel and driver comfort."
- "It's fuel cost savings, but with driver comfort in mind."
- "Idle reduction is a fundamental practice in fuel and maintenance cost reduction."
- "This topic tops the charts. When the engine is off, I am able to fall asleep counting sheep. When I have to idle due to extreme cold or when my 12V HVAC system is not working, I keep awake counting dollar bills going out the exhaust stack."

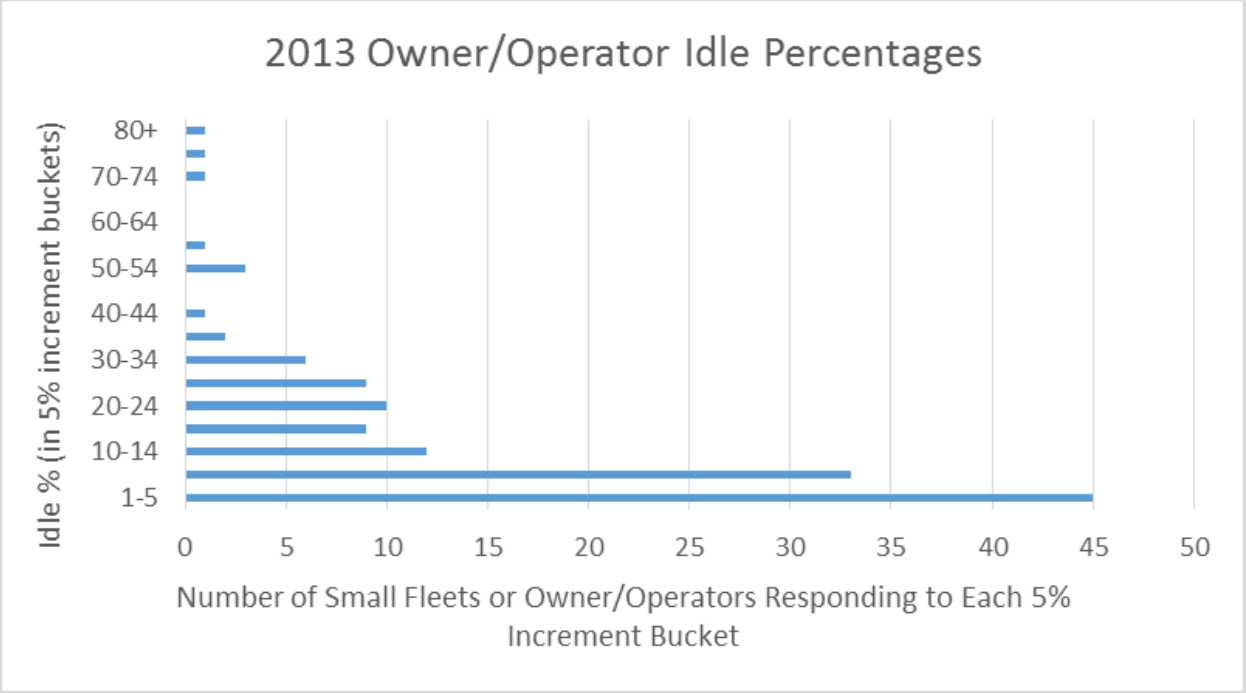


Figure 25: Small Fleet & Owner/Operator Idle Percentages as found by Kevin Rutherford's Survey

Survey respondents were evenly divided about what their idle challenges were, with a little less than one-third of them saying that hot weather presented the biggest challenge, a little less than one-third saying that cold weather was more of an issue, and a little more than one-third saying that both types of weather conditions are equally challenging when it comes to reducing idling.

Extra cab insulation (96 survey respondents), diesel APUs (89) and fuel-operated air heaters (83) are the most common idle-reduction technologies this group said it would employ if it were to buy a new truck today. This was closely followed by inverters/battery chargers (79) and off-board AC power (67).

When asked to rate satisfaction levels of various idle-reduction technologies, inverters/battery chargers and diesel APUs scored high. Interestingly, many survey respondents indicated that they had no experience with many of the currently available idle-reduction technologies. For example, 108 said they

had no experience with battery HVACs, 91 said they had no experience with truck stop electrification, and 80 had no experience with off-board AC power.

Diesel APUs were selected most often (41.9%) as being the most beneficial idle-reduction technology, followed by fuel-operated air heaters (28.6%). Driver pay incentives were seen as least beneficial.

Some of the reasons diesel APUs were seen as most beneficial include:

- "A/C in high temps is a must. I can now sleep in the truck in full sun in south Texas in 100+ temps. Only way to get high-capacity A/C is to use APU for powering it."
- "It takes care of all that is provided by the truck engine when I am not under way."
- "It is the technology that is most portable. I can use it at pick up/delivery areas, rest areas, and customer provided parking areas. And it provides me with power to use other items such as a fridge or kettle, and will allow me to have A/C and heat when required."

Payback times and upfront costs were both cited as important considerations in an owner-operator's decision to adopt an idle-reduction technology. Emissions reduction and idling regulations did not seem to factor into an owner-operator's choice of idle-reduction technology. Like the medium- and large-sized fleets surveyed for this report, very few owner-operators have received fines for violating idling laws.

More than half of the respondents to the owner-operator/small fleet survey said they have seen their overall maintenance costs decrease since installing idle-reduction technology on their vehicles. Another 33.8% said their maintenance costs remained the same since adoption.

When asked for additional insights on the subject of idle reduction, survey respondents were very vocal. Here is a sampling of comments:

- "Ad hoc or homemade solutions can replicate many of the so-called solutions provided by dealerships who steal any efficiencies gained by overpriced parts and service charges on labor and shop supplies."
- "I would like to see improvements in APU technology and an increase in solar and wind power to assist a truck to become self-contained and not emit as much pollution."
- "If we could find an APU that satisfied all our demands, we would consider adding them too our spec."
- "I know a combo of shore power, battery power and diesel APU power hooked together in the same truck is the answer."
- "I am looking forward to new technologies that are battery based."
- "It's gotten really frustrating to invest money in these products and realize little if any overall gain to profit."
- "Some of our shippers and receivers will accept our trucks for early loading and unloading if we call ahead, this reduces tie at the dock idling."

7 Payback Calculations

There are already a wide variety of payback calculators in existence for any given type of idle-reduction system. Many system manufacturers and agencies have developed payback tools that identify how a given idle-reduction system could provide a return on an investment. One generic calculator for determining the payback for many common technologies was created by the U.S. DOE and Argonne National Laboratory and can be found here:
http://www.afdc.energy.gov/conserve/idle_reduction_heavy.html

See Appendix A for links to other calculators sorted by type of idle-reduction system.

7.1 Elements of a Thorough Payback Calculation

Throughout all of the surveys and other conversations conducted in the course of completing this Confidence Report the industry clearly expressed to the study team its desire for a holistic payback calculator that can compare multiple idle-reduction solutions, including their interaction on the same vehicle. Quite simply, some technologies reduce certain causes or motivators of idling better than others, so the most fuel-efficient truck will have a complimentary package of these idle-reduction technologies installed. The task of creating such a payback calculator, however, is extremely complicated. Some idle-reduction systems run when the vehicle is turned off but do consume some fuel (diesel APUs), some consume additional energy while the vehicle is driving down the road (battery HVACs and thermal storage systems), some operate sporadically as required (automatic engine start/stop systems), and some are completely passive (light colored-paint, additional cab insulation, etc.). The challenge is also complicated by the law of diminishing marginal returns – some fleets have long been implementers of idle-reduction components and policies that have allowed them to drive their idle time down into the 5 to 10% range, while other fleets are just getting started with these efforts, and are currently near 40% idle time – and it is far easier to show paybacks to the fleets with high idle times than fleets that have already found some success.

However, in an effort to meet the industry's need for more information around the potentials of various idle-reduction technologies, this Confidence Report attempts to document all of the different factors fleets should consider when putting together an optimal idle-reduction technology package.

Benefits of idle-reduction, both financial and others that are more intangible, consist of the following:

- Fuel savings
- Driver comfort (sleep quality, convenience, productivity, and safety), which can help control the costs associated with driver recruiting and/or retaining
- Reduced emissions and increased environmental sustainability
- Reduced truck and engine wear, especially to main engine accessories (fan, alternator, air compressor, belts, power steering pump, HVAC system, electrical components, etc.), due to reduction of mileage, as well as longer component life due to lower vibration

- Decreased preventive maintenance costs due to longer periods between oil and filter changes
- Improved truck resale values, given fewer hours on the engine and the value-add of the idle-reduction systems installed
- For newer (2007 and later) vehicles with active exhaust systems, the reduction in regeneration of the exhaust systems (DPF/SCR) means less fuel is burned and diesel particulate filters may need to be cleaned less often
- Depending on the frequency and cost of the fleet's jump starts, some idle-reduction systems will reduce those jump starts, as both APUs and automatic start/stop systems can monitor and charge truck batteries, while off-board AC power as well as battery chargers can avoid hotel load battery drains
- Potentially the avoidance of fines from idling regulations and no-idle areas
- Reduced noise pollution both inside and outside the cab
- Some idle-reduction systems will reduce cold starts by providing heat to the engine or power block
- Reduced time spent fueling due to less fuel being consumed

Costs of idle-reduction systems consist of the following:

- Purchase price of system(s)
- Fuel used to operate the system (either while moving or stationary), per hour of operation, multiplied by the number of hours operating per year
- Parts and labor costs to maintain the system(s), including oil and belt changes for diesel APUs, filter changes, battery changes for battery HVACs, etc.
- Cost of downtime for maintenance if outside of normal PM schedule
- Out-of-service time required to maintain the system(s), as well as to install systems when they are being retrofit onto existing vehicles

More specifically, along with the purchase price of the system, the initial costs of adoption by new vehicles will also include:

- Installation labor costs (if not factory installed)
- Cost of any additional items (service contracts, interest if financed)
- Driver/technician training costs

A fleet's analysis additionally needs to include an understanding of current idle percentages (both unavoidable and avoidable) and the associated costs incurred by those instances of idling, in order to correctly asses the amount of savings they should reasonably seek from the adoption of idle-reduction technologies.

"Unavoidable idling," aka normal work-day idling, which most idle-reduction technologies will not be able to ameliorate, includes:

- Stuck in traffic
- Waiting in line to pick up or drop off a load
- Extreme cold (during which gelling of diesel fuel is a concern)
- Extreme heat (during which the current idle-reduction air conditioning systems cannot keep the cab comfortably cool)
- Engine shut-down / cool-down period
- Running power take-off (PTO)
- Engine/windshield warm-up to operating temperature following cold start

The "avoidable idling" which is the target of idle-reduction systems includes running the engine while:

- Using truck stop facilities
- Eating or doing paperwork inside the truck
- Rest periods during the driving cycle
- Overnight periods in the truck

Finally, the actual cost of idling will be dependent on the following factors:

- Number of hours per week the truck idles
- Number of weeks per year the truck operates
- Average price of diesel fuel
- Fuel consumption rate at the idle RPM (Figure 26)
- Additional engine/exhaust system maintenance costs due to idling

How much fuel is used for idling (gallons/hour)?			
	Idling Fuel Use (gallons per hour)		
RPM	**AC off**	**AC 50%**	**AC on**
800	0.64	0.7	0.76
900	0.73	0.79	0.85
1000	0.81	0.87	0.94
1100	0.92	0.98	1.05
1200	1.03	1.09	1.15

Figure 26: Diesel Fuel Use under Different Idling Conditions (Argonne National Laboratories)

In summary, the following key factors need to be analyzed and offset to complete a total operations review in selecting an idle-reduction system or complimentary package of systems. The plus signs (+) in Figure 27 indicate added costs while the minus signs (-) indicate cost savings:

+ Initial Purchase Costs
+ Initial Installation & Training Costs
+ Operational Costs (diesel fuel, off-board AC power time…)
+ Maintenance Costs (PM, filters, repairs…)
- Idling Fuel Costs Avoided
- Main Engine Maintenance Cost Reductions
- Resale Value
- Intangible Benefits (Driver Turnover, Sustainability…)
= True Benefit of Idle Reduction System(s)

Figure 27: High Level Payback Equation

8 Complementary Idle-Reduction Technology Packages

As mentioned in Chapter 7, the most efficient and effective idle-reduction solution for a fleet will entail a combination of complementary technologies among those cataloged in this report. For instance, several of the technologies, namely electronic engine parameters, driver incentives, and extra cab/sleeper insulation, are going to contribute positively to almost any solution chosen. Figure 28 shows, from an engineering perspective, which of the 19 technologies discussed here are technically/physically possible to pair on one vehicle. This diagram is meant to give a high-level overview, to indicate where the consideration of complementary systems might be warranted. Obviously, it is not meant to imply that all of the systems need to be used together, as that would most likely not offer the optimal return on investment. The right combination will depend on a given fleet's routes, fuel costs, climates of operation, shop costs, maintenance cycles, training methods, driver support, fleet policies, and other factors.

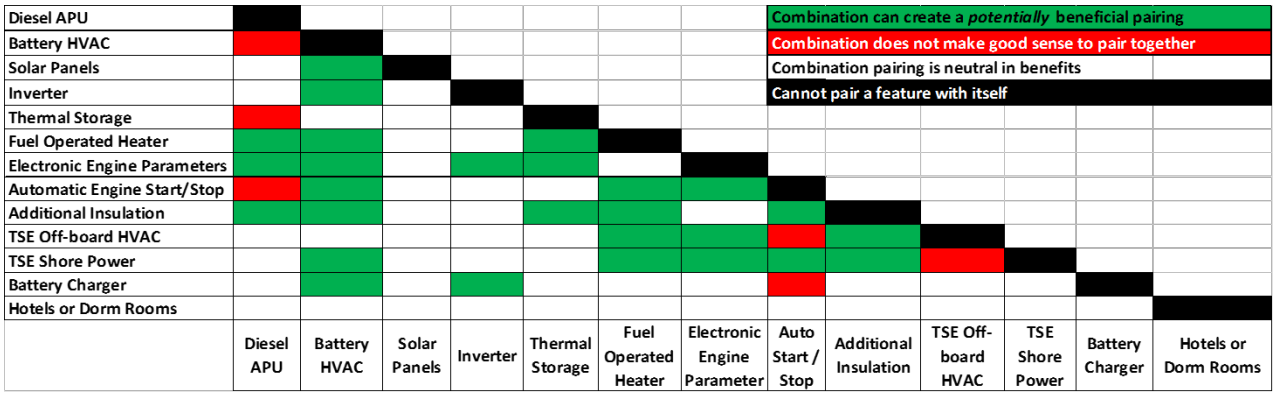


Figure 28: Complementary Technology Packages

In the course of conducting the interviews and consultations that went into this Confidence Report, however, it became clear that the industry is having the most success by choosing one of five technologies as the "anchor" of their overall idle-reduction strategies, and then adding the additional technologies that best complement or support the anchor, which is the primary selection of technology which best suits their fleet. These common fleet strategies incorporate both passive and active solutions. These are, of course, not all of the available combinations, but the most common ones noted by solution manufactures, fleets, and others.

Those five anchor choices are:

- Diesel APU
- Battery HVAC
- Automatic Engine Start/Stop System
- Truck Stop Electrification or Off-board AC Power
- Driver Controls + Fuel-Operated Heater

After one of these options is identified as the best for a fleet's specific needs and goals, ancillary solutions can be evaluated for their potential to reduce idling even further. For example, several fleets stated that their benchmark for idle-reduction technologies is the fuel-operated air heater, as they are relatively simple and straightforward to operate, easy to service, and very efficient. So even after settling on one of the above five anchor solutions, it may be beneficial to add a fuel-operated air heater for cold weather operations, depending on the amount of time the fleet's vehicles operate in cold climates.

Or, in another example, if a fleet selects a battery HVAC as its primary solution, it will need additional technologies to overcome the challenge of HOS restarts, because battery HVACs cannot power driver needs for the full 34 to 48 hours of the restart. The addition of either a 120V AC off-board AC power connection, or a battery-monitoring automatic engine start/stop system into such a fleet's idle-reduction package would allow continuous use of the battery HVAC throughout the restart period. If the 120V off-board AC power option is selected, that fleet should also consider reimbursing drivers for what they will pay to access that AC power at truck stops or other facilities, as well as providing better access to AC power at fleet facilities and key customer distribution points.

Finally, fleets should consider the conditions under which sleeping in the truck for an HOS restart is not the optimal solution. If the main engine will need to idle for the entire restart period to maintain comfortable temperatures and provide hotel loads, especially in very hot weather, a hotel room or dormitory may actually be a more cost-effective choice for the fleet, not to mention a preferable option for the drivers.

8.1 Diesel APU

There are a variety of makes and models of diesel APUs, but regardless of the specific features of the diesel APU a fleet installs as its anchor technology, the additional installation of maximum truck insulation will greatly increase the effectiveness and efficiency of diesel APUs. Specifically, extra insulation in the cab and sleeper area, plus an insulating sleeper curtain and/or window covering, will help retain the heat and air conditioning generated by the APU, thus allowing the APU engine to run less and therefore use less fuel.

From a fuel efficiency standpoint, the more HVAC and electrical power that must be generated directly by the APU the more fuel it will potentially use. Therefore, if a fleet uses diesel APUs to provide complete HVAC with a generator they would use the most fuel to reduce their idling. But a fleet that selects a diesel APU as its idle-reduction anchor technology and then additionally installs an inverter to power the HVAC system would use less fuel. And then a fleet which selects a diesel APU as its idle-reduction anchor technology and then additionally installs both an inverter for HVAC *and* a fuel-operated air heater for bunk heat would use the least amount of fuel to meet its idle-reduction goals.

Conversations with the industry found that the most common idle-reduction strategy at the moment, for fleets that have selected diesel APUs as their anchor technologies, is to also install extra insulation and a fuel-operated air heater, but still to use the diesel APU to meet their HVAC needs.

The study team also heard some common concerns or challenges from fleets that are either currently using diesel APUs as their main idle-reduction option or else who are considering adopting them. The following chart (Figure 29) serves to suggest solutions to those concerns, either by improving on that main system or converting to a different idle-reduction strategy entirely.

Figure 29: Currently Use Diesel APUs	
If your fleet's challenge is:	**Consider making this change:**
Can't keep the sleeper cool enough in the summer	• Change exterior cab paint to a lighter color • Use hotels for HOS restart periods • Make sure to cold soak the sleeper with the main HVAC before shutting off the main engine • Add thermal window curtains • Order new future trucks with extra insulation
Idling costs in the winter are too high	• Order new vehicles with extra insulation • Add a fuel-operated heater/turn off APU whenever possible • Utilize the bunk curtain to keep heat in sleeper • Add thermal window curtains • Order future vehicles with extra insulation
Maintenance costs and service frequency is too high	• Switch brands of APUs • Move away from APUs to automatic engine start/stop system with a Clean Idle engine • Move away from diesel APUs to battery HVAC and battery charging automatic engine start/stop system
Total vehicle weight is too high	• Move away from APUs to automatic engine start/stop system with a Clean Idle engine
Want to lower overall vehicle operating expenses and be more "green"	• Add AC outlets, or off-board AC power, or a truck stop electrification system to your longer stopping points such as distribution centers, near border crossings, etc.

8.2 Battery HVAC

The optimal package to combine with the selection or consideration of a battery HVAC system as the anchor technology of a fleet's idle-reduction strategy, and the most common strategy currently pursued by the industry, is one which pairs the battery HVAC with:

- Additional insulation

AND:

- A fuel-operated air heater – to most efficiently cover all climate zones for fleets working in regions which have both cool and hot weather

AND:

- An automatic engine start/stop system – to charge the battery when the truck is stopped for extended periods, thereby eliminating one of the most common concerns fleets have with battery HVACs – the limited periods for which they can function with one charge. Some automatic engine start/stop systems can actually be integrated with battery HVACs themselves, monitoring their charges and auto-starting the vehicle to recharge them when batteries run low.

AND/OR:

- Off-board AC power/truck stop electrification – this will also overcome the limited period that a battery HVAC can function by providing a constant power source to the truck in certain instances.

Figure 30 goes into more detail about the common concerns or challenges reported by fleets who are either currently using battery HVACs as their main idle-reduction option or else are considering their adoption, and serves to suggest solutions to those concerns, either by improving on that main system or converting to a different idle-reduction strategy entirely.

Figure 30: Currently Use Battery HVACs	
If your fleet's challenge is:	**Consider making this change:**
Batteries drain before the sleep period or HOS restart is complete	• Add a battery charging automatic engine start/stop system • Make sure to cold soak the sleeper with the main HVAC before shutting off the main engine • Minimize any hotel loads that may be draining the system • Utilize off-board AC power to charge to run the HVAC and charge the batteries • Add a solar charging panel to the sleeper or trailer roof • Switch to a diesel APU for longer run time
Battery replacement costs are too high	• Minimize battery cycling with any of the bullet points in the previous item
Batteries need to be replaced too frequently	• Minimize battery cycling with any of the bullet points in the previous item • Insure all electrical power connections are clean, tight and sealed appropriately.
Can't keep the sleeper cool enough in the summer	• Change exterior cab paint to a lighter color • Use hotels for HOS restart periods • Make sure to cold soak the sleeper with the main HVAC before shutting off the main engine • Add thermal window curtains • Order future vehicles with extra insulation • Switch to an APU system with a higher Btu cooling capacity
Want to lower overall vehicle operating expenses and be more "green"	• Add AC outlets, or off-board AC power, or a truck stop electrification system to your longer stopping points such as distribution centers, near border crossings, etc.

8.3 Automatic Engine Start/Stop

An automatic engine start/stop system alone will not allow fleets to achieve their ambitious idle-reduction goals of 10% or even just 5% idling time. But when paired with a Clean Idle given that technology's certified availability to idle at the same emissions levels as a diesel APU, automatic engine start/stop system make for attractive nationwide anchor technologies, as they maintain sleeper temperatures and battery charges without adding significant weight or componentry to the vehicle or increasing maintenance requirements.

It should be noted that for this technology to be fully functional as an anchor to idle-reduction strategies, any vehicles ordered with both Clean Idle engines and automatic engine start/stop systems should not be ordered with the non-adjustable mandatory five minute timer installed on those systems. This timer is available as an option for fleets seeking to meet various idling regulations, particularly those in California, and they are also a useful option for fleets pursuing fuel efficiency measures under the 2014 Greenhouse Gas GEM model. But as Clean Idle certifications allow engines to idle for longer than the five-minute limit, those timers will be counter-productive.

However, these two features alone may not present the most efficient way to operate a vehicle in the winter. The addition of a fuel-operated air heater, which are far more efficient than the main engine for heating the sleeper, will make for a better overall package, and additional insulation will always be beneficial as well. These four features together make up the most common/most ideal idle-reduction strategy using automatic engine start/stop systems as an anchor that the industry is pursuing today.

The study team also heard some common concerns or challenges from fleets who are either currently using automatic engine start/stop systems as their main idle-reduction option or else who are considering adopting them. Figure 31 serves to suggest solutions to those concerns, either by improving on that main system or converting to a different idle-reduction strategy entirely.

Figure 31: Currently Use Automatic Engine Start/Stop System	
If your fleet's challenge is:	**Consider making this change:**
Idling costs in the winter are too high	• Order new vehicles with extra insulation • Add a fuel-operated heater/turn off APU whenever possible
Can't keep the sleeper cool enough in the summer	• Change exterior cab paint to a lighter color • Order new vehicles with extra insulation • Use hotels for HOS restart periods • Make sure to cold soak the sleeper with the main HVAC before shutting off the main engine • Add thermal window curtains
Want to lower overall vehicle operating expenses and be more "green"	• Add AC outlets, or Off-board AC power, or a truck stop electrification system to your longer stopping points such as distribution centers, near border crossings, etc.

8.4 Truck Stop Electrification

One of the common challenges fleets cite as preventing them from pursuing truck stop electrification as their sole idle-reduction solution is a lack of available truck stops and rest areas that have actually been equipped with electrified parking spaces. Therefore, at present truck stop electrification coupled with a fuel-operated air heater and an inverter/battery charger may be a good option for some fleets.

Equipping a vehicle with a fuel-operated air heater and an inverter will provide drivers with heat and AC power to run hotel loads for those times when there are not electrified parking spaces available. The battery charger provides a way to both keep the main batteries charged and power hotel loads in the sleeper.

This combination solution does not provide a way to cool the cab in the summer when there are no electrified parking spaces available, so is not yet a viable solution for fleets operating in warmer climates. If a 120V AC powered air conditioning system is added to the available idle-reduction options in the future, this group of subsystems will become a more viable option, especially for fleets that already have AC power available in their parking lots.

The study team also heard some common concerns or challenges from fleets who are either currently using truck stop electrification as their main idle-reduction option or else who are considering adopting

it. The following chart (Figure 32) serves to suggest solutions to those concerns, either by improving on that main system or converting to a different idle-reduction strategy entirely.

Figure 32: Currently Use Truck Stop Electrification	
If your fleet's challenge is:	**Consider making this change:**
Not enough places to plug in for power	• Add AC electrical outlets to all light poles in your parking lots. May be a great time to transition to a more efficient type of lighting while making the lots more beneficial to power access. • Ask your freight customers to consider the same thing as part of their overall sustainability efforts
Can't use the AC powered devices in the vehicle when not connected to an AC power source	• Add an inverter, preferably a model with a battery charger so that when the vehicle does have access to AC power it will charge the batteries

8.5 Fuel-operated Air Heater + Driver Training & Incentives Program

Given not only the high cost of fuel but also recent and persistent increases in truck equipment costs, some fleets are pursuing an idle-reduction strategy wherein they make a minimal investment in technology coupled with a larger investment into driver engagement. This strategy is anchored around the adoption of a fuel-operated air heater for cold weather, supported by the adoption of some electronic engine idle parameters, such as ambient air shutdown, along with driver training and driver incentives. This strategy is probably the least demanding of fleet technicians and service support systems since it uses the least additional devices on the vehicle.

All four of these technologies are key to this idle-reduction strategy. Fuel-operated air heaters are presently the cheapest way to keep drivers from freezing in extreme conditions. Meanwhile ambient air shutdown settings automatically control idling when the outside temperatures are mild, but will still permit unlimited idling in extremely hot weather (or cold if needed), giving the driver the assurance that he or she can be comfortable in such conditions. Exact temperature ranges may be set by individual fleets depending on many variables such as the regions the trucks are operating, how aggressive they want to be with respect to idling, etc. Meanwhile driver training can include tips on parking in a direction away from the sun or in the shade, not idling when stopping for food or fuel, etc., and driver incentives generally entail the inclusion of percent idle-times in driver bonuses or award distribution calculations.

The study team also heard some common concerns or challenges from fleets who are either currently using fuel-operated air heaters coupled with driver training and incentives as their main idle-reduction option or else who are considering the adoption of such a strategy. The following chart (Figure 33)

serves to suggest solutions to those concerns, either by improving on that main system or converting to a different idle-reduction strategy entirely.

Figure 33: Currently Use Fuel-Operated Air Heaters (optionally: Air & Coolant Heaters)	
If your fleet's challenge is:	**Consider making this change:**
Batteries are discharged too soon	• Add a battery charging automatic engine start/stop system • Minimize any hotel loads that may be draining the system • Utilize battery charger and off-board AC power to keep the batteries charged • Add an auxiliary starting battery system • Utilize an auxiliary CPAP battery to reduce the loading of CPAP to main batteries
Want to lower overall vehicle operating expenses and be more "green"	• Add AC outlets, or off-board AC power, or a truck stop electrification system to your longer stopping points such as distribution centers, near border crossings, etc.

8.6 Most Common Fleet Strategies

Over the course of this study effort, five common fleet strategies emerged that incorporated this model of choosing an anchor technology for one's idle-reduction efforts and then adding various, additional and complementary technologies, both active and passive. As discussed above, these are not *all* of the possible combinations or options, but merely the more common ones that were highlighted by solution manufacturers, fleets themselves, and others. Note that a good starting place for any idle-reduction solution is spec'ing the vehicle with the highest-level insulation package available from the truck OEM. This will help to ensure maximum efficiency for whatever heating or cooling option is selected. Also note that fuel-operated air heaters are becoming a basic cornerstone of many of the technology packages currently being widely pursued.

Anchor Tech	Diesel APU	Battery HVAC	Automatic Engine Start & Stop System (without five-minute shut-off timer)	Truck Stop Electrification	Fuel-Operated Air Heater
Additional Techs	1. Extra Insulation 2. Fuel-operated air heater	1. Extra Insulation 2. Fuel-operated air heater 3. Automatic start/stop (Battery Version)	1. Extra Insulation 2. Fuel-operated air heater 3. Clean Idle Engine (with CA ARB sticker	1. Extra Insulation 2. Fuel-operated air heater 3. Inverter / Battery Charger	1. Extra Insulation 2. Electronic Engine Parameters 3. Driver Training 4. Driver Incentives

Figure 34: Summary of Anchor Technologies

9 Perspectives for Future Systems

One thing that became very clear to the study team in the course of compiling this Confidence Report is that the field of idle-reduction technologies and strategies is a constantly and rapidly evolving one. The options discussed here are currently available on the market today and have a good track record of functionality, though they may be more or less economical depending on the specifics of a fleet's operations. However the future may hold some combination of the following ideas as part of a more complete solution to idling:

Improved cab sealing and insulation

Continued advancements in the development of cab sealing and insulation will increase the efficiency of any and all other idle-reduction technologies or strategies. The most likely advancements coming in the pipeline include new developments in chemistry and materials engineering (such as technologies borrowed from space programs), improvements in the application of insulation and sealing during vehicle manufacturing, and advanced technologies for window glass and window curtains allowing them to provide a better barrier against solar loading.

Sleeper cab humidity controls

The conversation around which elements of sleeper cab comfort should be supplied by idle-reduction system has thus far largely centered on temperature, while the question of humidity has not been

addressed. Future systems will focus on humidity as well, seeking to find ways to bring moisture into the cab in the winter and reduce that moisture in the summer.

Solar-reflective paint

New solar-reflective paints will serve to reduce heat loading by reflecting undesirable solar energy and preventing it from warming the interior of the truck as drastically as it currently can today. A recent paper by NREL, Volvo, and PPG showed a 7.3% reduction in daily electrical cooling loads from using solar-reflective blue paint that was color-matched to the original, traditional blue paint of the trucks. Not only are these results potentially even stronger than those offered by the light-colored paints currently on the market and covered in this Confidence Report, but these new paints will overcome the fact that many fleets and drivers really dislike white or light-colored trucks, as solar-reflective paints can be produced in the fleet's own brand colors or to the tastes of the truck owners.

Natural gas powered heaters and APUs

The trucking industry is gradually embracing natural gas fuels for Class 8 vehicles. CNG (Compressed Natural Gas) is leading the way for vocational applications and LNG (Liquid Natural Gas) appears to be gaining market ground in long-haul applications. One manufacturer already markets a CNG bunk heater, and other natural gas products are probably starting in development now. For instance, natural gas APUs have likewise been developed, but the number of possible users is still very small.

Fuel cell powered APUs

A fuel cell APU is already in development in the European DESTA (Demonstration of the first European SOFC Truck APU) project in the form of a Solid Oxide Fuel Cell (SOFC). That technology is slated to be tested in the very near future on a Volvo truck in the United States. The system will require substantial vehicle integration due to its operational needs and numerous unique interfaces with other vehicle systems. The partners in this effort, AVL and Eberpacher, plan to have a commercial introduction in the 2016/17 time frame.

New batteries with improved capacities and longer lives

Given that a vehicle equipped with a battery HVAC for idle reduction may today be carrying up to eight batteries on-board, the opportunities for advancements in these technologies are significant. As hybrid car suppliers continue to create lighter batteries with higher capacities, the sleeper cab idle-reduction systems may be able to take advantage of those developments.

Failure-friendly diagnostics and options

As various idle-reduction technologies are gaining strong acceptance, one of the next steps in idle-reduction may be the integration of these technologies with diagnostic systems. A vehicle that can adjust its idle-reduction based on the health of those systems as well as the climate the vehicle is operating in could offer even greater fuel efficiencies. If for instance an APU became unable to perform its desired tasks, the vehicle's diagnostics system and/or telematics controls could automatically switch

the vehicle's idle-reduction to rely on a less-efficient but still effective automatic engine start/stop system, and the freight would continue to move until it is convenient to make the repairs to the APU.

Parking and Truck Stop Electrification availability notifications

The process of finding a parking place for sleeping can eat into a driver's hours-of-operation limits. There are already automotive parking garages that detect how many empty spaces exist at any given time. The future of idle-reduction may hold a system for tractor-trailer drivers that can monitor the upcoming facilities along their route and inform the driver via in-cab telematics which truck stops have open parking places and how many of those spots have truck stop electrification systems available.

Fuel Tax Credits for APUs

Diesel APUs today draw power from the main diesel fuel tanks, and so their fuel consumption is subject to the taxes assessed on the overall diesel fuel price. It may make sense to change legislation such that some taxes on this aspect of diesel fuel could be avoided, and idle time were treated the same way that vocational vehicles handle PTO (Power Take-Off) fuel use, i.e. as not part of road-use time. For this to be accomplished, diesel APUs will need to estimate and record their portion of fuel consumption.

A mindset shift which places greater importance on lifecycle sustainability

Several fleets surveyed for this Confidence Report described how they now need to provide sustainability audits to their customers, so that those customers can communicate the efforts they're making in creating a greener transportation system to shareholders and the public. Challenges and opportunities abound in light of this mindset shift in the industry. For just one example, while battery HVAC systems "burn no fuel while in operation," they do lead to the need to recycle twice as many batteries as vehicles used to. A focus on sustainability could create opportunities to find a second life for these batteries in a different application or a different power need.

On- and off-board solar charging systems and renewable energy grid dependence

Vehicle-mounted solar panels will continue to see improvements in efficiency and performance as solar PV cell technologies as a whole continue to improve. Improvements in PV efficiency will permit higher cell density, which in turn will increase the amount of charging capability offered by the surface area of the sleeper roof. In addition, the continued electrification of vehicles will present opportunities for solar power to be used to offset full-time parasitic loads and larger auxiliary loads (e.g., power steering pump, engine cooling fan, cab A/C), and even for motor power when integrated with hybrid electric vehicles.

Expected improvements in off-board charging equipment, primarily driven by a burgeoning plug-in electric vehicle market, will enable owners of vehicle-mounted solar panels to gain additional revenue by selling carbon credits and excess power when docked and plugged into off-board, grid-connected power sources. In particular, rapid (level 3), bidirectional, DC charging systems will make it possible to either top off a vehicle's batteries with off-board AC power, or send excess power from the solar panels back to the local utility. In any case, off-board AC power and truck stop electrification systems, which take their power from the electric grid, offer the industry the opportunity to reduce its emissions by proxy, taking advantage of the ongoing increase in renewable penetration into the general grid. For

example, terrestrial PV, would provide carbon-free charging and more efficient power transfer by avoiding AC to DC conversion. Electrification of as many systems as possible may be the gold standard ideal when looking toward the future. If infrastructure expands so that 120V AC power was *always* readily accessible for trucks, fleets could avoid the additional weight and cost of all the other options, such as heaters and APUs that are currently employed for idle-reduction.

What does the future hold?

This report has covered both current systems and future opportunities, allowing the study team to consider where long-haul trucking might be in a decade or two with respect to idling. This Confidence Report finds that the future could take several different paths:

- If intermodal freight continues to grow and short haul continues to cut into long haul, sleeper use could decline dramatically, making the construction of hotels and dormitories critical to such a transition. This vision probably makes driving a truck more appealing to future generations of drivers who have little desire to sleep in their vehicles.
- The use of off-board power could become easier if the wireless induction technologies now being introduced for hybrid and electric transit buses enter the Class 8 tractor-trailer parking facilities. With such systems a truck would be able to park directly over a wireless power connection and run all of its on-board systems, but with no cables to plug in and no need to exit the vehicle at all. Plowing the lot would become much easier without any charging pedestals to work around. Finally, under this model, whatever improvements are made to the energy grid as a whole are automatically enjoyed by the trucking industry.

10 Conclusions and Confidence Rating

This report focuses strictly on sleeper tractors pulling trailers in North America, and describes 19 separate technologies and practices available to support fleets in their idle-reduction efforts.

10.1 Confidence Report Rating

For each of the Confidence Reports completed by the Trucking Efficiency Operation, the various technologies assessed therein are plotted on a matrix in terms of the expected payback in years compared to the confidence that the study team has in the available data on that technology – that is, not only how quickly fleets should enjoy payback on their investment but how certain Trucking Efficiency is in the assessment of that payback time. Technologies in the top right of the matrix have a short payback, usually thanks to their low upfront cost, and moreover the risk to adopt them is low because the technology is more mature or otherwise has a more substantial track record of results.

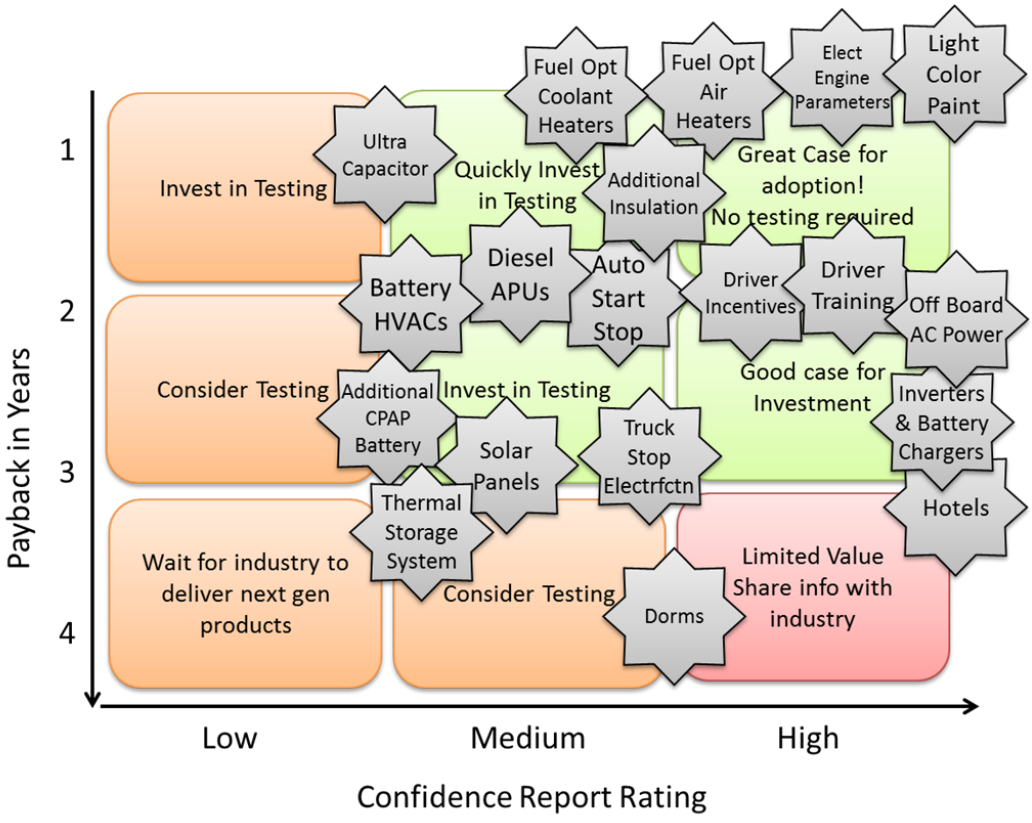


Figure 35: Confidence Matrix of Idle-Reduction Technologies

10.2 Key Takeaways

Over the course of this seven-month research project, including interviews with dozens of companies, the study team developed a set of 'key thoughts' on idle reduction. These thoughts were further refined during a workshop held with a truck OEM, the media, and a non-profit research laboratory. The nine

conclusions are presented here, in no particular order, as guide points for an ongoing dialogue on this important industry challenge: reducing the idling of Class 8 sleeper tractors.

1. Words matter.
    a. Idle-reduction discussions can be easily confusing as a result of complex and confusing terminology, OEM system rebranding, and supplier turnover. The idle-reduction industry, and the trucking industry as a whole, is not in unanimous agreement on what the different technologies or solutions should be called. For example, the terms 'battery APU,' 'battery HVAC,' and 'battery EPU' are all currently used to describe the same technology. There also seems to be significant confusion around the terms 'shore power' and 'truck stop electrification,' while many fleets did not seem to fully grasp what was meant by 'electronic engine parameters' or how they could be used as part of an idle-reduction strategy.
    b. If technology suppliers, regulators, and even fleet managers began characterizing these efforts as 'idle reduction,' as opposed to 'anti-idle,' they would gain more traction among the industry, particularly drivers. Over the years, the topic of idling seems to have evolved such that the ideal solution is now seen as one which never allows the main truck engine to idle – a difficult standard for drivers to achieve while remaining comfortable and safe. Given other technological advancements that have reduced the emissions from the main truck engine overall, a compromise which mixes small amounts of idling with other idle-reduction efforts to minimize idling is likely the best answer for many fleets.
2. Drivers matter.
    a. Drivers are key to a fleet's decision whether or not to install an idle- reduction technology, and moreover to the successful implementation of the chosen technology. Fleets can install all the appropriate technology, but if the driver does not use it and continues to idle the truck then those investments are wasted. Therefore, fleets queried for this Confidence Report indicated that the fact that they need to make sure their drivers were comfortable was a big factor in their decision to invest in a given idle-reduction technology. Drivers have also taken on increased importance given the driver shortage and the cost to recruit, train and retain new drivers.
    b. Since drivers work, live, and sleep in these trucks, they need to be supported in making their trucks safe, comfortable, and efficient. Long-haul truck driving is a demanding occupation. Many business models have truck drivers on the road for three weeks at a time, and some even longer. Drivers operate machines that can weigh up to 80,000 pounds at highway speeds, and as they operate on shared roadways, it is crucial that they be well rested.

3. Perceptions matter.
    a. The study team noted a misperception among the industry that idle reduction was a complicated undertaking, when in fact it does not have to be difficult in the least, especially as there are rather simple and quick actions that can be implemented first by any fleet or truck on the road today, including specifying trucks with light-colored paint and additional insulation to more efficiently regulate internal cab temperatures, as well as implementing effective driver training and incentive programs aimed at idle reduction.
    b. Idle-reduction technologies are maturing, but the industry is slow to forget past failures (early generations of many of these technologies were not sufficiently durable, among other issues.) Many of these technologies have been improved as new generations of products are released, and the industry needs new information to trust these options.
4. OEMs matter.
    a. More idle-reduction solutions need to be available directly through the truck OEMs. Fleets are seeking proven integrated solutions from their truck manufacturers. OEM solutions have been vetted, validated and warrantied by the manufacturer – making the technologies that they offer the most attractive choice for fleets.
5. Every idle-reduction technology has a downside.
    a. Concerns for fleets interested in battery HVAC systems include battery life and length and quality of the AC output. Concerns around diesel APUs include reliability and maintenance costs, as well as a lack of confidence based on legacy issues from earlier iterations of that technology. As yet, truck stop electrification is not viable as a primary solution for many fleets because there are not enough locations and not enough electrified spots at the available locations. Plus, fleets would need to revisit their policies and begin reimbursing their drivers for using such systems if they are really going to catch on.
6. Trucking is changing, and a variety of factors matter to idling.
    a. Emerging industry issues are compounding the challenge of idle reduction, including driver health issues that are causing an increase in the use of CPAP devices, as well as the increasing use of electronics by all drivers.
    b. The most relevant new issue for idle-reduction efforts is the Hours of Service regulations, and their mandatory rest periods lasting from 34 to 48 hours. These have created a substantial need in the industry for idling and for solutions that provide heating, cooling, and electric power for extended periods of time without having to idle the main engine.

However,

c. Anti-idling regulations and emission-reduction goals are not the primary reasons for fleets' decisions to purchase idle-reduction technology. Factors such as driver comfort, fuel savings, and preventing gelling of fuel are placed higher in a fleet's decision-making priorities.

7. Costs are king.

   a. Commercial trucking decision making is driven by payback, and so any technology assessment must include both benefits and consequences (pros and cons). Specific financial impacts that should be quantified include upfront cost, fuel savings, maintenance costs, etc. Others impacts are more difficult to quantify, such as driver attraction and retention, resale value, infrastructure, lost carrier business, etc.

8. There is no one-size-fits-all solution to idling.

   a. As demonstrated in this paper, there are at least 19 specific technologies that can be employed to reduce idling. Moreover, the very best solution for any fleet might involve one of many possible combinations of several of those technologies. This reality makes decision-making even more complex.

   b. Fuel-operated air heaters remain a cornerstone, and a benchmark, of idle-reduction efforts across the industry. They are relatively inexpensive, have very low operating costs, require little maintenance and are well accepted. The supplier that creates an equivalent system for cooling a sleeper will be highly valued.

   c. Certain solutions like hotels and additional CPAP batteries should be considered as backups to a fleet's primary idle-reduction solution.

9. The future is in electricity.

   a. The emerging smart energy grid, with greater renewable penetration, should be exploited by idle-reduction efforts. The electrification of vehicles using plug-in devices for battery charging is rapidly advancing, while the source for that electricity is becoming more based in renewables such as solar, wind and others. Electric-based idle reduction solutions could therefore be part of an overall sustainability strategy for the trucking industry in the long term.

10.3 Next Steps and Further Research

To refine the confidence ratings given in this report, these idle-reduction systems would benefit from head-to-head testing of the different systems and/or common combinations of systems on otherwise identical vehicles. This is a very complex task. Idle-reduction options that only consume fuel or energy while stationary, such as diesel APUs and automatic engine start/stop systems are easy to compare, since test vehicles can be parked and monitored. Systems that use additional fuel while in motion such as the battery HVAC and thermal storage systems make such testing much more complex. And attempting to determine the relative contribution of any one technology to a package of multiple idle-reduction technologies is harder still. Testing would also ideally include both winter and summer tests to determine operation effectiveness under all conditions.

11 References

"7 Factors to Consider When Installing an Inverter," Heavy Duty Trucking Truckinginfo.com, September, 2013.

American Transportation Research Institute, "Critical Issues In The Trucking Industry – 2013," October, 2013.

American Trucking Associations, Reports, Trends & Statistics, 2013.

Diesel Technology Forum, http://www.dieselforum.org/, 2013.

Kolman , David A. "The nuts and bolts of APUs," Vehicle Service Pros.com, December 6, 2010.

Lustbader, J., et al., "Impact of Paint Color on Rest Period Climate Control Loads in Long Haul Trucking," National Renewable Energy Laboratory NREL/CP-5400-61084, February, 2014.

Miller, Deanna, "Obstructive sleep apnea (OSA): Its effects on commercial truck drivers." National Registry of Certified Medical Examiners NRCME Training Online, https://www.nrcmetrainingonline.com/hot-topics/37-obstructive-sleep-apnea-osa-its-effects-, 2013.

"NACFE conducts extensive benchmarking study on fleet fuel efficiency," Truck News, February 21, 2012.

Rechberger, J., et al., "Fuel-cell APUs show promise for heavy-duty truck anti-idling," SAE International, December 9, 2013.

"Shore Power I-5 interstate corridor complete," Heavy Duty Trucking Truckinginfo.com, April 16, 2013.

Sieber, W. K., et al., "Obesity and other risk factors: The national survey of U.S. long-haul truck driver health and injury," American Journal of Industrial Medicine, November 2, 2013.

Skydel, Seth, "Idling reduction," Fleet Equipment, January 15, 2013.

Starr, Freddy, "Major factors leading to a CMV driver crash," National Registry of Certified Medical Examiners NRCME Training Online, https://www.nrcmetrainingonline.com/blog/55-major-factors-leading-to-a-cmv-driver-crash, 2013.

"How the Trucking Industry Can Save Billions of Gallons of Fuel Per Year," Sustainable America, http://www.sustainableamerica.org/blog/tse, 2014.

Technology & Maintenance Council, Recommended Practice RP 1108, "Analysis of Costs from Idling and Parasitic Devices for Heavy Duty Trucks," American Trucking Associations, 2013.

Technology & Maintenance Council, Recommended Practice RP 1113, "Guidelines for Driver Incentive Programs," American Trucking Associations, 2013.

United States Department of Energy: Argonne National Laboratory: Transportation Technology R&D Center, "Idle Reduction Technologies for Heavy Duty Vehicles," http://www.transportation.anl.gov/engines/heavy_technologies.html, 2013.

United States Department of Energy: Energy Efficiency & Renewable Energy, Alternative Fuels Data Center: Heavy Duty Truck Idle Reduction Technologies, http://www.afdc.energy.gov/conserve/idle_reduction_heavy.html, 2013.

United States Environmental Protection Agency, "Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles; Final Rule," September 15, 2011.

United States Environmental Protection Agency, Regulations & Standards: Heavy Duty, 2013.

Wikipedia, The Free Encyclopedia, "Auxiliary power unit," http://en.wikipedia.org/w/index.php?title=Auxiliary_power_unit&oldid=595674470, March 9, 2014.

Wikipedia, The Free Encyclopedia, "Idle reduction,", http://en.wikipedia.org/w/index.php?title=Idle_reduction&oldid=597946875, March 9, 2014.

12 Appendix A: Payback Calculators

GENERIC CALCULATOR

- http://www.afdc.energy.gov/conserve/idle_reduction_heavy.html

AUXILARY POWER UNIT CALCULATORS

- Dynasys
  - http://www.dynasysapu.com/dynasystm-apu-savings-calculator
- Rigmaster
  - http://www.rigmasterpower.com/savings-analysis.php
- Thermo King
  - http://www.na.thermoking.com/tk-innovation/global/en/products/apu/tripac-evolution-payback-calculator.html

AUTOMATIC ENGINE START/STOP CALCULATOR

- Idle Smart
  - http://www.idlesmart.com/calculator.html

BATTERY HVAC CALCULATOR

- Bergstrom
  - http://us.bergstrominc.com/nite-calculate-savings/
- Crosspoint Solutions
  - http://www.crosspointsolutionsgroup.com/climacab/product/savings-calculator.html

FUEL-FIRED HEATER CALCULATORS

- Espar
  - http://www.espar.com/products/fuel-operated-heaters/special-programs/calculator/usa/truck.html
- Webasto
  - http://www.techwebasto.com/redirect/calculators/heater/heater_fuel_calculator_us.htm

OTHER

- Natural Resources Canada
    - http://fleetsmart.nrcan.gc.ca/index.cfm?fuseaction=docs.view&id=1

13 Appendix B: Existing Web Resources

Existing Web Resources

This isn't the first report to study idle reduction and it probably won't be the last either. Listed in the table below are some resources on the subject of truck idling:

Owner	Content	Site
ATRI: American Transportation Research Institute	Anti-Idling Regulations By Area	http://atri-online.org/2013/02/20/idling-regulations-compendium/
Argonne National Labs	Anti-Idling News & Tools	http://www.transportation.anl.gov/engines/idling_tools.html
SmartWay	Certified Devices	http://www.epa.gov/smartway/forpartners/technology.htm
EPA	FET Exemptions	http://www.businessfleet.com/blog/market-trends/print/story/2009/02/epa-names-idle-reduction-systems-eligible-for-federal-excise-tax-exemptions.aspx
Natural Resources Canada	Idle Reduction Information	http://www.nrcan.gc.ca/energy/efficiency/transportation/commercial-vehicles/smartway/13895

14 Appendix C: Expanded List of Idle Reduction System Suppliers

Diesel APUs

Acemco Power System

7297 Enterprise Drive Spring Lake, MI 49456

877-810-6555

www.acemcopowersystems.com

APUs by Rex (Pony Pack)

2800 Vasar Dr. NE, Suite B, Albuquerque, NM 87107

855-472-2002

www.ponypack.com

Comfort Pro (Impco/Carrier)

3030 S. Susan St. Santa Ana, CA 92704

800.667.4275

www.impcotechnologies.com

Centramatic

5354 South I-35 West, Alvarado, TX 76009

800-527-8473

www.centramtic.com

Diamond Power Systems

13980 Mountain Ave.

Chino, CA 91710

866-882-8088

www.diamondpowersystems.com

Green APU

411 W. Factory Rd., Addison, IL 60101

877-751-0686

www.greenapu.com

Go Green APU

1052 Mill Run Rd., Altoona, PA 16601

814-942-9407

www.gogreenapu.com

Dynasys

2620 Brushy Creek Loop, Cedar Park, TX 78613

800-289-8282

www.dynasysapu.com

Parks Industries (HP2000)

1546 Crabtree School Rd., Marion, IL 62959

618-997-9608

www.hp2000apu.com

RigMaster Power

1320 Ellesmere Rd., #1, Toronto, Ontario, Canada M1P 2X9

855-472-0002

www.rigmasterpower.com

StarClass Inc.

3454 Ellwood Rd., New Castle, PA 16101

800-422-2865

www.starclassinc.com

Thermo King (TriPac Evolution)

314 W 90th St., Minneapolis, MN 55420

952-887-2200

www.thermoking.com/tripac

Tridako Energy Systems (Power Cube)

5610 Perkins Rd., Alliance, NE 69301

855-797-2823

www.tridako.com

Willis Power Systems

2950 N. Martin, Springfield, MO 65803

800-825-4631

www.willisapu.com

Battery HVAC Systems

Bergstrom (NITE Plus, NITE Phoenix

2390 Blackhawk Rd., Rockford, IL 61125

815-874-7821

www.bergstrominc.com

Crosspoint Solutions Group (ClimaCab 3.0)

551 W 79th St., Indianapolis, IN 46268

877-826-9399

www.crosspointsolutionsgroup.com

Dometic

PO Box 15299, Richmond, VA 23227

804-746-1313

www.dometic.com

Hammond Air Conditioning (Arctic Breeze Truck AC)

125 Samnah Crescent, Ingersoll, Ontario, Canada, N5C 3J7

800-267-26665

www.hammondac.com

Idle Free Systems

7633 Gasner Way, Suite 107, Madison, WI 53719

920-206-9333

www.idlefreesystems.com

Kingtec USA

1165 E Arcadia Court Unit A Ontario, CA 91761

909-930-1734

www.kingtecusa.com

Thermo King (TriPac e)

314 W. 90th St., Minneapolis, MN 55420

952-887-2200

www.thermoking.com/tripac

Fuel-operated Air and Coolant Heaters

Espar Heater Systems (Hydronic, Airtronic)

6099A Vipond Dr., Mississauga, Ontario, Canada L5T 2B2

800-387-4800

www.espar.com

Kingtec (Snugger)

1165 E. Acacia Court, Unit A., Ontario, CA 91761

909-930-1734

www.kingtecusa.com

Marine Canada Acquisitions (Proheat)

DBA SeaStar Solutions

3831 No. 6, Richmond, British Columbia, Canada V6V 1P6

604-270-6899

www.proheat.com

Webasto Thermo & Comfort (Air Top, Thermo Top)

15083 North Rd., Fenton, MI 48430

800-860-7866

www.webasto.com

Automatic Engine Start/Stop Systems

Detroit Optimized Idle (subsidiary of Daimler Trucks North America LLC)

13400 W Outer Drive, Detroit, MI 48239

(313) 592-5000

www.demanddetroit.com/performance/electronics.aspx

Idle Smart

14109 Overbrook Rd., Leawood, KS 66224

913-744-4353

www.idlesmart.com

Temp-a-Start

1619 Luthy Dr., Suite B, Peoria, IL 61615

303-904-9869

www.temp-a-start.com

www.emi-temp-a-start.comindex.php/temp-a-start

Vanner (IdleWatch)

4282 Reynolds Rd., Hilliard, OH 43026

800-227-6937

www.vanner.com

Inverters and Battery Chargers

Phillips & Temro

9700 West 74th St., Eden Prairie, MNN 55344

800-328-6108

www.phillipsandtemro.com

Tundra

2041-A Leonard-de-Vinci, Ste.-Julie, Quebec, Canada, J3E 1Z2

877-962-2582

www.tundrainternational.com

Vanner

4282 Reynolds Rd., Hilliard, OH 43026

800-227-6937

www.vanner.com

Xantrex

541 Roske Drive Suite A, Elkhart, Indiana 46516

800 446 6180

www.xantrex.com

Thermal Storage Systems

Webasto Thermo & Comfort (Blue Cool)

15083 North Rd., Fenton, MI 48430

800-860-7866

www.webasto.com

Off-board AC Power

Shorepower Technologies

2351 NW York St., Portland, OR 97210

503-892-7345

www.shorepower.com

Truck Stop Electrification

Convoy Solutions LLC (Idle Air)

2567 Prime Way, Suite 101, Knoxville, TN 37918

865-232-1700

www.idleair.com

Craufurd Manufacturing (Aire Dock)

6557 Gulf Gate Place, Suite 169, Sarasota, FL 34238

866-771-7466

www.airedock.com

Enviro Dock (E-Dock stationary, E-dock portable Powr Dock

59 Kenisco Rd., Thornwood, NY 10594

319 Business Lane, Suite 1000, Ashland, VA 23005

800-886-6757

www.envirodock.com

Truck Star Systems

1391 NW St. Lucie West Blvd. PMB # 149, Port St. Lucie, FL 34986

772-223-3344

www.truckstarsystems.com

Other Technologies

Aspect Solar (Energy Bar, battery for CPAP)

2205 W. 136th Ave., Suite 106, PMB 217, Broomfield, CO 80023

877-717-7778

www.aspectsolar.com/Resources-@CPAP_Power.aspx

Boyle Construction Management Inc.

220 N. Davidson St., Indianapolis, IN 46202

317-269-0543

www.bcmionline.com

Hotels4Truckers

1-855-438-7275

www.hotels4truckers.com

Maxwell Technologies

(877) 511-4324

www.maxwell.com/esm

15 Appendix D: List of Terms & Acronyms

AC — Alternating Current

AGM — Absorbed Glass Mat

APU — Auxiliary Power Unit

ARB — California Air Resources Board

ATRI — American Transport Research Institute

BAC — Battery Air Conditioning System

Btu — British Thermal Unit

CCU — Climate Control Unit

CFM — Cubic Feet Per Minute

CNG — Compressed Natural Gas

CSA — Compliance, Safety, Accountability (initiative of FMCSA)

DC — Direct Current

DEF — Diesel Exhaust Fluid

DFH — Direct Fired Heaters

DPF — Diesel Particulate Filter

EPA — Environmental Protection Agency

EPS — Electrified Parking Spaces

EPU — Electrical Power Unit

ESM — Engine Status Module

FET — Federal Excise Tax

FMCSA — Federal Motor Carrier Safety Administration

GPH — Gallons Per Hour

GS — Generator Sets

HOS — Hours of Service

HVAC — Heating, Ventilation & Air Conditioning

KW — Kilo Watt (1000 watts)

LCD — Liquid Crystal Display

LED — Light Emitting Diode

LNG — Liquefied Natural Gas

NACFE — North American Council for Freight Efficiency

NREL — National Renewable Energy Laboratory

OEM — Original Equipment Manufacturer

PTO — Power Take-off

PV — Photovoltaic

R134a — Refrigerant (a type of refrigerant)

ROI — Return on investment

SCR — Selected Catalytic Reduction

SOFC — Solid Oxide Fuel Cell

16 Appendix E: Idle Reduction Solution Overviews

Auxiliary Power Unit: ComfortPro	
PRODUCT INFORMATION	
System Type	Auxiliary Power Unit
Product Name(s)	ComfortPro (also branded Carrier) PC6022
Company Name	Impco Technologies
Company Address	3030 South Susan St., Santa Ana, CA 92704
Company Phone	519.576.4270 800.667.4275
Company Websites	www.impcotechnologies.com
SYSTEM SUMMARY	
The ComfortPro APUs are manufactured by Impco in Canada and sold exclusively thru most Carrier Transicold dealers. They offer both stand alone (not integrated with truck engine cooling system) and integrated (open-loop) units. A 6kW capacity generator is standard. The ComfortPro is a split system with A/C condenser mounted back of cab and CCU (comfort control unit) installed under the bunk.	

COMFORTPRO

Images from the websites of Impco Technologies & Carrier Transicold

Cooling Btu	12,000 Btu
Heating Btu	10,000 high speed, 5,000 low speed
Engine	Kubota 13.9 HP, 2 cylinder
Generator	6000 watt
Inverter	does not use an inverter
APU Alternator Size	60 Amps
Approximate Weight of APU (pounds)	396 pounds
Weight of Condenser Assembly (pounds)	85 pounds
Size of APU (H x W x L)	28.5" x 18.5" x 25" with air intake shroud and 28.5" x 22" x 25" with intake shroud and radiator
Maintenance (oil change)	1000 hours
Standard Warranty	Engine 2 years 4000 hours, 3 year generator warranty
Other Features	These APUs feature truck battery charging, low voltage auto start, weather watch auto start, programmable date/time auto start. Popular options include shore power connection, condenser winter cover, wall-mount ducts. A Diesel Particulate Filter (DPF), branded ClearSky is available.

Auxiliary Power Unit: Centramatic

PRODUCT INFORMATION	
System Type	Auxiliary Power Unit
Product Name(s)	Centramatic APU
Company Name	Centramatic
Company Address	5354 South I-35 West, Alvarado, TX 76009
Company Phone	800.527.8473
Product Website	www.centramatic.com

SYSTEM SUMMARY

The Centramatic APU is a self contained stand alone 6000 watt generator powered unit providing 14,000 Btu of cooling with heat provided from a 2500 watt heat strip. It has a connection to the engine block heater too. This is a split system with the air conditioning condenser assembly mounted on the back of the sleeper cab

Images used from the website of Centramatic

Cooling Btu	14,000 Btu
Heating Btu	not stated
Engine	Kubota 12.5 HP
Generator	6000 watt
Inverter	does not use an inverter
APU Alternator Size	60 Amp
Approximate Weight of APU (pounds)	400 pounds
Weight of Condenser Assembly (pounds)	100 pounds
Size of APU	Requires 30" of frame free space
Maintenance (oil change)	500 hours
Standard Warranty	not stated
Other Features	A 30 watt RV twist-lock Shore Power connection is available as an option. Also available is a battery condition monitoring system that automatically starts the APU to charge the batteries if needed. You can specify a bright finish diamond plate cover and a step is also available. Blower capacity is stated at 450 cfm.

Auxiliary Power Unit: Green APU

PRODUCT INFORMATION	
System Type	Auxiliary Power Unit
Product Name(s)	Green APU
Company Name	Green APU
Company Address	411 W. Factory Rd, Addison, IL 60101
Company Phone	877.751.0686
Company Website	www.greenapu.com

SYSTEM SUMMARY

The Green APU is a relatively light weight and self contained unit providing air conditioning to the sleeper integrated with the truck's existing ducting system. Hotel load AC power is provided though an optional inverter. This is an open system connected to the truck engine's cooling system to eliminate cold starts. Cab heating is optional.

Images is from the website of Green APU

Cooling Btu	18,000 Btu
Heating Btu	NA, varies based on truck HVAC system
Engine	Cat or Perkins 13.6 HP
Generator	Does not use an generator
Inverter	Yes, optional or customer supplied
APU Alternator Size	60 Amp
Approximate Weight of APU (pounds)	315 pounds
Weight of Condenser (pounds)	included above
Size of APU (H x W x L)	22" x 22" x 24"
Maintenance (oil change)	600 hours
Standard Warranty	Engine 2 years, 2000 hours
Other Features	The Green APU is a new entry to the market and was developed by a trucking company in the Chicago area. This unit can be installed in as little as four hours. The unit monitors battery condition and will restart to charge the batteries as needed.

Auxiliary Power Unit: Dynasys

PRODUCT INFORMATION	
System Type	Auxiliary Power Unit
Product Name(s)	Dynasys
Company Name	Tridako Energy
Company Address	2620 Brushy Creek Loop, Cedar Park, TX 78613
Company Phone	800.289.8282
Product Website	www.DynasysAPU.com

SYSTEM SUMMARY

The Dynasys APU is a full-featured closed system with 12,000 Btu of cooling and 12,000 Btu of heating capacity. It uses a 6000 watt generator. It is one of the most compact APUs needing only 20" of frame rail space. All connections are plug & play. The Dynasys APU was recently purchased by Tridako Energy from Hodyon.

Images from the website of Dynasys

Cooling Btu	12,000 Btu
Heating Btu	12,000 Btu, uses heat strips
Engine	Yanmar 12 HP
Generator	6000 watt, Markon brand, comes with 2 receptacles.
Inverter	does not use an inverter
APU Alternator Size	55 Amps
Approximate Weight of APU (pounds)	465 pounds
Weight of Condenser Assembly (pounds)	included above
Size of APU (H x W x L)	18" x 27" x 25"
Maintenance (oil change)	1000 hours
Standard Warranty	Engine 2 years, 4000 hours parts and service
Other Features	The Dynasys is a compact design requiring only 20" of frame rail space. A shore power kit is optional for fully electric HVAC. The AC compressor is beltless. A rugged stainless steel enclosure is used. The APU powers the truck engine's block heater and monitors truck batteries for low voltage start up if needed.

Auxiliary Power Unit: Parks Industries

PRODUCT INFORMATION	
System Type	Auxiliary Power Unit
Product Name(s)	HP2000
Company Name	Parks Industries, LLC
Company Address	1546 Crabtree School Rd., Marion, IL 62959
Company Phone	855.472.0002
Company Website	www.hp2000apu.com

SYSTEM SUMMARY

The HP2000 APU uses a quiet heat pump system providing 15,000 Btu of cooling, 18,000 Btu of Heating and 12 Volt DC power to be used with an inverter. The APU is available both as a stand alone (closed loop) or open loop system plumbed with the engine coolant system. The HP2000 is a self contained system with the condenser mounted on the APU so remote back-of-sleeper mounting is not necessary.

Image used from website of Parks Industries

Cooling Btu	15,000 Btu
Heating Btu	18,000 Btu
Engine	Koehler 15.5 HP
Generator	Does not use an generator
Inverter	Yes, optional or customer supplied
APU Alternator Size	65 Amps
Approximate Weight of APU (pounds)	345 pounds
Weight of Condenser Assembly (pounds)	included above
Size of APU (h x W x L)	21" x 21" x 23.5"
Maintenance (oil change)	500 hours
Standard Engine Warranty	4 years / 4000 hours
Other Features	A 110 volt AC inverter with shore power is available. The HP 2000 APU can be installed without drilling holes in the truck frame. A new controller, APU Commander, provides calendar and low temperature starts, oil change reminders, automatic climate controls and a USB phone charging port. Automatic shut down for high temperature or low oil is standard. Evaporative air flow is stated at 400 cfm.

Auxiliary Power Unit: Pony Pack

PRODUCT INFORMATION	
System Type	Auxiliary Power Unit
Product Name(s)	Pony Pack ®
Company Name	APUs by Rex, LLC
Company Address	2800 Vasar Drive NE, Suite B, Albuquerque, NM 87107
Company Phone	855.472.0002
Product Website	www.ponypack.com

SYSTEM SUMMARY

The Pony Pack APU, first introduced in 1984, is an open system that integrates with the truck's own HVAC and engine cooling systems thus requiring no holes to be cut in the cab or sleeper, nor do you lose storage space putting the AC evaporator in the sleeper. It uses an inverter (driver supplied) for hotel load electrical power to the cab.

Images used with the permission of Pony Pack

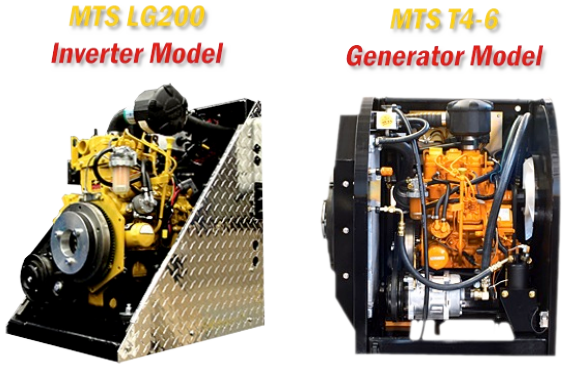
Cooling Btu	varies, based on truck's own HVAC system capabilities
Heating Btu	varies, based on truck's own HVAC system capabilities
Engine	Kubota 12 HP
Generator	Does not used a generator
Inverter	Yes
APU Alternator Size	110 Amp
Approximate Weight of APU (pounds)	350 pounds
Weight of Condenser Assembly (pounds)	Included above
Size of APU (H x W x L)	26" x 24" x 26"
Maintenance (oil change)	500 hours
Standard Warranty	2 years, 2000 hours
Other Features	The large 110 amp alternator and compressor are off-the-shelf Ford (Visteon) components. Pony Pack uses it's own compressor and their large condenser is rated at 45,000 Btus.

Auxiliary Power Unit: RigMaster Power

PRODUCT INFORMATION	
System Type	Auxiliary Power Unit
Product Name(s)	MTS T4-6 (generator model), MTS LG200 (inverter)
Company Name	RigMaster Power International Ltd.
Company Address	1320 Ellesmere Rd., #1, Toronto, ON, Canada M1P2X9
Company Phone	1-800-249-6222
Company Website	www.rigmasterpower.com

SYSTEM SUMMARY

RigMaster is unique in the APU market in that they offer both generator (MTS T4-6) and inverter (MTS LG200) models. Both models are closed loop systems not plumbed into the truck engine cooling system and are stand-alone units without the need to mount the condenser on the back of the sleeper.



Images from the website of RigMaster

Cooling Btu	20,000 Btu for MTS T4-6, 17,000 Btu for MTS LG200
Heating Btu	13,500 Btu
Engine	Cat or Perkins 11.5 HP
Generator	MTS T4-6 has a 6000 watt generator
Inverter	MTS LG200 uses an inverter
APU Alternator Size	MTS T4-6 has 60 Amp alternator, MTS LG200 has 170 Amp alternator
Approximate Weight of APU (pounds)	431 pounds for MTS T4-6, 327 pounds for MTS LG200
Weight of Condenser (pounds)	included above
Size of APU (H x W x L)	29" x 26.5" x 30" for MTS T4-6, 28.5" x 19.8" x 24.8" for MTS LG200
Maintenance (oil change)	1000 hours
Standard Warranty	Engine 2 years 2000 hours, longer coverage optional
Other Features	MTS T4-6 evaporative system is rated at 278 CFM. All RigMaster APUs power the truck engine block heater, and have multiple automatic start features including batteries auto-charge. Where frame side rail mounting is not available the MTS T4-V10 (generator) model can be mounted above the frame rails behind the sleeper in front of the fifth wheel. This model has the same engine, HVAC system, BTU capacities and alternator as the MTS T4-6 model. Rigmaster recently introduced their CAPP-18 generator model with a 3 cylinder 24.5 HP Cat diesel for applications needing hydraulic or air compressor functions.

Fuel-fired Auxiliary Power Unit: Thermo King

PRODUCT INFORMATION	
System Type	Fuel-fired Auxiliary Power Unit
Product Name(s)	TriPac EVOLUTION
Company Name	Thermo King
Company Address	314 W 90th St. Minneapolis, MN 55420
Company Phone	952.887.2200
Product Website	www.thermoking.com/tripac

SYSTEM SUMMARY

The TriPac EVOLUTION APU has a 2 cylinder 2013 tier IV final-compliant diesel engine with a 13,000 BTU air conditioning system including compressor, evaporator, controller and 7500 BTU Espar Airtronic fuel-fired air cab heater. It has a 65 amp alternator for battery charging and hotel loads are provided via an optional inverter. It is an open system providing truck and ape engine coolant heating from the APU. The air conditioning condenser assembly is remote mounted usually on the back of the sleeper cab.

Image used from the website of Thermo King

Cooling Capacity Btu	13,000 Btu
Heating Capacity Btu	7500 Btu (13,600 optional)
Engine	Thermo King 2 cylinder 7 HP
Generator	Does not use a generator
Inverter	Yes
APU Alternator Size	65 Amps, (120 Amps optional)
Approximate Weight of APU Power Unit (pounds)	345 pounds
Weight of Condenser & other components (pounds)	70 pounds
Size of APU (H x W x L)	26.9" x 25.8" x 23.6"
Maintenance (oil change)	2000 hours
Standard Warranty	1 year unlimited miles
Other Features	The new EVOLUTION model was introduced in July 2013 and all these models have the 2000 hour oil change interval. There is a new, configurable, easy-to-use in-cab controller with programmable temperature range which operates both the A/C cooling and fuel-fired heater. Options include Diesel Particulate Filter (DPF), Closed Loop Cooling, Appearance Packages, Inverter with 2 GFI receptacles, High Capacity Heater, High Output Alternator. Extended warranties are available. Thermo King has a large network of 225 dealers throughout North America.

Auxiliary Power Unit: Tridako PowerCube

PRODUCT INFORMATION	
System Type	Auxiliary Power Unit
Product Name(s)	PowerCube, PowerCube Slim
Company Name	Tridako Energy Systems, Inc.
Company Address	5610 Perkins Rd. PO Box 740 Alliance, NB 69301
Company Phone	866.526.7109
Company Website	www.powercubeapu.com

SYSTEM SUMMARY

First introduced in 2008, Tridako now offers two models of their PowerCube APU. The original PowerCube HC5128-IV is a generator model and the new PowerCube Slim HC 5119-IV uses an inverter for AC power. Both models are EPA tier IV compliant, provide maximum heating / cooling capacities and use 2-cylinder Caterpillar CO.5 diesel engines. Tridako Energy Systems is a Perrin Manufacturing company.

Images from the website of Tridako

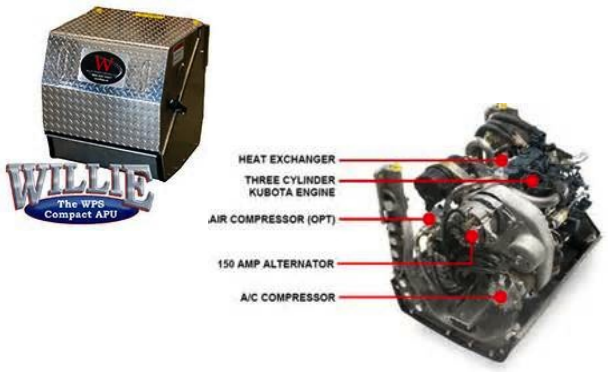
Cooling Btu	24,000 Btu for both models
Heating Btu	30,000 Btu for both models
Engine	Caterpillar CO.5 (Tier 4 lists at 8.8HP)
Generator	PowerCube HC 5128 uses a 6000 watt generator
Inverter	PowerCube Slim HC 5119 uses an inverter
APU Alternator Size	60 Amp denso
Approximate Weight of APU (pounds)	400 pounds PowerCube Slim HC 5119, 500 pounds PowerCube HC 5128
Weight of Evaporator (pounds)	47 pounds for both units
Size of APU (H x W x L)	19.5"x24"x25" PowerCube Slim HC 5119, 28"x24"x25" PowerCube HC 5128
Maintenance (oil change)	500 hours
Standard Warranty	2-year 2000 hour
Other Features	The in cab controller has three fan speeds and programmable auto-start features. The bunk unit has a built-in six-row evaporator , three-row heater and four vent/hose adaptors. The high-performance blower is rated at 600 cfm. PowerCube APUs can be built in custom colors to match cab body paint or fully finished in chrome. (we utilize power by the pound colors)

Auxiliary Power Unit: Willis Power

PRODUCT INFORMATION	
System Type	Auxiliary Power Unit
Product Name(s)	Willie
Company Name	Willis Power Systems, LLC
Company Address	2950 N. Martin, Springfield, MO 65803
Company Phone	800.825.4631
Company Website	www.willisapu.com

SYSTEM SUMMARY

The Willis APU is fully integrated into the truck HVAC and engine cooling systems. It requires no additional heater or A/C controls and no storage space is lost in the sleeper cab. This is an inverter APU system using a larger more powerful 3 cylinder engine (most other makes use 2 cylinder engines) for maximum HVAC Btu capacities. They offer an air compressor as an option.



Images from Willis Power System website

Cooling Btu	28,000 Btu (truck model dependent)
Heating Btu	22,000 Btu (truck model dependent)
Engine	Kubota 18.8 HP, 3 cylinder
Generator	does not use a generator
Inverter	110 Volt Tundra CM 2000 inverter, optional
APU Alternator Size	150 Amp
Approximate Weight of APU (pounds)	399 pounds (does not include hoses)
Weight of Condenser Assembly (pounds)	included above
Size of APU	NA
Maintenance (oil change)	500 hours
Standard Warranty	Engine 2 years / 2000 hours
Other Features	The Willis APU offers an additional alternator and an optional Meritor Wabco 12 CFM air compressor for inflating tires, powering pneumatic tools or as a back-up to the trucks' air system. For cold climates Espar fuel-fired coolant heaters and cold climate kits are available. A bright finish diamond plate APU enclosure is standard. Unit is shore power ready.

Battery Powered HVAC: Arctic Breeze

PRODUCT INFORMATION	
System Type	Battery HVAC
Product Name(s)	Arctic Breeze
Company Name	Hammond Air Conditioning Ltd.
Company Address	125 Samnah Crescent, Ingersoll, Ontario N5C 3J7
Company Phone	800-267-2665
Product Website	www.hammondac.com

SYSTEM SUMMARY

The battery-based Arctic Breeze HVAC system captures the energy produced by the truck's alternator and stores it in six AGM batteries. The system utilizes the truck's own starting batteries to operate. The system is quiet and has no emissions. It does not use transformers or inverters and operates on DC power.

Image used with the permission of Hammond Air Conditioning Ltd.

Battery Based HVAC Unit	
Cooling Btu	8,000 to 10,000 Btu
Cooling Hours	8- 10 hours
Heating Capacity (from company's fuel fired coolant heater)	12000 Btu
Inverter options	No
Alternator Capacity	200 - 240 amp
Battery Bank	6 Group 31 AGM deep cycle, uses trucks starting batteries
Approximate weight of unit (pounds)	200 lbs.
Weight of extra batteries (pounds)	200 lb.
Size of APU	Compressor/Condensor: 27" W x 15" D x 15" H Evaporator: 10" W x 10" D x 12" H
Maintenance	Clean the condensor and the evaporator periodically
Standard Warranty	2 year parts/1 year parts and labor
Other Features	A shore power connection is available as an option. A battery protection switch is included as standard.

Battery Powered HVAC: Bergstrom

PRODUCT INFORMATION	
System Type	Battery HVAC
Product Name(s)	NITE Plus, NITE Phoenix
Company Name	Bergstrom, Inc.
Company	2390 Blackhawk Road, Rockford, IL 61125
Company Phone	815-874-7821
Product Website	www.bergstrominc.com

SYSTEM SUMMARY

The NITE Plus and NITE Phoenix are battery-based no-idle systems that operate on four auxiliary Group 31 AGM/deep cycle batteries. The manufacturer requires an alternator with a minimum of 30 amps above the standard truck alternator. The units provide 8-10 cooling hours and have cooling capacities of 4,600 Btu/hr for the NITE Plus and 7,500 Btu/hr for the NITE Phoenix.

Image used with the permission of Bergstrom, Inc.

Nite Plus Specifications	
Cooling Btu	4600 Btu
Cooling Hours	8 - 10 Hours
Heating Capacity (from user's own system or fuel-fired heater)	Espar: 7,500 Btu/hr; Webasto: 7,000 Btu/hr
Inverter options	Tundra 1000Q, 1500W, 2000W
Alternator Capacity	30 amps larger than standard truck alternator
Battery Bank	4 Group 31 AGM deep cycle
Approximate weight of unit (pounds)	70 lbs.
Weight of extra batteries (pounds)	300 lbs.
Size of APU	22" high x 17" deep x 11" wide
Maintenance	Clean filter and keep battery connections clean
Standard Warranty	2 year limited on parts; 1 year limited on labor
Other Features	The unit features integrated driver controls. There is an optional shore power connection available. The unit installs under the bunk in 8-10 hours. Bergstrom offers multiple inverter and charger options.

Nite Phoenix Specifications	
Cooling Btu	7500 Btu
Cooling Hours	8 - 10 Hours
Heating Capacity (from user's own system or fuel-fired heater)	Espar: 7,500 Btu/hr; Webasto: 7,000 Btu/hr
Inverter options	Tundra 1000Q, 1500W, 2000W
Alternator Capacity	30 amps larger than standard truck alternator
Battery Bank	4 Group 31 AGM deep cycle
Approximate weight of unit (pounds)	70 lbs.
Weight of extra batteries (pounds)	300 lbs.
Size of APU	22" high x 17" deep x 11" wide
Maintenance	Clean filter and keep battery connections clean
Standard Warranty	2 year limited on parts; 1 year limited on labor
Other Features	A digital control system provides onboard service diagnostics, automatic temperature control and more. It is EPA SmartWay verified and CARB approved. It installs under the bunk in 8-10 hours. There are shore power and hotel load options and a fuel fired heater option. Bergstrom offers multiple inverter and charger options.

Battery Powered HVAC System: Crosspoint Solutions Group

PRODUCT INFORMATION	
System Type	Battery HVAC
Product Name(s)	ClimaCab 3.0
Company Name	Crosspoint Solutions Group
Company Address	551 W. 79th St., Indianapolis, IN 46268
Company Phone	877-826-9399
Product Website	www.crosspointsolutionsgroup.com

SYSTEM SUMMARY

A SmartWay certified battery-operated climate-control system. It features a power management system that allows it to deliver 11 or more hours of idle-free AC temperature control. The Power Management Module manages power while running but also manages battery charge and discharge cycles.

Image used with the permission of Crosspoint Solutions Group

Cooling Btu	7500 Btu
Cooling Hours	11 Plus Hours
Heating Capacity (from user's own system or fuel-fired heater)	Espar and Webasto 7,500 Btu
Inverter options	No
Alternator Capacity	200 amp minimum, 240 amp preferred
Battery Bank	4 Group 31 North Star AGM deep cycle with 4-year
Approximate weight of unit (pounds)	95 lbs.
Weight of extra batteries (pounds)	312 lbs.
Size of APU	Condenser: 31"W x 9.5"D x 15"H Evaporator: 20.6"W x 22.8"D x 8.9"H Power Management Module: 12"W x 16.6"D x 6"H Touch Screen: 6.2"W x 4.7"D x 1.5"H
Maintenance	Clean air filter in evaporator. Clean battery terminals and battery lugs. Check tightness of battery cables. Check cables for breaks and connections.
Standard Warranty	2 year limited parts and labor
Other Features	A load sharing system allows the air conditioner to borrow power from the truck batteries in addition to the auxiliary batteries until the point the voltage drops to a minimum that is required to start the truck. If a driver has drained the truck's batteries, the driver can go to the driver control panel and engage the Start Assist function and it will transfer power from the auxiliary batteries to the truck's starting batteries. This prevents the need for jump starting the vehicle if its batteries have been depleted. A Data Logger produces Compass Reports that allow the fleet to see air conditioning run time, battery voltage, alternator charging, heater usage and start assist usage. The Compass Report also provides a history of the operation of the unit to give the fleet profit information to determine return on investment.

Battery Powered HVAC System: Dometic

PRODUCT INFORMATION	
System Type	Battery HVAC
Product Name(s)	7,000, 10,000, 14,000
Company Name	Dometic
Company	PO Box 15299, Richmond, VA 23227
Company Phone	804-746-1313
Product Website	www.dometic.com

SYSTEM SUMMARY

The three battery-powered HVAC systems are designed by a company with roots in the air conditioning business. The auxiliary air conditioning system runs on 12-v power from an onboard bank of batteries using an inverter, which converts 12v DC battery output into 115v AC power. It can also run on 115v electricity from a shore power connection.

Image used with the permission of Dometic

Cooling Btu	7,000/10,000/14,000 Btus depending on unit selected
Cooling Hours	10 - 11 Hours
Heating Capacity (from user's own system or fuel-fired heater)	Optional on some models. Espar units with 7,500 Btu
Inverter options	2,00 watt modified sine wave
Alternator Capacity	320 amp high output
Battery Bank	4 Group 31 AGM deep cycle
Approximate weight of unit (pounds)	70 - 104 lbs. depending on model
Weight of extra batteries (pounds)	300 lbs.
Size of APU	Model 7,000: 11.94" H x 17.75" W x 24" D Model 10,000: 12.50" H x 20.87" W x 28.25" D Model 14,000: 12.75" H x 20.82" W x 32.81" D
Maintenance	Clean air filter and intake filter. Make sure the coils is clean and free of debris. Double check electrical connections
Standard Warranty	Not Available
Other Features	The units are EPA SmartWay certified and CARB compliant. They feature an optional shore power connection. A built-in low voltage cutoff circuit ensures sufficient battery power to restart engine. The company offers both self-contained and split systems.

Battery Powered HVAC: Idle Free

PRODUCT INFORMATION	
System Type	Battery HVAC
Product Name(s)	Idle Free (There is a battery based system & a reefer based
Company Name	Idle Free Systems
Company Address	7633 Ganser Way, Suite 102, Madison, WI 53719
Company Phone	608-237-6311
Product Website	www.idlefreesystems.com

SYSTEM SUMMARY

The battery-based Idle Free electric HVAC system captures the energy produced by the truck's alternator and stores it in an independent battery bank consisting of four AGM batteries. When the truck engine is off, the driver can switch on the system by pressing a remote switch located in the bunk. When the system is on, the pure sine wave inverter converts the 12v DC energy stored in the AGM battery bank into 120v AC electricity. The reefer-powered Idle Free system makes use of energy produced by the reefer unit when the truck isn't running. This is accomplished using a patented Reefer Link technology which "links" the reefer unit to system modules. When the system is on, a pure sine wave inverter converts 12 V DC energy produced by the reefer unit into 120v AC electricity.

Image used with the permission of Idle Free Systems

Battery Based HVAC Unit

Cooling Btu	10,000 Btu
Cooling Hours	10 Hours
Heating Capacity (from company's fuel fired coolant heater)	17000 Btus
Inverter options	1500 watt pure sine wave inverter
Alternator Capacity	200 amp
Battery Bank	4 Group 31 AGM deep cycle
Approximate weight of unit (pounds)	579 lbs. with 4 batteries
Weight of extra batteries (pounds)	NA
Size of APU	Frame rail unit: 18" W x 22" D x 26" H Power Module: 20.7" W x 11.2" D x 9.3" H Evaporator: 17" W x 13.2" D x 7" H
Maintenance	None, but manufacturer recommends checking tightness of connectors during normal PMs
Standard Warranty	2 year parts and labor
Other Features	The unit has a digital thermostat. A shore power connection is standard with the unit. The manufacturer says the system provides heating and air conditioning. The coolant heater that is part of the system allows the system to provide heat to both the bunk and the cab, and because the heat is run through the engine block the risk of the engine freezing overnight is eliminated.

Reefer-Based HVAC Unit

Cooling Btu	10,000 Btu
Cooling Hours	10 Hours
Heating Capacity (from the company's fuel-fired coolant heater)	17,000 Btu
Inverter options	1500 watt pure sine wave inverter
Alternator Capacity	65 amp for the reefer
Battery Bank	4 Group 31 AGM deep cycle
Approximate weight of unit (pounds)	579 lbs. with 4 batteries
Weight of extra batteries (pounds)	Not Applicable
Size of APU	Frame rail unit: 18" W x 22.5" D x 14" H Power Module: 22.2" W x 15.6" D x 10" H Evaporator: 17" W x 13.2" D x 7" H
Maintenance	Clean filter and keep battery connections clean
Standard Warranty	2 year parts and labor
Other Features	The unit has a digital thermostat. A shore power connection is standard with the unit. The manufacturer says the system provides heating and air conditioning. The coolant heater that is part of the system allows the system to provide heat to both the bunk and the cab, and because the heat is run through the engine block the risk of the engine freezing overnight is eliminated.

Battery Powered HVAC System: Thermo King TriPac e

PRODUCT INFORMATION	
System Type	Battery HVAC
Product Name(s)	TriPac e
Company Name	Thermo King
Company Address	314 W 90th St. Minneapolis, MN 55420
Company Phone	952.887.2200
Company Website	www.thermoking.com/tripac

SYSTEM SUMMARY

Thermo King's TriPac e (e stands for electric) system utilizes a frame rail mounted unit with a remote mounted condenser assembly. It features Smart Charger Module technology to provide individual charging and discharging for each battery to maintain balance between tractor and APU batteries during HVAC operation. The TriPac e uses 4 Thermo King NXT batteries. Sleeper heat is provided from an optional fuel-fired air heater which uses the same in-cab controller as the air conditioning system. The TriPac e uses the same controller and compartment packaging and requires the same frame space as their TriPac Evolution diesel powered APU.

Image used with the permission of Thermo King

Cooling Capacity Btu	7200 Btu
Cooling Hours	not stated
Heating Capacity (from user's own system or fuel-fired heater)	optional Espar fuel-fired air heater with 7,500 or 13600
Inverter options	1000 watt pure sine wave is an option
Alternator Capacity	200 amp minimum, higher is better
Battery Bank	4 Group 31 AGM deep cycle, NXT brand by Thermo King
Approximate weight of unit (pounds)	505 pounds includes weight of 4 batteries
Weight of extra batteries (pounds)	included above
Size of APU (H x W x L)	27" x 18" x 23"
Maintenance	Yearly inspection of HVAC system. Yearly clean out of fuel-fired heater
Standard Warranty	1 year unlimited hours/miles parts and labor, 2 years major components
Other Features	Thermo King uses one simple in-cab controller for both heating and cooling. Evaporator airflow is stated at 270 CFM. Options include shore power, inverter, 2 Espar AirTop heaters, brushed stainless steel condenser cover, flush mount kits, and additional NXT batteries for the tractor.

Thermal Storage System: Webasto BlueCool

PRODUCT INFORMATION	
System Type	Thermal Storage System
Product Name(s)	BlueCool
Company Name	Webasto Thermo and Comfort North America
Company Address	15083 North Rd, Fenton, MI 48430
Company Phone	800.860.7866
Company Website	www.bluecooltruck.com

SYSTEM SUMMARY

The BlueCool bunk cooling system produces cool air using thermal energy stored in a frozen graphite/water matrix (mounted on the truck frame rail). An electric refrigeration compressor freezes the water within the storage unit which is fully chilled in 4 to 6 hours of driving. A pump circulates the coolant through the storage core via an air handler (heat exchanger) with a blower inside the sleeper cab. The driver has controls for on/off, 4 fan speeds and temperature. This system requires no additional batteries and burns no fuel while the truck is parked. Heat is provided from an optional bunk heater.

Images from the Webasto website

Heating Output Capacity Btu/hour (optional bunk heater)	3,100-7,000 with Air Top 2000 ST, 5,100-13,300 with Air Top Evo 3900
Cooling Capacity Btu	17,000 Btu
Cooling Output	8-10 hours under most ambient conditions
Vehicle Alternator minimum	165 Amp
Power Consumption	3.5-10 Amps (coolant circulation pump)
Air Flow, maximum	150 Cfm at maximum setting
Dimensions (H x W x L)	26"x25.5"x33" for storage unite, 20"x24.5"x8" for in-cab air handler
Weight of unit	300 lbs for storage/refrigeration unit, 26 lbs for air handler
CARB Approved	Yes
SmartWay Verified	Yes
Maintenance	Periodically check coolant level and electrical connections
Standard Warranty	3 years
Other Features	No AC power for hotel loads is provided with this system unless the optional Shore Power (marketed as BlueCool Hybrid) connection with 2 in-cab AC outlets and truck battery charger is specified. Webasto's Air Top brand of bunk heaters provide the cab heat and are sold as an option. 26" of frame space is required for side rail mounting. Sleeper cab temperature control range is 68F to 78F degrees.

Fuel-Fired Air Heater: Airsnugger

PRODUCT INFORMATION	
System Type	Fuel-Fired Air Heater
Product Name(s)	Airsnugger SF2300 / SF4200
Company Name	Kingtec Group USA
Company Address	1165 E Acacia Court unit A Ontario, CA 91761
Company Phone	909.930.1734
Company Website	www.kingtecusa.com

SYSTEM SUMMARY

Kingtec sells 2 models of the Airsnugger fuel-fired air heater. The SF2300 is rated up to 7850 Btu/hour and the SF4200 at 14,334 Btu/hour. These heaters feature a compact design, safety protection, simple maintenance and a self diagnosis fault code system. An optional 7 day programmable timer with automatic temperature control will preheat the truck interior prior to engine start up.

Images from the Kingtec website

Heating Output Capacity Btu/hour	3072-7850 for Airsnugger SF2300, 3754-14,334 for Airsnugger SF4200
Fuel Consumption gallons per hour	0.02-0.07 for Airsnugger SF2300, 0.03-0.13 for Airsnugger SF4200
Rated Voltage	12 V
Power Consumption	9-34 watt for Airsnugger SF2300, 11-42 watt for Airsnugger SF4200
Air Flow, maximum, cubic feet per minute	20-49 cfm for Airsnugger SF2300, 32-86 cfm for Airsnugger SF4200
Dimensions (L x W x H)	12.5" x 4.7" x 4.9"
Weight of unit	5.9 pounds for Airsnugger SF2300. 9.5 pounds for Airsnugger SF4200
CARB Approved	NA
SmartWay Verified	NA
Maintenance	Annual system flush out and clean the lines and glow plug
Standard Warranty	2 years
Other Features	The in cab controller has four distinct settings. Kingtec also offers battery powered roof mount air conditioning systems and under the HYDEC brand, 2 models of fuel-fired coolant heaters. This product is available in Canada from Snugger Heater Systems www.snuggercanada.com 877.386.7320.

Fuel-Fired Air Heater: Espar

PRODUCT INFORMATION	
System Type	Fuel-Fired Air Heater
Product Name(s)	Airtronic D2/D4/D5
Company Name	Espar Heating Systems
Company Address	6009A Vipond Dr. Mississauga, ON, Canada L5T 2B2
Company Phone	800.387.4800
Company Website	www.espar.com

SYSTEM SUMMARY

Espar offers 3 models of their Airtronic fuel-fired bunk heaters with heating output capacity ranging from a 2900 - 18,800 Btu/hour. These air heaters cycle quietly through 4 heat levels to maintain a desired temperature range, without idling your truck engine and typically run 21-23 hours on one gallon of fuel. They have integrated control units,, self-diagnostics and can be serviced while still on the truck.

Images from the Espar website

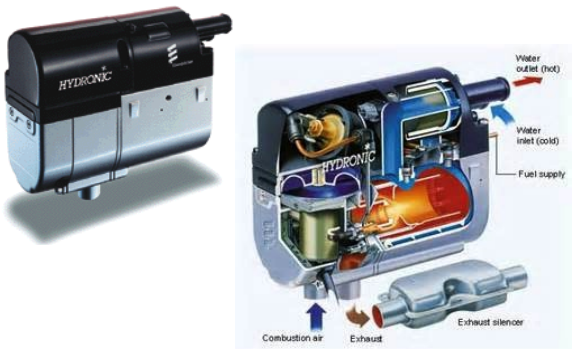
Heating Output Capacity Btu/hour	2900-7500 Airtronic D2, 3400-13,650 Airtronic D4, 4100-18,800 Airtronic D5
Fuel Consumption gallons per hour	0.02-0.07 Airtronic D2, 0.03-0.13 Airtronic D4, 0.04-0.17 Airtronic D5
Rated Voltage	12 V
Power Consumption	0.67-2.8 amps Airtronic D2, 0.6-3.3 amps Airtronic D4, 1.3-7.1 Airtronic D5
Air Flow, maximum, cubic feet per minute	NA
Dimensions	NA
Weight of unit	5.9 pounds Airtronic D2, 9.9 pounds Airtronic D4, 20 pounds Airtronic D5
CARB Approved	Yes
SmartWay Verified	Yes
Maintenance	Replace atomizer fuel screen annually
Standard Warranty	2 year / 2000 hour
Other Features	A thermostat in the sleeper area regulates the temperature through the 4 heat levels. There are a wide variety of driver control modules available, some with LCD screens. A CNG powered air heater was recently introduced. Espar also offers fuel-fired coolant heaters (Hydronic) and these are often sold in tandem with their fuel-fired air heaters.

Fuel-Fired Engine Coolant Heaters: Espar

PRODUCT INFORMATION	
System Type	Fuel-Fired Coolant Heater
Product Name(s)	Hydronic D4/5
Company Name	Espar Heater Systems
Company Address	6099A Vipond Drive, Mississauga, ON Canada L5T2B2
Company Phone	800.387.4800
Company Website	www.espar.com

SYSTEM SUMMARY

Espar offers 2 models of fuel-fired engine coolant heaters, the Hydronic D5 and Hydronic D4, with heating output capacity from 8200-17,500 Btu/hour. These engine pre-heaters operate as hot water furnaces utilizing the truck's own diesel fuel and batteries to produce heat using a water pump to heat and circulate engine coolant thus eliminating the need for electrical engine plug-ins and cold starts providing instant heat and defrost.



Images from the Espar website

Heating Output Capacity Btu/hour	8200-17,100 for Hydronic D5, 7100-17,555 for Hydronic D4
Fuel Consumption gallons per hour	0.08-0.16 for Hydronic D5, 0.07-0.17 For Hydronic D5
Power Consumption	1.9-4.2 amps for Hydronic D5, 1.9-3.3 amps for Hydronic D4
Dimensions	NA
Weight of unit	6.4 pounds for Hydronic D5, 5.3 pounds for Hydronic D4
CARB Approved	Yes
SmartWay Verified	Yes
Maintenance	NA
Standard Warranty	2 year / 2000 hour
Other Features	Multi Max controllers include diagnostic codes and are programmable and are available with our without LCD screen. A 7 day timer enabling one to preset the heater for advanced engine warming is available. Espar also offers fuel-fired air heaters (Airtronic) and these are often sold in tandem with their fuel-fired coolant heaters. Espar heaters' compact size enable simple installation without the need for electrical plug-ins.

Fuel-Fired Engine Coolant Heaters: Proheat

PRODUCT INFORMATION	
System Type	Fuel-Fired Air Heater
Product Name(s)	Proheat X45
Company Name	Marine Canada Acquisitions (DBA SeaStar Solutions)
Company Address	3831 No. 6 Road, Richmond, BC Canada V6V1P6
Company Phone	604.270.6899
Company Website	www.proheat.com

SYSTEM SUMMARY

The Proheat X45 is a powerful engine pre-heating solution with a 45,000 Btu/hour capacity and with the addition of an optional heat exchanger this unit can also heat the sleeper cab. The X45 uses a built-in electronic control panel displaying heater status as well as key functional and diagnostic codes.

Images from the Proheat website

Heating Output Capacity Btu/hour	45000 Btu
Fuel Consumption gallons per hour	0.1-0.32
Power Consumption	7.4 amps
Dimensions (L x W x H)	18.9"x11.2"x10.6", 20.5"x12.5"x11" with optional enclosure
Weight of unit	44 pounds, 55 pounds with optional enclosure
CARB Approved	NA
SmartWay Verified	NA
Maintenance	NA
Standard Warranty	2 years
Other Features	Options include a heat exchanger for sleeper cab heat, a rugged diamond plate coolant heater enclosure and a digital timer so drivers can program the start of the heater up to 7 days in advance. Proheat also offers 2 models of Proheat Air, their fuel-fired air heater for enhanced heating in the sleeper cab. Proheat products were previously sold by Teleflex Canada.

Fuel-Fired Air Heated: Webasto

PRODUCT INFORMATION	
System Type	Fuel-Fired Air Heater
Product Name(s)	Air Top 2000 ST, Air Top Evo 3900
Company Name	Webasto Thermo and Comfort North America
Company Address	15083 North Rd, Fenton, MI 48430
Company Phone	800.860.7866
Company Website	www.webasto.com

SYSTEM SUMMARY

The Webasto truck engine-off Air Top fuel-fired heaters are available in two models in a compact design with maximum heating output Btu/hour from 7000 to 13,300 Btu. They use as little as 1 gallon of fuel in a 22 hour period. Webasto uses their new SmarTemp Control in-cab precision bunk temperature management system which can sense the temperature inside the sleeper and has a digital display.

Images from the Webasto website

Heating Output Capacity Btu/hour	3,100-7,000 for Air Top 2000 ST, 5,100-13,300 for Air Top Evo 3900
Fuel Consumption gallons per hour	0.03-0.06 for Air Top 2000 ST, 0.05-0.13 for Air Top Evo 3900
Rated Voltage	12 V
Power Consumption	1.25-2.4 Amps for Air Top 2000 ST, 3-7.5 Amps for Air Top Evo 3900
Air Flow, maximum, cubic feet per minute	37 cfm for Air Top 2000, 81.8 cfm for Air Top Evo 3900
Dimensions (L x W x H)	12.3"x4.8"x4.8" for Air Top 2000 ST, 16.8"x5.8"x6.4" for Air Top Evo 3900
Weight of unit	5.7 pounds for Air Top 2000 ST, 13 pounds for Air Top Evo 3900
CARB Approved	Yes
SmartWay Verified	Yes
Maintenance	not stated
Standard Warranty	2 year / 2000 hour
Other Features	Air Top heaters have a self cleaning evaporative burner. The Air Top Evo 3900 has a boost mode and the maximum ratings shown above for heating output, fuel consumption, power consumption and air flow are rated at boost mode. Options include 7-day comfort timer, remote temperature sensor and multi-functional controller. Webasto also offers fuel-fired coolant heaters (Thermo Top) and these are often sold in tandem with their fuel-fired air heaters.

Fuel-Fired Engine Coolant Heaters: Webasto

PRODUCT INFORMATION	
System Type	Fuel-Fired Coolant Heater
Product Name(s)	Thermo Top C, Thermo 90 ST, DBW 2010
Company Name	Webasto Thermo & Comfort
Company Address	15083 North Road, Fenton, MI 48430
Company Phone	800.860.7866
Company Website	www.webasto.com

Webasto offers 3 models (Thermo Top C, Thermo 90 ST and DBW 2010) of fuel-fired coolant heaters ranging from 8600 to 45,000 Btu/hour heating capacity. The Thermo Top C provides engine pre-heat without idling, eliminating cold starts and the other models also offer some degree of cab heat and higher Btu levels of heating capacity. Units have on/off switches and various integral control units.

Images from the Webasto website

Heating Output Capacity Btu/hour	8600-17,200 Thermo Top C, 6100-31,000 Thermo 90 ST, 45,000 DBW 2010
Fuel Consumption gallons per hour	0.08-0.16 Thermo Top C, 0.06-0.29 Thermo 90 ST, 0.4 DBW 2010
Power Consumption	3.8 amps Thermo Top C, 3.0-7.5 amps Thermo 90 ST, not stated for DBW
Dimensions (LxWxH)	9.1"x4.1"x6.4" Thermo Top C, 15.8"x7.5"x14 Thermo 90 ST, 24"x10"x12" DBW 2010
Weight of unit	7 pounds Thermo Top C, 10.5 pounds (35 pounds w/enclosure) Thermo 90 ST, 65 pounds w/enclosure DBW 2010
CARB Approved	Yes
SmartWay Verified	Yes
Maintenance	not stated
Standard Warranty	2 year / 2000 hours
Other Features	The Thermo Top C model burns as little as 1 gallon of fuel in a 10 hour period. Options include a 7-day digital timer with alarm and the Thermo 90 ST is available with or without an enclosure. Some models have the capacity to also heat hydraulic fluid as well as warm diesel fuel to keep it from gelling. Webasto also offers fuel-fired air heaters (Air Top) and these are often sold with the coolant heaters for enhanced sleeper cab comfort.

Automatic Engine Start & Stop: Idle Smart

PRODUCT INFORMATION	
System Type	Automatic Engine Start & Stop
System Name	Idle Smart
Company Name	Idle Smart
Address	14109 Overbrook Road, Leawood, KS 66224
Phone	913-744-4353 (IDLE)
Product Website	www.idlesmart.com

SYSTEM SUMMARY

Idle Smart was reintroduced to the market in a second generation system in 2013. The new system is J1939 CAN based to reduce the amount of sensors and provide a higher level of integration. The new Idle Smart is compatible with all vehicles powered by J1939 equipped diesel engines.

Image used with the permission of Idle Smart

System Inputs:	2 Temperature Sensors (internal cab/sleeper and external ambient)
	3 Safety Switches (Park Brake, Transmission Neutral & Hood Closed)
	J1939 CAN Data Link for all other information
Display Unit:	4.5" x 3.5" x 2.0"
Operational Modes:	4 (can use all or any combination of the following 4)
Temperature Mode:	Engine is automatically started ad stopped to maintain desired cabin temperature.
Timer Mode:	Idle Smart runs the engine for a programmed amount of time when the cabin temperature is outside the comfort range. The Timer settings can be customized as well, which is particularly useful for areas with idling restrictions.
Battery Protection Mode:	As battery voltage drops below a user selectable level (11.2 to 12.7 VDC), the engine restarts and runs for a user selected amount of time.
Cold Weather Guard Mode:	When vehicle is not in operation and a driver is not in the vehicle, this feature will start the engine once the ambient temperature drops below the user's selected temperature and shut it back off after a selected time period.
System Weight	5 Pounds
Preventative Maintenance Requirements	None
MSRP	$2,500
Installation Time	Approximately 4 hours is typical
Warranty	Lifetime (plus money back satisfaction guarantee)
Equipment Transferability	Can be moved from used vehicle to a new vehicle

Automatic Engine Start & Stop: Optimized Idle

PRODUCT INFORMATION	
System Type	Automatic Engine Start & Stop
System Name	Optimized Idle
Company Name	Detroit (subsidiary of Daimler Trucks North America LLC)
Address	13400 W Outer Drive, Detroit, MI 48239
Phone	(313) 592-5000
Product Website	www.demanddetroit.com/performance/electronics.aspx

SYSTEM SUMMARY

Detroit's Optimized Idle system is fully integrated into the DDEC engine controls on the DD13, DD15 and DD16 diesel engines. Optimized Idle has been on the market since 1999. A new option combines Optimized Idle and ParkSmart to create unlimited ParkSmart run time.

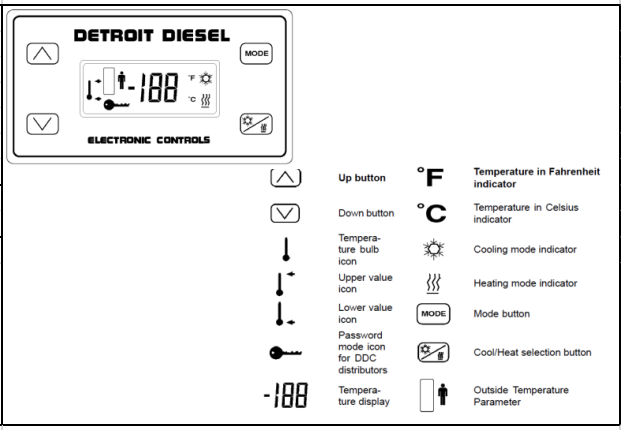


Image used with the permission of Detroit

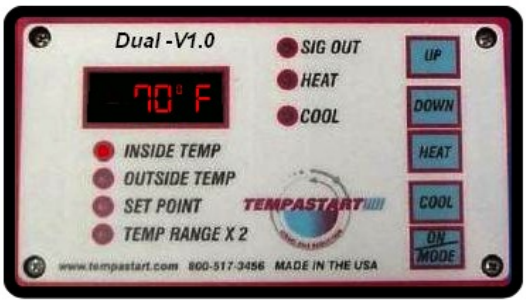
Additional System Inputs:	2 Temperature Sensors (internal cab/sleeper and external ambient)
	3 Safety Switches (Park Brake, Transmission Neutral & Hood Closed)
	J1939 CAN Data Link for all other information
Display Unit:	The display with data code 156-045 is located on the driver's side cabinet facing the bunk.
Operational Modes:	3 (can use all or any combination of the following 3)
Sleeper Temperature Mode:	Engine is automatically started and stopped to maintain desired cabin temperature. All set points are programmed via the factory or an electronic service tool.
Engine Temperature Mode:	Optimized Idle monitors the engine oil temperature and automatically starts the temperature drops below a programmable set point. The engine will continue to run until an programmable upper set point is obtained, at which time it will turn off again.
Battery Protection Mode:	Controls initiate engine operation to maintain the battery voltage levels above 12.2 Volts. Once this level has been obtained the engine turns off again.
Additional System Weight	2 pounds
Preventative Maintenance Requirements	None
MSRP	$771 List price for 156-045
Installation Time	Factory Installed
Warranty	Display & harnesses follow the standard electrical warranty

Automatic Engine Start & Stop: Temp A Start

PRODUCT INFORMATION	
System Type	Automatic Engine Start & Stop
System Name	Temp A Start
Company Name	EMI-Global
Address	5265 South Rio Grande Suite 205 Littleton CO 80120
Phone	303-904-9869
Product Website	www.emi-temp-a-start.com

SYSTEM SUMMARY

Temp-A-Start has been on the market for over 20 years and spawned other similar functioning products. The latest versions are J1939 data link based systems. There are two models available, Engine Mode Only, and Engine Mode featuring the Driver Comfort Control Center.



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The following description is for the Driver Comfort Control version.	
System Inputs:	3 Temperature Sensors (engine oil, internal cab/sleeper & external ambient)
	3 Safety Switches (Park Brake, Transmission Neutral & Hood Closed)
	J1939 CAN Data Link for all other information
System Outputs:	Under hood start alarm & 2 Color Dash Panel System Status LED
Driver Comfort Management System Controller:	3.5" W x 5.5" L x 1" D
Operational Modes:	3 (can use all or any combination of the following 3)
Sleeper Temperature Mode:	Engine is automatically started and stopped to maintain desired cabin temperature. All set points are programmed through the display module.
Engine Temperature Mode:	Temp A Start monitors the engine oil temperature and automatically starts the temperature drops below a programmable set point. The engine will continue to run until an programmable upper set point is obtained, at which time it will turn off again.
Battery Protection Mode:	The system will sense a 50% state of charge, go through its safety loop, start the engine and charge the system to OEM specifications
System Weight	12 Pounds
Preventative Maintenance Requirements	Periodic replacement of the Transmission Neutral Switch is recommended (every 200,000 miles)
MSRP	$2,500
Installation Time	Approximately 8 to 10 hours is typical
Warranty	One year

Automatic Engine Start & Stop: Vanner idleWATCH®II

PRODUCT INFORMATION	
System Type	Automatic Engine Start & Stop / Auxiliary Battery Energy Management
System Name	idleWATCH®II Energy Management System
Company Name	Vanner Inc.
Address	4282 Reynolds Drive, Hilliard OH 43026
Phone	1-800-AC-POWER
Product Website	www.vanner.com

SYSTEM SUMMARY

The Vanner idleWATCH®II system monitors the auxiliary batteries and restarts the vehicle's engine to charge the batteries as required. It was developed for use on work trucks and ambulances to provide engine-off power for tools and battery HVAC. It was introduced for sleeper tractors in March 2013. The sensors and patented model based battery management system allow it to protect and extend the life of the vehicle's batteries. The idleWATCH®II system can also be paired with a battery HVAC system or an inverter to provide extended availability of HVAC and/or AC power without draining the batteries through an HOS reset. The idleWATCH®II enables the auxiliary batteries to supply continuous and uninterrupted power, regardless of the duty cycle duration.

idle*WATCH*®II Module

Remote Panel

Battery Voltage & Temperature Sensor

Dual 80A / 600A Current Sensor

Image used with the permission of Vanner

System Inputs:	1 Temperature/Voltage Sensor (Batteries)
	1 Dual Current Sensor (Loads)
	Tachometer or Oil Pressure input (For engine start awareness)
Safety Interlocks: (3 required)	Park Brake Set, Transmission Neutral, Hood Closed, Ignition Key Removed, Service Brake Actuated
System Outputs:	Engine restarting alarm - 10 second advance notice
	J-1939 Communication - Broadcasts Auxiliary Battery State of Charge, State of Health, Time to Run, and other Diagnostics.
Driver Comfort Management System Controller:	Provided by the Battery APU Manufacturer
Operational Modes:	The driver engages the idleWATCH®II system and sets the HVAC to the desired temperature. All loads in the sleeper cab that are wired through the Vanner sensors are then constantly monitored throughout the night. When the auxiliary battery State of Charge reaches the programmed level (default is 50%) the idleWATCH®II I will auto-start the vehicle's engine. When the batteries recharge to the proper level (typically 45-60 minutes) the engine is turned off. All with no driver interaction.
Battery Protection Mode:	The system monitors the auxiliary battery State of Charge, State of Health, Current Draw and Internal Battery Temperature to compare against a known model of battery operation. The vehicle will be restarted as required to recharge the batteries. Once batteries are back to proper levels the engine is turned off again. One 45 -60 minute engine start for an 8-10 hour period of HVAC operation is typical.
System Weight	Vanner Components - > 5 lbs (Excluding auxiliary batteries and DC cables)
Preventative Maintenance Requirements	idleWATCH®II components do not require maintenance. Proper battery maintenance should be performed, per the battery manufacturers instructions.
MSRP	$1,588
Installation Time	Approximately 4-6 man hours is typical.
Warranty	2 Year Limited Warranty - Standard
	Extended Warranty Programs Available

AC Wiring: Phillips & Temro

PRODUCT INFORMATION	
System Type	AC Power Distribution
System Name	Cab Power/ Cab Power *Plus*
Company Name	Phillips & Temro Industries
Address	9700 West 74th Street, Eden Prairie, MN 55344
Phone	800-328-6108
Product Website	www.phillipsandtemro.com

SYSTEM SUMMARY

Phillips and Temro Industries understands the importance of 'driver retention' in todays trucking world. PTI designs and manufacturers the AC wiring systems utilized to distribute 120VAC power throughout the cab of Class 8 sleeper tractors. The system allows the driver the comfort and convenience of home while reducing idle and fuel costs for the fleet. Cab Power and Cab Power *Plus* are both available as OEM spec'd items or aftermarket retro-fit kits.

Image from Phillips & Temro website

Cab Power *Plus* Kit (Aftermarket kit for shore power & AC power with inverter)	Kit includes exterior and interior wiring, battery cables, fuse holder and fuse, interior Y-splice AC wiring, duplex outlets, fasteners, weatherproof receptacle, 1800W Inverter, required hardware and install instructions.
	#8500652
Weight	11 pounds
Cab Power Kit (Aftermarket kit for shore power without an inverter)	Includes exterior and interior wiring, load center, weatherproof receptacle, duplex outlets, fasteners, and instructions.
	#8500633
Weight	5 pounds
Warranty	1 Year (aftermarket kits)

Inverters: Tundra

PRODUCT INFORMATION	
System Type	Inverters
System Name	E Series, HD Series & HTST Series
Company Name	Tundra
Address	2041-A Léonard-de-Vinci, Ste-Julie J3E 1Z2, Québec, Canada
Phone	877-964-2582
Product Website	www.tundrainternational.com

SYSTEM SUMMARY

Tundra International has been producing inverters since 1995. Both Sine wave and Modified sine wave versions are available in a variety of power levels. Battery chargers are available as a separate option. Tundra's inverters are capable of operating at the rated continuous power levels 24 hours per day and 7 per week.

Low Battery Voltage Alarm Level	11.5 VDC
Low Battery Voltage Shutdown Level	11 VDC (custom settings are available)
Protection Systems	Battery over-voltage, Under-voltage, Over-temperature shutdown, Automatic overload, and Reverse polarity
Sine Wave or Modified Sine Wave	Both are available
Modified Sine Wave Continuous Power Level in Watts (Peak Level)	1000w (2000w) 1500w (3000w) 2000w (4000w) 1200w (2400w) 1800w (3600w) 2500w (5000w)
Modified Sine Wave AC Output Efficiency	92%
Sine Wave Continuous Power Level in Watts (Peak Level)	300w (600w) 600w (1200w) 1200w (2400w)
Sine Wave AC Output Efficiency	98% +
Battery Charger Feature	Fully automatic battery charger/converters are available separately at 15a, 45a, 70a and 80a levels
Installation Kits	Available with options for different truck OEM's
Warranty	1 year

Inverters: Vanner

PRODUCT INFORMATION	
System Type	Inverters
System Names	Bravo, Powercraft, VLT, & RoadStar
Company Name	Vanner Inc.
Address	4282 Reynolds Drive, Hilliard, OH 43026
Phone	1-800-AC-POWER
Product Website	www.vanner.com

SYSTEM SUMMARY

Vanner offers a variety of industrial and commercial vehicle grade inverters in several categories. Both Sine Wave and Quasi Sine wave style inverters are offered. Battery Chargers are also available integrated into some of the inverters or as a standalone component.

1200W Inverter / Charger with Phillips & Temro Cab Power(TM) Connection

300W to 3000W Sine wave Inverter

Images used with the permission of Vanner

Low Battery Voltage Shutdown Level	10.5 - 11.0 VDC (Depending on model)
Protection Systems	Battery over-voltage, Under-voltage, Over-temperature shutdown, Automatic overload, Short-circuit protection and some models have Ground-fault protection
Sine Wave or Modified Sine Wave	Both are available
Modified Sine Wave Continuous Power Level in Watts (Surge Amps) **Bravo** Inverter Charger Product Line	1050w (17.5 Amp)
Modified Sine Wave Continuous Power Level in Watts (Surge Amps) **RoadStar / ProStar** Inverter Charger Product Line	1200w (21.6 Amp) / 2000w Extended Power (for +/- 20 minutes) OEM for Navistar ProStar model tractors
Modified Sine Wave Continuous Power Level in Watts (Surge Amps) **PowerCraft** Inverter Product Line	300w (5.0 Amp) 500w (8.0 Amp) 1000w (16.0 Amp) 1500w (25.0 Amp) 2500w (40.0 Amp)
Battery Chargers DC Input Volts (DC Output Amps) **PowerCraft** Battery Charger Product Line	12 Volts DC (12 Amps)
Sine Wave Continuous Power Level in Watts (Peak Level) **TruWave VLT** Inverter Charger Product Line	300w (3.3 Amp) 600w (6.6 Amp) 1000w (16.0 Amp) 1500w (16.7 Amp) 2000w (33.3 Amp) 3000w (50.0 Amp)
Installation Kits	Customized installation kits available.
Remote Display	Remotes and Single Wire Remote Controls (Depending on model)
Warranty	2 Years from DOM Extended Warranty Programs Available

Inverters: Xantrex

PRODUCT INFORMATION	
System Type	Inverters
System Name	Freedom & PROsine
Company Name	Xantrex
Address	541 Roske Drive Suite A, Elkhart, Indiana USA 46516
Phone	800 446 6180
Product Website	www.xantrex.com

SYSTEM SUMMARY

Xantrex, a division of Schneider Electric, has produced a wide range of inverters and chargers for 30 years. Both Sine wave and Modified sine wave versions are available in a variety of power levels. Their inverters are certified by ETL to UL458 and CSA Standard C22.2 No. 107.1 for mobile vehicle applications.

Low Battery Voltage Shutdown Level	10.5 VDC
Protection Systems	Battery over-voltage, Under-voltage, Over-temperature shutdown, Automatic overload, Short-circuit protection and some models have Ground-fault protection
Sine Wave or Modified Sine Wave	Both are available
Modified Sine Wave Continuous Power Level in Watts (Peak Level)	1000w (2000w) 1800w (3600w) 2000w (6000w) 2500w (7500w)
Modified Sine Wave AC Output Efficiency	87%
Sine Wave Continuous Power Level in Watts (Peak Level)	2000w (3000w) 2000w (4500w) 3000w (6000w)
Sine Wave AC Output Efficiency	89%
Battery Charger Feature	Available in both integrated and separate packages and at different amperage levels from 20A to 150A
Installation Kits	
Remote Display	Option available for some models
Warranty	2 years

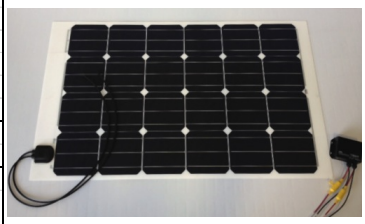
Confidence Report on Idle-Reduction Solutions

Solar Energy Capture: eNow

PRODUCT INFORMATION	
System Type	Solar Energy Capture
System Name	e-Charge System for In Cab HVAC
Company Name	eNow
Address	133 Hallene Road, Warwick, RI 02886
Phone Number	866-571-0175
Product Website	www.enowenergy.com

SYSTEM SUMMARY

The eNow solar panels are a recent entry into the sleeper tractor idle reduction market. The system has been developed to capture solar energy to recharge batteries. It is now moving from trailer lift gate systems into the battery HVAC applications.



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Surface Area of Solar Panels (per 300W panel), sq ft	22
Thickness of Solar Panels, inch	0.19
Solar Panel Type	Laminated, semi-flexible, mono crystalline cells with top or bottom mounted junction box and adhesive backed panel
Types of Batteries Charged	Auxiliary batteries and truck batteries, including flooded lead acid, absorbed glass mat (AGM), gel, lithium ion (Li-ion)
Charging Sources	Solar PV, truck's alternator, shore power
Charge Control Algorithm	Maximum Power Point Tracking (MPPT)
Operating Temperature	122 to -40 degrees F (50 to -40 degrees C)[1]
PV Panel Testing	International Electrotechnical Commission (IEC)
MSRP	Please call to request a quote
Standard Warranty	5 years[2]
Warranty Options	First Year Savings Guarantee[3]
Maximum Power Output/PV Charging Power (1000 W/m^2 solar irradiance and 25°C)	
Tractor roof-mounted 1-panel and 2-panel systems	300 W and 600 W
Trailer roof-mounted 3-panel and 4-panel systems	900 W and 1200 W
Estimated Time to Recharge 420 A-Hr Battery HVAC System based on Kansas City in July (HVAC batteries drained with no power from engine's alternator), hours[4]	
300 W system	35.4
600 W system	17.7
900 W system	11.8
1200 W system	8.8
Estimated Fuel Savings Compared to 10 Hours of Idling based on Kansas City in July (HVAC batteries drained), gal/day[4]	
300 W system	9.5
600 W system	9.8
900 W system	10.0
1200 W system	10.3
Total System Weight with adhesive (approximate), lbs	
300 W system	23
600 W system	45
900 W system	68
1200 W system	90
Available Options	
High-Power HVAC Kit	24V operation for high-power output HVAC
Jump-Start Kit	Emergency jump-start of truck battery from auxiliary batteries
Battery Gage Kit	Battery monitoring system that wirelessly sends battery state of charge (SOC) information
Auxiliary 12V Outlet	Power outlet for auxiliary 12-volt device operation
Auxiliary 120V Outlet	Power outlet and inverter for 120-volt device operation (e.g., TV, stereo, DVD, refrigerator, microwave)

[1] Operating temperature can exceed 122 degrees F, but the charge controller will be derated.

[2] If the minimum peak panel power falls below 80% during the first 5 years from date of shipment of the panel from eNow, and its determined that the power loss has occurred solely from defects in materials or workmanship, then the panel will be either replaced, repaired, or reimbursed at a reduced rate of 10% annual depreciation form the original panel value. The charge controller and solar panel has a limited warrantee to be free from defects in materials (2 years) and workmanship (1 year) from the date of shipment from eNow Inc.

[3] eNow will work with a truck owner to estimate first year savings based on the vehicle's operating profile. If the truck is operated according to the profile and estimated savings aren't met, eNow will make up the difference.

[4] Based on PVWatts for conditions representative of Kansas City in July with 0 degree PV array tilt (i.e., flat roof surface) and 0.862 panel derate factor. Assumes auxiliary HVAC battery capacity is 4 x 105 A-Hr, usable capacity is 70%, average charge voltage is 12.8V, charge controller efficiency is 92%, and roundtrip (i.e., charge controller plus battery charge and discharge) energy storage efficiency is 86%. Fuel Savings calculations include over-the-road fuel savings when excess PV is available. Assumes idling the truck's engine to power auxiliary loads consumes 1 gal diesel fuel/hour; over-the-road engine and alternator efficiencies are 33% (LHV) and 50%, respectively; and diesel fuel energy density is 37.64 kWh/gal (LHV). Please contact eNow for results based on other locations and usage rates.

Truck Stop Electrification: Shorepower

PRODUCT INFORMATION	
System Type	Truck Stop Electrification
Product Name(s)	Shorepower
Company Name	Shorepower Technologies
Company Address	2351 NW York Street, Portland, OR 97210
Company Phone	503-892-7345
Product Website	www.shorepower.com

SYSTEM SUMMARY

The system consists of a power pedestal which is used to power convenience items and hotel loads inside a truck and a payment and control system. Pedestals can be found at truck stops and allow drivers to turn off their engines and plug into all-weather electrical and communication outlets during mandatory rest periods. To use Shorepower, a trucker needs an appliance or electrical device that uses 110v alternating current and a heavy-duty 12-gauge extension cord to plug into the Shorepower stanchion and into the electrical device in the cab. The electrical device can be a heater, air conditioning unit, microwave, coffee maker, TV, refrigerator, etc.

Image used with the permission of Shorepower Technologies

Number of states available in	30
Number of truck stops	62
Number of electrified spaces (connection points)	1,800
Available services	Electricity
Optional services	Cable TV, Wi-Fi in some locations
Cost to trucker	$1/hour for cab power/hotel loads; $2 for reefer power
Equipment needed	12 gauge or heavier extension cord and an electrical appliance
Optional equipment	Wiring kit or wiring harness in cab
Window Unit needed	No
OEM Availability	All OEMs offer an option for an onboard shore power electrification module
Other Features	Many APU manufacturers are wiring their systems to be shore power compatible. Fleet accounts are available. Loyalty programs are available where drivers can earn points for using the service and then use the points toward free power or prizes.

Truck Stop Electrification: Craufurd Manufacturing / Aire Dock

PRODUCT INFORMATION	
System Type	Truck stop electrification
Product Name(s)	Aire Dock
Company Name	Craufurd Manufacturing LLC
Company	6557 Gulf Gate Place, Suite 169, Sarasota, FL 34238
Company Phone	866-771-7446
Product Website	www.airedock.com

SYSTEM SUMMARY

The Aire Dock system delivers electric power, fresh air, thermostatically-controlled heating and air conditioning and Internet to the truck cab via a hose attached to a window adapter plate.

Image used with the permission of Craufurd Mfg.

Number of states available in	7
Number of truck stops	13
Number of electrified spaces (connection points)	Not Available
Available services	Electricity, heating, air conditioning, Internet
Optional services	None
Cost to trucker	$1 per hour
Equipment needed	A window unit that weighs less than 10 lbs.
Optional equipment	None needed
Window Unit needed	Yes.
Other Features	Truckers can pay via credit or debit card at a secure 24/7 pay at the dock service. A screen allows the trucker to select the number of hours he wants to plug in for and a receipt is issued. The unit comes on after about a minute and the trucker places the window bracket in the truck window and has access to all the services. 22,000 Btu of heating and 14,500 Btu of cooling are available using this system. Two GFCI all weather capped dual power plugs deliver 115v 20 amp electric service.

Truck Stop Electrification: Enviro Dock

PRODUCT INFORMATION	
System Type	Truck stop electrification
Product Name(s)	E-Dock stationary, E-Dock portable, Powr Dock
Company Name	Enviro Dock Inc.
Company Address	59 Kenisco Road, Thornwood, NY 10594 and 319 Business Lane, Suite 1000, Ashland, VA 23005
Company Phone	800-886-6757
Product Website	www.envirodock.com

SYSTEM SUMMARY

Enviro Dock offers three stand-alone heating, air conditioning and shore power systems to the transportation industry. The systems can be installed at truck stops, distribution centers and rest areas to allow drivers to comply with anti-idling requirements.

E-Dock stationary is a steel-enclosed powder coated unit which delivers electronically filtered temperate controlled air through a thermally insulated flexible hose through a Window Air Delivery Unit control panel. The WADU features 120v/15 amp power for in-cab appliances and simple controls for temperature and fan speed. The system also has a duplex 110v/15 amp power supply located on the unit itself. E-Dock portable is constructed with a reinforced steel cabinet set on four 8" casters for maneuverability. A steel pole is mounted into the unit that allows the driver to install the WADU into the window. Through the WADU the driver has one 120v/15 amp power supply and individual temperature controls. There is also a duplex 110v/15 amp power supply on the unit itself. PowrDock allows drivers with shore power capable trucks and electric APUs to plug into a stationary power pedestal mounted to a concrete pad. It is equipped with one duplex 20 amp power

Image used with the permission of Enviro Dock

Number of states available in	New York
Number of truck stops	Two
Number of electrified spaces (connection points)	11
Available services	Electricity, heating, air conditioning
Optional services	Internet
Cost to trucker	$1 per hour
Equipment needed	A Window Air Delivery Unit. One primary component with five attachments. Each attachment fits several types of windows. Two 6" ducts are provided for supply and return air.
Optional equipment	NA
Window Unit needed	Yes.
Other Features	The system is said to hear or cool the cab in a matter of minutes. There are easy to use controls for temperature control and air delivery. Payment can either be at a central payment kiosk, pay at the unit or pay inside at the cashier depending on the truck stop.

Truck Stop Electrification: Convoy Solutions/Idle Air

PRODUCT INFORMATION	
System Type	Truck stop electrification
Product Name(s)	Idle Air
Company Name	Convoy Solutions LLC
Company	2567 Prime Way, Suite 101, Knoxville, TN 37918
Company Phone	865-232-1700
Product Website	www.idleair.com

SYSTEM SUMMARY

Idle Air's Advanced Travel Center Electrification (ATE) service provides heating and air conditioning, satellite television, color touch screen control modules with basic Internet access, standard electricity inside and outside the cab. The company also offers Convoy TV which includes power, TV and Internet for drivers who have an HVAC system built into their trucks or who do not need HVAC services. Services are delivered either via pedestals or overhead trusses.

Image used with the permission of Convoy Solutions

Number of states available in	14
Number of truck stops	30
Number of electrified spaces (connection points)	Not Available
Available services	Heating, air conditioning, electricity, television, Internet
Optional services	NA
Cost to trucker	$2 per hour
Equipment needed	A 1.5 lb. plastic window adapter.
Optional equipment	None
Window Unit needed	Yes
Other Features	Idle Air offers loyalty programs for regular users of its systems. Drivers are also able to use fuel cards. An attendant is on duty at each Idle Air location and performs the function of sales, maintenance and parking lot management.

Auxiliary Batteries: AspectSolar

PRODUCT INFORMATION	
System Type	Auxiliary Battery for CPAP
System Name	EnergyBar 250A
Company Name	Aspect Technologies Inc. d/b/a AspectSolar
Address	1724 Majestic Drive, Suite 103, Lafayette, CO 80026
Phone Number	877-717-7778
Product Website	www.aspectsolar.com/Resources-@-CPAP_Power.aspx

SYSTEM SUMMARY

The EnergyBar 250 was designed and developed to provide portable power for applications where power is not readily accessible. It utilizes a Lithium Iron Phosphate (LiFePO4) battery for long-life and thousands of cycles. When plugged into a 12 Volt DC power plug in the truck, it will start recharging once the battery has been sufficiently depleted by the CPAP machine or other devices. Also comes with a weather-resistant neoprene carrying case for sleeper use as well as outdoor power needs such as camping. It can charge anything with the universal AC output up to a maximum of 100-Watts.

Image used with the permission of AspectSolar

Battery Capacity	12.8V 20AH, 256Wh LiFePO4 (NOT Lithium Polymer)
USB (4 Sockets)	5V 2A Max
12V DC Socket	12V ± 20% 10A
AC Universal (110 VAC Wall Outlet type)	100 Watt Modified Sine Wave
DC Charging	15V 4A (For wall charging and daisy chaining)
Charging Time (110 VAC)	5 Hours
Charging Time (12 VDC Input)	6 Hours
Charging Time (Solar Panel)	6 Hours in full sun, about 12 hours under windshield tinting
Operating Time for non-humidified CPAP machine (10 Watts)	24 Hours
Operating Time for humidified CPAP machine (40 Watts)	6 Hours
Daisy Chaining (operating 2 units linked together)	Doubles the run times above
Dimensions	2"H x 16.5"L x 6.3"D
Total Weight	8 pounds
MSRP (Battery with 110V wall charger, neoprene carry case and D2MP battery power protector)	$399.99 (Volume discounts are available)
Standard Warranty	1 year parts and labor
Warranty Options	1 or 3 year and/or ADH (Accidental Damage and Handling)
Available Options	EP-55 Solar Panel, EC-250 Protective Carrying Case

Ultracapacitor Starting System: Maxwell ESM

PRODUCT INFORMATION	
System Type	Auxiliary Truck Engine Starting Battery
Product Name(s)	Engine Start Module (ESM) from Maxwell
Company Name	Maxwell Technologies
Company Address	3888 Calle Fortunada Ave. San Diego, CA 92123
Company Phone	877.511.4324 or 858.503.3300
Company Website	www.maxwell.com/esm

SYSTEM SUMMARY

The Maxwell Engine Start Module (ESM) works in tandem with the truck engine starting batteries providing a reliable burst of power at ignition. This eliminates costs associated with dead or discharged batteries and reduces the need for idling to maintain battery voltage. The ESM contains Ultracapacitor cells in a case the size of the truck battery providing 1800 CCA for reliable starts from -40 F to +149 F. The systems weighs just 21 pounds, is rugged and requires little maintenance.

Images from the website of Maxwell Technologies

Operating Range	- 40 degrees F to +149 degrees F
Voltage	12V starter, nominal. 15V module voltage. Maximum module voltage 16V
Peak Current	1500A (at -40 degrees F) 1700A (at 77 degrees F)
Cranking Power	32kW
Recharge Time	15 minutes (recharge from battery at 10 amps)
Battery Type	BCI Group 31
Approximate Weight	21 pounds
Size of system	13" L x 6 13/16" W x 9 7/16" H
Maintenance	Only need to clean terminals and connections during normal battery Preventative Maintenance.
Standard Warranty	4 year
Other Features	System is available from all truck OEM dealers and is easy to install, replacing one Group 31 battery. Recharges in just 15 minutes or less. Easily cranks all diesel engines up to 16 liters.

Hotels: Hotels4Truckers.com

PRODUCT INFORMATION	
System Type	Hotels
System Name	Hotels4Truckers
Company Name	Hotels4Truckers
Phone	1-855-GET-PARKED (855-438-7275)
Product Website	www.hotels4truckers.com

SYSTEM SUMMARY

Hotels4Truckers.com is a membership supported nationwide data base of hotels that are available for commercial trucks and truck drivers. It offers the opportunity for improved quality of sleep (away from noises, HVAC, power for CPAP...), TV, a bathroom with a shower as well as possible workout room, coffee and breakfast amenities. This system went live in January 2011.

Image used with the permission of Hotels4Truckers

Hotel Chains Included In Data Base	Motel 6
	Red Roof Inn
	Wyndham Group (Wyndham, Wingate, Hawthorn, Ramada, Microtel, Days Inn, Howard Johnson, Super 8, Baymont Travelodge, Knights Inn)
	Choice Group (Comfort Inn, Quality Inn, Sleep Inn, Clarion, Cambria, MainStay, Suburban, EconoLodge, Roadway Inn, Ascend…)
Discount off standard room rates	15-20% (typically a savings of $13 per night)
Truck Parking	Verified to have parking for a tractors with a 53 foot trailers
	Some motels have electrical outlets for block heaters in locations convenient for trucks (such as on light poles) but that is not common yet
Membership fee	$9.95 per year
Access	Now part of the Transcore DAT system that has 200,000 users (including MyDAT smart phone apps)

Dormitories: Boyle Construction Management

PRODUCT INFORMATION	
System Type	Dormitories
System Name	Custom Built Facility
Company Name	Boyle Construction Management Inc.
Address	220 N Davidson Street, Indianapolis, IN 46202
Phone	(317) 269-0543
Product Website	www.bcmionline.com

SYSTEM SUMMARY

A user specified facility can serve a multitude of purposes for a truck fleet. It can offer a dormitory and restroom facilities to avoid hotel charges. It can provide driver and service training classrooms as well as business conference rooms. Amenities such as recreational facilities, laundry rooms,

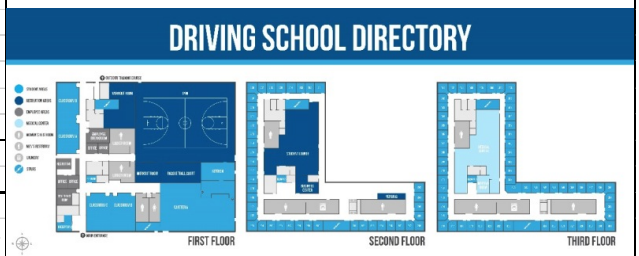

Image used with the permission of Boyle Construction Management

Business Facility Options	Driver training classrooms and simulators, Service and Parts training classrooms, general conference rooms and business offices
Housing	Dormitory rooms and rest rooms
Food	Cafeteria, commercial kitchen, dining room and vending machines
Relaxation Areas	Television, lounge, business center with computers and Wi-Fi, laundry machines
Workout Facilities	Weight room, exercise machines, basketball/volleyball court, racquetball court & locker rooms
Healthcare	Medical offices, physical therapy facilities and exam rooms
Truck Parking	Parking lot with 120 Volt AC outlets for block heaters and shorepower