White Paper

Reducing Idle Time & Fuel Costs

Lithium Powered Solutions for Commercial Fleets

presented by

Dragonfly Energy Corporation



PACCAR, Inc.



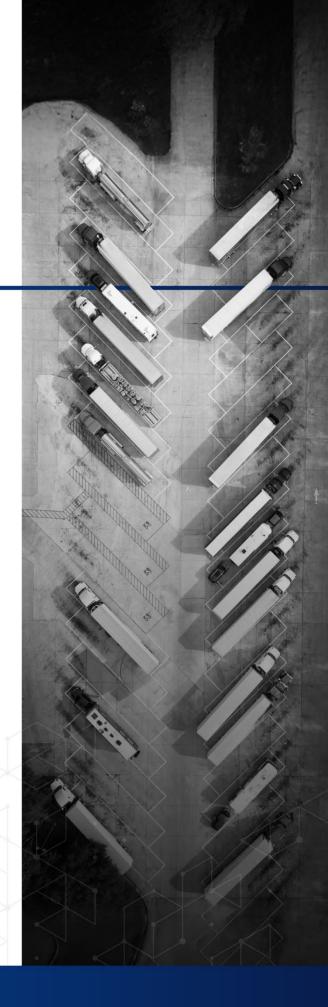


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Executive Summary

Heavy-duty fleets face growing pressure to reduce fuel consumption, lower maintenance costs, and prepare for future emissions regulations, all while maintaining driver comfort and operational reliability. Engine idling, long recognized as a major contributor to unnecessary fuel burn and engine wear, remains one of the largest controllable costs in fleet operations.

This whitepaper evaluates lithium-powered anti-idling solutions, focusing on the performance, reliability, and total cost of ownership benefits of Dragonfly Energy's Battle Born® lithium iron phosphate (LiFePO₄) systems compared to diesel-powered and AGM-based alternatives.

LiFePO₄-powered systems offer three critical advantages:

- **Extended runtime and engine-off operation**: Full depth of discharge provides increased usable capacity, keeping engines off longer and reliably powering all hotel loads through mandated rest periods.
- Operational efficiency and maintenance savings: By reducing idle hours, fleets improve effective fuel economy and
 extend oil change intervals. PACCAR engine guidance shows that higher idle time drives shorter service intervals. Lithiumpowered APUs help fleets shift into longer maintenance cycles, cutting costs and reducing unplanned downtime.
- **Driver safety and comfort**: Stable, uninterrupted power eliminates disruptive engine restarts, improving rest quality, safety, and driver satisfaction.

These solutions are regulation agnostic. Whether under current EPA Phase 2 rules, upcoming GHG Phase 3 standards, or evolving state-level policies, lithium-powered APUs reduce fuel burn and emissions while improving bottom-line performance. Fleets achieve measurable savings today while positioning for tomorrow's compliance environment without relying on future charging infrastructure or full vehicle electrification.

With a proven track record across more than 400,000 deployed batteries, a 10-year warranty, and U.S.-based manufacturing, Dragonfly Energy's Battle Born systems provide a practical, cost-effective path to idle reduction, operational efficiency, and long-term fleet resilience.

Presented by





Dragonfly Energy Holdings Corp. (Nasdaq: DFLI) is a leading lithium battery technology company specializing in battery pack assembly, system integration, and advanced energy storage solutions. Through its Battle Born® brand, the company delivers proven, reliable LiFePO₄ power systems trusted by top RV manufacturers and now advancing electrification in heavy-duty trucking.



PACCAR is a global technology leader in the design, manufacture and customer support of premium light-, medium- and heavy-duty trucks under the Kenworth, Peterbilt and DAF nameplates. PACCAR also designs and manufactures advanced diesel engines, provides financial services, information technology, and distributes truck parts related to its principal business.







🔀 Challenge of Idling & The Shift to Advanced APU Solutions

Evolving Emissions Standards

For decades, the trucking industry has reduced harmful emissions, with NOx down more than 99% since 1994 (Figure 2.1). To further curb greenhouse gases, the EPA introduced a series of fuel-efficiency and CO₂ regulations for heavy-duty trucks, known as GHG Phases 1, 2, and 3. Phases 1 and 2 have already driven significant efficiency improvements, and Phase 3, set to take effect in 2027, will require even greater reductions. These rules link directly to fuel use: every 1% cut in fuel consumption equals a 1% drop in GHG emissions. While regulations have pushed progress, OEMs and fleets have consistently pursued greater efficiency through advanced engines, aerodynamics, and anti-idling technologies.

Evolving Challenges

Future emissions standards, including EPA27 Low NOx and GHG Phase 3, may raise compliance requirements. As engines become more efficient, exhaust temperatures drop, requiring additional fuel to keep catalysts active at low loads. This leads to higher idle fuel burn and added fleet costs, further emphasizing the need for advanced idle-reduction technologies.

Emissions Reduction Since 1991

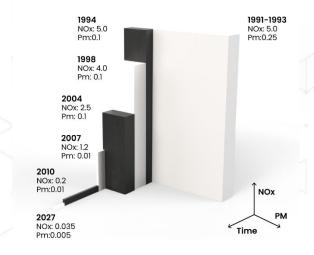


Figure 2.1 INACFE Run on Less Messy Middle Boot Camp

At the same time, the regulatory landscape remains uncertain. Greenhouse gas standards could continue to tighten, shift, or even phase out. Regardless of the path forward, the benefits of idle-reduction solutions remain consistent: lower fuel consumption, reduced CO2 output, and measurable cost savings. This makes advanced APUs featuring lithium battery technology a practical investment whether driven by compliance needs or pure operational efficiency.

Practical Path to Compliance

In an ever-changing regulatory environment, fleets need solutions that deliver value today and tomorrow. Dragonfly Energy's Battle Born® All-Electric APU and DualFlow Power Pack provide that flexibility, cutting fuel burn and emissions while keeping operations cost-efficient. Even if greenhouse gas standards evolve or disappear, these systems still offer a win-win by reducing operating costs, improving fleet sustainability, and ensuring compliance where required.

By combining compliance readiness with proven fuel economy gains, Dragonfly Energy's solutions give fleets a regulationagnostic path forward that balances environmental responsibility with bottom-line performance.







Anti-Idling & APU Solutions Overview

A variety of technologies are available to reduce engine idling while maintaining driver comfort. Each option offers unique advantages and limitations depending on fleet needs, operating conditions, and cost considerations. The table below provides a side-by-side comparison of the most common idle-reduction solutions in use today.

Idle-Reduction Tech	Description	Benefits	Limitations	
Fuel-Operated Heaters	Burns diesel to heat cab (air) or engine (coolant) without main engine	Low Upfront Cost of Ownership • Quiet Operation • Easy Installation & Upfitting	No A/C • Still Produces Emissions • Coolant Heaters Don't Heat Cab	
Base Engine: Auto-Start/Stop	Cycles engine on/off to maintain cab temp or battery SOC	Maintains Comfort • Battery Integrates with HVAC • Avoids Idling Penalties	Noise/Vibration from Restarts • Engine Wear & Tear • No Fuel Savings While Running	
Diesel APUs	Small diesel engine providing HVAC & electrical power	Works In Extreme Temps • Runs as Long as Fuel Is Available • Supports Heating, Cooling, & Hotel Loads	High Upfront & Install Cost • Ongoing Fuel & Service • Emissions & Noise	
Electric APUs (AGM)	Battery-based HVAC/electrical, typically using AGM batteries	Zero Emissions During Use • Quieter Than Diesel APUs • Lower Fuel Use vs. Idling	Limited Runtime • Heavy Battery Weight • AGM Shorter Cycle Life	
All-Electric APUs (LiFePO ₄)	Advanced battery APU powered by LiFePO ₄	Long Cycle Life • Lightweight vs. AGM • Zero Emissions/Noise • Lower Lifetime Cost	Higher Upfront Cost of Investment • Requires Charging Infrastructure	

While many solutions offer incremental benefits, next-generation lithium-powered systems and practical hybrid alternatives are emerging as the most effective tools for fleets seeking both cost savings and operational reliability.

All-Electric APUs (with LiFePO₄ Batteries)

Lithium-based APU systems address the shortcomings of traditional AGM battery solutions. Using LiFePO $_4$ (lithium iron phosphate) chemistry, these systems reliably power HVAC and hotel loads for the full 10-hour rest period, enabling true zero-idle operation.

Key Benefits:

- Extended runtime without requiring engine restarts
- Consistent comfort in a wide range of climate conditions
- Lightweight, long-lasting performance with minimal maintenance needs

OEMs and fleets increasingly adopt LiFePO₄-powered APUs to lower total cost of ownership, improve driver satisfaction, and comply with anti-idling regulations.





A Practical Alternative: The Battle Born DualFlow Power Pack

For fleets not yet ready to adopt full electric APUs, especially those operating in regions with limited seasonal A/C demand, Dragonfly Energy offers the **Battle Born DualFlow Power Pack** as a cost-effective, drop-in anti-idling solution.

This system:

- Installs easily under the sleeper cab bunk, retrofit or factory
- Powers non-A/C hotel loads such as cabin lighting, electronics,
 CPAP machines, and auxiliary accessories
- Maintains chassis starting batteries, preventing jump starts and reducing strain on electrical systems



While not a complete HVAC solution, the DualFlow Power Pack delivers immediate, measurable savings and improves reliability. For fleets with modest cooling requirements, it offers an affordable entry point into electrified hotel load support.

The Lithium Advantage: Why Lithium Batteries Outperform AGM & Lead-Acid Batteries

At a fundamental level, lithium batteries (especially LiFePO₄) are technologically superior to traditional AGM and lead-acid chemistries in nearly every category that matters to fleet operators:

Attribute	Lithium	AGM	
Energy Density	150 – 200 Wh/kg	50 – 70 Wh/kg	
Weight Savings	Up to 75% Lighter	Heavier System	
Depth of Discharge (DoD)	100% Usable	~50% Usable	
Cycle Life	3,000 - 5,000 Full Cycles	~400 Cycles	
Lifespan	8 - 10 Years (Warranted)	1 – 2 Years (Typical)	
Performance In Extreme Conditions Superior Thermal Tolerance		e Limited Reliability in Extreme Cold & Hot Conditions	

Figure 4.1

Voltage Stability & Power Consistency

Another critical advantage of LiFePO $_4$ batteries over AGM and lead-acid chemistries is the flat voltage discharge curve. Lithium batteries maintain a consistently high voltage output throughout most of the discharge cycle, delivering steady, reliable power to all hotel loads until nearly fully depleted.

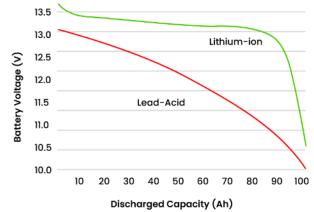


Figure 3.1





In contrast, AGM and lead-acid batteries experience a gradual voltage drop as they discharge. This declining voltage not only limits usable capacity but also causes a noticeable reduction in performance of connected systems:

- Bunk air conditioning output declines, with reduced cooling performance, lower fan speed, and rising cabin temperatures
- Microwave and liftgates slow down or shutoff early
- CPAP machines and electronics become unreliable

LiFePO₄ batteries avoid these issues by holding voltage near 13.2–12.8V for most of the discharge cycle, ensuring full operational performance of all in-cab systems without degradation, even at lower states of charge. This enables more efficient energy use and eliminates the common power complaints seen with aging or partially discharged AGM systems.

Extended Runtime Through Depth of Discharge

While Battle Born lithium systems are capable of supporting air conditioning loads, a major advantage of the technology is its ability to reliably power the hotel loads drivers depend on during mandated rest periods. From CPAP machines and lighting to microwaves and device chargers, these non-A/C loads are essential for comfort, health, and compliance. Consistent capacity is critical to ensure uninterrupted rest and driver readiness.

Limitations of AGM-Based Systems:

- Usable Capacity: An 8-AGM setup rated at 800Ah provides only ~320-360Ah at 50% depth of discharge, typically depleted within 4-6 hours.
- Starter Battery Risk: Without isolation, hotel loads may drain starter batteries, creating reliability and safety concerns.

40% - 60% Depth of Discharge

Example of Usable Deliverable Power: 640 Wh (100Ah 12V battery)

Advantages of Battle Born LiFePO₄ Systems:

- Full Depth of Discharge = Greater Runtime: A dedicated 540Ah lithium bank provides its full rated capacity, supporting hotel loads for the entire 10-hour rest period and keeping the engine off longer.
- Isolation from Starter Batteries: Ensures reliable power availability without risk to vehicle starting.

With Battle Born LiFePO₄ systems, full depth of discharge (100% DoD) equals increased usable capacity, which directly keeps the engine off longer while reliably powering hotel loads through mandated rest periods.

100% Depth of Discharge

Example of Usable Deliverable Power 1.28 kWh (100Ah 12V battery)

Figure 3.2

LiFePO4

Safety & Reliability of LiFePO₄ Systems

In commercial transportation, battery safety is just as critical as performance. LiFePO₄ (lithium iron phosphate) systems are widely recognized for their thermal stability, chemical safety, and long service life, making them well suited for rugged, mobile applications such as anti-idling APUs. Battle Born Batteries incorporate proven design features that enhance safety and reliability for long-haul operations.

Key Safety Features

- LiFePO₄ Chemistry: Intrinsically stable and resistant to thermal runaway or combustion.
- Cylindrical Cell Format: Provides strong mechanical integrity and uniform performance, with built-in safety vents to eliminate uncontrolled failure risk.





- Passive Cooling Design: Air gaps enable natural convection and passive heat dissipation, reducing hotspots and minimizing reliance on external cooling systems.
- Advanced Battery Management System (BMS): Monitors and protects against overcharging, over-discharging, short circuits, and cold-temperature charging.

Proven in Real-World Use

With over 400,000 units deployed in mobile and stationary applications, including RVs, marine vessels, off-grid properties, and industrial equipment, Battle Born Batteries have been tested under conditions that closely mirror sleeper cab environments. This track record demonstrates that LiFePO₄-based systems can deliver dependable, safe, and long-lasting performance at scale, even under the demanding conditions of heavy-duty trucking.

Summary of APU Solutions: Comparison Table

The following table summarizes the pros and cons of major APU and idle-reduction solutions across key operational attributes. Ratings use the following scale:

Diesel APU: HVAC Comfort: Diesel APUs can offer strong HVAC performance, particularly in extreme heat or cold, often matching or slightly exceeding lithium-based systems in thermal output. However, this comes at the cost of fuel consumption, noise, and emissions. LiFePO₄ systems provide quieter and emissions-free HVAC with slightly lower peak output in extreme climates

Best in Class Good	🔀 Poor 🔀	Worst		
Attribute	Auto start/stop	Diesel APU	Electric APU (AGM)	All-Electric APU (LiFePO4)
Fuel Consumption	8	8	②	•
HVAC Comfort	Ø	②	②	Ø
Driver Comfort & Rest	8	8	8	•
Weight	•	8	8	Ø
Maintenance	8	8	×	•
Lifespan*	N/A	2 Years	1-2 Years	10+ Years
Payback	8	8	8	< 1.5 Years
Sustainability	8	8	8	•

Figure 3.3 *Lifespan values reflect typical battery or diesel APU component life, not overall system *Auto-Start/Stop HVAC

Comfort is Temperature Only

AGM-Based Systems: While lower in cost than diesel or lithium, the limitations in usable capacity, maintenance frequency, and lifecycle make them less favorable for long-term fleet strategy. Also, while initial cost is lower, the payback period is worse than that of the lithium solution.

LiFePO₄ Systems: Represent the most balanced solution across all categories, delivering performance, longevity, and sustainability benefits with a strong Return on Investment (ROI) over time.







Operational Advantages of a LiFePO₄ System

Delivering driver comfort, reduced idling, and measurable cost savings in real-world fleet operations.

Driver Comfort & Safety

Dragonfly Energy's LiFePO₄-powered systems minimize disruptive engine restarts, enabling uninterrupted 10-hour rest periods. Better rest directly improves driver safety, health, and productivity.

Risks of Sleep Deprivation

< 7 hours sleep → ↑ accident risk

< 6 hours sleep → 1.3× higher accident risk

4 hours sleep → 11.3× higher accident risk

4 2 hours sleep → performance = 3 alcoholic drinks

Chronic sleep loss \rightarrow linked to depression, obesity, cardiovascular disease

Benefits of Uninterrupted Sleep

Focused drivers → fewer errors

Optimal driving → safer routes & practices

Efficient operation → better fuel economy & less truck wear

Healthier workforce → improved retention & productivity

Reliable, uninterrupted power means better rest—reducing accidents, improving efficiency, and ultimately strengthening fleet performance.

Studies Referenced: Acute Sleep Deprivation and Risk of Motor Vehicle Crash Involvement, Fatigue – You're More Than Just Tired

Maximizing Fuel Efficiency with LiFePO₄ Battery Technology

How exactly can upgrading auxiliary batteries save fuel? The answer is usable capacity. A similarly sized LiFePO₄ battery can run the same exact appliance for twice the amount time. Therefore, the auxiliary appliances (i.e. bunk air-conditioner) will run twice as long before hitting the engine start threshold when powered by LiFePO₄ batteries compared to AGM batteries.

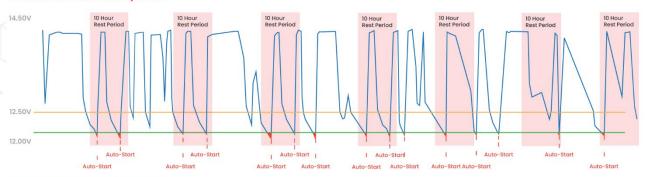
- LiFePO₄ batteries can often power hotel loads through an entire 10-hour rest period without triggering an engine autostart
- AGM and lead-acid systems, by contrast typically require the engine to auto-start multiple times throughout the rest period, often idling for 2-4 hours cumulatively to recharge batteries



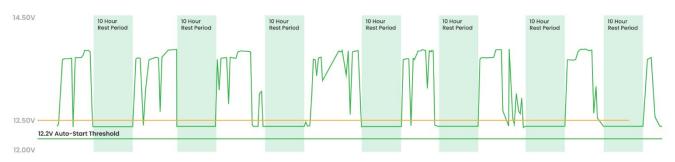


Battle Born DualFlow Power Pack: Performance Data





Battle Born DualFlow Power Pack



Chassis battery voltage shown.

Figure 4.1

Understanding Engine Parasitic & Accessory Loads Heavy-duty diesel engines have become far more efficient over the past few decades, but it is important to recognize that powering engine accessories still consumes fuel. Figure 4.2 provides an estimate of the horsepower required for these accessory loads. With Dragonfly Energy's LiFePO₄-based solutions, significantly more energy capacity is available, often eliminating the need to idle the engine over a 10 hour period. This allows the alternator to charge the batteries while the engine is already doing productive work, in contrast to AGM systems that require additional engine runtime and all of the accessory loads that come with it to recharge.

Fuel Waste from AGM Battery Charging The impact of this inefficiency becomes clear when comparing how AGM and LiFePO₄ batteries are recharged:

In an AGM-based system, the engine will likely idle for hours overnight, consuming fuel not only to recharge the batteries but also to overcome frictional and accessory loads—which can be a significant load on the engine. This prolonged idling also leads to unnecessary wear and tear on engine components, including the turbocharger, aftertreatment system, fuel injectors, and emissions hardware.



In a LiFePO₄-based system, the alternator recharges the battery while the truck is already running for operational purposes, meaning only a fractional amount of additional power is needed. As illustrated in Figure 4.2, the alternator is negligible versus the sum of all the accessories and friction required to run the engine. If the engine does not need to restart during the night, only a minimal amount of energy is required for recharge—eliminating overnight idling altogether.

By avoiding unnecessary engine idling, LiFePO₄-powered APUs not only reduce fuel consumption but also prevent avoidable engine wear, resulting in lower maintenance costs, fewer breakdowns, and extended vehicle lifespan. For fleets, this translates to improved uptime, reduced total cost of ownership, and greater operational efficiency.

Heavy Duty 15L Engine

Engine Friction & Parasitic Loads

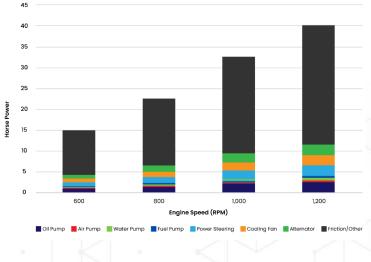


Figure 4.2 A cumulative cost summary is shown, equaling the average costs for the entire vehicle.

Maintenance & Reliability

Extended idling is one of the largest hidden contributors to higher maintenance costs and reduced engine life in Class 8 trucks. Continuous operation at low RPMs stresses key components, accelerates wear, and shortens service intervals.

Research from Oak Ridge National Laboratory shows that prolonged idling produces sulfuric acid, which corrodes components, while low-temperature combustion causes incomplete fuel burn, soot buildup, and premature engine wear. The U.S. Department of Energy further notes that excessive idling can even void certain vehicle warranties. (How Truck & Van Idling Increases Fleet Costs)

Studies quantify the impact: just one hour of daily idling equates to ~12,000 kilometers (7,500 miles) of wear annually, driving oil changes and other preventive maintenance up to 50% more frequently. (The Costs of Fleet Idle Time)

PACCAR engine guidance reinforces this link, showing how lower effective MPG from idle time pushes trucks into severe-duty service schedules, with oil change intervals as short as 30,000 miles versus 75,000 miles for efficient operations. By adopting anti-idling technologies such as Dragonfly Energy's LiFePO₄-based APU systems, fleets reduce idle hours, improve effective MPG, and move into longer service intervals. The result is fewer oil changes, less component stress, and higher system reliability. Fleets benefit from:

- Reduced preventive maintenance costs (extended oil change intervals)
- Higher reliability through minimized engine wear and soot buildup
- More uptime from fewer unplanned service events
- Decreased corrosion and component degradation

In practice, reducing preventive maintenance frequency by 25 percent, from two events to 1.5 per truck annually, saves about \$250 per truck each year. For a fleet of 4,000 units, that equates to \$1 million in annual maintenance savings, not including the additional value of increased uptime and extended engine lifespan. For fleets outsourcing maintenance, the savings potential is even greater.

As vehicles age, annual maintenance expenses nearly double, rising from about \$12,000 in years 1–3 to more than \$27,000 in years 6–7. Reducing idle-related wear directly lowers these lifecycle costs while supporting greater fleet reliability. By minimizing idle hours, fleets achieve lower maintenance expenses, stronger operational continuity, and increased asset utilization, which is a key driver of long-term profitability.





Extreme Climate Performance: Hot & Cold Weather Impacts on Idling and Battery Systems

Hot Climates: Fuel Consumption & Engine Stress in Elevated Temperatures

Hot climates and summer months significantly increase idle time and fuel consumption in heavy-duty trucks. A study by Samsara found that idle time rises by approximately 15% during heat waves, primarily due to increased air conditioning demand and greater engine cooling requirements. Dragonfly Energy has worked with several fleets, and we have seen idle time increasing by 30-40% during summer months. In some cases, we have seen much larger increases as many fleets have a policy to allow idle anytime ambient temperatures exceed 95F. Fleet examples are discussed in the Fleet Experiences and Real-World Data section of this paper. (Samsara Data Reveals How Extreme Summer Heat Drives up Vehicle Idling and Fuel Costs)

Limitations of AGM Batteries in Cold Weather

The 'Lead Is Dead' White Paper Study from Battle Born Batteries highlights the wide performance gap between AGM and LiFePO₄ batteries in sub-freezing conditions. While AGM systems often retain only 25–30% of their capacity, LiFePO₄ batteries deliver three to four times more usable energy, even in extreme cold (see Figure 4.3 for details).

Key AGM limitations in cold weather:

- Significant loss of capacity below 32°F
- No Battery Management System (BMS) safeguards
- Accelerated sulfation and shorter lifespan

Advantages of LiFePO₄ with integrated BMS:

- Maintains higher usable capacity in cold conditions
- Protects cells by preventing charging below safe temps (*25°F)
- Extends battery lifespan in northern or high-altitude fleets

Cold Weather Battery Discharge Performance at 13–18°F

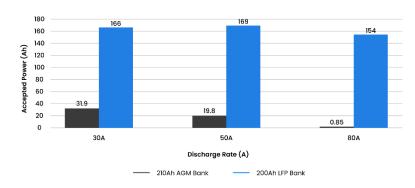


Figure 4.3 Battle Born Batteries | 'Lead Is Dead' White Paper Study

This proven cold-weather performance ensures LiFePO₄ systems deliver consistent, dependable power throughout winter operations. For more technical detail, see the full white paper.

Financial Savings: Total Cost of Savings & Payback Period

Figures 4.4 and 4.5 illustrate the comparative value of implementing Dragonfly Energy's Battle Born All-Electric APU system, benchmarked against three common alternatives. As illustrated in Figure 4.4, the Battle Born solution offers substantial reductions in fuel consumption and operating costs, driven by decreased idle hours, improved energy efficiency, and reduced engine wear.





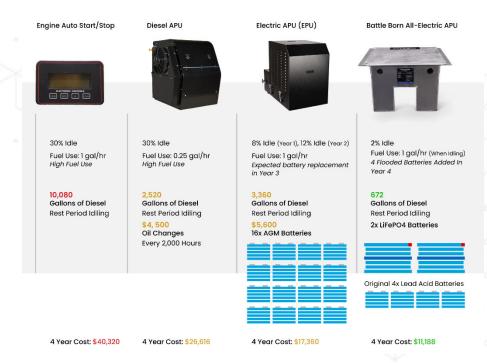


Figure 4.4 These savings estimates do not include reductions in engine maintenance or oil changes, which are addressed in the maintenance cost section.

Cost Model Assumptions To evaluate total cost of ownership (TCO), a consistent operating profile was used across all solutions: (1) Diesel priced at \$3.50/gallon, (2) 350 operating days per year, (3) Comparison periods of 4 years and 8 years (reflects expected 10+ year battery lifespan and use across 2 truck life cycles), (4) Idle fuel consumption rate: 1 gallon per hour, (5) Idle time varies based on system type and degradation over time.

Note: We believe these figures represent a conservative estimate. In real-world applications, the reduction in idle time with Dragonfly Energy's Battle Born All-Electric APU is often greater than shown here, which may further widen the cost and efficiency gap compared to other solutions.

Payback Period & Return On Investment To help fleets evaluate the financial impact of lithium powered idle-reduction systems, this section provides modeled payback timelines and break-even points across various idle scenarios and fleet types. The analysis includes sensitivity modeling based on fuel cost and idle percentage assumptions.

Calculating the payback period is a standard method for assessing the return on investment of new technologies. While each fleet's operational profile will vary, the following analysis provides a representative comparison using consistent assumptions.

The figure to the right summarizes the estimated number of years it takes to recover the initial investment in idle-reduction systems. The analysis compares three solutions: Diesel APU, Electric APU (AGM), and Dragonfly Energy's Battle Born All-Electric APU (LiFePO₄), against a baseline of no anti-idle solution. Payback periods are modeled at 30%, idle time, over a 4-year ownership period to represent the additional savings that can be recognized by using a Battle Born All-Electric APU that has a 10+ year product lifespan.

4-Year Payback

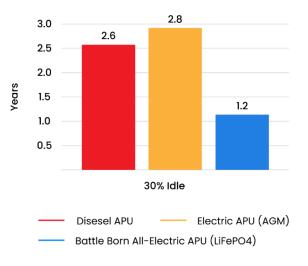


Figure 4.5

Estimated Payback Periods for Fleets Note: Fleets are encouraged to calculate their own payback periods using operational data.

These results reinforce that an All-Electric APU using LiFePO₄ battery power consistently delivers the fastest payback period, especially as idle time increases. While many fleets evaluate ROI over shorter timeframes (such as four years), Dragonfly Energy's lithium-powered systems are backed by a 10-year warranty and designed for long-term performance, making them well-suited for extended TCO analysis.







PACCAR Environmental Chamber Testing

Dragonfly Energy's Battle Born All-Electric APU was tested at the PACCAR Technical Center. To complete the testing, the All-Electric APU was integrated onto a 2015 Peterbilt 579 with a 72" sleeper. The class 8 heavy-duty truck at the time of testing was painted a dark purple color, color has a large impact on this test due to the solar load. This particular truck was chosen because of the color and was equipped with a factory installed SmartAir system. The All-Electric APU was installed between the rails and behind the cab (Figure 5.1). The All-Electric APU input was connected to charging source via the chassis ground and Alternator output, both connections were located in the main battery box. The all-electric output was connected to the ground and supply of the SmartAir System. The only source of electrical power the SmartAir system could draw from was the All-Electric APU. With integration complete a functional check was completed.



Figure 5.1

Testing Overview

Testing was conducted at the PACCAR Technical Center in Mount Vernon, WA within a vehicle environmental chamber capable of maintaining conditions listed below. The test procedure used was Recommended Practice 432B for Air Conditioning issued by TMC (Technology Maintenance Council). The recommended practice calls for the SmartAir system to maintain the Sleeper compartment of the truck for 10 hours.

- Ambient Temperature 100°F
- Solar Load 600 W/m²
- Interior Target Temperature 73°F +3°F/-5°F

The engine was not running during this test, which means the All-Electric APU is not charged during the test. No other electrical loads, besides SmartAir system, were on or drawing electrical power.

Test Preparation

Prior to the start of the test the batteries and SmartAir system were confirmed fully charged. The SmartAir system was confirmed to have the correct charge of refrigerant. The only electrical energy storage source available to the SmartAir system was the Battle Born All-Electric APU.

Test Results and Conclusions

Under these harsh conditions the All-Electric APU powered the SmartAir system for 9 hours 44 minutes. The cabin temperature was maintained within the target temperature while the All-Electric APU was powering the SmartAir system.

Air Conditioner Test Results

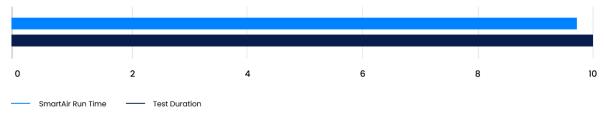


Figure 5.2





Fleet Experiences & Real-World Data

Dragonfly Energy's Battle Born All-Electric APU and DualFlow Power Pack systems have been deployed across numerous commercial fleets, all of which have reported substantial reductions in idle time, improvements in operational efficiency, and increased driver satisfaction. These real-world results reinforce the modeled total cost of ownership and performance advantages highlighted in previous sections.

Fleet data suggests that trucks often idle far more than expected—with some fleets reporting idle rates in excess of 40%, and some individual trucks exceeding 70%. By replacing AGM-based or diesel-powered APU systems with lithium-powered solutions, these fleets have achieved measurable improvements in fuel efficiency, idle time reduction, and system reliability.

Case Study 1: Trucks With vs. Without Battery-Powered A/C (Cooler Seasons)

In cooler months when air conditioning isn't needed, trucks in this fleet typically idle 4 hours per day over 250 service days per year to support hotel loads. By integrating the Battle Born DualFlow Power Pack, idling is eliminated on 180 of those days—saving 720 gallons of fuel, over \$4,500 in fuel and engine maintenance costs, and preventing more than 16,000 lbs. of CO₂ emissions annually per truck, while also eliminating the need for jump starts and battery swaps.

Truck Without the DualFlow Power Pack

Truck #89218 Field Data: FLA Batteries Only

Data: (1) Graph below shows field data from January 1 – January 16; (2) This truck averages 2+ auto-starts per 10-hour rest period during the test; (3) Engine remained on for 4+ hours of the 10-hour rest period (40%+ Idle time) every night; (4) Averaged 4+ gallons of diesel consumed, more than 2 cycles on chassis batteries, and produced 89 lbs. of CO₂

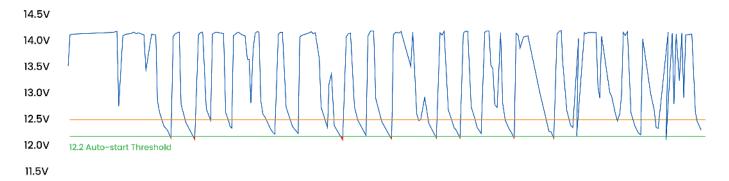


Figure 6.1

Truck With the DualFlow Power Pack

Truck #87857 Field Data: Battle Born LiFePO₄ Batteries

Data: (1) Graph below shows field data from January 1 – January 16; (2) The lithium system ran all 12V loads the entire 10-hour rest period resulting in; (3) 0 auto-starts; (4) 0 discharges / cycles on chassis batteries

Over a typical week, this performance equates to more than 28 gallons of diesel saved, 14 avoided chassis-battery cycles, and over 600 lbs. of CO₂ emissions prevented.





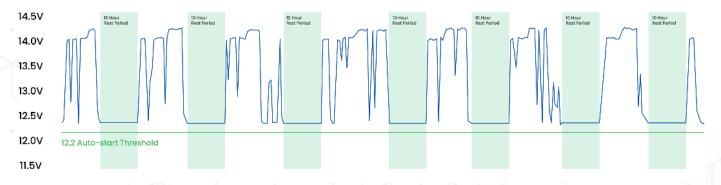


Figure 6.2

Case Study 2: Trucks With Factory Battery-Powered A/C + DualFlow Power Pack (Hotter Seasons)

During hotter months when cab cooling is required, a second fleet is piloting the DualFlow Power Pack system in combination with their factory-installed battery A/C setups (8 AGMs + DualFlow). This configuration allows for full elimination of idling across all 250 operating days—saving 1,000 gallons of fuel, \$6,250 in combined costs, and over 22,000 lbs. of CO₂ emissions per truck, while delivering reliable, uninterrupted power without jump starts or battery replacements.

Last 30 Days

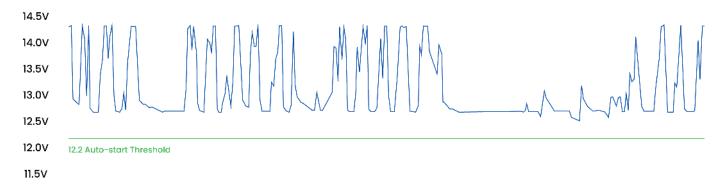


Figure 6.3

Ploger Transportation

"I do not show any voltage drops below 12.3V on the APU batteries. This looks very promising to me, we are on the right path with this technology."

Jerry Morrow, VP & Owner

Paragon Leasing

"The Dragonfly Energy solution has finally allowed us to consider an electric APU over diesel, due to the extended run time of a full 10-hour rest period. When compared to any other way of hoteling it has the lowest total cost of ownership over a 3-4-year trade cycle."

Nick Forte, Vice President of Maintenance





Case Study 3: Idle Time Reduction With All-Electric APU (LiFePO₄) Systems

Across multiple fleet evaluations, vehicles retrofitted with the Battle Born All-Electric APU system consistently demonstrated meaningful reductions in idle time compared to those equipped with AGM-based APUs.

In one regional delivery fleet, AGM-based APU units showed an average idle time of ~45 percent. A vehicle upgraded to the lithium system achieved an average idle time of 27 percent, an 18 percent reduction under similar duty cycles.

In a separate controlled trial, two trucks with AGM-based APUs were compared against identical trucks outfitted with lithium APUs. The lithium-equipped vehicles achieved an average idle time reduction of 12 percent.

Result: These real-world trials confirm that lithium-based APUs reliably reduce idle time across different operating environments, cutting unnecessary fuel burn and enabling greater efficiency for fleets.

Average Idle Time of AGM-Based APU Units

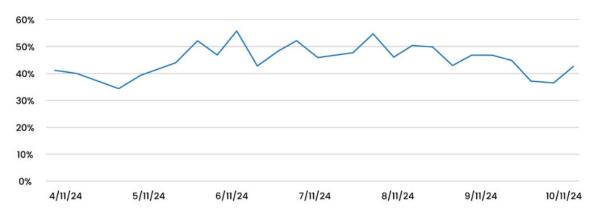


Figure 6.4

Comparison of AGM vs LiFePO₄ APU solutions in similar duty cycles

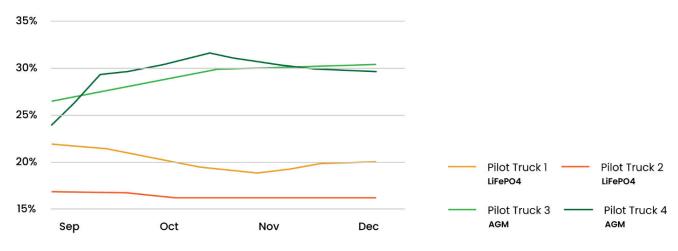


Figure 6.5 Dragonfly Energy's Internal Monitoring Data



Broader Industry Idle Behavior Additional industry data supports the trend that HVAC needs are the primary driver of idle time during off-duty hours:

- A survey of commercial drivers indicated that 70–80% idle their trucks during rest periods to run heating or air conditioners (How Truck & Van Idling Increases Fleet Costs)
- Idle rates across sectors show similar patterns
 - Delivery trucks: ~25% idle time
 - o Construction and maintenance equipment: 40% or more (The Cost of Fleet Idle Time)

Fleet Feedback Beyond the Numbers In addition to idle-time and fuel savings, fleets implementing LiFePO₄ anti-idling solutions have reported several operational advantages:

- Lower fuel consumption: Reduced idling directly translates to significant fuel savings
- Uninterrupted rest periods: Drivers report better quality sleep due to the elimination of engine start-stop cycles.
- Higher reliability: No Dragonfly Energy batteries required replacement, whereas AGM-based systems frequently required battery replacements after just one year

As commercial fleets increasingly transition to hybrid and electrified power systems, field data continues to validate that Dragonfly Energy's Battle Born LiFePO₄ -based APU solutions offer measurable, real-world improvements in efficiency, comfort, and cost of operation, making them a smart investment for modern trucking operations.







🛂 Conclusions & Recommendations

The data presented throughout this whitepaper makes clear that Dragonfly Energy's Battle Born All-Electric APU and Battle Born DualFlow Power Pack offer a compelling opportunity for fleets seeking to reduce costs, enhance driver comfort, and prepare for regulatory change.

Fuel Economy & Cost Savings Compared to diesel APUs, AGM systems, or idling alone, LiFePO4 solutions consistently delivers:

- Reduced fuel consumption and idle time
- Lower total cost of ownership
- Extended asset lifespan and fewer maintenance events

Fleets adopting the Battle Born All-Electric APU system have reported annual savings of up to \$6,500 per vehicle, with 8-year cumulative savings exceeding \$60,000 per truck compared to no anti-idling solution.

Environmental Impact & Sustainability Electrified APUs reduce CO2 emissions without requiring full EV adoption. According to the North American Council for Freight Efficiency (NACFE):

> "Eliminating idling is one of the most cost-effective ways to reduce emissions and fuel consumption. It's the lowest-hanging fruit in a decarbonization strategy."

By reducing idle hours by up to 70%, a lithium-powered APU system can prevent the release of 10−12 metric tons of CO₂ per vehicle annually—a significant and immediate impact when scaled across large fleets.

Practical, Scalable Adoption In an environment of shifting regulations, uncertain EV timelines, and rising fuel costs, the Battle Born solution offers:

- Immediate payback and measurable ROI
- No need for charging infrastructure
- A scalable path to electrification that fits today's operational demands

Fleets seeking to modernize, reduce operational costs, and prepare for the regulatory landscape ahead should consider LiFePO₄ powered systems as a practical, near-term solution. Dragonfly Energy's proven performance, American manufacturing, and longterm battery warranty position it as the industry-leading choice for decarbonizing sleeper cab hotel loads and achieving compliance-ready, cost-efficient electrification.





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White Paper

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Lithium Powered Solutions for Commercial Fleets



presented by

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