

FROM LP TO ELECTRIC LIFT TRUCK FLEET CONVERSION

Minimizing Costs & Maximizing Productivity with Smart Fast Charging



white paper 



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ABSTRACT

Continually faced with the pressure to reduce costs and improve productivity, fleet managers of industrial light- and medium-duty trucks must consistently be on the lookout for a competitive edge to increase overall fleet efficiency and cost effectiveness. With huge technological advancements and growing market acceptance, more fleet managers are making the switch from Liquid Propane (LP) gas to electric lift truck fleets. The purpose of this paper is to provide an overview on how transitioning your fleet from LP to electric lift trucks can increase your fleet's productivity, lower total cost of ownership, improve environmental conditions for your employees.

And in conclusion we will show you, with the help of AeroVironment's (AV) proprietary LP Meter, how you can accurately measure the fuel use and truck activity of your existing fleet, and subsequently help you turn that into savings up to \$8500/truck annually by making the transition to electric.



1. INTRODUCTION

In a market traditionally dominated by the internal combustion engine (ICE), industrial lift truck fleets have had to adjust to compensate for rising fuel costs and stricter emissions standards. Looking for an efficient and cost effective solution, an increasing number of companies and fleet managers have decided to make the transition to electric powered lift trucks. Now accounting for almost 65% of the total North American forklift market, electric lift trucks have gained industry-wide acceptance, demonstrating their merit in performance, utility, and reliability. [1] Despite its growing popularity, common misconceptions revolving around equipment capability, cost, and battery/charging support persist. However, within the last few years advancements in motor, battery, and charger technology have completely transformed the value proposition for electric powered lift trucks, enhancing vehicle performance, reliability, efficiency, and practicality. Benefits you will see from making the switch from Liquid Propane (LP) gas to electric lift truck fleets include:

- **LOWER TOTAL COST OF OWNERSHIP**
 - Lower fuel costs
 - Longer vehicle life
 - Lower maintenance costs
- **LESS “REFUELING” DOWN TIME AND INCREASED PRODUCTIVITY**
- **LESS NOISE AND VIBRATION**
- **ZERO EMISSIONS**
- **INDOOR/OUTDOOR AND ALL WEATHER OPERATION**



[1] EPRI, Electric Forklift Conversion Transforms Building Products Manufacturer http://www.nrel.gov/rredc/pvwatts/changing_parameters.html#dc_rating



LP vs ELECTRIC FLEET

2. ELECTRIC FLEET CHARGING 101

Electric lift trucks need to refuel just as their LP counterparts do. And in high throughput plants a timely, powerful charge is an operational necessity.

2.1. CONVENTIONAL CHARGING / BATTERY CHANGING

Conventional charging charges a battery at a very low rate (16-18A / 100Ahrs), taking 8-10 hours to fully recharge to 100% state-of-charge (SOC). Best suited only for one-shift operations, in one day a battery would charge over an 8-10 hour period, rest and cool for another 6-8 hours, and then be discharged over an 8 hour shift. For multi-shift operations, more than one battery would be required per truck, introducing the additional cost of maintaining extra batteries and the additional complexity of needing to rotate out batteries during the day.

2.2 FAST CHARGING

With fast charging, batteries are charged at a much higher rate (40+A / 100Ahrs) at regular intervals throughout the day (including breaks, lunches, and shift changes), without ever leaving the vehicle. Fast chargers are placed throughout the facility where drivers take their breaks so they can plug in during non-productive times, instead of taking time out of their productive work cycle, thus minimizing truck downtime and maximizing driver productivity. In addition, smart chargers are universally sized to charge any battery, and are intelligently equipped to recognize a battery's size and voltage to provide a charge profile within the safety parameters of the battery. This means that drivers are productive, batteries are protected, and battery warranties are honored. And because the battery is always charged on-board the vehicle, assets are optimized at a 1:1 ratio of batteries to trucks, eliminating the extra burden of stocking extra batteries.

3. OPERATIONAL BENEFITS

3.1. SIMPLE REGIMEN MEANS MINIMAL TRAINING

Asking operators to plug in before breaks is similar to locking a door before you leave a room. The act of plugging and unplugging is a simple practice that leaves little room for error. An identification device that sits on the battery communicates with the smart chargers, ensuring that

each unique battery is recognized and served the right charge profile (current, voltage, power) to protect the battery's health.

3.2. PRODUCTIVITY GAINS

Smart charging allows forklift operators to charge in their work area or where they're typically parked when they're not working, minimizing productivity losses. In comparison, LP tank replacement has a total downtime of up to fifteen minutes per driver, not including round-trip travel time to the swap-out site, at least once per shift.

Figure 1.0 illustrates the differences between battery changing and smart charging when measuring the battery's SOC throughout the day. Note that the two places where battery changes occur are during the work cycle, causing a decrease in productivity during swapping. In comparison, the smart-charged battery's SOC is maintained between 40% and 80% throughout the day, with quick boosts of energy during breaks and shift changes.

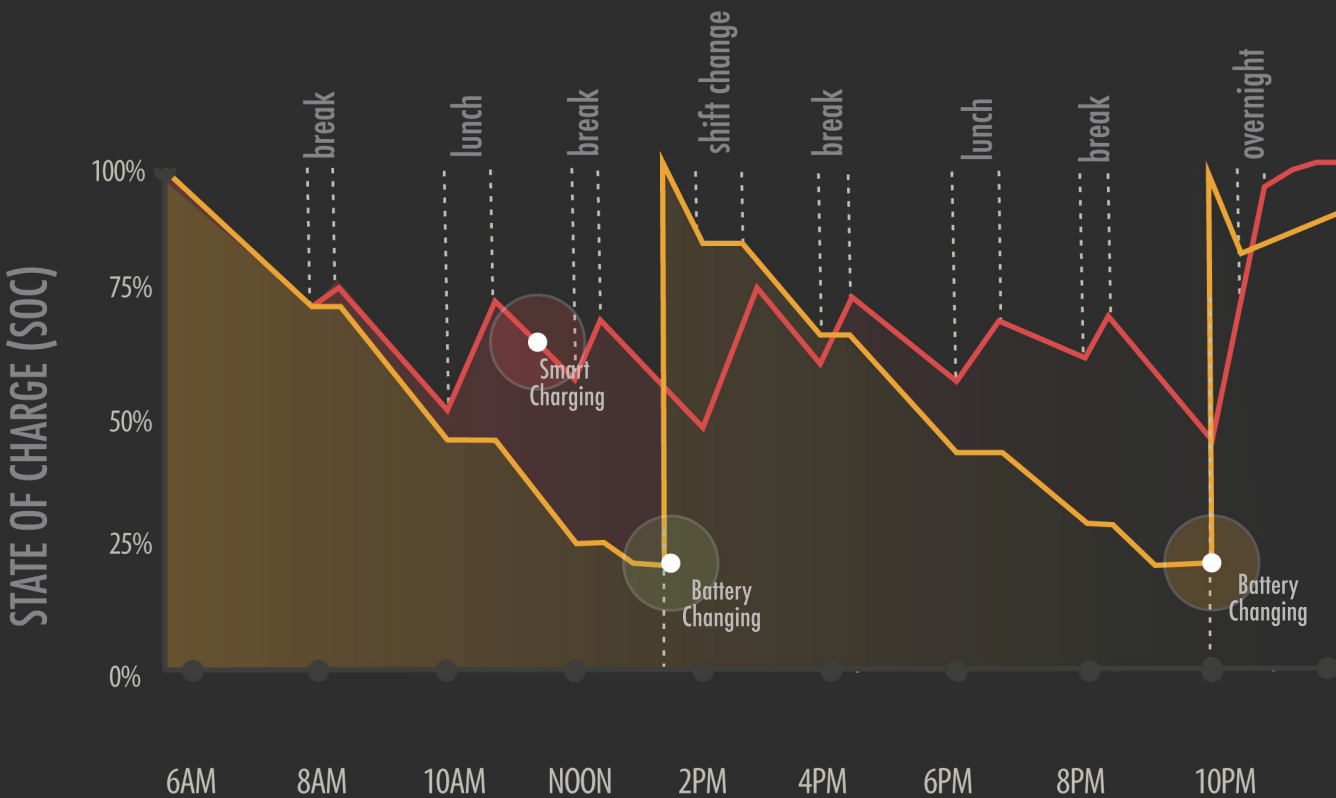


FIG.1.0 STATE OF CHARGE VS. TIME: SMART CHARGING VS. BATTERY CHANGING

3.3. AUTOMATIC BATTERY CARE

Today's most advanced smart chargers are also equipped with automatic watering and equalization capabilities. The charger is pre-programmed to equalize the vehicle whenever there is eight hours of contiguous downtime to ensure cell balance and health; and its automatic watering system is also activated during equalization for hands-free battery care.

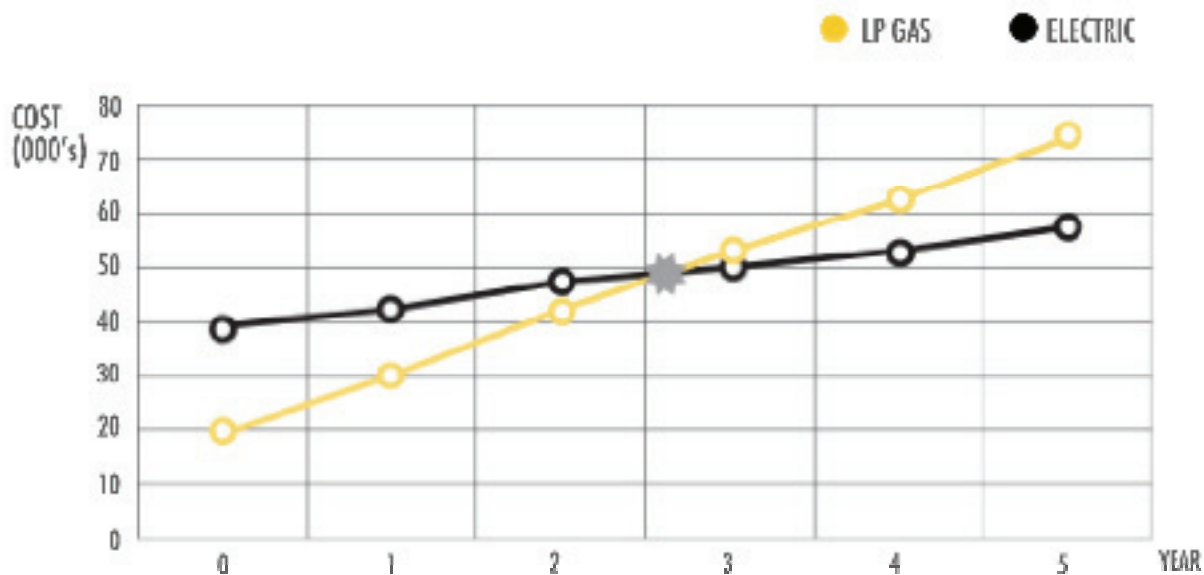
4. FINANCIAL BENEFITS & ANALYSIS

In addition to enabling fleet managers to improve overall efficiency in ongoing operations, each of

these benefits translate into a quantifiable cost reduction, thereby improving the value proposition of making the switch to a fully electric fleet. Another important thing to consider is that a huge part of this value proposition is demonstrated through a comparison of the Total Cost of Ownership (TCO) over the lifespan of the truck. Looking at the TCO helps to illustrate the direct and indirect costs related to the purchase of a capital investment, like a forklift.

For example, when making a comparison of the upfront capital costs between LP and electric trucks, you must take into consideration ongoing costs like fuel, maintenance and replacement parts, as well as opportunity costs. Looking at it this way, the magnitude of the initial investment can be offset by ongoing cost savings, and by the end of the vehicle's service life will be only a fraction of the total cost of ownership.

Figure 2.0 below demonstrates an example of the TCO curve for electric vs LP lift trucks (25 trucks) over a five year period, illustrating the approximate return-on-investment period of 2-2.5 years. [2]



[2] Hyster-Yale, LPG VS. Battery Electric Forklifts http://www.aalhyesterforklifts.com.au/index.php/about/blog-post/lpg_vs._electric_forklifts

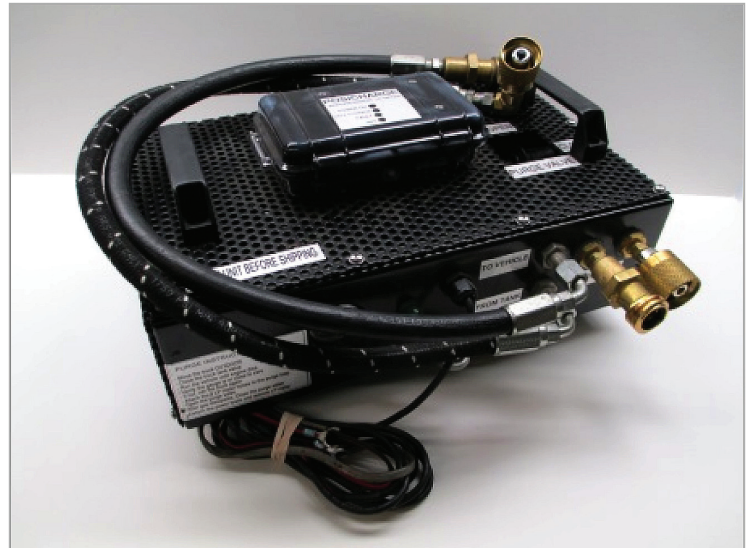
4.1. AV CASE STUDY: TOTAL COST OF OWNERSHIP

This case study shows data from an actual facility comparing the cost of operating an LP fleet on an ongoing basis compared to the costs of running an electric fleet using chargers from AeroVironment's (AV) PosiCharge™ line of fast chargers. Payback of the electric fleet is 2.5 years based on a facility converting from LP vehicles (i.e., considering the purchase of new electric vehicles with LP vehicles accounted for as a sunk cost). This analysis includes hands-free equalization and watering options, charger installation costs, and vehicle modifications that allow for adequate ventilation and the ability to communicate with batteries to protect battery health and maximize vehicle uptime.

	LP	ELECTRIC
TRUCK LIFE	7 years	11 years
MAINTENANCE	50 hrs./yr	30 hrs./yr
REPLACEMENT PARTS	\$2,200/yr	\$1,250/yr
FUEL COST	\$247,609/yr	\$91,435/yr
ANNUAL COST TO OWN	\$602,213	\$390,278

5. MAKING THE TRANSITION

While the idea of converting an entire fleet from LP to electric may seem daunting, the potential operational benefits and cost savings to you and your fleet could completely justify making the switch. First, it is critical to fully understand the application operation requirements and truck usage in order to provide a smart charging system solution. But in order to properly measure the trucks usage you must have the proper tools. To satisfy this need, AV has developed a one-of-a-kind product, the LP Meter, which measures and analyzes the energy used by the LP fleet and translates the data into a detailed electric fleet profile – including the number of trucks, batteries, and chargers required, and recommended battery sizes and charge power requirements.



This meter is installed on the forklift for a minimum of one week to collect the fuel use and activity of the truck. The design of the LP meter allows it to be mounted on the tank or on top of the overhead guard. If it is installed on the tank it is design to be easily removed during tank changes.



The data collected by the LP meter is analyzed and is summarized in two formats: 1) Summary Table and 2) Highest Usage Day Graph.

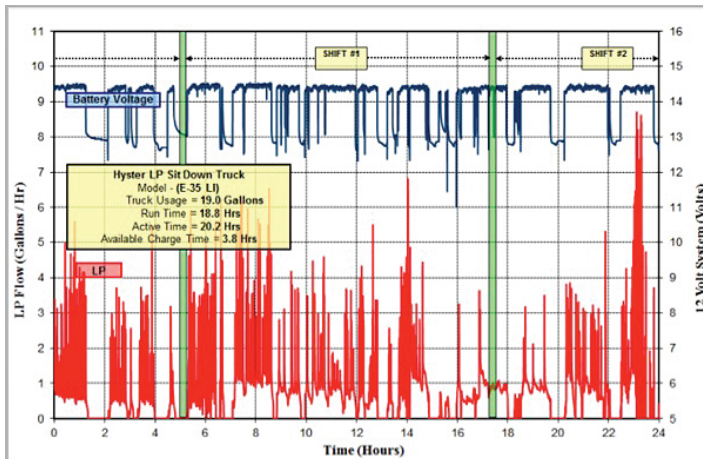
Fig 3.0 Summary Table

The summary of the test period that identifies the highest usage day of LP. Each day is described in total gallons used, how long each vehicle is being run, and the remaining available time to charge vehicles.

Date	Day	Gallons	Run Time	Idle Time	Charge Time	Total Time
3/7/2012	Wednesday	6.8	6.6	2.8	2.3	9.4
3/8/2012	Thursday	16.1	16.7	7.3	6.1	24.0
3/9/2012	Friday	19.0	18.8	5.2	3.8	24.0
3/10/2012	Saturday	15.8	16.3	7.7	6.1	24.0
3/11/2012	Sunday	16.3	17.2	6.8	4.8	24.0
3/12/2012	Monday	18.7	18.6	5.4	3.3	24.0
3/13/2012	Tuesday	15.9	18.3	5.7	3.8	24.0
3/14/2012	Wednesday	16.7	15.6	8.4	7.3	24.0
3/15/2012	Thursday	16.8	17.6	6.4	4.3	24.0
3/16/2012	Friday	6.4	5.8	1.6	0.5	7.4
	Totals	148.4	151.6	57.2	42.5	208.8

Fig 3.1 Highest Usage Day Graph

A 24 hour graph further detailing the highest usage day. This graph describes the real-time LP usage and the operational work intensity.



Using the data, AV's application team can size the correct system and ensure a smooth transition to an electric fleet. No other company has an equivalent tool that validates a recommended battery and charger system.

6. WHAT NEXT?

For a limited time, AV is offering a complimentary fleet audit by its team of application engineers and its proprietary LP Meter. The team also works with finance and operations managers to develop a site layout and total cost-of-ownership study comparing all capital and operating expenses related to manning an LP vs. electric fleet based on the unique demands of your operation. Contact an AV representative to help further illustrate how electric trucks translate to operational efficiencies and overall savings.



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ABOUT AEROVIRONMENT

AeroVironment is a technology solutions provider that designs, develops, produces, operates and supports an advanced portfolio of electric transportation solutions and electric-powered Unmanned Aircraft Systems (UAS). AeroVironment's comprehensive EV charging solutions include EV home charging, public charging, fast charging, data collection, grid-integrated communications and complete installation, training and support services for consumers, automakers, utilities, government agencies and businesses. AeroVironment's industrial electric vehicle charging systems support thousands of electric materials handling vehicles in mission-critical supply chains for Fortune 500 enterprises. AeroVironment's power cycling and test systems provide EV developers and EV battery manufacturers with market-leading simulation and cycling capabilities. Agencies of the U.S. Department of Defense and allied military services use the company's electric-powered, hand-launched unmanned aircraft systems to provide situational awareness to tactical operating units through real-time, airborne reconnaissance, surveillance and communication. More information is available at www.avinc.com.

ABOUT POSICHARGE

Committed to continually improving, enhancing and releasing new intelligent energy management products for the material handling market, PosiCharge fast chargers set the standard for rapid charge systems. AeroVironment, PosiCharge's parent company, has developed breakthrough power electronics and battery management technologies for over 30 years. PosiCharge systems - the most advanced line of fast chargers available today, is a product of this rich heritage. As the developer of the premier fast charge system for electric cars, PosiCharge was able to effectively reduce charge times by a factor of 12. When applied to the world of material handling, this revolutionary innovation saved the material handling industry millions of dollars annually by eliminating battery-changing* operations. Moreover, PosiCharge makes the conversion from internal combustion to electric vehicles more affordable by reducing battery costs for operations executives and managers. By reducing the number of cost-prohibitive batteries and optimizing assets, AeroVironment and PosiCharge fast chargers continue to play a critical role in improving the way industries and individuals minimize impact on the environment. Entire fleets of industrial electric vehicles that move, store and make product for Fortune 500 companies are powered by PosiCharge, every single day.

