

High-efficiency battery chargers save energy, cut costs



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High-efficiency battery chargers

As today's consumers become increasingly more mobile and wireless, they are also finding themselves more dependent on portable and rechargeable batteries. For years, the amount of electric energy consumed to charge these batteries has been left largely unchecked; in fact, it's been rapidly increasing. With no clear energy efficiency standards for charging systems, there has never been a real motivator for manufacturers to implement waste-reducing charging technology.

That's about to change.

This year, the California Energy Commission (CEC) mandated that all new *small consumer* battery chargers—those drawing less than 2kW of peak power and used by most consumer electronic devices such as cell phones, electric toothbrushes, electric razors and power tools—will be manufactured to operate more efficiently and consume less energy while providing the same level of performance.

By 2014, this mandate will expand to large commercial battery chargers drawing more than 2kW or more of peak power. This covers those chargers used to power fleets of industrial mobile equipment—from pallet jacks to forklifts—in industrial facilities across America's supply chain. And by 2017, compliance for small commercial chargers, such as portable bar code scanners and other similar technology, will also be similarly required.

Why the big push? In California alone, the CEC identified that 8,000 gigawatt hours (GWhrs) of electricity is used by households to operate battery chargers and almost two-thirds of this energy is wasted due to charging system inefficiencies. Much of the energy is lost through heating and power loss dissipation during the charging process. Some charging systems continue to consume energy even when a battery is fully charged.

Since 2008, the energy commission has been collaborating with stakeholders including the state's major utility companies, battery charging manufacturers and other consumer groups to put together cost-effective and feasible regulations that will improve the energy efficiency of battery chargers. Under these new standards, wasted electricity is anticipated to decrease by about 40% and save the state nearly 2,200 GWhrs per year—enough energy to power nearly 350,000 homes. Once fully implemented, California ratepayers will save more than \$300 million annually and

The REVOLUTION Series is the first full line of smart battery chargers that is fully compliant with the California Energy Commission efficiency standards. The REVOLUTION Series features very high charge cycle efficiencies and state-of-the-art MOSFET soft switching technology resulting in lower energy costs, smaller sizes, and lighter units.



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reduce carbon emissions by 1 million metric tons, according to the CEC.
(See Figure 1)

For now, California is the only state in the nation mandating these standards. However, the federal government is considering similar standards and mandates. As a result, many battery charging manufacturers, in anticipation of such sweeping regulations, have already pushed forward to ensure their new product lines are designed and manufactured so that they comply with California's highest standards. Today, new high-efficiency battery chargers can provide improved power conversion efficiency over current charger technologies.

While users are anticipating slight increases in these new chargers' price points, this new generation of chargers can potentially pay for themselves in energy savings in the short term—sometimes within months—and can result in a further reduction in operating and maintenance costs over the long term.

This white paper explains how these new standards are ready to revolutionize the battery charging industry. It gives special emphasis to large commercial battery chargers used by lift trucks and other mobile materials handling equipment in plants and warehouses. It also details how improved charging technology was leveraged to comply with the new standards. If planning on purchasing or replacing your chargers, these chargers may be your best option for saving energy and costs.

The new standards: Transforming battery charger systems

Over the years, industrial battery charging systems used to power mobile equipment and electric vehicles inside warehouses and manufacturing plants have undergone a few transformations. While the technology to minimize energy waste during the charging process has been readily available, these conventional chargers were not designed with the goal of reducing wasted energy.

For decades, the market was dominated by conventional ferroresonant (FR) and silicon-controlled rectifier (SCR) type chargers due to their durability, reliability, relatively low cost and simple design. However, because these chargers operate at low frequencies (60Hz) and employ larger low-frequency isolation transformers, they tended to be bulky and heavy. In addition, these transformers also incurred heating and power loss dissipation resulting in lower charging efficiencies when compared to newer, high-frequency chargers.

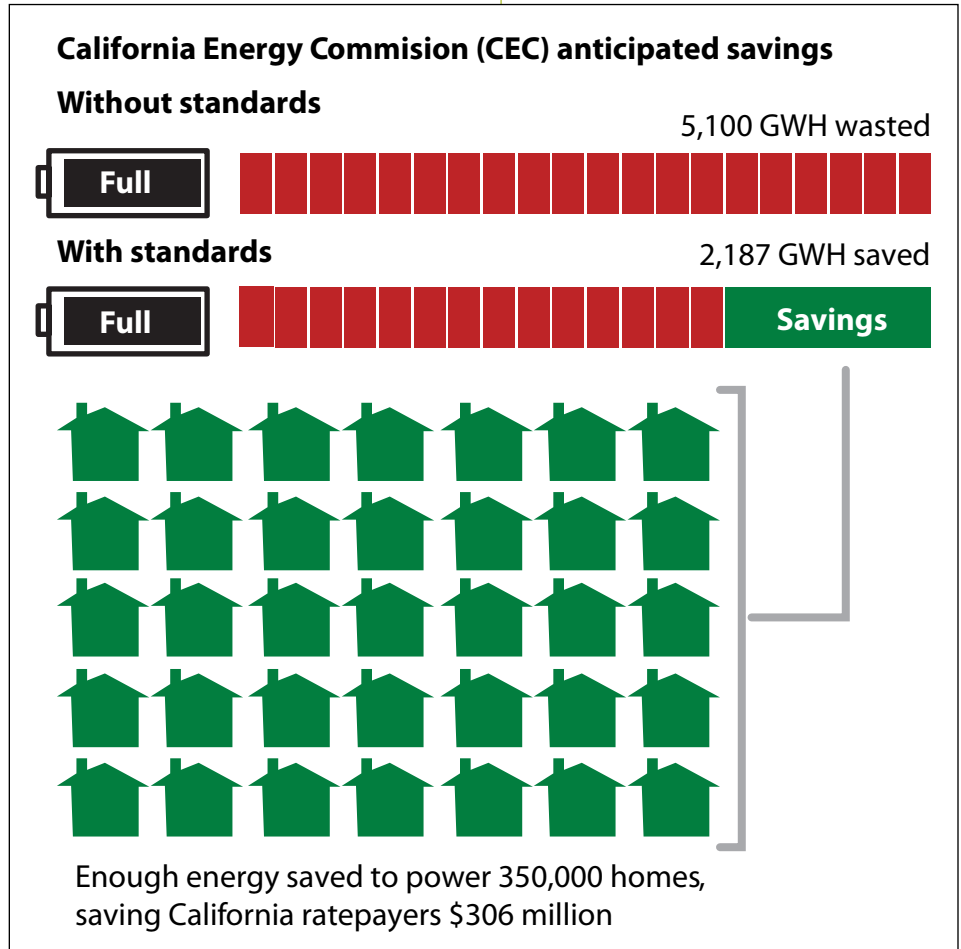


Figure 1. Anticipated savings with compliance to energy efficiency standards for Battery Charger Systems, according to the California Energy Commission (CEC)
(Source: www.energy.ca.gov/appliances/battery_chargers/documents/Chargers_FAQ.pdf)

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High-frequency (HF) chargers use switch mode power conversion technologies that allow switching at higher frequencies. Simply put, these technologies significantly reduced the size and weight of magnetic components (inductors and transformers) leading to lower transformer heating and power dissipation losses. This design resulted in subsequent improvements in transformer efficiency and overall charger efficiency.

The new CEC standards focus on eliminating the energy waste of battery chargers by setting limits on the total electricity consumed by chargers during the chargers' operating modes, including:

- (1) the charge mode, which refers to the energy used to actually charge batteries;
- (2) no-battery mode, which refers to the energy consumed by the battery charger when the battery has been removed or disconnected; and
- (3) battery-maintenance mode, which refers to the energy consumed after the battery has been fully charged.

While high-frequency chargers achieve relatively higher frequencies compared to conventional FR and SCR chargers, most charger manufacturers only report the maximum efficiency value that their chargers can achieve. However, one of the key provisions of the new CEC standards requires that manufacturers report the average charger cycle efficiency by taking efficiency measurements at three operating modes and calculating the arithmetic average of the resulting efficiencies. As such, the new chargers must not only be efficient at full power (100%) or during the bulk-charging mode of the charge cycle, but also efficient at lower power levels during the finish and equalize charge modes.

The problem was while conventional and high-frequency chargers may report high efficiencies greater than 90%, these are peak efficiencies measured at power levels greater than 60%. When these chargers operate below 60% of rated power, mainly during the latter stages of the charge cycle, the charging efficiency drops, reducing overall charge cycle efficiency to less than 90%—typically 84% or less. The new CEC standards require that average charger cycle efficiency be at least 89%. (See Figure 2.)

Using a combination of improvements in electronic circuit design, plus innovations in microprocessor controls, also called digital signal processing controls, leading-edge manufacturers successfully developed a new line of high-efficiency, industrial battery chargers to comply with the CEC standards.

Not only does this new line of battery chargers feature a very high charge cycle efficiency of greater than 90%, these chargers also maintain this high efficiency over their entire charge cycle. This has resulted in true energy savings of 6% or greater, as compared to leading HF chargers. For a typical 36V/850Ahr battery, these savings translate into energy savings of about 3.5kWhr per charge cycle or greater than 1MWhr per battery per year.

By shifting from a bulky transformer into what's called switch mode technology and leveraging advances in components, devices and digital controls, these

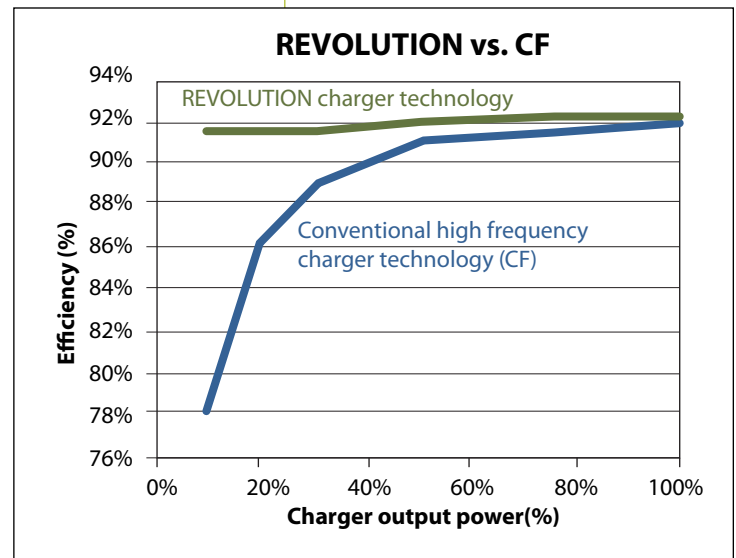


Figure 2. Efficiency of high efficiency chargers versus conventional chargers at varying charger output modes.

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new chargers are not only much more efficient, but they are also smaller and lighter. It also takes less time to charge because less energy is wasted and more power is being transferred into the battery. The requirements on the AC circuit are also significantly reduced, drawing fewer amps from AC circuits, thus adding to energy savings. No changes are anticipated to charger set-up and installation requirements.

Establishing the business case for these chargers

Although more definitive price points have yet to be established for these new chargers, it is estimated that they will only be slightly higher than the cost of current chargers in the market. The energy savings from their deployment, however, are expected to be significant—as much as 4% to 5% of true energy savings of a facility's energy bill. These energy savings are expected to more than pay for the difference in the price of the new chargers. Preliminary calculations estimate a payback period of less than two years.

Because the new standards only apply to new equipment, the full benefits of the new chargers will not be immediately realized in many facilities. Current chargers typically have a lifetime of five to 10 years with companies buying new chargers either for new equipment or to replace an existing fleet. It's estimated to take anywhere between five to 10 years to deplete the whole stock of old chargers and replace them with CEC-compliant chargers.

Understanding the impact of these chargers

It's a natural trend of design cycles to always try and improve on previous technologies and designs. It's predicted that these new CEC-compliant chargers could revolutionize the industrial battery charging market and that it may even render FR and SCR chargers obsolete as manufacturers push toward the highest levels of efficiency.

These new efficiency standards will also re-define testing and reporting requirements for specifying charger efficiency. The new regulations will require battery charger designers to focus on the total amount of energy consumed in the process of converting AC electricity from the utility grid into DC electricity stored in the battery and to continue to develop new techniques to minimize energy waste, not just at peak but throughout the charge cycle.

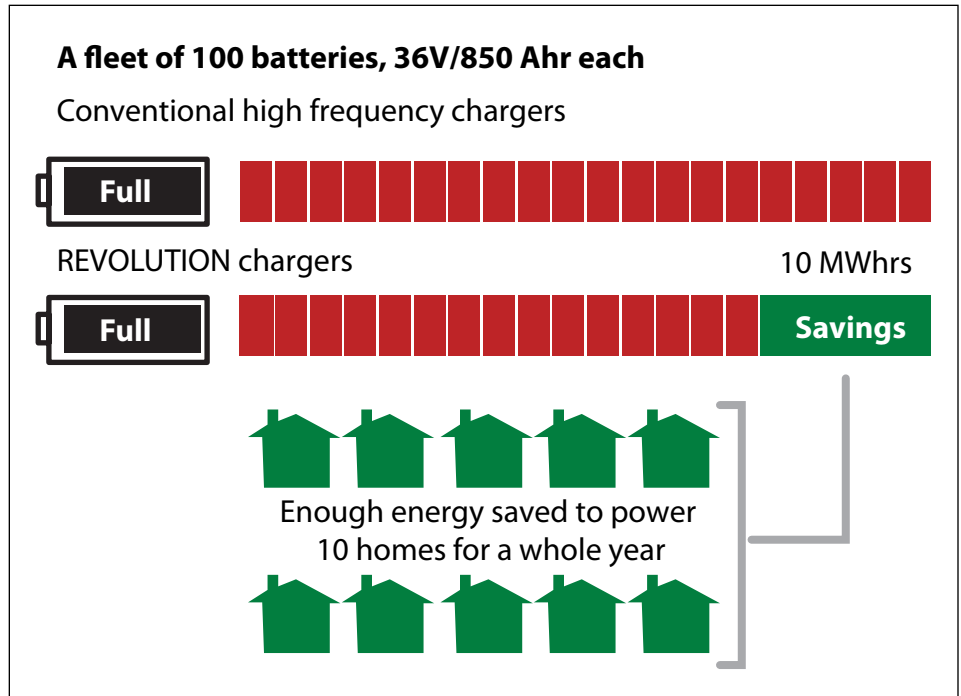


Figure 3. Sample energy saved with new high efficiency chargers versus conventional chargers



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