Discover®
Innovative Battery Solutions

AES $LiFePO_4$ Battery

POSITIONING AND MARKETECTURE FOR

INDUSTRIAL BATTERY POWERED MACHINES AND ELECTRIC VEHICLES

PRODUCT BENEFITS AND FEATURES

Rev B

#4 -13511 Crestwood Place, Richmond, BC, V6V 2E9, Canada + 1.778.776.3288 info@discoverbattery.com

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PRODUCT FAMILY OVERVIEW

Discover Battery's Advanced Energy System (AES) $LiFePO_4$ batteries enable the highest level of productivity from battery powered industrial machines and electric vehicles, and unlike lead-acid batteries AES $LiFePO_4$ batteries deliver a predictable return on investment.

Designed for 100% depth of discharge, >95% round-trip efficiency, lightning fast 1C continuous charge/discharge and built with the highest-grade cells and Battery Management System (BMS), AES $LiFePO_4$ batteries can handle the DC current demands of EV motors and partial state-of-charge operation without degradation in performance.

A single AES $LiFePO_4$ battery will do the work of many lead-acid batteries, last much longer and install using fewer cables. Voltage Specific Models of 12V, 24V, 36V and 48V parallel easily to extend vehicle operating times.

With zero maintenance requirements and an unlimited cycle 4-year warranty, AES $LiFePO_4$ batteries provide commercial operators with bankable performance and deliver dramatic total cost of ownership savings.

Commercial operators will transform the productivity of their battery powered machine and Electric Vehicle fleets with Discover AES $LiFePO_4$ batteries.

AEON
Extended Service Life

RAPI-CHARGE
Fast Charging

MISER
High-Efficiency

RUSH
Surge Power

PARALLEL POWER
Scalable Energy Storage

LYNK
Dynamic Performance

JUCE
Enhanced Run Time

SENTRY
Reliable, Safe, Certified

QUICKFIT
Quick Installation

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MARKETECTURE

AEON©

Extended Service Life

Feature

Discover AES $LiFePO_4$ batteries will significantly outlast lead-acid batteries, dramatically improve machine up time and reduce your customer's battery power costs over the life of their system.

Value Proposition

You can tell a lot about a company by how it defines success and failure. Lead-acid battery manufacturers (including Discover) have conditioned you to look at Temperature vs. Cycle Life, or Cycle Life vs. Depth of Discharge (DoD) graphs to indicate expected life or, more accurately, their remaining time to failure. There are many industry references for determining the point of FAILURE, but often this is technically described as the point at which the battery fails to deliver at least 50% of its original capacity (BCI S-06). However, what is often misunderstood is that lead-acid batteries start to lose their original capacity the moment they are put into service and that the total available capacity in cycle 250 will be much less than the total available capacity in cycle 10. In other words, lead-acid powered equipment will continuously be capable of doing less and less work.

The industry aggressively contends that 'Cycle life' is the measure of battery quality versus the competition. A successful high-quality lead-acid battery will maintain its ability to deliver the same amount of energy for <100 cycles (less than 6 months of daily cycling), and only if the battery is never operated in high ambient temperatures, not deeply discharged, recharged completely every cycle and watered regularly (flooded cells). In the real world, cycle counting is neither verifiable nor reflective of the amount of energy delivered on a daily basis. Cycle life does not ensure the daily period of time a machine can do work.

Discover AES $LiFePO_4$ batteries with AEON© cycle life technology can be continuously operated in a partial State of Charge (SoC), or alternatively discharged and charged to 100% of its rated capacity without consequence. Discover AES $LiFePO_4$ batteries will provide >90% of original energy storage capacity for a minimum of 10x that of a high-quality lead-acid bank.

Discover AES $LiFePO_4$ batteries are warranted by a 4-year, unlimited cycle, 13 MWh total energy throughput warranty*. Discover batteries will provide your customers with reliable long-term daily energy storage capacity and asSoCiated lifetime machine productivity they are paying for.

Positioning

Discover AES $LiFePO_4$ batteries versus lead-acid batteries.

- 10x the Life of Lead-acid Battery (BCI-06)
- Unlimited Partial State of Charge Cycles
- 4 Year Energy Throughput Mobile Warranty

**Applies to AES 6.65kWh Battery*

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MARKETECTURE

RAPI-CHARGE©

Fast Charging

Feature

Discover's RAPI-CHARGE© charge source optimization allows Discover AES $LiFePO_4$ batteries to fully recharge up to 5x faster than new lead-acid batteries or up to 10x faster than aged lead-acid batteries.

Value Proposition

The Battery Management System (BMS) and charge control system of Discover AES $LiFePO_4$ batteries optimize charge current and voltage to safely recharge the battery at the highest and most efficient rate regardless of its state of charge. For battery powered machine operators, this means opportunity charging anytime has no negative impact on battery life.

Even the highest quality lead-acid batteries require lengthy absorption and equalization stages to achieve a fully charged state. Unlike flooded batteries, Discover AES $LiFePO_4$ batteries accept a charge at maximum input throughout the charging process and do not require 'absorption' or 'equalization' overcharge stages. Those charging stages waste energy, money and time, and the losses are further compounded as lead-acid batteries age.

The RAPI-CHARGE© capability of a Discover AES $LiFePO_4$ battery to recharge much faster than a lead-acid battery will allow operators to schedule much shorter periods of machine down time. Battery swap-out programs and associated equipment expenses can also be eliminated.

Positioning

Discover AES $LiFePO_4$ batteries versus lead-acid batteries.

- Opportunity Charge Anytime, Regardless of SoC
- 1C Continuous Charge Rate, Regardless of SoC
- Up to 5x Faster than New Lead-acid Batteries
- Up to 10x Faster than Old Lead-acid Batteries

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MARKETECTURE

MISER©

High-Efficiency

Feature

Round trip efficiency measured at >95%, MISER© technology by Discover saves industrial EV operators at least 15 - 30% of their energy costs each and every time they cycle their machine when compared to lead-acid batteries.

Value Proposition

To borrow an old cliché, a penny saved is a penny earned. Charger and inverter manufacturers beat each other up mercilessly over fractions of % efficiency gains and, to their credit, the chargers and inverters on the market today are far superior to what was available even 10 years ago. Current charger technologies are nearly fully optimized for efficiency leaving batteries as the only component offering a real, tangible opportunity for improvement.

In the battery business, Round Trip Efficiency (RTE) is the measure of the energy wasted each and every charge/discharge cycle. New high-quality lead-acid batteries have at best an 80% RTE, which can decline rapidly as the batteries age resulting in a life-time average of 65%.

Discover AES $LiFePO_4$ batteries with MISER© offer your customers the ability to save up to 30% or 3 kWh in energy cost for every 10 kWh of battery capacity they own, each and every cycle. With an average electricity tariff of 0.18 $/kWh in the United States, 3kWh saved is $0.54 per cycle, or $200 per year with only a single cycle use per day.

In Japan, Australia and Northern Europe the savings per year would be even greater. Everyone knows there is a dollar value for the cost of energy. Why is it that lead-acid batteries are let off the hook? They don't even bother to report RTE on their product specification sheets.

Discover AES $LiFePO_4$ batteries with MISER© technology will allow battery powered machine operators to actually use up to 95% of the energy they pay for when charging their machines. Compare that to the best case 80% RTE of new lead-acid batteries, and 65% RTE lifetime average for aged lead-acid batteries, and you can give the charger guys a break for a while.

Positioning

Discover AES $LiFePO_4$ batteries versus lead-acid batteries.

- 30% Less Wasted Energy than Lead-acid Batteries
- 95% Round Trip Efficiency

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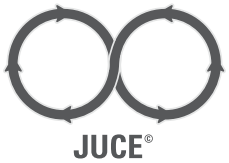
MARKETECTURE

JUCE©

Enhanced Run Time



Feature

Discover AES $LiFePO_4$ batteries have JUCE©, doubling runtime and energy output over lead-acid batteries of the same capacity.

Value Proposition

Because deeply discharging lead-acid batteries decreases life expectancy, a design maximum of 80% Depth of Discharge (DoD) typically leads to large and heavy lead-acid battery systems for battery powered EVs. Furthermore, because Peukert's Law dictates that the capacity of a lead-acid battery decreases as the discharge current increase, lead-acid battery systems for battery powered EVs are further oversized to meet expected operating time.

With Discover AES $LiFePO_4$ batteries and JUCE©, what you see is what you get. Discover's 100% DoD battery ratings represent the actual usable energy output available from a fully charged battery. This means lighter weight Discover AES $LiFePO_4$ batteries provide at least 1.2x the usable energy in a single cycle versus an equivalent high-quality lead-acid battery without any risk of damaging the battery.

Positioning

Discover AES $LiFePO_4$ batteries versus lead-acid batteries.

- 120% the Run Time of Lead-acid Batteries
- 100% Usable Capacity
- 100% Depth of Discharge

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MARKETECTURE

RUSH©

Surge Power

RUSH©

Feature

Discover's RUSH© technology embedded in the Battery Management System (BMS) design enables an AES $LiFePO_4$ battery to handle the high discharge current and regenerative braking current common to electric motors.

Value Proposition

The BMS of most lithium batteries can only handle steady, low current loads over long durations. They overload or restrict their output when they are hit with inductive in-rush or regenerative braking motor loads. RUSH© by Discover is the capability, unique to our BMS design, that allows our $LiFePO_4$ batteries to handle the high discharge and regenerative braking demands of DC motor systems.

Discover AES $LiFePO_4$ batteries handle continuous charge and discharge currents up to 1C and inductive in-rush and regenerative breaking motor load currents up to 2.3C.

When an industrial machine or EV design calls for multiple batteries, RUSH© ensures that the current handling capabilities scale with your battery capacity: doubling with two batteries, tripling with three, and so forth.

Discover AES $LiFePO_4$ batteries with RUSH© allow fleet operators to run the same machines they could with lead-acid while enjoying the advantages of $LiFePO_4$ lithium technology.

Positioning

Discover AES $LiFePO_4$ batteries versus other Lithium batteries.

- 2.3C Peak Current for Motor Surge
- 2.3C Peak Regenerative Current Handling
- 1C Continuous Charge Current
- 1C Continuous Discharge Current

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Innovative Battery Solutions

MARKETECTURE

SENTRY©

Reliable, Safe, Certified

SENTRY©

Feature

Discover AES $LiFePO_4$ batteries with SENTRY© are cleaner and safer than lead-acid batteries. Stable and high-performing $LiFePO_4$ cells managed by our proprietary, 3rd generation BMS design have been tested and certified to stringent UL 2271 LEV standards for safety in Light Electric Vehicles and IEC 62133. They are UN 38.3 certified for safe transport.

Value Proposition

Industrial battery power machine OEMs have been using lead-acid batteries a long time and, regardless of the benefits lithium batteries offer, there is familiarity and comfort in those traditional lead-acid batteries. To be successful replacing lead-acid battery power for application in machines we knew we'd need to convince OEMs and fleet operators that Discover AES $LiFePO_4$ batteries not only outperform lead-acid batteries, but that they are safer too.

The first and most important consideration in designing a safe lithium-ion battery is the selection of cell chemistry. When Discover decided to develop an advanced industrial grade battery we considered each lithium chemistry before finally committing to $LiFePO_4$.

Lithium Cobalt (LCO) is an advanced lithium battery type and is commonly used in portable electronics because of its high, power density. However, LCO has a relatively short life span, limited load capabilities (specific power) and low thermal stability which make it susceptible to thermal runaway.

We also considered NMC (Lithium Nickel Manganese Cobalt Oxide), another chemistry common to electric automobiles and power tools. It's versatile, in that it can be tailored for high specific energy or high specific power, but for industrial machine applications we needed both. Another concern is that high charge current promotes thermal runaway in NMC batteries and fast recharge times are critical for fleet operators of battery powered machines.

With the application knowledge gained from years of observing Discover's own lead-acid batteries in the field, we chose to use Lithium Iron Phosphate (LFP or $LiFePO_4$) cells as they are ideally suited to the demands of the applications and customers we serve.

$LiFePO_4$ works for our customers because it:

- is very thermally stable with no risk of thermal runaway;
- offers the longest cycle life;
- can be recharged at 1C rate;
- and can handle heavy loading and rapid discharge rates.

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The second critical component in the design of safe, high-performance, lithium batteries is the Battery Management System (BMS). Unlike lead-acid batteries, Discover AES $LiFePO_4$ batteries are managed by a sophisticated BMS internal to each battery which continuously monitors and manages all electrical inputs and outputs, as well as monitoring the status of all cell temperatures.

Highly engineered power electronics controlled by proprietary firmware and device drivers protect the cells and ensure our batteries provide the performance and safety your customers demand. Compared to lead-acid batteries, there is no risk of arcing from shorted terminals because the BMS simply disengages a relay and interrupts power. There is no exposure to corrosive electrolyte and no off-gassing from overcharging. Even the highest quality, sealed batteries cannot make that claim.

It is fairly easy to build a lithium battery. A quick Google search will show you a market awash with products with minimal to no safety protection and built using 'second life' cells, without any validation or testing at prices that are too good to be true. On the other hand, it's incredibly difficult to design and build a robust, safe lithium battery. One that's survived serious destructive testing and manufactured under the scrutiny required to meet rigorous IEC, UL and UN standards.

How do we know? Since 2009, Discover has been developing its range of Advanced Energy Systems suitable for the extremes of motive power, industrial and renewable energy applications. Securing regulatory approvals, like UL 2271, is an extremely expensive process so you've got to have complete confidence in your battery design before you start. Even then, the testing process is designed to expose flaws that are only revealed once these agencies start to shake, drop, bake, and abuse products under the most extreme conditions.

Discover AES $LiFePO_4$ batteries are certified to UL2271 LEV, the regulatory standard applicable for battery packs used in Light Electrical Vehicles, and UN38.3, which is required to legally and safely transport lithium batteries. Certifications represent a serious commitment to quality, technical integrity and robust design. Above all else our investment in certifications demonstrates our own belief in our product, down to the last nut and bolt. You can be comfortable in the knowledge that the performance and design of our Discover AES $LiFePO_4$ batteries have been independently validated and approved.

From the choice of chemistry in the cells that make up our batteries, to the regulatory markings on their labels, Discover AES $LiFePO_4$ batteries are safer and will perform better than the lead-acid batteries you are used to selling and installing.

Positioning

Discover AES $LiFePO_4$ batteries versus other Lithium and lead-acid batteries.

- $LiFePO_4$ is Safe and Maintenance Free
- Integrated High Current BMS
- Field Serviceable BMS
- IP 55 Rated
- IEC 62133 Safety
- UL 2271 LEV Safety Certified
- UN 38.3 Transport Certified

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Innovative Battery Solutions

MARKETECTURE

PARALLELPOWER©

Scalable Energy Storage

PARALLELPOWER®

Feature

Discover AES $LiFePO_4$ batteries easily scale to meet the runtime requirements for industrial battery powered machines.

Value Proposition

Discover AES $LiFePO_4$ batteries are system voltage specific: 12V, 24V, 36V or 48V models. Discover AES $LiFePO_4$ batteries can be paralleled, no external BMS is required. When Discover AES $LiFePO_4$ batteries are paralleled there is a linear increase in charge and discharge current capacity.

The Battery Management System (BMS) of each Discover AES $LiFePO_4$ battery has the capability to aggregate SoC and balance up to 20 units in parallel over Discover's AEbus. AEbus is Plug and Play configured and standard CAT5 cable is used to connect between the RJ45 port of each battery in parallel.

Discover AES $LiFePO_4$ batteries with PARALLELPOWER© provide battery powered machine designers with easily scalable battery capacity to meet productivity and up time demands.

Positioning

Discover AES $LiFePO_4$ batteries versus other Lithium batteries.

- Parallel Battery Capacity to Over 133 kWh
- Linear Scaling of Charge and Discharge Capacity
- Plug-and-Play AEbus for Parallel BMS Network

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MARKETECTURE

LYNK©

Dynamic Performance Realized

Feature

Discover AES $LiFePO_4$ LYNK© technology enables real time adaptive charge and discharge interaction between the battery system and compatible power electronics.

Value Proposition

LYNK© technology enables Discover AES $LiFePO_4$ batteries to dynamically control the charge voltage and discharge cut-off points of compatible chargers. By integrating closed loop communications with power conversion devices over a CANbus protocol, Discover AES $LiFePO_4$ batteries will deliver up to a 25% improvement in 0% to 100% State of Charge (SoC) recharge times.

AES $LiFePO_4$ batteries are able to log current-state and historical data for monitoring, diagnosis and troubleshooting over CANbus, RS232 or USB port.

Positioning

Discover AES $LiFePO_4$ batteries versus other Lithium batteries.

- Real-Time Optimization of the Charge Rate
- Up to 25% Faster Recharge from 0% to 100% SoC
- Dynamic BMS Integration with Power Devices over CANbus
- Log Current State, kWh, Faults over CANbus / RS232 / USB

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MARKETECTURE

QUICKFIT©

Quick Installation

Feature

Discover's QUICKFIT© design allows for a faster installation than lead-acid batteries.

Value Proposition

Battery cables complicate and slow down the installation process. Discover AES $LiFePO_4$ batteries are voltage specific (12V, 24V, 36V and 48V) eliminating the need for series cables and connections. Paralleling remains as simple as connecting one battery to another using standard battery cables attached to the positive and negative M8 terminals of Discover AES $LiFePO_4$ batteries.

Discover AES $LiFePO_4$ batteries are designed to fit into the space occupied by the pre-existing lead-acid batteries without change to the machine. For example, one AES $LiFePO_4$ 14-24-2800 battery occupies the same foot print and volume as four 6V batteries (i.e. GC2), or the same as two 12V batteries (i.e. Group 31). And with JUCE© technology that same Discover AES $LiFePO_4$ battery has a much higher energy density and lower weight than the multiple lead-acid batteries it replaces.

Discover AES $LiFePO_4$ batteries communicate with each other over AEbus and broadcast SoC and other data over Canbus to chargers and power conversion equipment. Harness installation is plug-and-play with automatic configuration of compatible power conversion devices saving valuable time and eliminating installation errors. Discover also offers digitally accurate remote SoC display meters for integration into the dashboard of the machine or EV.

Discover AES $LiFePO_4$ batteries are a direct drop-in replacement for lead-acid batteries and install quickly with no need for new installation procedures, tools or special battery cables.

At Discover, we've been designing and building batteries for commercial, industrial and energy storage applications for a long time and along the way we've learned a thing or two about the installation process. Discover's QUICKFIT© design reflects that knowledge and our desire help our customers 'make-the-leap' into the era of Lithium battery power without having to do 'everything different'.

Positioning

Discover AES $LiFePO_4$ batteries versus lead-acid batteries.

- Fast Standard Install Procedure
- 12V/ 24V / 36V / 48V Models
- Compact High Energy Density
- Drop-in Lead-acid Replacement
- Digitally Accurate SoC Displays