WAVETECH®

Crystal Control Technology® in Energy Storage

Tapping the Full Potential of Lead Acid Batteries

Energy Storage and Grid Integration

Not wasting energy does not only mean consuming less, but also making the best use of it. Today's power supply is heading towards greater sustainability and renewable energies are transforming grids all around the globe. They are fed from a variety of sources and depend on wind and weather, which poses unprecedented challenges.

New Energy Landscapes

Power generation is becoming increasingly versatile. Besides gleaming photovoltaic panels on suburban roofs, whole building complexes are designed to autonomously generate, consume, store or convert energy to heat. Solar and wind parks have become a familiar sight in many regions, even though most governments have drastically reduced their subsidies. Technological advances have simply made renewables competitive.

The capacity of photovoltaic systems worldwide has increased from below 10 GW to over 200 GW between 2006 and 2015. Germany, Italy, Japan, China and Australia take the lead in this field, while others focus on wind energy. The U.S., for example, are planning on covering 20% of their energy demand by means of wind power by 2030.

However, what if the sun does not shine or if the wind abates? What if only a fraction of the energy produced can be directly consumed? The answers lie in energy storage—a concept whose implementation at grid level is still in its infancy, but which is already deemed indispensable for the future.

Intelligent Electricity Feed-in

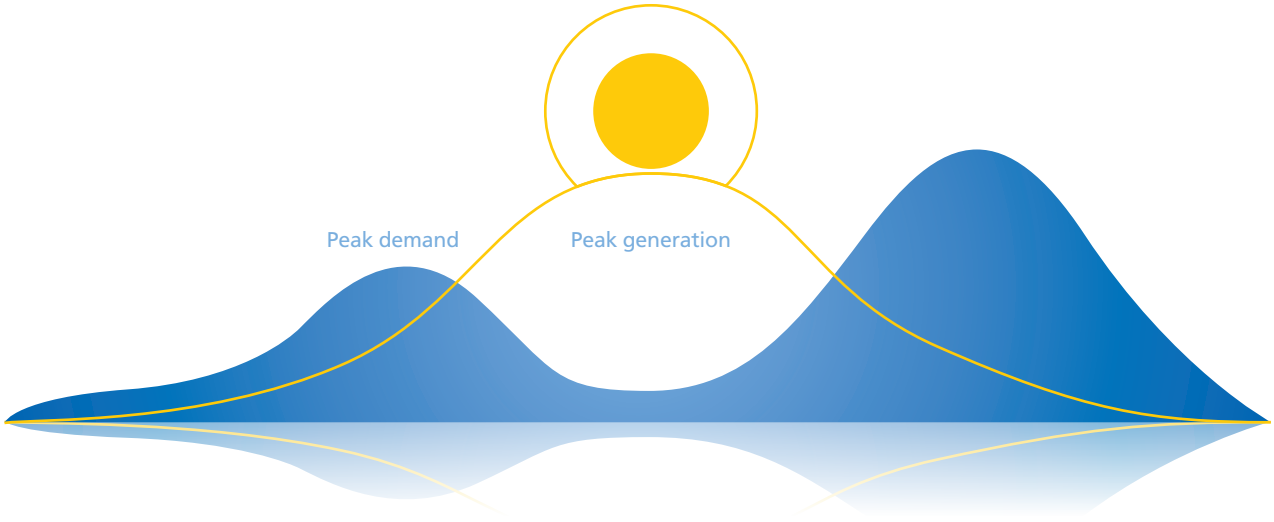
Power plants generate a steady flow of ultra high voltage electricity to minimize transmission loss. The voltage is then repeatedly converted and reduced before it reaches the consumer. Since many consumers in turn feed in excess energy from their photovoltaic systems, energy has to be transmitted in various directions. Therefore, the grid structure is becoming increasingly complex.

Levelling Grid Fluctuations

The energy output of wind and solar systems varies strongly, which can destabilize the grid. These fluctuations need to be smoothed out to ensure the power supply is not interrupted.

Peak Shifting

Not only energy output, but also power demand during the day varies as becomes evident with the domestic photovoltaic system. Its production peaks around noon when the demand is usually low, because nobody is at home. In the evening, when the demand is high, the sun has already set and solar energy needs to be supplemented by grid power.



At domestic as well as at grid level, excess energy can be stored for later use. This so-called time-shifting helps consumers reduce their energy costs. For the grid, the reserve also serves as back-up power.

Grid Expansion

The power supply needs to be tailored to peak demand, even though such peaks may be brief and far exceed the average. Instead of being forced to expand the grid, because of occasional peaks, providers can use energy storage to prolong investment until the average demand increases. Previously stored energy can be fed into the grid during times of increased energy consumption.

Battery-based Energy Storage

Battery Energy Storage Systems (BESS) boast short reaction times and require comparatively little maintenance. Due to their high flexibility, they can be used for domestic solar systems as well as for industrial facilities, wind parks or grid integrations. Systems of 10 MW storage capacity are already successfully in operation, but this is not the limit. In the U.S., for example, there is a lead acid BESS under construction that will link the country's three major interconnections.

A BESS usually consists of battery modules that are connected to the grid via a converter. Several battery types can be used, such as lead acid, lithium or sodium sulfur. Depending on the main application of the storage system, the technology is chosen on the basis of its charge time, cycle life, energy density, discharge depth and costs.

Technologies of Choice: Lead and Lithium

Lead acid and lithium are dominant in BESS. While lead acid is a mature and highly cost-efficient technology, lithium has a longer cycle life. Lead acid batteries last for about 8.5 years, whereas lithium has a life span of 11.5 years. The latest generation, which still needs to prove itself in practice, is expected to last up to 20 years. Crystal Control Technology®, however, can double the life span of lead acid batteries as well as improve their charge behaviour and capacity.

Battery Energy Storage Systems contribute to a stable and smart power supply by way of:

- Levelling voltage fluctuations
- Storing excess energy for times of higher demand
- Supporting the energy transmission in complex grids
- Providing back-up power to prevent blackouts
- Prolonging investments in grid expansion

Crystal Control Technology® at a Glance

Crystal Control Technology® leads to significant improvements in battery capacity and life span by manipulating the electrochemical processes in lead acid batteries. It enables surface control of the electrodes and increases the reaction sites.

Ageing in Lead Acid Batteries

Lead batteries store energy by means of a chemical reaction between lead and lead dioxide at the electrodes and sulphuric acid. The different electrode surface materials generate voltage. The most detrimental effects on battery capacity and useful life are the growth of lead sulphate crystals on both electrodes, which destroys the imbalance of the surfaces, and a lack of density in lead dioxide crystals on the positive electrode, which reduces the energy density.

During charging, lead sulphate is dissolved and the lead dioxide layer is renewed, but not completely. With every cycle, the unwanted crystals form an increasingly impenetrable barrier while lead dioxide crystals tend to bind to existing crystals in a heap instead of distributing evenly across the electrode surface. Over time, the battery loses its capacity.

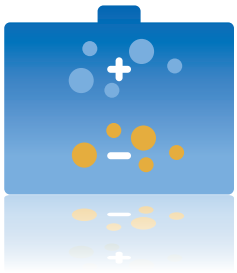
The Effects of Crystal Control Technology®

Crystal Control Technology® slows down battery ageing by using overvoltage pulses to manipulate the charging process. This creates more overvoltage at the battery electrodes and the additional energy in the electrolyte helps to increase the movement of the ions with three beneficial effects:

- Residual lead sulphate is more effectively dissolved from both electrodes, increasing battery life span
- Lead dioxide forms a more even coating on the positive electrode, increasing battery capacity
- Increased charge efficiency

The stimulation of the battery's electrochemical processes improves its performance in various ways. Independent research institutes have tested the technology and verified its effectiveness. It has been validated by HORIBA MIRA Ltd. (UK), SINTEF Materials and Chemistry (Norway) as well as various battery manufacturers.

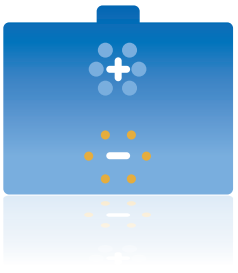
Ageing process in untreated batteries



At the positive electrode, lead dioxide crystals form heaps that reduce the reaction site

Lead sulphate crystals are not effectively dissolved and form a physical barrier on the negative electrode

Renewal with Crystal Control Technology®



Lead dioxide forms an even coating on the positive electrode to renew the reaction site

The increased ion movement effectively rids the negative electrode of lead sulphate crystals

Crystal Control Technology

Longevity

Crystal Control Technology® has been proven to double the useful life of batteries. Even when applied to worn batteries, it slows down the ageing process and stops it at about 40 - 50% rest capacity.

Higher Capacity

Even after repeated charge cycles, batteries treated with Crystal Control Technology® show 340% more capacity than untreated ones. Already weak batteries reach higher voltages again.

Optimised Charging Process

Due to higher capacity retention, batteries need less frequent recharging. They also charge about 14% faster and require 20% less current. The storage efficiency is thereby improved and the system is able to react more swiftly to generation peaks.

Less Sensitive to Extreme Temperatures

Although heat and extreme cold are among the most detrimental factors for battery performance, BESS are often housed in containers that hardly offer protection against ambient temperature. Batteries treated with Crystal Control Technology® have demonstrated improved stability and a longer life span under extreme climatic conditions ranging from -20°C to +50°C.

Balancing Effect

When batteries are connected in series without a battery management system, they often show strong variations in terms of energy output and discharge time. The technology has a balancing effect, which results in a homogeneous power supply and protects battery banks against the negative effects of charge imbalance.

Reduced Downtime

Crystal Control Technology® reduces the harmful effects of deep discharge and undercharge by actively renewing the battery's reaction site. This makes batteries more reliable and minimizes downtime.

Good for the Environment

Longer lasting batteries cause less waste and greenhouse gases. CO_2 emissions from battery production and recycling are thus reduced by 67% in addition to fewer emissions caused by maintenance, logistics and the like. This is how Crystal Control Technology® helps companies minimize their ecological footprint.

Find out more about
Crystal Control Technology®

Higher Cost-Efficiency for Lead Acid Batteries

Although lithium and lead acid are the most frequently employed battery types in energy storage, they differ greatly in terms of costs as well as cycle life. Crystal Control Technology® however, gives lead acid batteries a competitive edge.

Large-Scale Energy Storage

Since operating conditions like temperature or grid stability vary decisively, batteries for larger energy storage systems are especially tailored to the application. The costs and life span are accordingly very different.

Battery systems are best compared on the basis of energy costs measured in kilowatt-hours per charge cycle. This value is calculated by dividing the investment cost by the system's capacity, which is in turn divided by battery life cycle. A direct comparison of lead acid and lithium batteries reveals that lower acquisition costs compensate a higher number of cycles. The energy costs for both systems are about the same. Lead acid batteries are only half as expensive, but have to be replaced twice as often as lithium batteries.

COMPARISON OF THE COSTS OF ENERGY STORAGE*

	Lead acid	Lithium
Acquisition cost	€ 8,900	€ 18,900
Energy capacity	7.2 kWh	8 kWh
Life cycle	2,800 Zyklen	6,000 Zyklen
Costs/stored kWh/cycle	€ 0.44/kWh	€ 0.39/kWh

Paradigm Shift

The use of Crystal Control Technology® tips the balance towards lead acid batteries, since it makes them last twice as long, which is nearly as long as lithium batteries. This reduces energy storage costs per kilowatt-hour by 50%, which is also about half the cost of the lithium system.

* Source: IRENA, Battery Storage for Renewables: Market Status and Technology Outlook. January 2015

COSTS OF ENERGY STORAGE WITH CRYSTAL CONTROL TECHNOLOGY®

	Lead acid	Lithium
Acquisition cost	€ 8,900	€ 18,900
Energy capacity	7.2 kWh	8 kWh
Life cycle	**5,600 Zyklen**	6,000 Zyklen
Costs/stored kWh/cycle	**€ 0.22/kWh**	€ 0.39/kWh

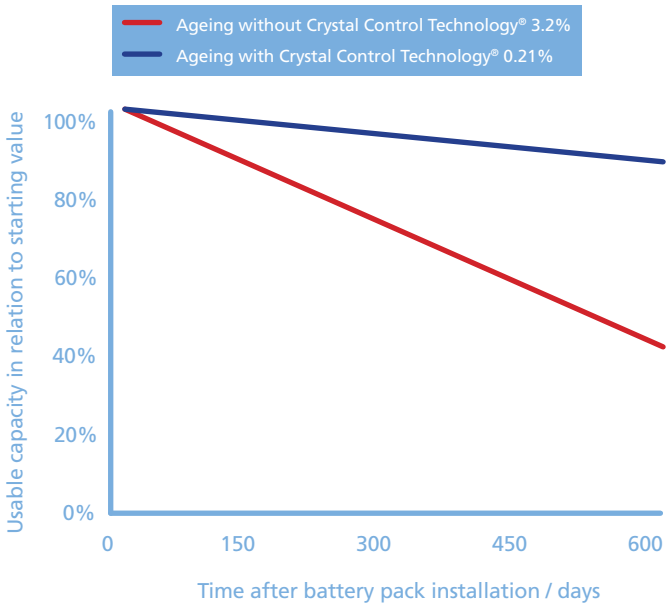
The above calculation considers only the savings resulting from doubled battery life span, which amount to at least 50%. Over time, however, up to 300% more energy is available due to improved capacity retention and output. The actual savings potential accordingly lies between 50 - 75% per kilowatt-hour.

WaveTech's Crystal Control Technology® is applied in the company's BEAT© product series. Their compact size and flexible connecting cables make the devices an easy-to-install add-on for lead acid batteries.

Verifiable Life Time Increase

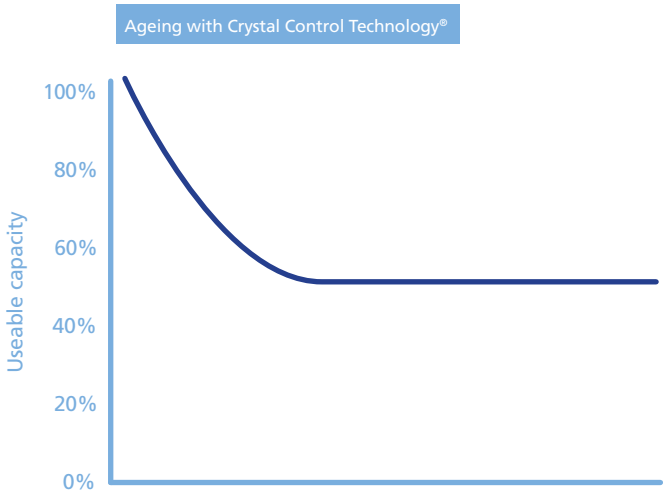
Crystal Control Technology® has proven effective in field tests across a wide range of applications. Under real life conditions, the technology even surpassed expectations, as was the case with back-up batteries in an Uninterrupted Power Supply.

Under adverse conditions such as extreme heat and frequent, strong grid fluctuations, the batteries had to be replaced every 2.5 years on average. After only two months of treatment with Crystal Control Technology®, the batteries began to show a higher capacity retention. Within 12 months, the ageing rate had dropped from 3.2% to 0.21%. The useful life was not only doubled, but had actually increased ten-fold.



Improved Charge Acceptance

While some benefits only become visible over a longer period of time, improvements in charge behaviour can be observed from the beginning. The batteries in the above-mentioned application accepted 7% higher voltages. Charging therefore required less time and 20% less energy. This is beneficial for energy storage, since the batteries can absorb generation peaks more swiftly. It also increases storage efficiency, because less energy is lost in the process.



Energy Storage with Used Batteries

Space requirements are of lesser importance in large-scale energy storage—what counts is the cost. Crystal Control Technology® opens up new research potential in this regard, because treated batteries typically cease to age at about 45% rest capacity. They maintain this level for an indefinite period of time.

After three years of use, back-up batteries had reached between 40% and 60% rest capacity. With the help of Crystal Control Technology® they have remained on this level for over a year now without losing further capacity. They are still in operation and the observations suggest that treated batteries stop ageing at a certain point. Lead acid batteries with a life span of 20 years or more become possible under this premise.

Equipping BESS with used batteries would require more, but much cheaper batteries. Another option would be a recycling concept where the re-use of scrapped batteries could be turned into profit. In many applications, batteries are replaced at 50 - 60% rest capacity. Instead of paying dearly for scrapping the batteries, companies could for a minor fee dispose of them to be re-used in energy storage. Together with the immense savings potential, the findings encourage further research in this field.

Crystal Control Technology®—
A Game Changer in Lead Acid Energy Storage Systems

- Doubled life span gives lead acid a competitive edge over lithium by reducing battery costs by 50%
- Faster charging at lower energy consumption accelerates reaction time and increases storage efficiency
- A capacity level at which battery ageing comes to a halt, opens up unforeseen possibilities in terms of useful life and profitability

For the Best Connection

Contact our experts at WaveTech for more information on our technology and products. We will be happy to advise you according to your special requirements!

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WAVETECH®

WaveTech was founded in 2003 with the ambition to take battery efficiency to a higher level. Expert knowledge and innovative strength paved the way for the development of Crystal Control Technology®, which forms the basis for the BEAT© product family. With a clear focus on research and quality, the German-based company provides solutions for a broad range of battery applications in the telecommunications, automotive, power storage and other sectors