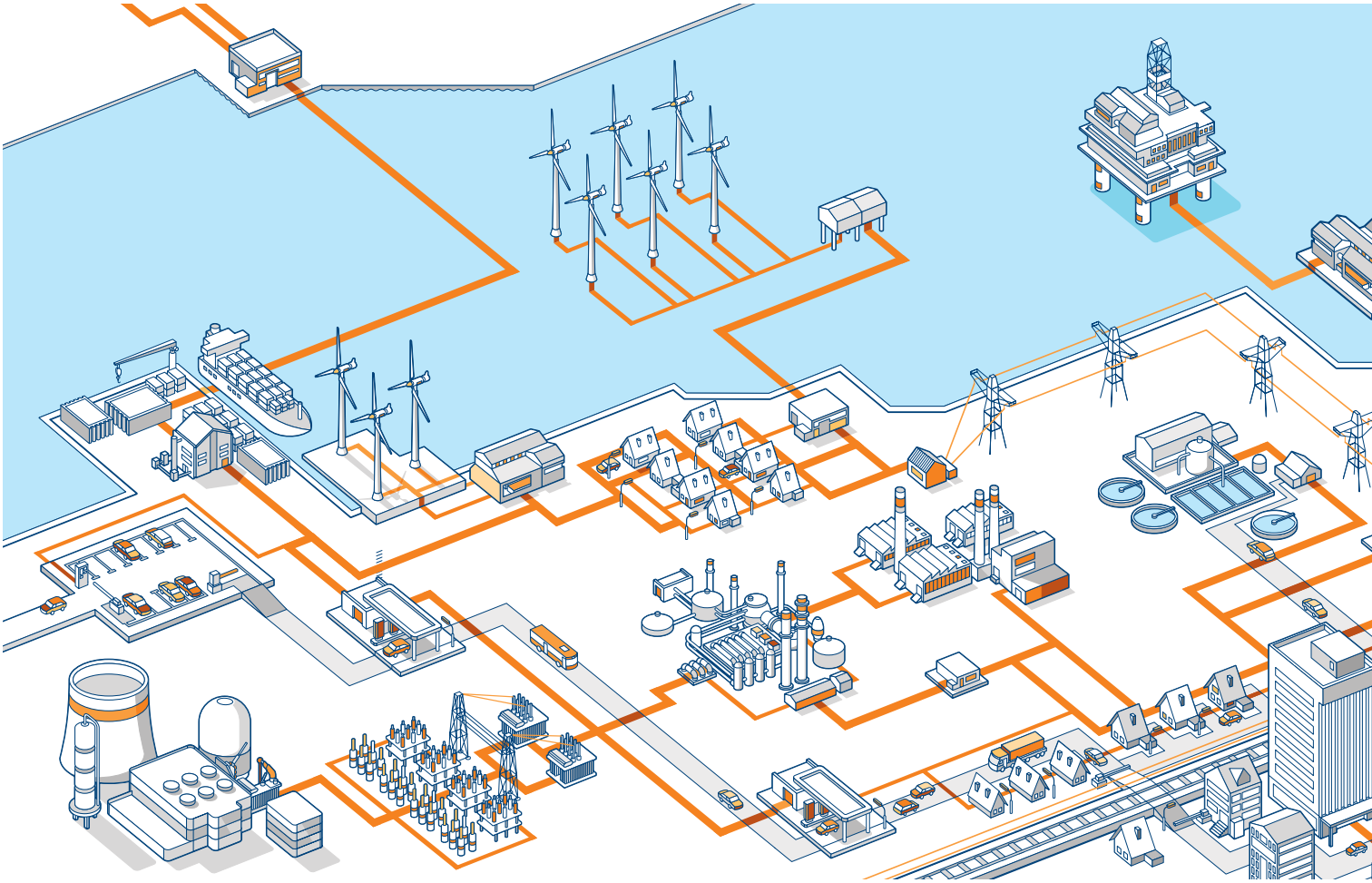
Overview brochure

Energy Storage
Keeping smart grids in balance

Power and productivity
for a better world™

Reliable power, where and when it's needed



Energy storage is not a new concept in itself. It has been an integral component of electricity generation, transmission and distribution systems for well over a century. Traditionally, energy storage needs have been met by the physical storage of fuel for fossil-fuelled power plants, by keeping some capacity in reserve and through large scale pumped hydro storage plants.

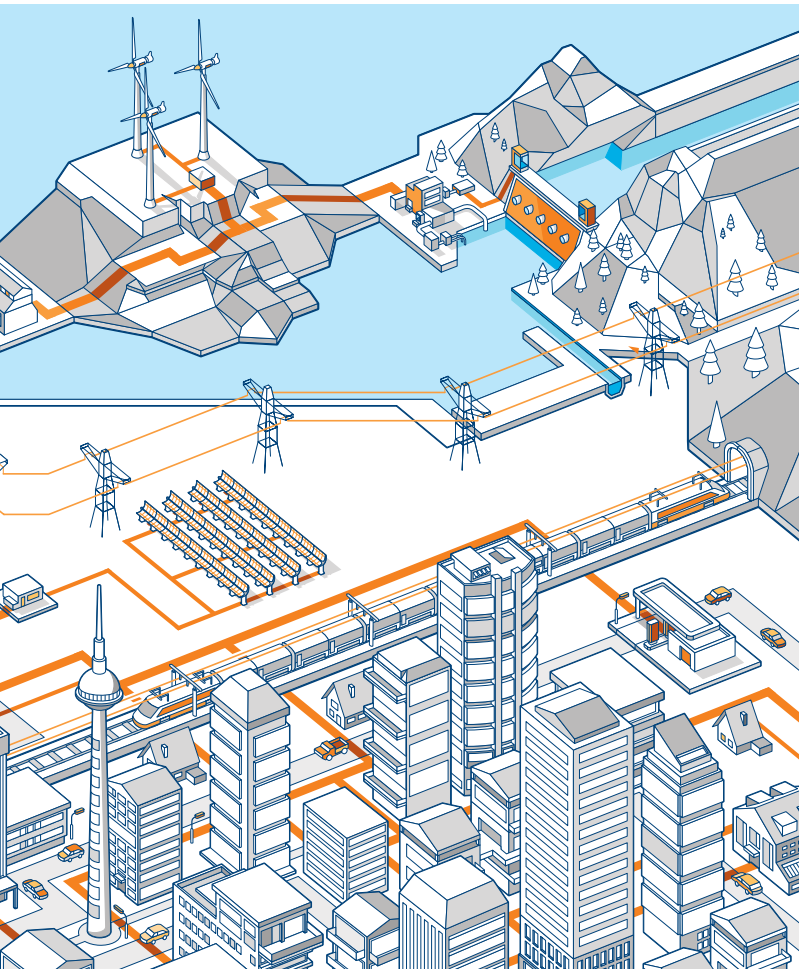
But now the power landscape is changing dramatically with a move to 'fuel-free' power, mainly in the form of wind and solar photovoltaic (PV). This shift to renewable sources is good for the environment and sustainability. However, it also makes delivering power reliably where and when it's needed a bigger challenge than ever before. Since there is no fuel to store, the grid must adapt to store electrical energy efficiently after it is generated.

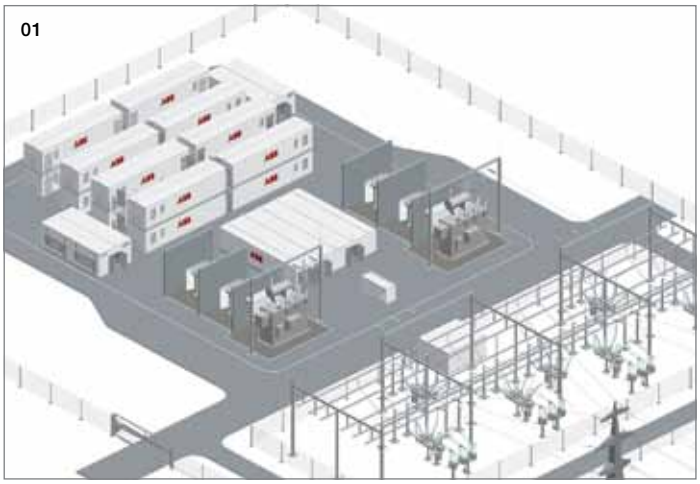
Wind and solar power installations generate power only intermittently and with a highly variable output. Furthermore, unlike a traditional centralized generation plant, these new sources may be located anywhere on the grid, perhaps close to the load centers they serve, dispersed across the network, or even in remote locations far offshore or in deserts.

Such fundamental changes in the architecture and controllability of the grid call for smart, efficient power transmission and distribution networks. And they require the storage of energy at appropriate times and locations – both to balance the 'ebb and flow' between generation and consumption and also to maintain grid stability.

Increasing the use of traditional methods of building storage capacity into the grid – fossil-fuelled peaking plants or providing spinning reserve – would reduce the very environmental benefits that renewable power sources are intended to bring.

That's why energy storage is becoming a key component of smart grids.





The right energy storage solution for the job

ABB's track record in the delivery of energy storage solutions goes back over 100 years, to the very first pumped hydropower schemes. And we have over a decade of expertise in implementing battery energy storage systems. That breadth and depth of experience enables ABB to offer the ideal efficient and reliable energy storage solution for a wide variety of applications – ABB offers a range of energy storage technologies, covering every power requirement from tens of kilowatts up to hundreds of megawatts.

For bulk-level grid storage, ABB offers advanced converter technology as well as control systems and electrical balance of plant (EBoP) to maximize the flexibility and efficiency of pumped hydro storage plants, which are experiencing a renaissance with plants being built or upgraded around the world.

For distributed grid storage, ABB offers battery energy storage systems that integrate seamlessly into the power network. They are designed and developed independent of battery technology. We employ a variety of battery technologies provided by a number of world-class manufacturers and even non-battery technologies such as flywheels and supercapacitors. This ensures that our customers get the perfect combination of energy storage and power technologies to match their application needs.

This flexible approach includes:
– Consulting and grid studies
– Turnkey battery energy storage facilities
– Pre-designed energy storage modules
– Standalone energy storage converters

01 Configuration for a 20 megawatt (MW), 20 megawatt-hour (MWh) battery energy storage system with high voltage connection I 02 ABB PCS8000 converter/variable speed drive for pumped hydro storage

Energy storage for every application

ABB has energy storage systems to fit every grid application, whether individually, across multiple applications, or as one of many assets managed as an integral part of the grid.

The basic role of energy storage is the same across all applications: to absorb energy generated at one time and to discharge it to supply power at a later time. However, the choice of storage medium for each application is strongly influenced by the required power rating and the duration for which it may need to continuously charge or discharge.

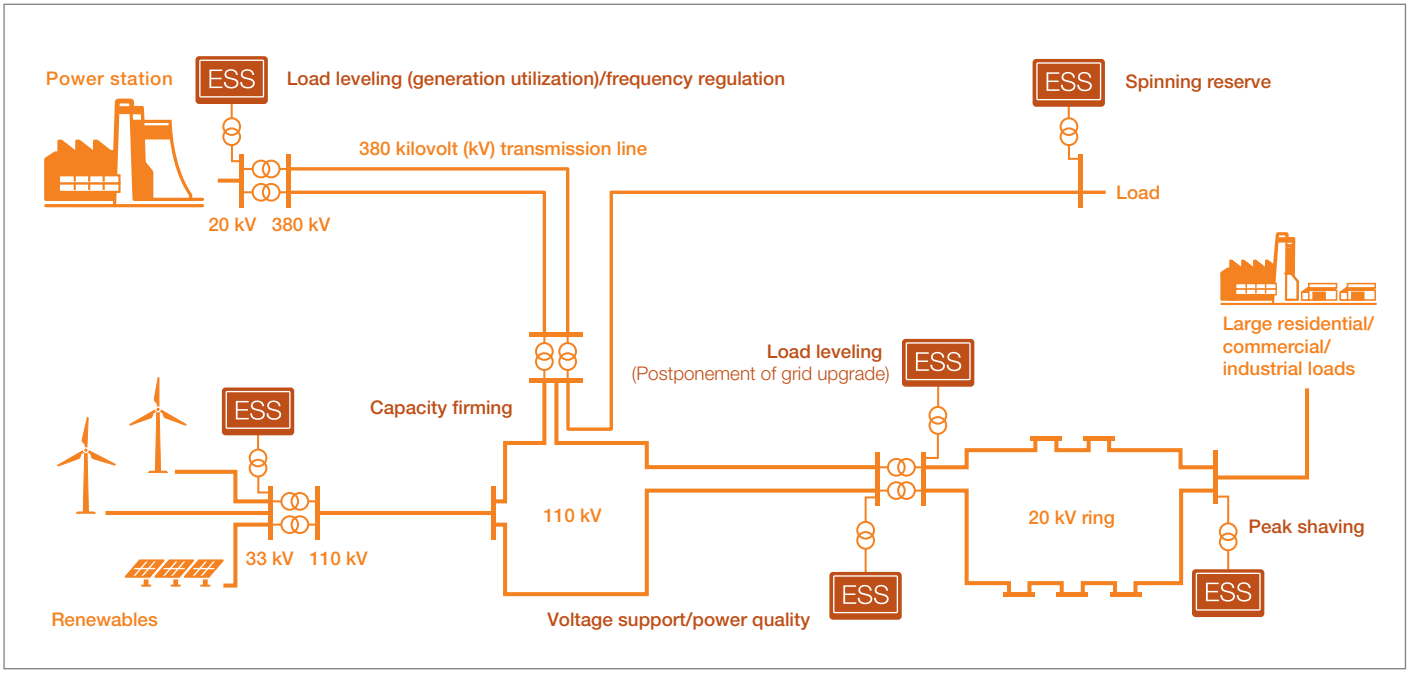
The typical grid energy storage applications are summarized on the following pages.

Frequency regulation

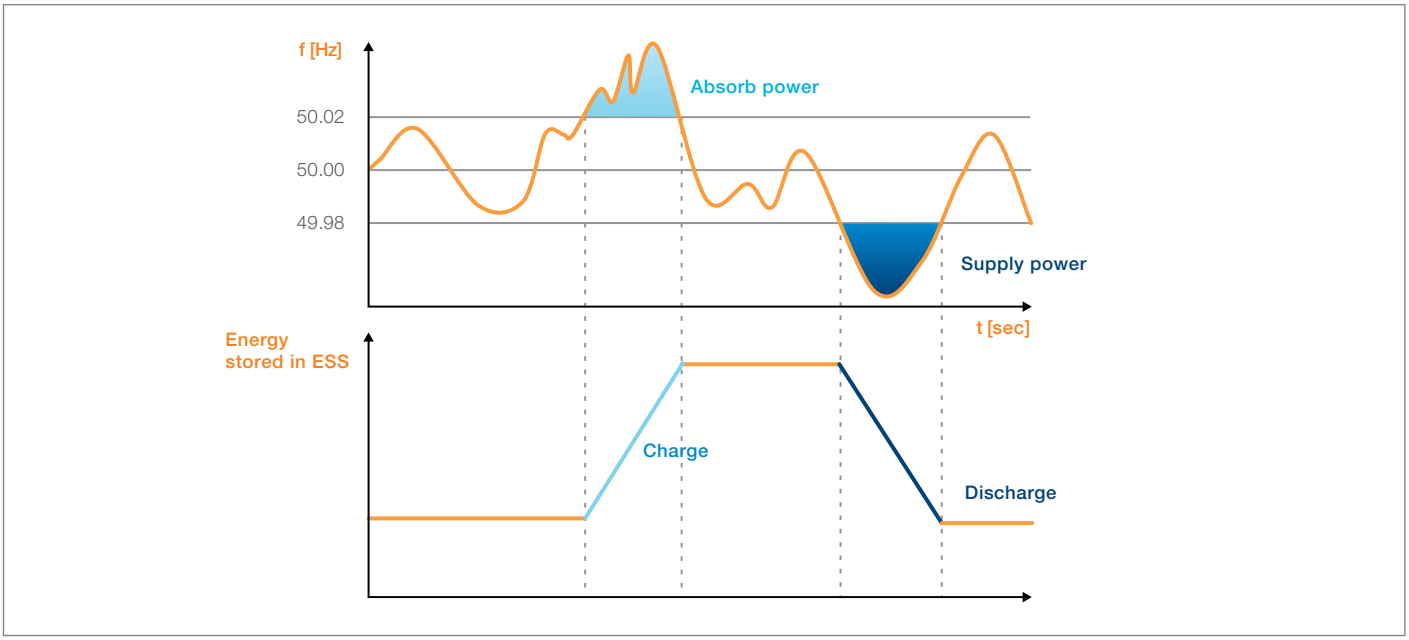
The energy storage system is charged or discharged in response to an increase or decrease, respectively, of grid frequency. This approach to frequency regulation is a particularly attractive option due to its rapid response time and emission-free operation.

Spinning reserve

To provide effective spinning reserve, the energy storage system is maintained at a level of charge ready to respond to a generation or transmission outage. Depending on the application, the system can respond within milliseconds or minutes and supply power to maintain network continuity while the back-up generator is started and brought on line. This enables generators to work at optimum power output, without the need to keep idle capacity for spinning reserves. It can also eliminate the need to have back-up generators running idle.



Typical grid energy storage applications



Frequency regulation

Power quality

In power quality applications, an energy storage system helps protect downstream loads against short-duration events that affect the quality of power delivered.

Capacity firming

The variable, intermittent power output from a renewable power plant, such as wind or solar, can be maintained at a committed (firm) level for a period of time. The energy storage system smoothes the output and controls the ramp rate (MW/min) to eliminate rapid voltage and power swings on the electrical grid.

Load leveling

Load leveling usually involves storing power during periods of light loading on the system and delivering it during periods of high demand. During these periods of high demand the energy storage system supplies power, reducing the load on less economical peak-generating facilities. This allows for the postponement of investments in grid upgrades or in new generating capacity.

Voltage support

An energy storage system can help to maintain the grid voltage by injecting or absorbing both active and reactive power.

Peak shaving

Peak shaving is similar to load leveling, but may be for the purpose of reducing peak demand rather than for economy of operation. The goal is to avoid the installation of capacity to supply the peaks of a highly variable load. Peak shaving installations are often owned by the electricity consumer, rather than by the utility.

Benefits:

- Commercial and industrial customers save on their electricity bills by reducing peak demand
- Utilities reduce the operational cost of generating power during peak periods (reducing the need for peaking units)
- Investment in infrastructure is delayed due to the flatter loads with smaller peaks

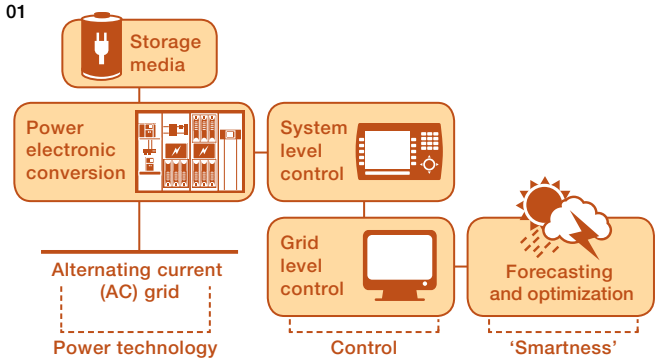
Delivering energy storage for smart grids worldwide

No two energy storage applications are the same. ABB has comprehensive knowledge of the demands of the grid and each of the storage technologies available, to help power utilities make the right choices. We offer consultancy, design, service and support services on a global scale to help customers derive maximum operational benefits and return on their investment.

Building an efficient, reliable and durable grid energy storage system demands a range of technologies and competencies – from storage media and power electronic conversion, through system- and grid-level control, to smart forecasting. ABB can provide all of these from a single source.

ABB has implemented all the enabling technologies for energy storage in live grids around the world. The examples presented over the next few pages are just a small sample of the scope of applications, advantages and benefits of our technology and expertise in real-world energy storage installations.

01



02

Storage media

Selecting the right storage medium for an application requires deep understanding of the functional demands on the storage system, as well as the demands this system places on the grid. There is no one-size-fits-all option.

Our combination of a comprehensive knowledge of the particular advantages and disadvantages of each energy storage technology and of the behavior of the grid enables ABB to make the right selection.

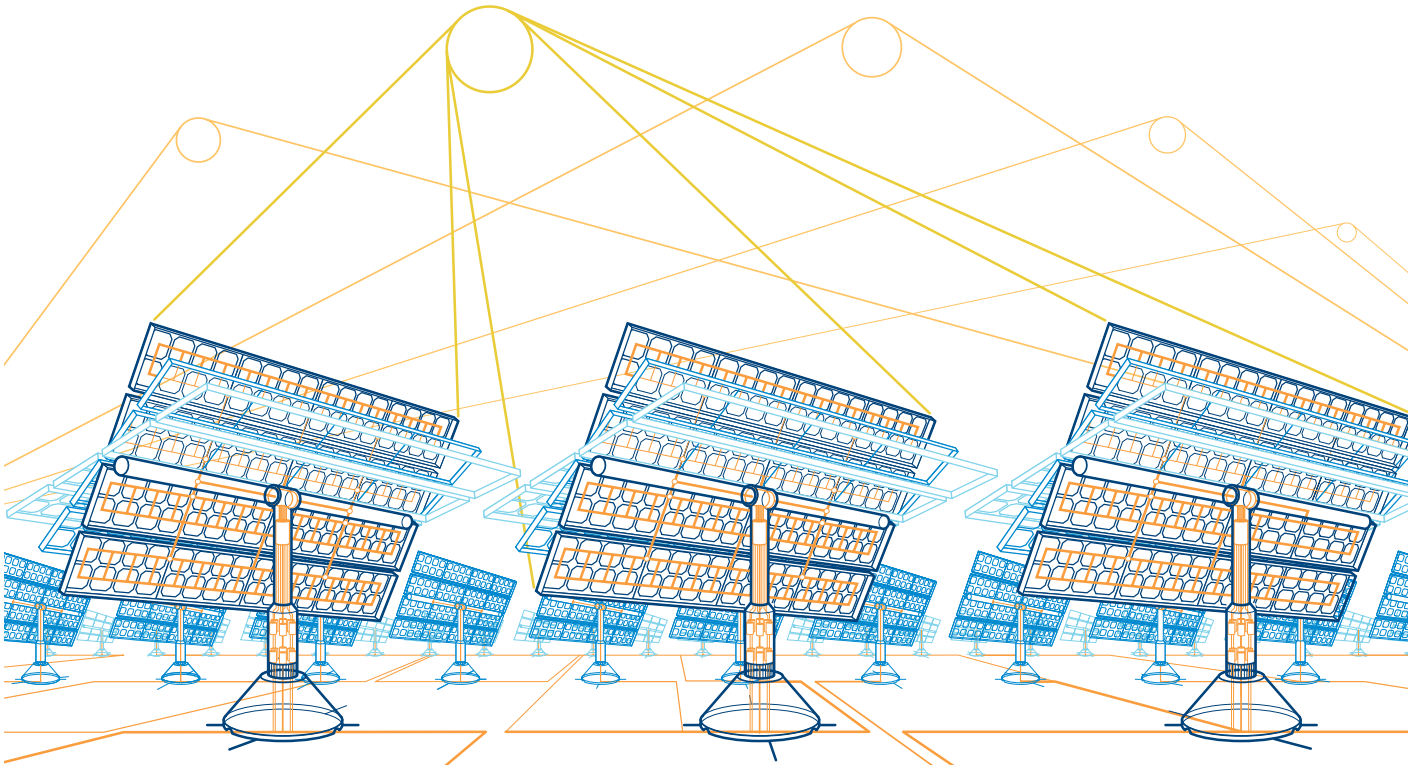
Spinning reserve solution provides back-up electricity in Alaska

The Golden Valley Electric Association (GVEA) operates and maintains around 5,000 kilometers (km) of transmission and distribution lines and 35 substations in the Alaska region.

ABB applied battery storage technology to create a spinning reserve solution that provides back-up electricity for GVEA when necessary.

In 2003, we commissioned a power converter system solution, using nickel-cadmium batteries, to supply power at 27 MW for 15 minutes or 46 MW for 5 minutes, which allows ample time for local generation to come online.

Alaskan winters frequently experience temperatures that fall as low as -52 °C, so our battery energy storage solution was also specifically designed to operate reliably at these extremely cold temperatures.



01 ABB is a single source provider of expertise and systems for energy storage | 02 Spinning reserve solution provides back-up electricity in Alaska | 03 Switzerland's largest battery energy storage project | 04 Battery energy storage increases the role of renewables in Sweden

Switzerland's largest battery energy storage project

ABB recently commissioned the largest battery energy storage project of its kind in Switzerland with EKZ, a leading distribution utility and one of the largest energy companies in Switzerland.

To enable additional power to be provided to the grid on demand, ABB supplied and installed a battery energy storage solution using Lithium-ion (Li-ion) batteries that can provide one megawatt of power for 15 minutes.

The storage facility is integrated into EKZ's power distribution network and is being used to evaluate performance in key areas such as balancing peak loads and intermittent power supply, and the viability of the solution for grid optimization.

Battery energy storage increases the role of renewables

Falbygdens Energi is a Swedish utility which already has a significant proportion of wind power connected to the grid in the Swedish city of Falköping.

ABB was selected to supply an innovative dynamic energy storage solution for the utility's power distribution network, to maximize the integration of renewables into the power chain.

For this project, we utilized our battery energy storage expertise to store locally produced energy from wind turbines to create a storage capacity of 75 kilowatt (kW) in cycles of up to 60 minutes. The stored energy will then be used to stabilize the grid and help balance peak loads during the day.

This project is a key step in evaluating the role of energy storage technology and the further integration of renewable energies and evolution of smarter grids. The solution will also be used to investigate the feasibility of deploying the stored energy as auxiliary power for the charging of electrical vehicles.

Power electronic conversion

Most energy storage technologies – including batteries, capacitors and super-capacitors – are based on direct current (DC). To connect these storage media to the alternating current (AC) grids mainly used for power transmission and distribution requires a conversion step, using power electronics.

Even energy storage technologies that are natively AC – such as pumped hydro and flywheels – rely on power electronics to integrate them optimally into an AC grid.

ABB has an outstanding track record in delivering power electronics systems that combine excellent performance with instantaneous response to create the stable interface essential to integrate energy storage media into the AC grid. Constructing a stable electrical connection between the power electronics and the grid then calls for a range of key technologies and competencies, from circuit breakers and transformers through simulation of harmonics in the grid, all of which ABB offers.

Dynamic energy storage installation in the UK

ABB recently worked with UK Power Networks, which supplies power to over eight million homes and businesses in the UK, to develop a dynamic energy storage solution. The installation enables renewable energy generated by local wind power plant to be fed into the power network when needed. It also ensures that some of the energy is kept in reserve to regulate power flow to compensate for the intermittence of wind power and to support power quality in the event of a fault.

To meet these needs, ABB implemented a turnkey DynaPeaQ® solution incorporating SVC Light®, which included eight stacks of 13 Li-ion battery modules located in an 11 kV grid. Together, these high power density modules can store up to 200 kilowatt-hour (kWh) of electrical energy.

The installation provides dynamic voltage control in the distribution system and, at the same time, enables dynamic storage of surplus energy from the wind power plant. This surplus energy is used to level out peaks in grid loading to provide grid stability.

Dynamic energy storage installation in the UK

System-level control

Once they are electrically connected into the grid, energy storage systems require effective control. Today's solid-state power electronics can respond almost instantly to commands. Exploiting this capability demands controllers that react with the same speed. With the right infrastructure in place, the logic and the algorithms to determine the right command can be implemented.

ABB has a range of control hardware and software to suit all energy storage applications. These range from distributed control systems (DCS) for applications such as microgrids to dedicated power generation control systems for pumped hydro storage plants.

Remote-controlled pumped hydro storage system in China

ABB provided the electromechanical package for the 4 x 250 MW remote-controlled Yixing pumped hydro storage plant, which was commissioned in 2007 to help boost the overall efficiency of the power sector in Jiangsu province in China.

The ABB solution included control and protection systems, electrical balance of plant, including MV switchgear, generator circuit breaker, isolated phase bus, excitation systems, static frequency converter, cabling, 500 kV gas-insulated switchgear and low-voltage switchgear.

The result is a completely automated solution with remote control from two dispatch centers, together with fully integrated control, protection and electrical systems.

Pumped hydro storage system

Grid-level control, forecasting and optimization

The benefits of grid energy storage systems can only fully be realized grid-wide if they are managed in concert with all other generation, loads and storage systems. Sophisticated approaches are needed to pull together the smaller, distributed energy storage systems into virtual power plants that a grid level generation management system can manage in conjunction with all the other power plants on the grid.

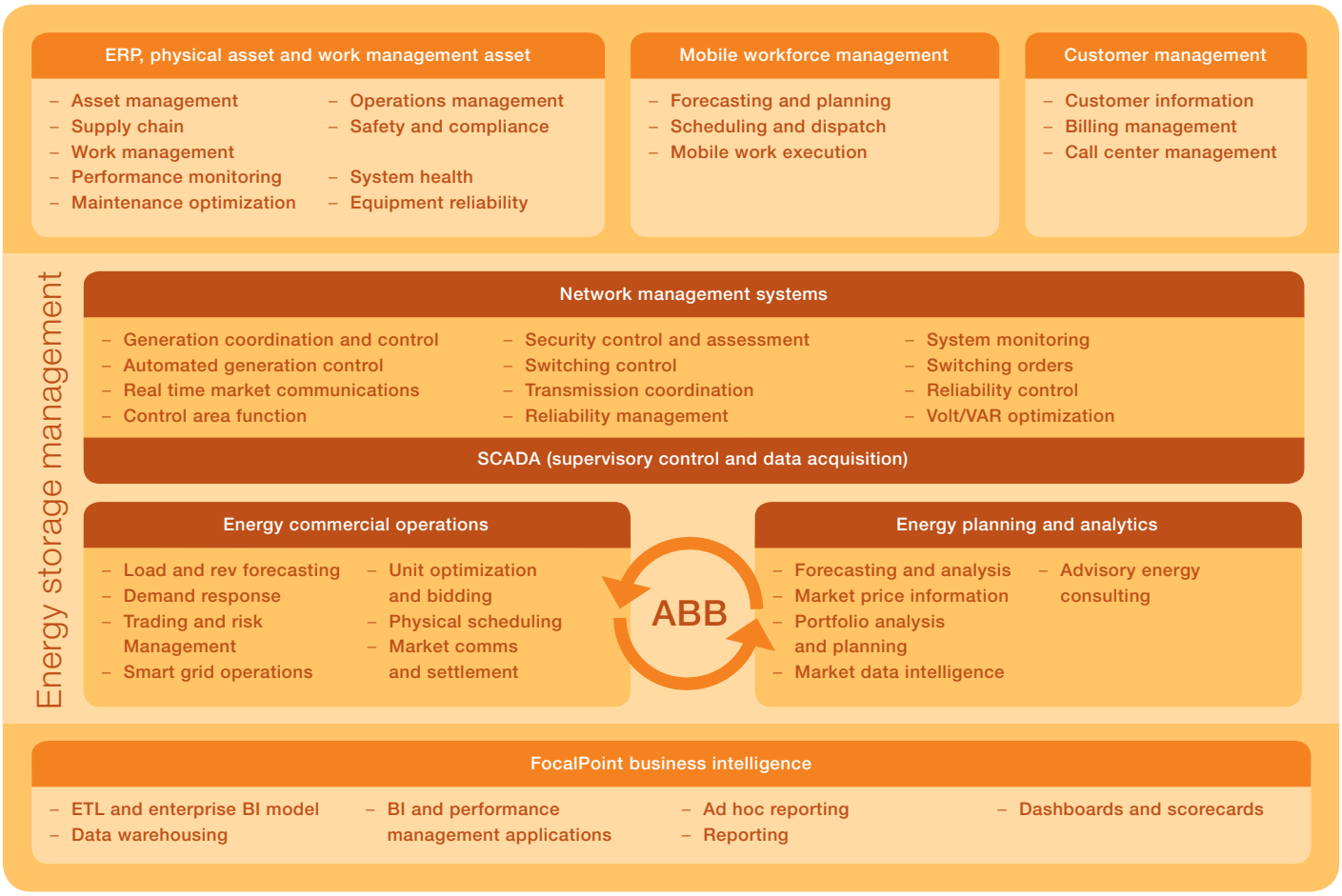
Furthermore, as the proportion of intermittent, variable power generation increases, the ability to accurately forecast the generation capacity – along with loads – is becoming essential. Forecasting the state of such a complex system, with the vast number of dependencies and interdependencies, from weather to energy prices, calls for new levels of intelligence offered by a neural network solution, provided by Ventyx.

Accurate forecasting, along with modeling the constraints of energy storage, the distribution network and the market, allows for optimum use of energy storage across the grid, ensuring that the right level of energy is stored at the right time, and maximizing the value of the energy storage. Optimization of this sophistication requires modeling the complex hierarchy and constraints of both intermittent generation assets and energy storage assets, using the latest advances in mathematical programming techniques, provided by Ventyx's optimization engine

Demonstration energy management system in Germany

In Trier, Germany, ABB is partnering with the city's university and the infrastructure and energy services provider for the region, Stadtwerke Trier, in a pioneering energy management system project. This project will demonstrate the ability of the management system to integrate renewables, energy storage, combined heat and power (CHP) systems and electric vehicles into the grid.

Ventyx (an ABB company) solution map



Energy storage – solutions for today and tomorrow

ABB is making energy storage a practical reality today

Understanding all of the key elements of the power landscape and how they fit together is the key to defining an effective energy storage strategy for smart grids.

Not only does ABB have extensive power industry expertise, we also have the capability to develop and deliver the ideal system for virtually any energy storage application. Through this powerful combination we are transforming energy storage from a distant dream into commercial solutions, ready to deploy now.

With a 125 year heritage of technology and innovation and a presence in over 100 countries, ABB continues to shape the grid of the future, delivering power and productivity for a better world.

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