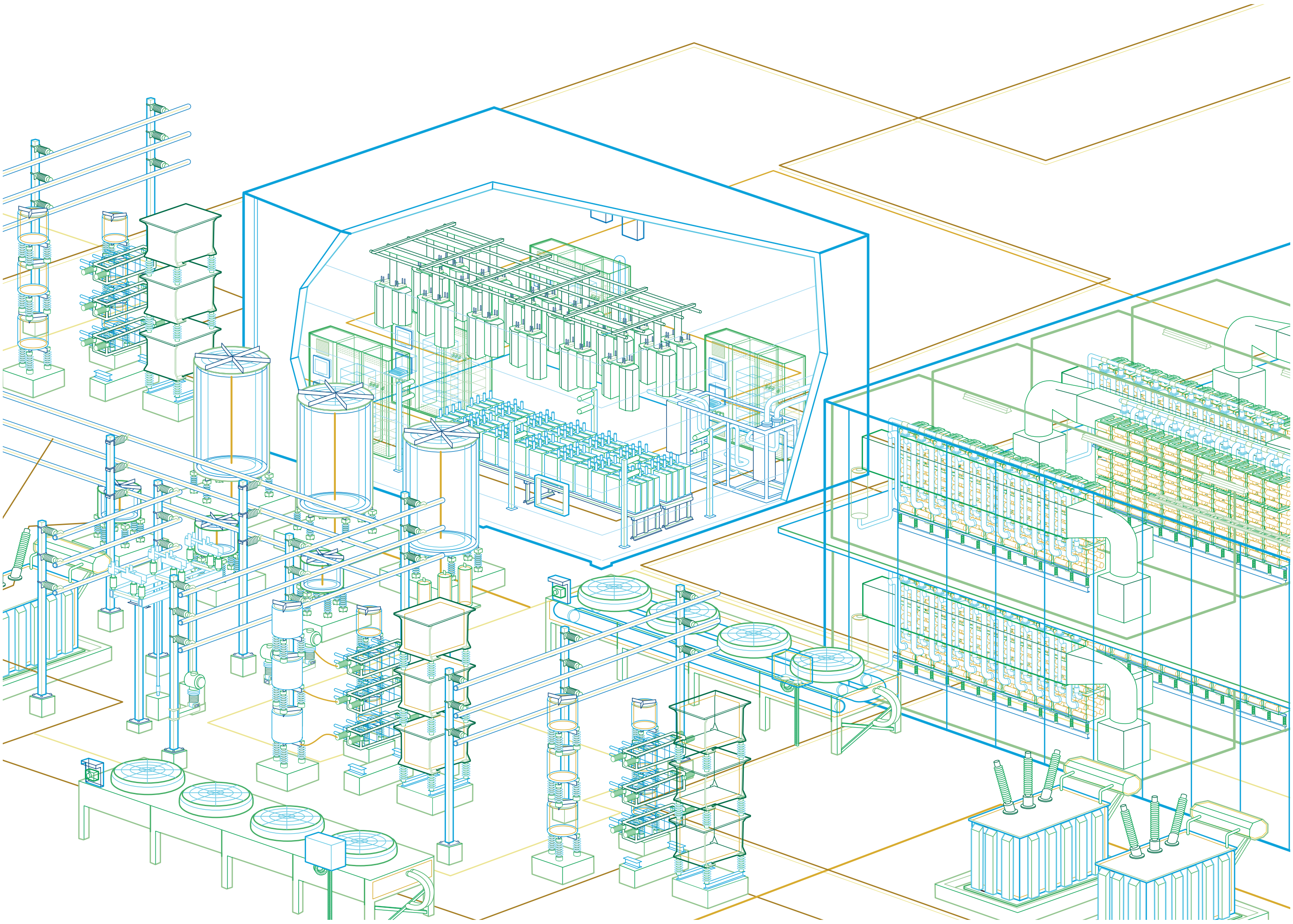
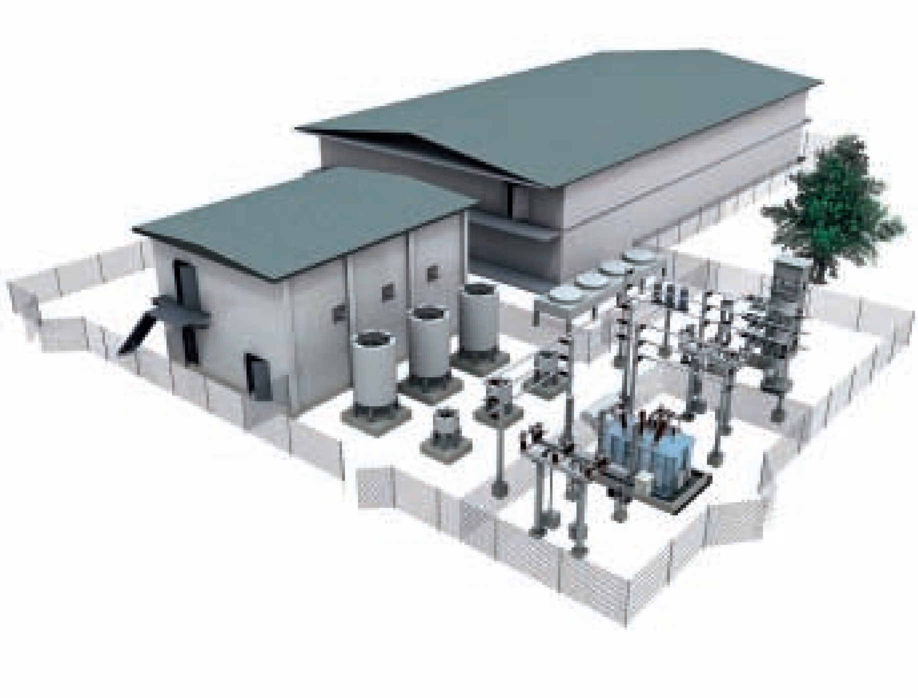


Storage for stability

The next FACTS generation

ROLF GRÜNBAUM, PER HALVARSSON – One of the challenges of a smart grid is ability to cope with intermittent and variable power sources. But this is a must, since power sources such as wind and solar are becoming increasingly important. ABB is meeting this challenge through its energy storage solutions. The newest member of the ABB FACTS family is one such solution, combining SVC Light® and the latest battery energy storage technology. This “marriage” of technologies enables the balancing of power to accommodate large amounts of renewable energy. Likewise, it can help improve stability and power quality in grids with a greater reliance on renewable generation.

1 An artist's view of an SVC Light® with Energy Storage installation. A typical rating of ±30 MVAr, 20 MW over 15 minutes will have a footprint of around 50x60 m.



As the prevalence of renewable power grows, increasing demand is being placed on maintaining grid stability and fulfilling grid codes. ABB's answer is SVC Light® with Energy Storage, a dynamic energy storage system based on Li-ion battery storage, combined with SVC Light ➔ 1. SVC Light is ABB's STATCOM [1] concept, which is connected to the grid at transmission as well as subtransmission and distribution levels. State-of-the-art IGBTs (insulated-gate bipolar transistors) are utilized as switching devices in SVC Light.

ABB's SVC Light with Energy Storage solution is designed for industry-, distribution- and transmission-level dynamic energy storage applications, focusing on those that require the combined use of continuous reactive power control and short-time active power support. The technology enables the independent and dynamic control of active as well as reactive power in a power system. The control of reactive power enables the subsequent control of grid voltage and stability with high dynamic response. With the control of active power, new services based on dynamic energy storage are introduced.

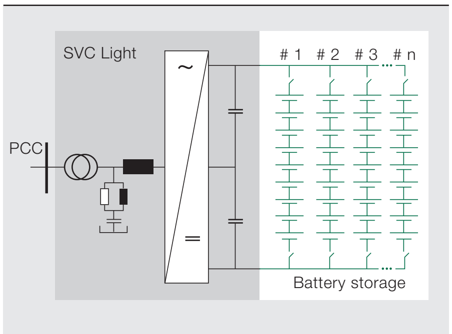
The energy storage solution can be used for load support as well as ancillary grid services, eg, regulating power frequency. Another promising use is as part of the infrastructure for PHEVs (plug-in hybrid electric vehicles). And its highly scalable ability to store energy is remarkable. At present, rated power and storage capacity are typically in the range of 20 MW; however, up to 50 MW for 60 minutes and beyond is possible with this new FACTS technology. And as the price of batteries continues to drop, applications requiring larger battery storage will become viable, enabling for example multi-hour storing of renewable power during low demand for release into the grid during higher demand.

Basic mechanisms

The energy storage system is connected to the grid through a phase reactor and a power transformer ➔ 2. SVC Light with Energy Storage can control both reactive power *Q* as an ordinary SVC Light, as well as active power *P*. The grid voltage and the VSC (voltage source converter) current set the apparent power of the VSC, while the energy storage requirements determine the battery size. Consequently, the peak active power of the battery may be smaller than the apparent power of the VSC; for instance, 10 MW battery power for an SVC Light of ± 30 MVAr.

As a contingency typically lasts for mere fractions of a second, the required backup power must be made available for only a short time. Similarly, an ancillary

2 Basic scheme of SVC Light with Energy Storage

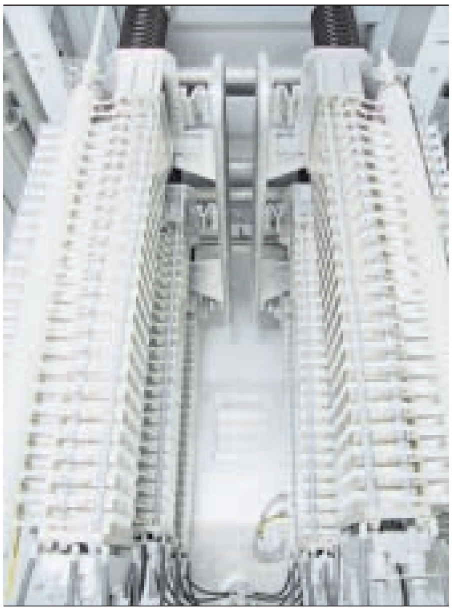


The technology enables the independent and dynamic control of active as well as reactive power in a power system.

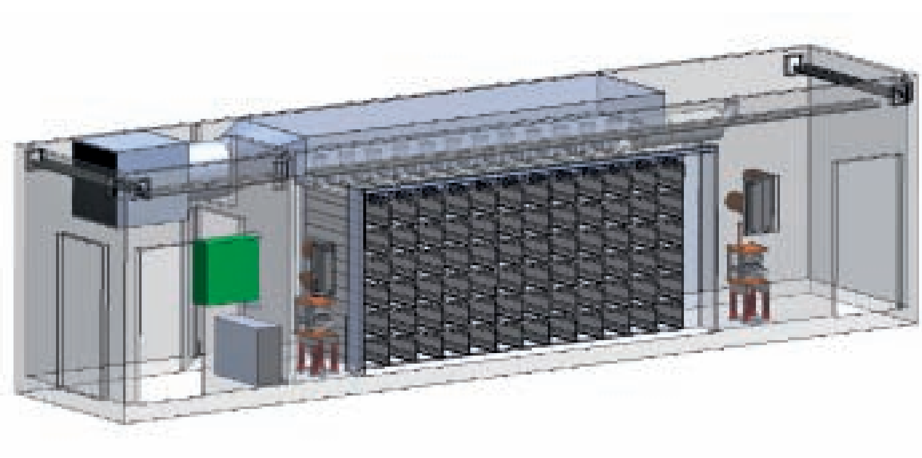
Footnote

1 STATCOM: Static synchronous compensator, a device similar in function to an SVC but based on voltage source converters.

3 VSC valve



4 Battery room



service like area frequency control will generally be needed for only a few minutes at a time. An energy storage system can then provide the necessary surplus of active power and later be recharged from the grid during normal conditions.

Main system components

A complete SVC Light with Energy Storage system is comprised of the following:
– Power transformer
– SVC Light
– Battery system
– AC and DC high-voltage equipment
– Control and protection system
– Auxiliary power equipment

The modularized design of the new energy storage technology makes it simple to scale, in power rating as well as energy. Its batteries and VSC are integrated, with detailed supervision and status checks of both within the same system. It focuses on safety and ensures the ability to respond to the consequences of possible faults. In addition, the solution boasts low losses and very high cycle efficiency.

The VSC is composed of IGBT and diode semiconductors → 3. To handle the required valve voltage, the semiconductors are connected in series. Water cooling is utilized for the VSC, resulting in a compact converter design and high current-handling capability.

Each IGBT and diode component is contained in a modular housing consisting of a number of submodules, each of which has multiple semiconductor chips (ie, ABB's StakPak™ semiconductors).

Battery system

Since SVC Light is designed for high-power applications, and series-connected IGBTs are used to adapt the voltage level, the pole-to-pole voltage is high. Therefore, a number of batteries must be connected in series to build up the required voltage level in a battery string. To obtain higher power and energy, several parallel battery strings may be added.

The battery system is made of rack-mounted Li-ion modules. An array of battery modules provides the necessary rated DC voltage as well as storage capacity for each given case. The Li-ion batteries have undergone thorough testing for the application in question [1]. A battery room is shown in → 4.

The Li-ion battery technology selected for SVC Light with Energy Storage has many valuable features:
– High-energy density
– Very short response time
– High power capability both in charge and discharge
– Excellent cycling capability
– Strongly evolving technology
– High round-trip efficiency
– High charge retention
– Maintenance-free design

Applications

Dynamic energy storage is finding uses in a multitude of areas. Not only can it support the black start of grids, it can also bridge power until emergency generation is online and provide grid support with an optimum mix of active and reactive power. This type of storage is an alternative to transmission and distribution reinforcements for peak load support, and enables optimum pricing. It becomes possible to reduce peak power to avoid high tariffs. Dynamic energy storage can also provide power quality control in conjunction with railway electrification, and help balance power in wind and solar generation, which have stochastic behavior.

ABB's dynamic energy storage system will be available in 2010.

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Reference
[1] Callavik, M., et al. (October 2009.) Flexible AC transmission systems with dynamic energy storage. EESAT 2009, Seattle, Washington, USA.