Battery energy storage
Optimize integration of renewable energy to the grid

Introduction

In today's power systems, growing demand, aging infrastructure and system constraints, as well as the increasing renewable energy portfolio, have amplified the need for utilities to find new ways to manage their system and improve reliability. One potential solution is what is commonly referred to as the "holy grail" of the industry -- energy storage.

The utility industry does not have a common warehouse or inventory of the product they produce. When a customer turns on a light switch or starts a large industrial motor, the power is consumed immediately from on-line generation. Until now, it has not been economical to store this power. The increased spotlight on renewable energy makes battery energy storage a practical option, and increasing production of electric vehicles is driving cost improvements that make battery storage a solution that is finally viable.

Renewable energy is in the political spotlight due to stimulus funding, environmental pressure, and other public policies, and such resources are being integrated into utility grids all over the world. Two of the most prominent types of renewable energy are solar (PV) and wind; however, because the sun disappears behind clouds and the wind fluctuates, renewable power is variable.

Battery Energy Storage Systems (BESS) can be applied to support the grid and help solve these issues created by increased penetration of renewable energy.

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BESS Renewable Energy Drivers

In the public eye, integrating renewable energy onto the utility grid may seem like an easy decision to make. Wind and solar resources are “free”, so it may appear that operating costs are negligible. However, the truth is that the grid operator has many obstacles to overcome, such as:

– State mandated renewable portfolio standards dictate the minimum percentage of generation to be supplied from renewable energy sources. Additionally, he more saturated the grid is with renewable energy, the more volatile the energy supply.

– Thermal and hydro generation are designed to operate continuously and deliver consistent power to loads. This is called dispatchable power, meaning the generator can be turned on and off as needed. Wind and solar energy sources are not dispatchable, simply because the wind does not always blow and sun does not always shine. Figure 1 shows the generation profile of a solar farm on a cloudy day and the variability of the generation capacity.

– Another issue with renewable energy, is that typically the generation capacity profile and the demand profile are not aligned. Figure 2 shows the generation profile of a solar farm and the winter demand profile in Florida. The peak load is at 7 AM and the peak solar output is at 1 PM.

– Because of the two prior issues, base-load plants cycle to “fill in” when needed to support the system. This increases maintenance requirements and emissions, and decreases efficiency. Base-load plants were not designed to cycle and be subjected to related thermal stresses – they were designed with constant output ratings.

– Coal-fired plants are under environmental scrutiny. Older coal plants will be retired rather than benefit from capital spending for new emission control equipment. This eliminates the steady base-load generation on the system.

– Wind and solar sites are not located where power is used, so extra transmission capacity is needed.

Energy storage, and specifically battery energy storage, is an economical and expeditious way utilities can overcome these obstacles.

Figure 1: Courtesy of Frank Barnes – University of Colorado at Boulder

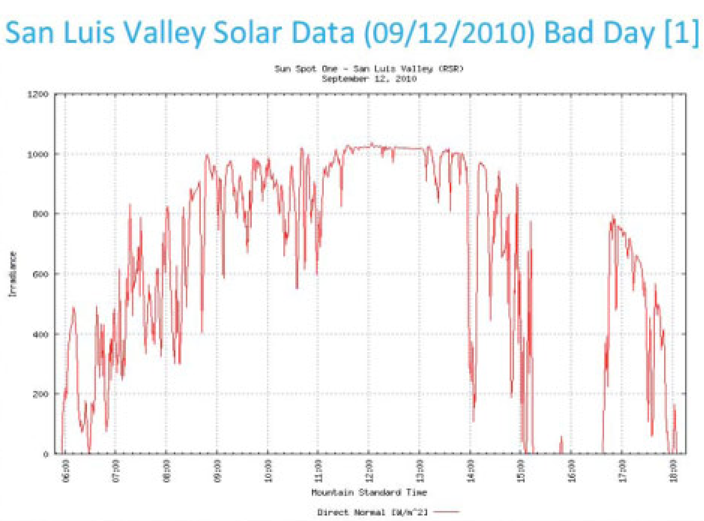
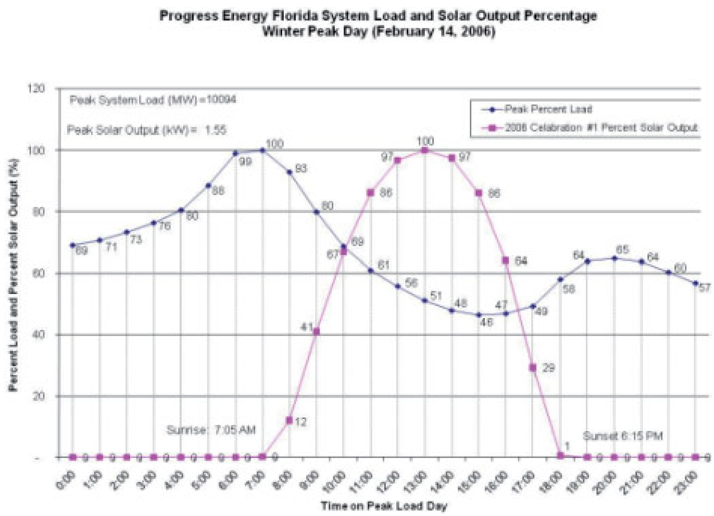


Figure 2: Courtesy of George Gurlaskie – Progress Energy



BESS Applications with Renewable Resources

Battery energy storage solutions (BESS) store energy from the grid, and inject the energy back into the grid when needed.

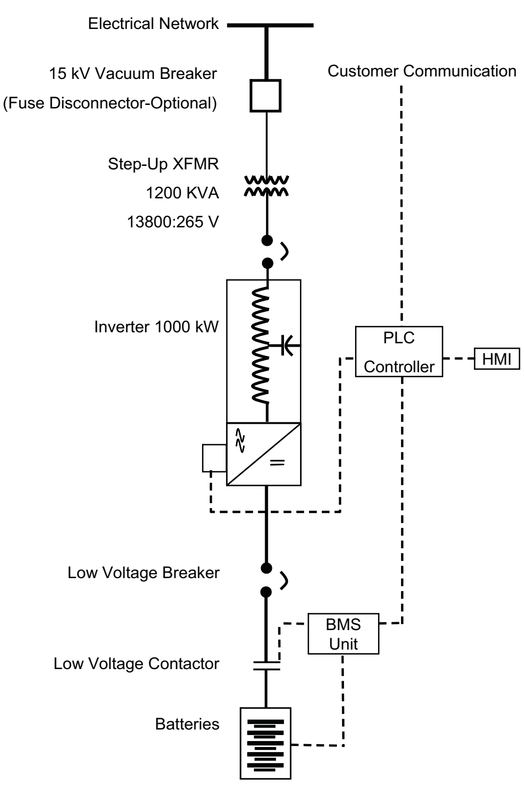
This approach can be used to facilitate integration of renewable energy; thereby helping aging power distribution systems meet growing electricity demands, avoiding new generation and T&D infrastructure, and improving power quality and reliability. The demand for battery energy storage solutions will grow as the benefits of their implementation on the grid are recognized.

A BESS is an integrated solution for storing energy for use at a later time. It contains all components required to store energy and connect onto the grid:

a. Connection breaker/switch
b. Step-up transformer
c. AC/DC protection equipment
d. Inverter
e. Batteries
f. Battery management system

Figure 3 shows a typical single line diagram of an integrated solution.

Figure 3: Typical one line diagram for a three-phase system



A BESS can perform the following applications to facilitate the integration of these renewable generation resources into the grid:

– Load shifting - time of use management: Altering the pattern of energy use so that on-peak energy usage is delivered from energy that has been stored in off-peak periods. The use of BESS for this application effectively shifts renewable generation to peak times.

– Renewable generation smoothing and transient support: Allows use of an intermittent electric supply resource to serve as a reliable power source. BESS used for this application can help increase the capacity factor of the solar or wind generation in the area. It can also be used to ensure wind farm ramp-rates (MW/min) are kept to within design limits and eliminate rapid voltage and power swings on distribution systems where high-penetration levels of solar systems are found.

– Controlled Ramp Rates: BESS to maintain power until alternative power is brought online (or until dispatchable load is disconnected). This would avoid a power system collapse when renewables are quickly dispatched from the network.

– Ancillary Services: BESS can be the balance between supply and demand. Because BESS has the ability to supply both active and reactive power, it can support frequency and voltage of the grid. The BESS can perform load following, where the generation will follow the demand up or down instead of making a baseload plant cycle, thus decreasing emissions and increasing efficiency of the system.

BESS Options

Customers have several options to purchase and implement BESS systems:

A. Individual components, such as integrated solutions with connection equipment (inverter, AC/DC protection, transformer, enclosure). While this option allows for more flexibility to select individual components, it does require the utility to have available engineering and project management resources.

B. Distributed Energy Storage (DES) Solutions - Integrated solutions (in e-house/outdoor enclosures), including all the components (batteries, BMS, AC/DC protection, transformer, inverter, connection equipment). The main benefit of a DES solution is that it is assembled and pre-tested at the factory, minimizing the risk and the extent and variety of skills required on-site. In addition, a DES solution can be easily relocated if needed.

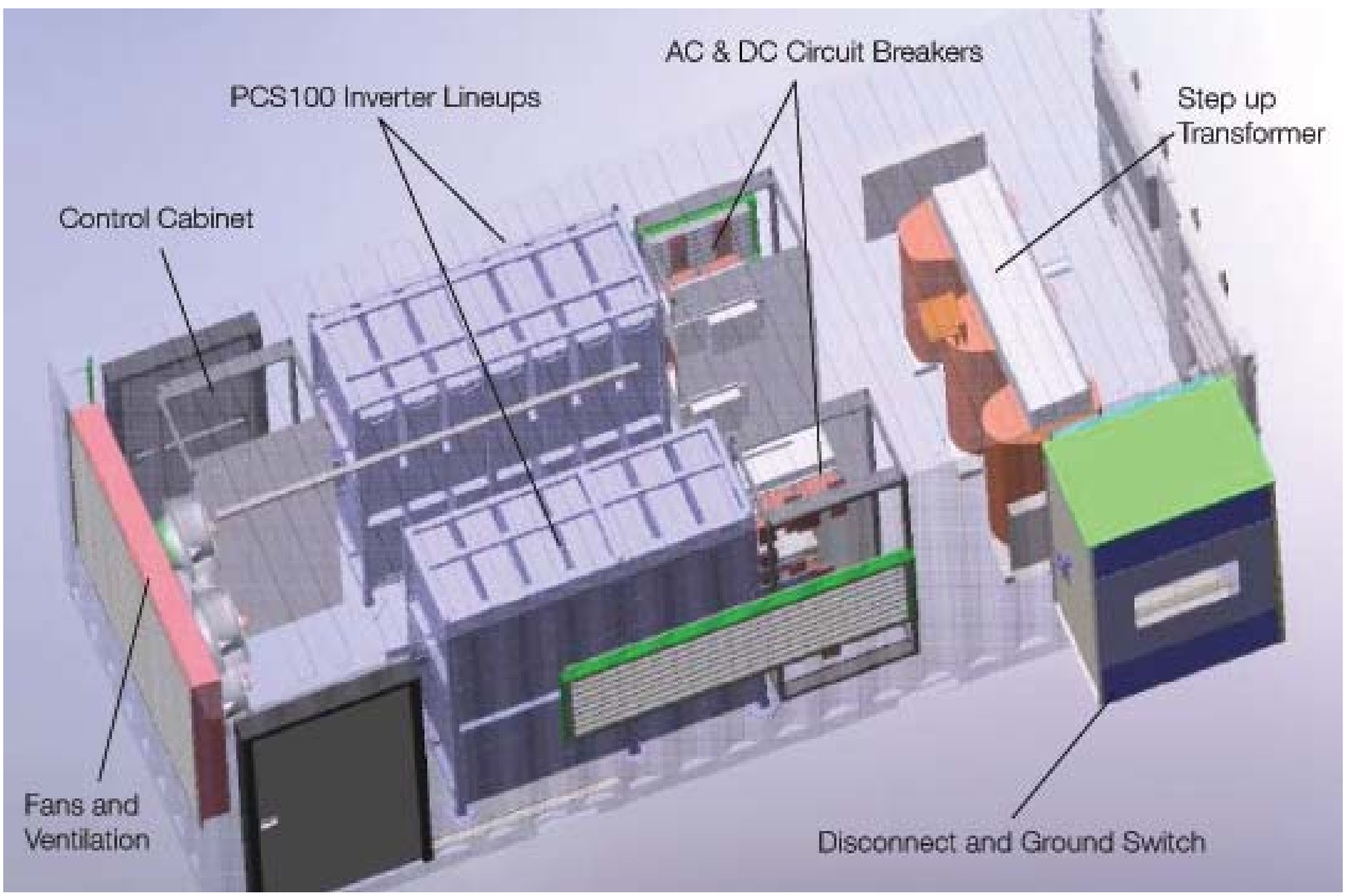
C. Complete turn-key solutions installed in "built on-site" substations, including equipment, installation and commissioning. The main benefit of this option is to have one sole point of contact from the pre-studies to civil works, installation, commissioning and life cycle support. This significantly reduces integration and coordination efforts, and minimizes the overall risk.

Examples of solutions available in the market

A. Integrated solutions with connection equipment

Solutions are already available that integrate all components required to connect a battery to the grid. Figure 4 illustrates an e-house that includes all the components required to connect a two MW battery string into the grid.

Figure 4: E-house including all the components required to connect a two MW battery string into the grid.



This offer is a Power Conditioning System (PCS) designed to be a complete package and includes everything between the battery and the utility connection point. The main components of the PCS include:

a. Incoming or primary switching and protection
b. Main step-down transformer and power distribution
c. Sine wave filter networks
d. Inverters
e. DC switching and protection
f. Local control

B. Distributed Energy Storage (DES) solutions

DES modules integrate batteries, transformers, medium and low voltage switchgear, together with automation equipment such as inverters, in a completely compartmented and segregated enclosure. The DES solution's module enclosure is engineered to maintain the internal temperature within design limits, as well as provide protection. The modules are carefully engineered and tested, including the enclosure, assuring high reliability and safe performance.

Figure 5 shows the layout of a typical ABB 1MW - 250 kwh solution.

C. Turn-key solutions

Turn-key solutions will offer:

a. Fully integrated components
b. A scope that includes full performance responsibility encompassing all component parts
c. A system that is fully tested in the field as well as in the factory

Figure 5: Simplified layout sketch of a 1 MW - 250 kWh solution

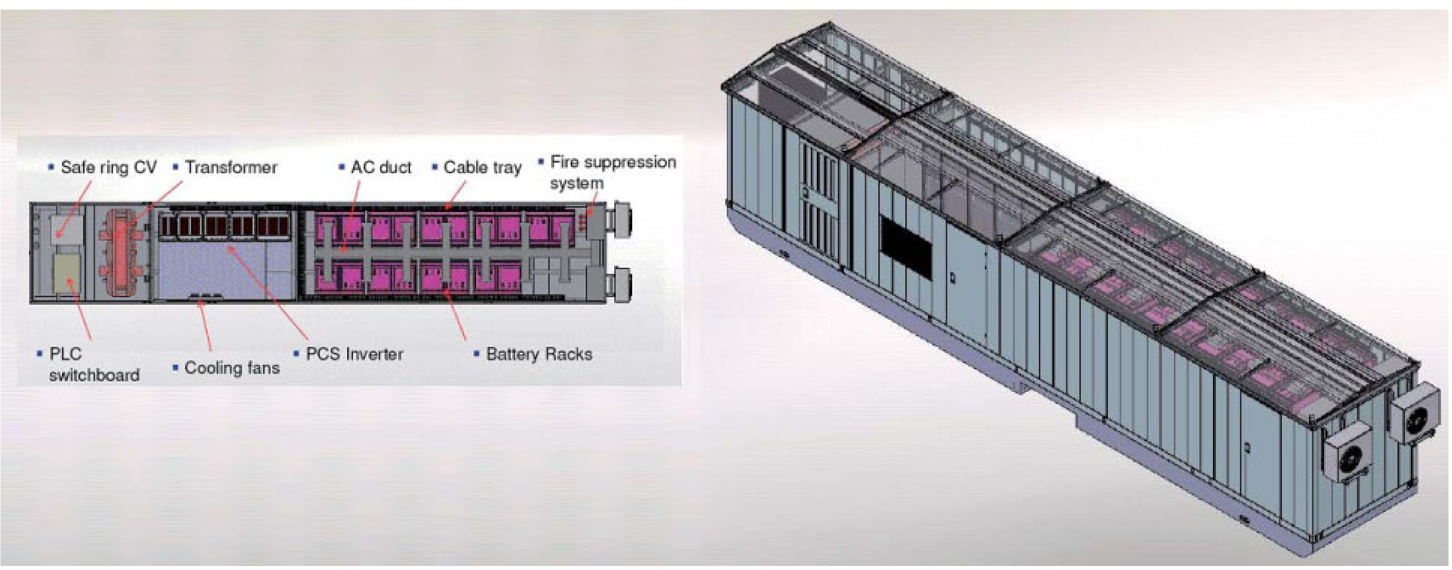
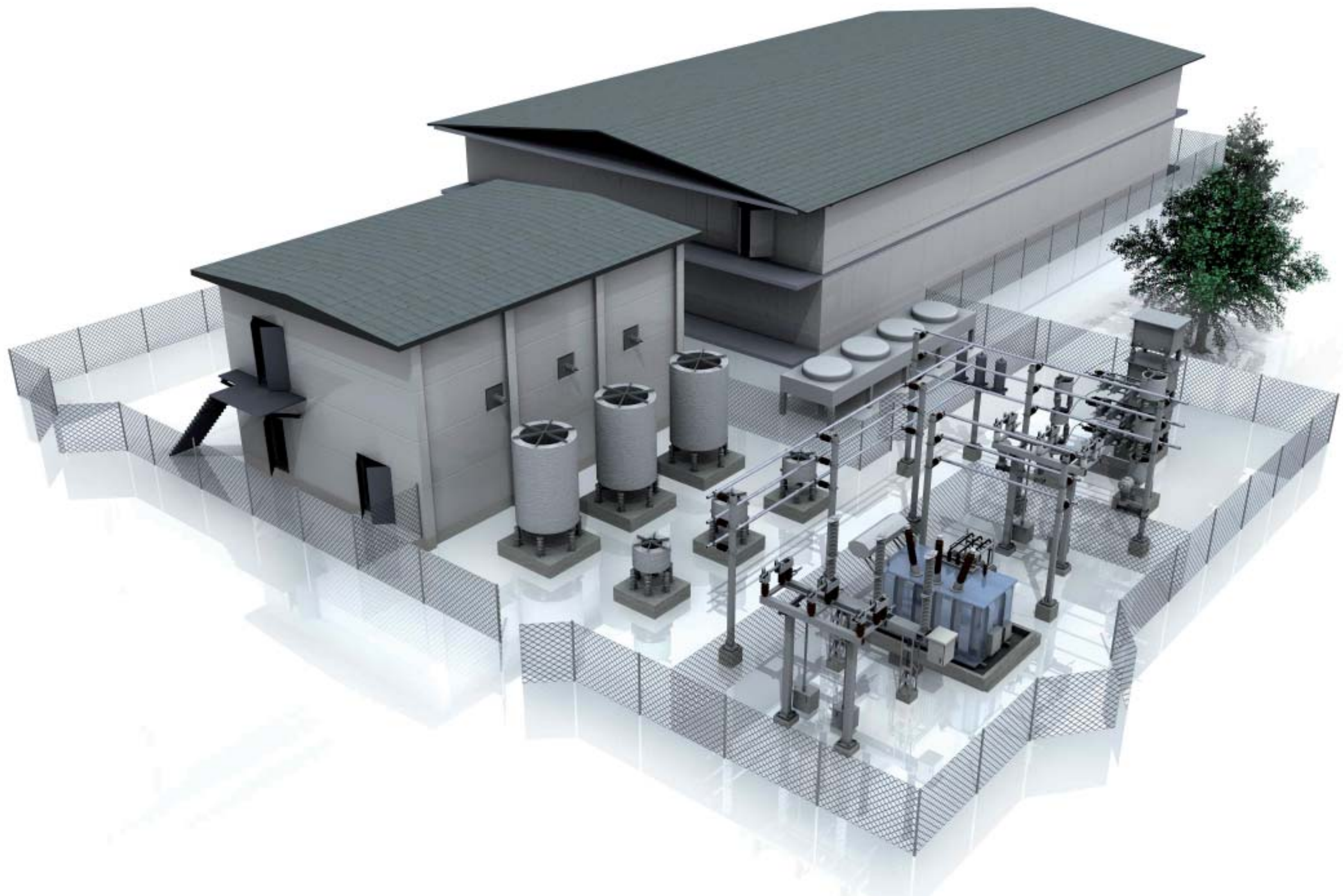


Figure 6: Typical layout for 30 MW (ABB DynaPeaQ solution) during 15 minutes +/- 30 Mvar continuously



An approach such as ABB's DynaPeaQ (see Figure 6), offers a dynamic energy storage solution which combines SVC Light performance – ABB's proven solution to reactive power compensation with special attention to weak networks with severe voltage support problems - with the latest battery storage technology. DynaPeaQ technology and ratings enable a significant increase in the penetration of renewable generation by providing cost-effective, environmentally attractive and high quality service for integrating renewables into existing networks.

Summary

Bringing renewable energy onto the grid can be challenging; however, Battery Energy Storage Solutions can help utilities lower generation cost and maximize the return on investments in renewable generation. Energy Storage Systems will play a key role in integrating and optimizing the performance of variable sources, such as solar and wind grid integration. The fundamental concept of energy storage is simple: generate electricity when wind and solar are plentiful and store it for a later use when demand is higher and supplies are short.

ABB Inc.
Power Products and Power Systems
Cary, North Carolina
U.S.A.
Phone: Tel. 1-800-HELP-365 or +1-440-585-7804

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