EssPro™ - Battery energy storage
The power to control energy
## Challenges of the future power grid

### Long-term drivers for energy storage

**Electricity Consumption on the rise**
- Electrification of everything – moving towards electricity as the primary source of power
- Economic and population growth will lead to increasing demand for power

**Coal plant retirements**
- Reducing baseload power capacity
- Limited resources for ancillary services on the utility grid

**Growth in renewables**
- Governments and industry moving towards solar and wind
- Intermittent generation sources can reduce reliability on the electrical grid.

**Electrification of transportation**
- More users of EVs can increase peak loads placing more strain on the electrical grid.
- Increase in high speed rail

**Proliferation of Smart Grid Technology**
- Bi-directional flow of power requires additional coordination between power supply and demand

**Tax and regulatory incentives**
- Renewable mandates and incentives increasing demand for clean grid technologies
- Potential tax benefits for storage systems (residential, commercial and utility)
EssPro™ Energy Storage Solutions

Applications
Grid connected energy storage applications

- **Load leveling**: For generation utilization 10-1000 MW, 1-8h
- **Integration of renewables**: 1-100 MW, 1-10h
- **Peak shaving**: 0.5-10 MW, 1h
- **Load leveling**: For postponement of grid upgrade 1-10 MW, 1-6h
- **Spinning reserve**: In case of line loss 10-500 MW, 0.25-1 h
- **Stabilization**: 0.1-5 MW, 5 min
- **Frequency regulation**: 1-50 MW, 0.25-1h
- **Solar PV time shift**: 1-100 kW, 2-6h
- **Residential/Small commercial
- **Industry/Large commercial
- **Microgrid

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Energy storage applications

Load shifting

Description
- Load shifting involves storing power during periods of light loading on the system and delivering it during periods of high demand

Response time
- Long duration application that requires sufficient storage capacity (generally one more hour)

Benefit
- Reduce T&D congestion
- Renewables time shifting
- Postponement of investment in T&D upgrades
Energy storage applications

Peak shaving

Description
– Peak shaving is similar to load leveling, but may be for the purpose of reducing peak demand for the electricity consumer

Response time
– Short duration application that requires ability for fast discharging (generally measured in minutes)

Benefit
– Customers can save on their utility bills by reducing peak demand charges
– Utilities can reduce the operational costs meeting peak demand
**Energy storage applications**

**Frequency regulation**

**Description**
- Used to reconcile momentary differences between generation and loads. The energy storage system is charged or discharged in response to an increase or decrease, respectively, of grid frequency.

**Response time**
- Requires instant response on a second-by-second basis to maintain grid frequency at 50/60Hz.

**Benefit**
- Increases reliable operation of the grid.
- Reduces the need for additional generation facilities (expensive to operate and maintain).
Energy storage applications

Spinning reserve

**Description**
- The energy storage system is maintained at a level of charge ready to respond to a generation or transmission outage

**Response time**
- Requires a response time within minutes to compensate until back up power supply can come online

**Benefit**
- Minimizes the impacts from power outages
- Reduces need for generation sources to be online and ready to use (lower O&M costs as well as emissions)
Energy storage applications
Capacity firming & ramp support

Description
- Smoothes the output and controls the ramp rate (MW/min) to eliminate rapid voltage and power swings on the electrical grid often caused by intermittent sources (wind/solar)

Response time
- Requires instant charge and discharging capabilities (generally within seconds)

Benefit
- Increases reliability of the grid
- Improves efficiency of the renewable plant
- Enable grid code compliance
EssPro™ Energy Storage Solutions
Technology overview
# Energy storage media

Various types of methods of storing energy

## Mechanical

- **Gravitation**
  - Pumped hydro

- **Kinetic**
  - Fly wheels

## Thermo-dynamic

- **Heat**
  - Thermo-electric

- **Pressure**
  - Compressed air (CAES)

- **Pressure heat**
  - Adiabatic CAES

## Electromechanical

- **Batteries**
  - Lead acid
  - NiCd
  - NaS
  - NaNiCl
  - Lithium
  - Ni-MH
  - Metal Air

- **Flow Cells**
  - Vanadium
  - ZnBr
  - PSBr

- **Hydrogen**
  - Electrolyzer and fuel cell

## Electromagnetic

- **Electric**
  - Capacitors super caps

- **Magnetic**
  - Super-conducting (SMES)
ESS applications

Applications and corresponding technologies

- **Vanadium Redox Flow**
- **Sodium Sulfur (NaS)**
- **Pumped Hydro Systems (PHS)**
- **Li-ion**
- **Flywheels**

**Storage time [min]**
- 1000 min
- 300 min
- 100 min
- 30 min
- 10 min

**Power requirement [MW]**
- 100 kW
- 1 MW
- 10 MW
- 100 MW
- 1000 MW

**Applications**
- Renewable Integration
- Load leveling
- T&D postponement

**Technologies**
- Prim. Frequency Regulation
- Load leveling
- Generation utilization
- Power shaving

**Energy and Power**

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EssPro™ Energy Storage Solutions

ABB’s energy storage portfolio
Battery energy storage solutions
ABB stationary energy storage offering

Residential – REACT

C & I – EssPro™

Utility-scale – EssPro™

ABB offers battery energy storage solutions from kW to MW range
**EssPro battery energy storage solutions**

**Utility-scale offering**

- **EssPro™ PCS**
- **Advanced Controls and Algorithms**
- **EssPro™ Electrical Balance of Plant (EBOP)**
- **EssPro™ Grid Turnkey Solution**

- ABB is a pioneer and leader in energy storage
- Advanced controls and algorithms for full asset value and optimization
- Expertise in grid operations and systems
- Minimized risk due to proven technology
- Flexible and modular solutions to fit customer requirements
- Utility grade, robust designs
EssPro™ Energy Storage Solutions
Power conversion systems
EssPro power conversion system (PCS)
System sizes from 50 kW to 50 MW
Modular and flexible design
Wide range of standard product offering

**50kW-300kW power converters**
- Dynamic power control (P) and reactive power control (Q)
- Harmonic mitigation up to 50th
- Islanding mode and black start
- CAN communication
- Modularity for high-current applications
- Full redundancy & flexibility (independent DC busses)

**100kW-50MW power converters**
- Dynamic power control (P) and reactive power control (Q)
- Generator emulation control mode
- Grid stabilization features (synthetic inertia and active damping)
- High and low-voltage ride through
- Island mode and black start
EssPro™ Grid
The power to control energy
# EssPro Grid

## Overview of system components

<table>
<thead>
<tr>
<th>System components</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Power Converters</td>
<td>Range of leading-edge power converters to suit a wide range of applications and system sizes</td>
</tr>
<tr>
<td>Batteries</td>
<td>Optimal battery technology for every application</td>
</tr>
<tr>
<td>Control systems and algorithms</td>
<td>Integrated EssPro EPIC control system enables manual and automatic operation of all system components in various control modes</td>
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<tr>
<td>Protection equipment</td>
<td>State-of-the-art protection systems for AC and DC equipment</td>
</tr>
<tr>
<td>Transformers and switchgear</td>
<td>Full range of transformers for local standards</td>
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<tr>
<td></td>
<td>LV, MV and HV switchgear ensures safe and reliable grid connection</td>
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<tr>
<td>Modular and scalable</td>
<td>Scalable and flexible systems facilitate easy and safe operation</td>
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</table>
EssPro Grid
Flexible layouts

Scalable solutions
Containerized solutions and buildings
Coupled and decoupled solutions
Including ancillary equipment
- Fire fighting
- HVAC (heating, ventilation and air-conditioning)
- Intrusion control
- Auxiliary supplies
- AC and DC protection
- Power and control cables
- Distribution boards
- Current and voltage transformers (CT’s and VT’s)
Energy Storage

A technology changing the maritime industry
EssPro™ Energy Storage Solutions
Selected References
EssPro™ Installed Base (Full Turnkey/PCS)

Worldwide experience

- USA: 104 MW
- Canada: 5.5 MW
- Chile: 20 MW
- UK: 2.5 MW
- Africa: 1.8 MW
- Middle East: 200 kW
- Europe: 4.4 MW
- Asia: 70 MW
- Australia: 1.8 MW

Worldwide: 210 MW
EssPro™ Installed Base (Full Turnkey/PCS)

North America

NAM: 130 MW

* note: installed base for North America includes projects in South America

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ABB Energy Storage Experience
BESS Project Chitose Hokkaido - Japan 17 MW

Need:
- 28 MW PV grid integration
- Ramp Rate control 1%/min - Voltage support - Capacity firming

Project details:
- Li-ion batteries
- Installed in 2016

ABB Scope:
- (4) x 4 MW + (1) x 1 MW Outdoor PCS
- PCS inverters, DC contactors, AC circuit breakers
- MV-LV Coupling transformer
- MV Switchgear
- Local controller integrating PCS, Switchgear and MBMS
- Local HMI
ABB Energy Storage Experience
BESS Project Yangguang Power Plant - China 9 MW

Need:
- Integration with coal fired power plant 300 MW
- Frequency regulation

Project details:
- Li-ion batteries (15 minutes)
- Installed in 2016

ABB Scope:
- (3) x 3 MW Outdoor PCS
- PCS inverters, DC contactors, AC circuit breakers
- MV-LV Coupling transformer
- MV Switchgear
- Local controller integrating PCS, Switchgear and MBMS
- Local HMI
ABB Energy Storage Experience

KIUC Anahola Project – Hawaii 6 MW

End user & Installation year:
- KIUC installed in 2015

System size & Technology:
- 6 MW - 4 MWh lithium-ion batteries

Customer needs:
- Help integrate solar power on the network
- Frequency & Voltage regulation; spinning reserve

ABB Scope:
- PCS rated at 6 MW integrated in (2) 20’ISO containers
  - 2 x 3 MW Converters
  - HVAC
- EssPro Controller
  - Frequency regulation
  - Voltage regulation
  - Firming
ABB Energy Storage Experience

BESS Integrator / PJM - USA 20 MW

**Need:**
- PJM Regulation Market
- Frequency regulation

**Project details:**
- Li-ion batteries
- Installed in 2014

**ABB Scope:**
- (4) x 5 MW Outdoor PCS / 35kV
- Includes inverters, dc circuit breakers, ac circuit breakers, control, protection and external isolation / step-up transformer to 35kV grid
- Metering / Data Management
- Noise suppression
ABB Energy Storage Experience

Tehachapi – USA 8 MW

Customer needs
- Smart grid program
- Assess the capability and effectiveness of storage to support 13 operational applications

Project details
- Li-ion batteries
- Installed in 2013

ABB response
- (2) x 4 MW / 4.5 MVA PCS100 for BESS
- EssPro Vantage Controller
- DC bus and protection circuit breakers
- System models, RTDS and simulations
- Commissioning, training and installation supervision
ABB Energy Storage Experience
Angamos, Chile - 20 MW

Need:
- Spinning reserve
- Frequency regulation

Project details:
- Li-ion batteries
- Installed in 2011

ABB Scope:
- 5 x 4 MW PCS Containers
- Each containing inverters, circuit breakers, step up transformers, control, MV Disconnect Switch

20 MW / 5MWh
ABB Energy Storage Experience
World’s largest battery – Fairbanks – Alaska 46 MW

Need:
– Improve reliability of electricity services
– Emergency power source to feed energy to the grid until backup generation can come online

Project details:
– 15 minutes power boost to get generators online, leading to 90 percent reduction of power blackouts due to grid faults
– Cost-effective and reduced carbon emission solution.
– Installed in 2003

ABB Scope:
– Turnkey BESS including converter, transformer, Ni-Cd batteries (battery supplier SAFT), metering, protection and control devices and service equipment
– 27 MW - 15 minutes / 46 MW - 5 minutes
– BESS operation at temperatures as low as -52°C
Need:
- Battery energy storage system connected to the distribution grid

Project details:
- Peak shaving
- Frequency regulation
- Renewable integration

ABB Scope:
- Turnkey BESS providing 2MW for 30 minutes including system studies and specification
- Containerized Li-ion-battery based solution (battery supplier FAAM/FIB) including converter, transformer, switchgear, control and protection systems
- Standard control algorithms
ABB Energy Storage Experience

EKZ, Switzerland 1 MW

**Need:**
- Battery energy storage facility connected to the distribution grid, with integrated solar panels and e-mobility charging stations

**Project details:**
- Possibility to evaluate grid-linked BESS for peak shaving, frequency regulation and integration of renewables
- Forecasting to enhance operational efficiency
- State-of-the-art technologies enabling to address future demands on the grid

**ABB Scope:**
- Turnkey BESS providing 1 MW for 15 minutes including system studies and specification
- Containerized Li-ion-battery based solution (battery supplier LG Chem) including converter, transformer, switchgear, control and protection systems
- Standard and advanced control algorithms