EssPro™ - Battery energy storage
The power to control energy
Dario Cicio; Global Product Manager Energy Storage Solutions
### Challenges of the future power grid

#### Long-term drivers for energy storage

<table>
<thead>
<tr>
<th>Topic</th>
<th>Details</th>
</tr>
</thead>
</table>
| **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**          | - Electrification of everything – moving towards electricity as the primary source of power  
- Economic and population growth will lead to increasing demand for power                                                                  |
Grid connected energy storage applications

- **Conventional central generation**
  - ESS
  - Integration of renewables
    - 1-100 MW, 1-10h
  - 220 kV

- **Variable renewable generation**
  - ESS
  - Stabilization
    - 0.1-5 MW, 5 min
  - 20 kV

- **Load leveling**
  - For generation utilization
    - 10-1000 MW, 1-8h
  - 220 kV

- **Spinning reserve**
  - In case of line loss
    - 10-500 MW, 0.25-1 h
  - 220 kV

- **Load center**
  - ESS
  - Load leveling
    - For postponement of grid upgrade
      - 1-10 MW, 1-6h
  - 220 kV

- **Industry/Large commercial**
  - ESS
  - Peak shaving
    - 0.5-10 MW, 1h
  - 20 kV ring

- **Residential/Small commercial**
  - ESS
  - Solar PV time shift
    - 1-100 kW, 2-6h
  - 0.4 kV

- **Microgrid**
  - ESS
  - Frequency regulation
    - 1-50 MW, 0.25-1h
  - 110 kV

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## Energy storage media

Various types of methods of storing energy

<table>
<thead>
<tr>
<th>Mechanical</th>
<th>Thermo-dynamic</th>
<th>Electromechanical</th>
<th>Electromagnetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravitation</td>
<td>Heat</td>
<td>Batteries</td>
<td>Electric</td>
</tr>
<tr>
<td>– Pumped hydro</td>
<td>– Thermo-electric</td>
<td>– Lead acid</td>
<td>– Capacitors supercaps</td>
</tr>
<tr>
<td>Kinetic</td>
<td>Pressure</td>
<td>– NiCd</td>
<td>Magnetic</td>
</tr>
<tr>
<td>– Flywheel</td>
<td>– Compressed air (CAES)</td>
<td>– NaS</td>
<td>– Super-conducting (SMES)</td>
</tr>
<tr>
<td></td>
<td>Pressure heat</td>
<td>– NaNiCl</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– Adiabatic CAES</td>
<td>– Lithium</td>
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<tr>
<td></td>
<td></td>
<td>– Ni-MH</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>– Metal Air</td>
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<td></td>
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<td>Flow Cells</td>
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<tr>
<td></td>
<td></td>
<td>– Vanadium</td>
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<td>– ZnBr</td>
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<td>– PSBr</td>
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<td></td>
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<td>Hydrogen</td>
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<tr>
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<td>– Electrolyzer and fuel cell</td>
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</tr>
</tbody>
</table>
ESS applications
Applications and corresponding technologies

- Storage time [min]
  - 100 kW
  - 1 MW
  - 10 MW
  - 100 MW
  - 1000 MW
- Power requirement [MW]
  - 10 min
  - 1 h
  - 10 h

- Power
- Energy

- Renewable Integration
- Load leveling
- T&D post postponement
- Frequency Regulation
- Prim.
- Generation utilization
- Peak shaving

- Pumped Hydro Systems (PHS)
  - Vanadium Redox Flow
  - Sodium Sulfur (NaS)
- Li-ion
- Flywheels
- Sodium Sulfur (NaS)
- Lead acid
- Li-ion
- Flywheels
- Energy
- Power
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

- ABB is a pioneer and leader in energy storage
- Flexible and modular solutions to fit customer requirements
- Advanced controls and algorithms for full asset value and optimization
- Minimized risk due to proven technology
- Expertise in grid operations and systems
- Utility grade, robust designs
EssPro power conversion system (PCS)

System sizes from 100 kW to 50 MW
## EssPro Grid

### Overview of system components

<table>
<thead>
<tr>
<th>System components</th>
<th>Description</th>
</tr>
</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>
</tr>
<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>
</tr>
<tr>
<td></td>
<td>LV, MV and HV switchgear ensures safe and reliable grid connection</td>
</tr>
<tr>
<td>Modular and scalable</td>
<td>Scalable and flexible systems facilitate easy and safe operation</td>
</tr>
</tbody>
</table>
**EssPro Grid**

Flexible layouts

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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)
EssPro EPIC

Electrical plant and inverter controller (EPIC)
Battery energy storage systems

Electrical plant and inverter controller (EPIC)

Secure and high level of redundancy – Multi-processor architecture

Proven substation technology

Wide range of communication protocols available (61850, 101, 104, Modbus, DNP3)

Application algorithms

Data logging

Independent of battery technology
EssPro™ Energy Storage Solutions
Selected References
EssPro™ Installed Base (Full Turnkey/PCS)

Worldwide experience

- USA: 104 MW
- Canada: 5.5 MW
- UK: 2.5 MW
- Europe: 4.4 MW
- Africa: 1.8 MW
- Middle East: 200 kW
- Chile: 20 MW
- Australia: 1.8 MW
- Asia: 70 MW
- Worldwide: 210 MW
EssPro™ Installed Base (Full Turnkey/PCS)
North America

Last Updated: March 2017

* note: installed base for North America includes projects in South America
**ABB Energy Storage Experience**

**BESS Project Chitose Hokkaido - Japan 17 MW**

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**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
### 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

Tehachapi – USA 8 MW
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
NYPA, Garden City – USA 1 MW

Need:
- Load leveling
- Peak shaving

Project details:
- NaS battery technology
- Installation in 2006

ABB Scope:
- Powered gas compressors during the day and recharge at night
- Shift compressor demand to night, lowers daytime peak demand rates
- BESS provides backup power supply

1MW / 6.5MWh
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