Energy Storage Modules (ESM)
Up to 4 MW
Output voltage range of
120 volts to 40.5 kV
Table of contents

Definition ........................................................................................................................................................................... 3
Applications .......................................................................................................................................................................... 4
Features ............................................................................................................................................................................... 6
Components........................................................................................................................................................................ 7
Technical data sheet - ESM pre-designed modules ........................................................................................................ 12
Typical sketch - ESM pre-designed unit ........................................................................................................................ 14
Technical data sheet - CEM pre-designed units ............................................................................................................... 15
Summary ........................................................................................................................................................................... 16
Notes ................................................................................................................................................................................ 18
An Energy Storage Module (ESM) is a packaged solution that stores energy for use at a later time. The energy is usually stored in batteries for specific energy demands or to effectively optimize cost.

ESM can store electrical energy and supply it to designated loads as a primary or supplementary source. Moreover, it provides a stable and continuous power supply regardless of the supply source status. Voltage and frequency regulation can also be improved by using ESM modules.

ESM contains inverters that rectify the AC energy into DC to store in the batteries and then invert the DC energy into AC energy. The energy inverted into AC power can be connected to the electrical network at low (<1000 Volts) or medium voltage (<40.5 kV).

ABB provides the necessary electrical, protective and monitoring equipment along with the battery system to utilize the batteries safely with a pre-designed system designed to meet ANSI, IEC, and other international standards. This will guarantee a high level of energy continuity and superior power quality in a safe and cost effective module.

ESM is available in several capacities with individual modules up to 4 MW and an output voltage range from 120 volts to 40.5 kV at 50 or 60 Hertz, single or three phase system.

The ESM enclosure is engineered to maintain the internal temperature within the design limits as well as provide protection. Different temperature classes and protection degrees are available according to the application and size. The degree of protection for the ESM enclosure is designed according to IP or NEMA standards.
ESM has different applications within the distribution network aiming to improve the quality and continuity of the power at optimal cost. The main applications of the ESM are:

**Load shifting / time of use management**: The practice of altering the pattern of energy use so that on-peak energy use is shifted to off-peak periods.

**Benefits:**
- a) Reduces the cost of energy by charging the system with low priced energy and discharging later when the energy prices are high
- b) Shifts renewable generation to peak times, allowing for participation in capacity markets as a dispatchable resource, smoothing the renewable output

**Peak shaving**: Peak shaving is related to Load Shifting. Both are part of the demand management in which the ultimate goal is to increase the load factor.

**Benefits:**
- a) Commercial and industrial customers reduce their energy charges by improving their load factor
- b) Utilities reduce the operational cost of generating power during peak periods (reducing the need for peaking units)
- c) Investment in infrastructure is delayed because they have flatter loads with smaller peaks.

Graph 1 below shows a peak shaving/load shifting application. The blue line shows the customer demand profile, which is peaking late in the afternoon. The purple line shows what the Energy Storage Module is doing, charging early in the morning when the demand is low and discharging when the demand is peaking. The yellow line shows the net effect on the electrical grid (a lower demand peak and a more balanced demand).

**Renewable energy smoothing or ramp control**: Reduces the impact of quick changes in renewable generation levels. It can be used to ensure that wind-farm ramp-rates (MW/min) are kept within design limits and to eliminate rapid voltage and power swings on the electrical grid.

Graph number 2 on the next page shows a renewable smoothing ramp control application. The wind farm power is shown in orange. The ESM system power is shown in blue. The black line shows the net effect on the electrical grid (a gentler ramp slope and lower variability).

**Renewable capacity firming**: Helps maintain the power output at a committed (firm) level for a period of time.
Frequency regulation: In this application, the ESM charges and discharges in response to analog signals received every 1 to 4 seconds. The system supports the frequency on the grid and keeps a state-of-charge of approximately 50%. ESM is an attractive option for this application due to its rapid response time.

Spinning reserves: In this application, the ESM remains charged and responds in case of a generation or transmission outages. Depending on the application need, the system can respond within milliseconds or minutes. The ESM supplies power until the back-up generator is started and running.

This application allows the generators to work at optimum power, without the need to keep idle capacity for spinning reserves. The system can also eliminate the need of having back-up generators running idle.

Outage management: ESM can provide power for short periods of time to a network reducing or eliminating the effect of a temporary outage.

Delay in line upgrades: An ESM can be placed electrically downstream in a congested transmission system, helping to reduce the overloads in the lines and delay investments in line upgrades.

Power quality: An ESM helps protect the loads further downstream against short-duration events that affect the quality of power delivered to the load.

Voltage and VAR support: An ESM can help to maintain the grid voltage by injecting or absorbing reactive power (VAR)

Railroad applications: Accelerating a heavy train can expose the grid to a peak load that traditionally necessitated extensive investment in capacity expansion. An ESM unit can supply the required acceleration power that is taken from the most recent deceleration.

Graph 2: Renewable energy smoothing or ramp control
Features

- High level of reliability and power supply continuity
- High level of safety for equipment and personnel
- Simple and quick installation
- High quality galvanized steel sandwich type housing solutions
- Concrete substations available upon request
- Upon request, certain ESM modules can be designed with arc proof design (according to IEC standard 62271-202)
- Modules with a power rating of up to 4MW
- For power requirements higher than 4 MW, several ESM modules can be connected in parallel and be controlled as a single unit
- Output voltage range of 120 volts to 40.5 KV at 50 or 60 Hertz, single or three phases system
- Dry type transformers to reduce maintenance costs and risk
- Oil type transformer also available
- Upon-request battery racks designs to maximize cooling and efficiency
- Compartmented and segregated enclosures available
- Standard ratings and enclosure sizes. Tailor made dimensions are available upon request
- Safety interlocked designs available
- Engineered enclosure for efficient cooling in order to keep the temperature of the equipment within the design limits
- SCADA ready packages available
- Optimal product selection for grid connection combining ABB products and customer interface requirements
- Seamless integration of high quality products to assure high reliability
- Proven track record of containerized solutions in many severe environments all over the world
ESM is an integrated system of power equipment such as transformers, low and medium voltage switchgear together with automation equipment such as inverters in a galvanized steel enclosure. This unique design provides quick, simple installation, with a high level of safety for the equipment as well as for operators or people around.

The ESM portfolio includes two types of ABB inverters, which are selected depending on the application and the power of the modules: ABB LV ESI inverter and ABB LV PCS inverter. A description of these two platforms is included in the following section.

Battery Management System (BMS)
The BMS will perform the measurement necessary to manage the batteries (measuring variables like voltage, temperature, current) in order to extend the battery life and increase the safety of the system. The communication between the BMS and inverter control system is pretested in order to achieve a safer and quicker installation.

Batteries
ESM includes different types of preselected Lithium ion battery technologies, selected by ABB’s in-house team of battery experts to ensure that they can perform according to the application requirements. ABB can also design and supply customized solutions with other battery technologies (Lead acid, Nickel Cadmium, Sodium Nickel Chloride, among others).

Typical one line diagram for a three-phase system:

Low and medium voltage switchgear
The energy from batteries is connected to the network through the medium or low voltage switchgear depending on the application. The ABB switchgear guarantees state-of-the-art protection for a safe and reliable performance of the ESM in the electrical network. ESM can be provided with a SCADA package which facilitates the remote monitoring and control of the switchgear and inverters.

Transformer
The transformer can be a dry or oil type per user requirements. Several ratios, voltage, connections, and frequencies are available to meet network ratings.

Inverter
The inverter changes AC power to DC to charge the batteries (if supplied as AC) and the DC energy from the batteries into single or three phase AC energy at 50 or 60 Hertz depending on the user requirements.
Components - ESM ABB inverters
ABB/LV ESI inverters for energy storage applications

Experienced and reliable inverter technology
ABB is a world leader in inverter technology. The ESM portfolio includes two types of ABB inverters, which are selected depending on the application and the power of the modules.

Flexible, modular and redundant
ESI inverter is a modular design. Up to 32 inverters can be connected together which provides a wide range of power. Furthermore redundancy functionality permits compliance with even the most stringent requirements on redundancy imposed in critical applications.

Power quality
ABB ESI inverter propose unsurpassed functionality in term of power quality such as:
- Reactive power compensation of both inductive and capacitive loads
- Unprecedented harmonic filtering efficiency
- Load balancing in both 3 and 4-wire systems

Features
- Allows a range of energy storage devices to be coupled to the grids
- Dynamic power control (P)
- Dynamic reactive power control (Q)
- Harmonic mitigation
- Islanding mode
- CAN communication

<table>
<thead>
<tr>
<th>Model</th>
<th>ESI-I</th>
<th>ESI-M</th>
<th>ESI-S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inverter maximum power at 415V&lt;sub&gt;AC&lt;/sub&gt; (3-phase)</td>
<td>Up to 323 kw in one unit</td>
<td>Up to 108 kw in one unit</td>
<td>Up to 72 kw in one unit</td>
</tr>
<tr>
<td>Battery voltage range</td>
<td>V1: 600-830V&lt;sub&gt;DC&lt;/sub&gt; at 415V&lt;sub&gt;AC&lt;/sub&gt;</td>
<td>600-830V&lt;sub&gt;DC&lt;/sub&gt; at 415V&lt;sub&gt;AC&lt;/sub&gt;</td>
<td>600-830V&lt;sub&gt;DC&lt;/sub&gt; at 415V&lt;sub&gt;AC&lt;/sub&gt; (3-phase)</td>
</tr>
<tr>
<td></td>
<td>V2: 975-1200V&lt;sub&gt;AC&lt;/sub&gt; at 690V&lt;sub&gt;AC&lt;/sub&gt;</td>
<td></td>
<td>170-830V&lt;sub&gt;DC&lt;/sub&gt; at 120V&lt;sub&gt;AC&lt;/sub&gt; (single-phase)</td>
</tr>
</tbody>
</table>

Electrical characteristics

<table>
<thead>
<tr>
<th>Connection method</th>
<th>3-phase</th>
<th>3-phase</th>
<th>3-phase/3-phase + N/single-phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Nominal Network voltage</td>
<td>V1: 208-480V&lt;sub&gt;AC&lt;/sub&gt;</td>
<td>V1: 208-480V&lt;sub&gt;AC&lt;/sub&gt;</td>
<td>208-240V&lt;sub&gt;AC&lt;/sub&gt; (3-phase)</td>
</tr>
<tr>
<td></td>
<td>V2: 480-690V&lt;sub&gt;AC&lt;/sub&gt;</td>
<td></td>
<td>380-415V&lt;sub&gt;AC&lt;/sub&gt; (3-phase)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>120-415V&lt;sub&gt;AC&lt;/sub&gt; (single-phase)</td>
</tr>
<tr>
<td>Network frequency</td>
<td>50 Hz/60 Hz - +/- 5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC Line current per inverter (I&lt;sub&gt;lin&lt;/sub&gt;)</td>
<td>V1: 300 A, 450 A</td>
<td>70 A, 100 A, 130 A, 150 A</td>
<td>30 A, 45 A, 60 A, 70 A, 80 A, 90 A, 100 A</td>
</tr>
<tr>
<td></td>
<td>V2: 180 A, 320 A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutral current rating per inverter (I&lt;sub&gt;neu&lt;/sub&gt;)</td>
<td>-</td>
<td>-</td>
<td>3 times the line current rating&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Modularity</td>
<td>Maximum 32 inverters can be combined</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Redundancy&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Master/master or master/slave arrangement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment losses</td>
<td>3% of the equipment rated power typically</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Components
ABB/LV ESI inverters for energy storage applications

<table>
<thead>
<tr>
<th>Model</th>
<th>ESI-I</th>
<th>ESI-M</th>
<th>ESI-S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal power circuit protection</td>
<td>Circuit breaker</td>
<td>Fuse box disconnector (optional)</td>
<td>-</td>
</tr>
<tr>
<td>Power quality characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactive power compensation: target cos Φ</td>
<td>Programmable from 0.6 (inductive) to 0.6 (capacitive)(3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harmonic mitigation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harmonic range</td>
<td>Up to 2nd to 50th harmonic(4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harmonics selectable</td>
<td>20 individual harmonics</td>
<td>3-wire: 20 harmonics</td>
<td>4-wire: 15 harmonics</td>
</tr>
<tr>
<td>Filtering target</td>
<td>Programmable for each harmonic in absolute Ampere value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harmonic attenuation factor</td>
<td></td>
<td>Better than 97% at rated load</td>
<td></td>
</tr>
<tr>
<td>(I₀ (source)/Iₚ (load))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reaction time</td>
<td>&lt; 500 μs instantaneous response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response time</td>
<td>2 networks cycles typically (10-90% filtering)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load balancing characteristics</td>
<td>Balance the currents between phases and/or between phases and neutral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programming/communication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital I/O</td>
<td>2 digital inputs/6 digital outputs (potential free)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alarm contact</td>
<td>1 NO/NC alarm contact (potential free)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programming/Monitoring</td>
<td></td>
<td>Using PQF-Manager GUI</td>
<td></td>
</tr>
<tr>
<td>Battery Management System communication</td>
<td></td>
<td></td>
<td>CAN</td>
</tr>
<tr>
<td>Mounting</td>
<td>Free floor standing cubicle (ESI-I-M) or IP00 plate (ESI-M)</td>
<td>Wall-mount enclosure</td>
<td></td>
</tr>
<tr>
<td>Dimensions per inverter</td>
<td>800 x 600 x 2150 mm</td>
<td>600 x 600 x 2150 mm (cubicle)</td>
<td>585 x 310 x 700 mm</td>
</tr>
<tr>
<td>(W x D x H)</td>
<td>498 x 432 x 1697 mm (plate)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approximate weight (unpacked)</td>
<td>180 A/250 A units: 525 kg</td>
<td>270 kg (cubicle)</td>
<td>120 kg</td>
</tr>
<tr>
<td></td>
<td>320 A/450 A units: 620 kg</td>
<td>150 kg (plate)</td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>RAL 7035 (light gray)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IP protection</td>
<td>IP21</td>
<td>Plate version: IP00</td>
<td>IP30</td>
</tr>
<tr>
<td>Optional: IP41(5)</td>
<td>Cubicle version: IP21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optional: IP41(5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation aspects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Altitude</td>
<td>Indoor installation in clean environment up to 1000 m altitude(6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>-10°C to 40°C(6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humidity</td>
<td>Maximum 95% relative humidity, non-condensing(7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable entry</td>
<td>Bottom</td>
<td>Top or bottom (to be specified at time of ordering)</td>
<td>Bottom</td>
</tr>
<tr>
<td>CT requirements</td>
<td></td>
<td>Only required for Power Quality features</td>
<td></td>
</tr>
<tr>
<td>Standards</td>
<td></td>
<td>UL-508</td>
<td></td>
</tr>
<tr>
<td>UL</td>
<td></td>
<td>IEC 60439-1 (EMC class)</td>
<td></td>
</tr>
<tr>
<td>IEC</td>
<td></td>
<td>EMC Immunity: 61000-6-2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>EMC Emissions: 61000-6-4</td>
<td></td>
</tr>
</tbody>
</table>

(1) Neutral current rating of PQFS 100 A units is limited to 270 Aₚₑₚₑ.
(2) For full redundancy combine only master units. If limited redundancy is acceptable, master and slave units can be combined. The desired redundancy level can be obtained by selecting more or less master units.
(3) If cos Φ of the installation is higher than the target cos Φ, the filter will not downgrade the existing cos Φ.
(4) ESI inverter cannot filter zero sequence if it does not have a neutral connection.
(5) For IP41 models, 10% derating applies.
(6) Higher altitudes (up to 2000 m/ 6600 ft max.) and temperatures (up to 50°C/122°F max.) with suitable derating.
(7) The maximum relative humidity for operational purposes is 95%. When the units are stored for a longer time, do not exceed a relative humidity of 85%. 

Descriptive bulletin | ESM Energy Storage Modules | 9
Components - ESM ABB converters
ABB/LV PCS inverters for energy storage applications

Experienced and reliable inverter technology
ABB is a world leader in inverter technology. The ESM portfolio includes two types of ABB inverters, which are selected depending on the application and the power of the modules.

Features
– Allows energy storage devices to be coupled to the grid
– Dynamic power control (P)
– Dynamic reactive power control (Q)
– Current source mode for sub-cycle response to power commands
– Virtual Generator Control Mode providing grid stabilization via synthetic inertia and active damping
– High and low voltage ride through
– Modular inverter blocks for simple long term maintenance
– Scalable building block design
– Redundant inverter design increases reliability and availability

Options
– Island mode
– Black start capability
– Dynamic control for applications such as peak-shaving, spinning reserve, etc.

The ABB Power Conversion System is designed to be a complete package including everything between the battery and the utility bus.

Main components of the PCS
– AC circuit breakers and protection
– Main isolation/step-up transformer
– Auxiliary transformer and power distribution circuit
– Sine wave filter network
– Inverters
– DC circuit breakers and protection
– Local and remote control
Components - ESM ABB converters
ABB/LV PCS inverters for energy storage applications

<table>
<thead>
<tr>
<th>Configurations</th>
<th>500 kW cabinet</th>
<th>1000 kW rack</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protection class</td>
<td>NEMA 1, 3R &amp; 4</td>
<td>NEMA 1, 3R &amp; 4</td>
</tr>
<tr>
<td>Unit continuous kW rating</td>
<td>70-500</td>
<td>300-700</td>
</tr>
<tr>
<td>MVAR System applied</td>
<td>All configurations can be paralleled to obtain higher ratings needed</td>
<td></td>
</tr>
</tbody>
</table>

### DC system

| DC voltage range (VDC)         | 400-1120       | 400-1120       |
| Voltage ripple                 | IEEE compliant | IEEE compliant |

### AC grid

| AC grid voltage (kV)           | .2 to 35       | .2 to 35       |
| AC tolerance                   | +/-10%         | +/-10%         |
| Output Frequency               | 50 / 60        | 50 / 60        |
| Harmonic Distortion, Current   | IEEE compliant | IEEE compliant |

### Efficiency

| PCS efficiency                 | >94%           | >94%           |
| PCS100 inverter efficiency     | >97%           | >97%           |

### Environmental limits

| Cooling                        | Forced Air     | Forced Air     |
| Ambient temperature range (nominal) A | 0°C to 50°C     | 0°C to 50°C     |
| Relative humidity              | 0 to 100%      | 0 to 100%      |
| Maximum altitude ft (m)B       | 9843 (3000)    | 9843 (3000)    |
| Seismic rating                 | Zone 4         | Zone 4         |
| Noise level of inverters       | 75-85 dBA      | 75-85 dBA      |

### Housing options - dimensions and weights

| A) Indoor package, in (mm)      | 32Wx32Dx85H (809x804x2154) | 88Wx32Dx97H (2241x800x2464) | 128Wx32Dx97H (3241x800x2464) |

A - PCS temperature rating depends on housing selection; PCS100 inverters are derated over 40°C
B - Systems derated above 1000 m
C - Indoor 500 kW cabinet solution control cabinet mounted in cabinet if space permits, otherwise separate mounting
An Energy Storage Module (ESM) is a packaged solution that stores energy for use at a later time. The energy is usually stored in batteries for specific energy demands or to effectively optimize cost. The Energy Storage Modules include all the components required to store the energy and connect it with the electrical grid.

<table>
<thead>
<tr>
<th>Storage Energy Size (kW / kWh)</th>
<th>Typical Application</th>
<th>Phases</th>
<th>Output Voltage</th>
<th>Type of Enclosure / Approximate Dimension</th>
<th>Cycle life</th>
<th>Components</th>
</tr>
</thead>
</table>
| 25 / 50                       | Outage management/ Time of use management/Peak Shaving/Capacity Firming | 1 or 3 | Up to 690 V    | Two Enclosures  
a) Connection equipment (one):  
W=3’11”/1185 mm  
D=2’4”/710 mm  
H=5’8”/1710 mm  
b) Battery Enclosure (one):  
W=5’8”/1715 mm  
D=5’4”/1610 mm  
H=4’10”/1470 mm | 1000 cycles at rated power and energy | Battery rack, Battery Management system, DC protection, Inverter, AC protection, control system |
| 500 / 125                     | Outage management/ Capacity Firming/Frequency regulation | 3      | Up to 690 V    | W=26’9”/8141 mm  
D=8’3”/2513 mm  
H=8’4”/2539 mm | The system will charge or discharge, per 5 years, in response to a frequency regulation signal received every 4 seconds | Battery rack, Battery Management system, DC protection, Inverter, AC protection, control system  
Note: The scope does not include an Isolation transformer |
| 500 / 1500                    | Outage management/ Time of use management/Peak Shaving/Capacity Firming/Frequency regulation | 3      | Up to 690 V or Medium Voltage up to 24 kV | Three Enclosures:  
a) Connection equipment (one):  
W=15’11”/4830 mm  
D=8’3”/2515 mm  
H=8’4”/2539 mm  
b) Battery Enclosure (two):  
W=40’/12192 mm  
D=8’/2438 mm  
H=8’6”/2591 mm | 2000 cycles at rated power and energy | Battery rack, Battery Management system, DC protection, Inverter, AC protection, control system  
Note: The scope does not include an Isolation transformer |
| 1000 / 250                    | Outage management/ Capacity Firming/Frequency regulation | 3      | Up to 690 V or Medium Voltage up to 24 kV | W= 49’ 3” /15000 mm  
D= 8’3” /2513 mm  
H= 8’4” / 2539 mm | The system will charge or discharge, per 5 years, in response to a frequency regulation signal received every 4 seconds | Battery rack, Battery Management system, DC protection, Inverter, AC protection, control system, Step-up Transformer, MV Switchgear |
<table>
<thead>
<tr>
<th>Storage Energy Size (kW / kWh)</th>
<th>Typical Application</th>
<th>Phases</th>
<th>Output Voltage</th>
<th>Type of Enclosure / Approximate Dimension</th>
<th>Cycle life</th>
<th>Components</th>
</tr>
</thead>
</table>
| 1000 / 3000                   | Outage management/ Time of use management/Peak Shaving/Capacity Firming/Frequency regulation | 3      | Up to 690 V or Medium Voltage up to 24 kV | Four Enclosures:  
a) Connection Equipment (one): W= 22’ 5'/ 6830 mm  
D= 8’3” / 2515 mm  
H= 8’4” / 2539 mm  
b) Battery Enclosure (three): W= 43’ 12” / 13400 mm  
D= 8’3” / 2513 mm  
H= 8’4” / 2539 mm | 2000 cycles at rated power and energy | Battery rack, Battery Management system, DC protection, Inverter, AC protection, control system, Step-up Transformer, MV Switchgear |
| 2000 / 500                    | Outage management/ Capacity Firming/Frequency regulation | 3      | Up to 690 V or Medium Voltage up to 24 kV | Three Enclosures:  
a) Connection equipment (one): W=20'/6096 mm  
D=8’2438 mm  
H=8’6”2591 mm  
b) Battery Enclosure (two): W=40’/12192 mm  
D=8’2438 mm  
H=8’6”2591 mm | The system will charge or discharge, per 5 years, in response to a frequency regulation signal received every 4 seconds | Battery rack, Battery Management system, DC protection, Inverter, AC protection, control system, Step-up Transformer |
| 2000 / 6000                   | Outage management/ Time of use management/Peak Shaving/Capacity Firming/Frequency regulation | 3      | Up to 690 V or Medium Voltage up to 24 kV | Seven Enclosures:  
a) Connection equipment (one): W=20’/6096 mm  
D=8’2438 mm  
H=8’6”2591 mm  
b) Battery Enclosure (six): W=43’12”/13400 mm  
D=8’3”2591 mm  
H=8’4”2539 mm | 2000 cycles at rated power and energy | Battery rack, Battery Management system, DC protection, Inverter, AC protection, control system, Step-up Transformer |
| 4000 / 1000                   | Outage management/ Capacity Firming/Frequency regulation | 3      | Up to 690 V or Medium Voltage up to 24 kV | Three Enclosures:  
a) Connection equipment (one): W=40’/12192 mm  
D=8’2438 mm  
H=8’6”2591 mm  
b) Battery Enclosure (two): W=40’/12192 mm  
D=8’2438 mm  
H=8’6”2591 mm | The system will charge or discharge, per 5 years, in response to a frequency regulation signal received every 4 seconds | Battery rack, Battery Management system, DC protection, Inverter, AC protection, control system, Step-up Transformer |

All information subject to change without notification.  
Scope and dimensions may vary depending on the application.  
For connection voltages higher than 24 kV, a customized solution can be supplied.  
For power requirements higher than 4 MW, several ESM modules can be connected in parallel and be controlled as a single unit.
## Typical sketch - Pre-designed unit

### Energy Storage Module for 1000 kW/250 kWh

<table>
<thead>
<tr>
<th>Applications</th>
<th>Capacity Firming</th>
<th>Voltage Support</th>
<th>Frequency regulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions with Connection equipment (Transformer, MV switchgear), as showed in the sketch</td>
<td>W= 49’ 3”/ 15000 mm</td>
<td>D= 8’3” / 2513 mm</td>
<td>H= 8’4” / 2539 mm</td>
</tr>
<tr>
<td>Total Number of Enclosures</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Voltage</td>
<td>15 kV</td>
<td>3 Phases</td>
<td>60 Hertz</td>
</tr>
<tr>
<td>Components</td>
<td>Battery rack</td>
<td>Battery Management System</td>
<td>DC protection</td>
</tr>
<tr>
<td></td>
<td>Inverter</td>
<td>AC protection</td>
<td>Control system</td>
</tr>
<tr>
<td></td>
<td>Step up transformer</td>
<td>Medium Voltage (MV) Switchgear</td>
<td></td>
</tr>
<tr>
<td>Enclosure Type</td>
<td>Outdoor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All information subject to change without notification.
A **Connection Equipment Module (CEM)** unit is a packaged solution that includes all the components required to connect a battery system with the AC grid (Inverter, transformer, protection equipment, control system, etc.)

<table>
<thead>
<tr>
<th>Storage Energy Size (kW)</th>
<th>Phases</th>
<th>Output Voltage</th>
<th>Type of Enclosure / Approximate Dimension</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>3</td>
<td>Up to 690 V or Medium Voltage up to 24 kV</td>
<td>W= 22’ 5” / 6830 mm D= 8’3” / 2515 mm H= 8’6” / 2591 mm</td>
<td>DC protection, Inverter, AC protection, control system, Step/up- Isolating transformer, MV switchgear</td>
</tr>
<tr>
<td>1000</td>
<td>3</td>
<td>Up to 690 V or Medium Voltage up to 24 kV</td>
<td>W= 20’ / 6096 mm D= 8’ / 2438 mm H= 8’6” / 2591 mm</td>
<td>DC protection, Inverter, AC protection, control system, Step/up- Isolating transformer. Note: MV switchgear is not included</td>
</tr>
<tr>
<td>2000</td>
<td>3</td>
<td>Up to 690 V or Medium Voltage up to 24 kV</td>
<td>W= 20’ / 6096 mm D= 8’ / 2438 mm H= 8’6” / 2591 mm</td>
<td>DC protection, Inverter, AC protection, control system, Step/up- Isolating transformer. Note: MV switchgear is not included</td>
</tr>
<tr>
<td>4000</td>
<td>3</td>
<td>Up to 690 V or Medium Voltage up to 24 kV</td>
<td>W= 40’ / 12192 mm D= 8’ / 2438 mm H= 8’6” / 2591 mm</td>
<td>DC protection, Inverter, AC protection, control system, Step/up- Isolating transformer. Note: MV switchgear is not included</td>
</tr>
</tbody>
</table>

All information subject to change without notification. Scope and dimensions may vary depending on the application. For connection voltages higher than 24 kV, a customized solution can be supplied.
Soaring energy prices and concerns about climate change from man-made emissions of carbon dioxide have propelled energy efficiency to the top of the agenda in the boardroom, in public debate and in public policy. Under this scenario, Energy Storage Modules are a state-of-the-art technology which contributes to raise the efficiency at every stage of the energy chain by:

- Increasing the capacity factor of generation, transmission and distributions assets
- Improving the uniformity and efficiency with which electrical energy is being used
- Raising Power Quality with better voltage and frequency regulation as well as minimum interruptions
- Increasing the capacity factor of renewable energy sources in order to make clean energy available for longer periods
- Providing a reliable source of energy to communities

An ESM module integrates batteries, transformers, and medium and low voltage switchgear together with automation equipment such as inverters in a galvanized steel enclosure. Completely compartmented and segregated enclosures are available upon request.

The modules are carefully engineered and tested, including the enclosure, assuring high and safe performance.

ESM is the energy storage alternative for efficient and smart electrical network operation through:

- Individual modules up to 4 MW
- Output voltage range of 120 volts to 40.5 kV at 50 or 60 Hertz, single or three phase system
- Enclosure designs with different temperature classes and protection degrees according to the application and size
- Different types of batteries according to the application and size
- Optimal product selection for grid connection combining ABB products and customer interface requirements
- Seamless integration of high quality products to assure high reliability
- Proven track record of containerized solutions in many severe environments all over the world
- ABB’s vast and global experience in designing Modular Systems, integrating electrical equipment in enclosures for renewable, industrial and Utilities applications
- Global service coverage with a high level of engineering capabilities
We have factories located all over the world to support your needs. For more information please contact the Modular Systems Product Group of North America, Asia, or Europe.

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