ABB Electrification Wind Offering
Utility, EPC, Developer, Service Low Voltage Parts

ABB wind offers a large product portfolio: From low to medium voltage

Explore the industry’s broadest portfolio in wind

ABB offers the industry’s most comprehensive portfolio of products, systems, solutions and services.

Optimize the performance, reliability and return on investment of any wind installation.

ABB’s solution portfolio is covering the whole scope of wind applications ranging from small onshore installations up to full scale offshore wind farms.

A proven track record in wind since the 1990s.

Global presence and expertise from wind systems to grid connection and integration to smart grids we are your expert partner.
ABB wind competitive offerings
Explore the industry’s broadest portfolio in utility scale wind

Low to Medium Voltage

ABB has over 140 years of experience developing power electronics equipment. With the most sophisticated engineering and power electronics professionals.

ABB has expertise and experience needed to deliver a complete solution to maximize revenues by optimizing the efficiency and uptime of the wind farms.

Successfully manufacturing, deploying, connecting, integrating and deploying wind plants requires a deep understanding of utility-scale applications.

From generator to interconnect - Low to Medium Voltage: ABB offers the complete range of solutions from generator and converters in the turbine up to the collection and connection of the power to medium grids.

And, don’t forget about Service, ABB offers a wide range of services to help you get the most power from your plant – ranging from remote monitoring to full operation and maintenance (O&M).
Systems and Solutions for successful utility plant design

ABB key offerings in utility segment

**Electrical balance of plant**

ABB’s solutions for wind power plants are designed to meet grid standards, maximize plant performance and provide owners with a rapid return on investment and long plant operating life.

Optimized standard concepts for each stage of the wind power plant process and a complete capability in design, engineering, and commissioning.

**Grid integration (Medium voltage)**

As an intermittent, widely dispersed source of energy, wind presents a challenge to power grids. It demands sophisticated solutions to balance supply and demand and avoid stress on the grid.

ABB has the advanced technologies needed for successful grid integration for installations of all sizes both at the connection point and at the system level with our smart grid components and solutions.

**Turnkey stations**

ABB turnkey solutions capitalize on ABB’s long expertise in the development and manufacturing of secondary substations and medium voltage (MV) components.

ABB solutions include all critical complete plug-and-play portfolio for transformer stations inside the power collection and low and medium voltage eHouses. Also battery energy storage modules

**Energy storage and Battery chargers**

With our range of dynamic battery energy storage systems for wind applications, ABB has developed an effective and efficient approach that enables energy produced from a renewables system to be stored and then used when required.

As a major contribution to achieving stringent environmental targets, our battery systems maximize the efficient use of renewable energy sources by reducing their inherent intermittency, facilitating integration into the grid.

**Grid connection**

ABB offers a range of products and solutions that help to efficiently connect wind farms to the medium-voltage grid.

In-depth knowledge of renewable power generation technologies and comprehensive experience with grid codes and utility practices in use around the world enables us to provide grid connection solutions for wind plants of all sizes.

**Plant automation**

ABB offers a versatile and scalable automation solution designed for monitoring and control of wind power plants. The solution includes our ABB Ability monitoring system for major components and systems.

SCADA ABB Ability™
# ABB wind offers the largest product portfolio: Low to Medium Voltage

**System & Solutions: Electrification options for wind plants of all sizes**

## Low Voltage & Connection
- Switch gear, Panel boards and switch boards – ReliaGear
- Breakers’ Disconnects
- Safety switches
- Contactors and Relays
- Insulation monitors
- Meters and timers
- Fuse holders
- Power supplies, Power monitoring
- Connecting and grounding
- Wire and cable management; Cable tray, basket trey, conduit, cable ties and strain relief

## Medium Voltage Products
- Air-insulated switchgear
- Gas-insulated switchgear
- Dead tank circuit breaker
- Recloser, breakers and disconnects
- Voltage and current sensors
- Surge arrestors
- Transmission line and current limiting fuses
- Transmission line connection and protection relays
- Wireless communications
- Packaged solutions
- Mobile substations
- Automation and SCADA

## OEM Replacement parts
- LV and MV components for converters, yaw and pitch control panels and lubrication control panels:
  - Breakers, Contactors, Relays
  - Power supplies
  - Disconnects
- Lighting control panels
- Panel boards and switch boards – ReliaGear
- Power monitoring
- Surge protection, Ground fault
- Voltage and current sensors
- Wire duct, Cable tray, cable ties

## Wind turbine nacelle

## Energy Storage / Chargers
- Energy storage:
  - EssPro PCS
  - EssPro EBOP
  - EssPro Grid Tie
  - storage(BESS) modules and solutions
- Battery chargers: and UPS
  - Integritas wall, and floor mounted
  - Infinity Industrial
Utility applications: power-plant products
Solutions - products, systems, software and services


★ = ABB offering
ABB’s offering for collection and connection

Wind plant grid connection - electric balance of plant

ABB can deliver from products to engineering packages or turnkey S/S BoP available in specific markets
Medium Voltage Products

Typical Wind power plant – overview

- Generation of electrical energy from kinetic Wind energy
- Conversation into AC current at grid frequency

Low Voltage
(690 - 3300V AC)

Medium Voltage
(Onshore: 12 - 38 kV)
(Offshore: 33 - 66 kV)

High Voltage
(acc. to utility grid)

- Stepping up to medium voltage
- Inside-tower and out-side of tower

- Collection point for all strings
- Step up to utility grid medium voltage
- Feed into utility grid
Medium Voltage Products

Wind power plant – main components (example)

Turbine Nacelle

Generator / Converter

Generator

Converter

Converter

Turbine tower & Yard

MV station / Transformer station

WTG Transformer

Secondary Switchgear

Generator / Converter

Converter

MV station / Transformer station

WTG Transformer

Secondary Switchgear

Station Transformer

HV Switchgear

Yard

Grid Connection Substation

Primary Switchgear

Station Transformer

HV Switchgear

Low voltage components: Breakers, contactors, Surge Protections power supplies, metering, monitoring

A Series & ReliaGear® Lighting Panels

Inside tower

Out-of-tower: CSS / transformer station

NALFWind

Recloser

Switchgear

E-house solution

Outdoor solutions

Building
Wind farms: Low/Medium voltage systems, components and sensors
Sold to Utilities, Developers, EPCs and their distributors
Utility applications
Medium Voltage Solutions

Electrical houses
Compact secondary substations
Energy storage modules

Skid mounted unit-substations
# Utility applications

## Medium Voltage Switching Products

<table>
<thead>
<tr>
<th>Air-insulated primary switchgear</th>
<th>Gas-insulated primary switchgear</th>
<th>Gas-insulated secondary switchgear</th>
<th>Dead tank vacuum magnetic CB</th>
<th>Recloser</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal-clad and arc-resistant ANSI switchgear:</td>
<td>Full line of gas insulated primary switchgear:</td>
<td>SafeRing is a ring main unit (RMU) for the secondary distribution network. SafePlus is a metal enclosed compact switchgear system for distribution applications.</td>
<td>ANSI, Magnetic actuator, Vacuum interruption</td>
<td>Mechanically ganged operation</td>
</tr>
</tbody>
</table>
| Arc-resistant SafeGear®:  
  - up to 4000 A, 63 kA, 15 kV  
  - smallest footprint available in the industry | ZX2:  
  - 38kV (85kV/200kV), 4000, 40kA  
  - Flexible/adaptable design, ETL labeled |  
  - RMU Safering: up to 40.5 kV, 630A  
  - Compact switchgear SafePlus: up to 40.5 kV, 630A | R-Mag 15.5kV, ...3700A  
  - R-Mag 27kV, ...2000A  
  - R-Mag 38kV, ...2000A | OVR-15, OVR-27  
  - Controller: ABB Relion  
  - 3ph network  
  - Pole & substation |
| ReliaGear® ND:  
  - ABB’s narrow-design  
  - 31.5kA, 5 and 15 kV | ZX2.2  
  - 38kV (85kV/200kV), 4000, 40kA  
  - Disconnect & earth switch on cable side of CB |  |  | }

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Utility applications
Indoor circuit breakers and switches

**ADVAC / AMVAC**

Generator breakers: ADVACG, VD4G
- 15KV 4000A 63KA

Distribution breakers:
- ADVAC – spring actuator
  15KV 4000A 63KA
- AMVAC – magnetic actuator
  27KV 4000A 50KA

**VD4-CS**

Safe and relentless operation of 38KV power quality
VCB with servomotor drive for 20,000 transient free operations
- 20,000 operations with extreme low probability of re-strike
- No inrush reactors
- Optimize assets combines protection (circuit breaker) and switch (frequent operations) features
- 1200A capacitive current

**DS1**

Synchronous transient-free capacitor switch
The first diode-based MV switch worldwide at 15KV
- Transient free
- 50,000 maintenance free operations
- No inrush reactors
- Compact solution
- Embedded diagnostics
- 600A capacitive current
## Utility applications

### Special solutions

<table>
<thead>
<tr>
<th>Alternative relays</th>
<th>Arc fault protection</th>
<th>Ultra-Fast Earthing Switch UFES</th>
</tr>
</thead>
</table>
| Electromechanical and solid-state relays | Solutions designed to detect an internal arc in 1.5 ms and eliminate it in less than 4 ms, improving safety and availability of the power system. Operating the network with a conventional solution with an operating time of 80 – 100 ms results in cable fire and copper and steel melting. | Innovative arc quenching  
Highest level of safety for LV and MV systems against the internal arc faults  
In case of an internal arc fault the arc detection relay trips the UFES, which initiates a three-phase earthing to break the arc voltage immediately. The switching time is less than 1.5 ms, the arc flash is extinguished in less than 4 ms |
| Solid state electronic components provide a similar function to electromechanical relays but do not have any moving components, increasing long-term reliability. | | |
Utility applications
Outdoor apparatus – fuse cutouts and disconnectors

Fuse cutouts for distribution applications

3 Types
- ICX, fuse holder interchangeable with S&C, Cooper, ..
- ICX LBU, fuse switch application (breaking chamber)
- NCX, non interchangeable fuse holder (ABB type only)
- Ratings
  • 15, 27, 38kV
  • Up to 200A , ...20kA
- Insulators types; porcelain, silicon rubber, polymer concrete.
- Protection of overhead lines (laterals) and loads such as distribution transformers
- Protection and visible break

Overhead disconnect switches

Up to 38kv, ..900A ,..25kA
- SID, single insulator disconnect
- LSID, load break single insulator disconnect
- DCD, double insulator single phase disconnect switch
- RBD, single phase by-pass disconnect switch
- Sectionalize and isolate OHL or equipment for maintenance
- Isolating CBs, etc. reclosers by-pass
**Instrument transformers**
Traditional primary measurement solutions proven through the ages

100 years+ old technology
Uses ferromagnetic circuit to tightly couple primary and secondary, with special attention to maximizing accuracy of translation of voltage and current signals
Also able to transfer power from primary to secondary
Typically 1 or 5 amp current output, 120 or 240 volt voltage output
Wide array of meters and relays supporting (electromechanical & solid state)
# The role of instrument transformers (ITs)

Dry type ITs in ABB’s indoor and outdoor portfolio are used in three main types of applications:

<table>
<thead>
<tr>
<th><strong>Metering applications</strong></th>
<th><strong>Protection and Control applications</strong></th>
<th><strong>Power supply applications</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Providing voltage and current signals to power and energy meters for both revenue (tariff) metering and non-revenue (non-tariff) metering applications.</td>
<td>Providing voltage and current signals to protection and control relays and controllers for protecting and managing the power grid.</td>
<td>Small dry type form factor of ITs perfect for supplying power to protection and control apparatus. May be used for both measurement and supply in the same application.</td>
</tr>
</tbody>
</table>
## What you must know
Minimum information when specifying ITs

<table>
<thead>
<tr>
<th>Basic information</th>
<th>... specifically for CTs</th>
<th>... specifically for VTs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor or outdoor use</td>
<td>Primary current, taps if applicable</td>
<td>Primary voltage, taps if applicable</td>
</tr>
<tr>
<td>System voltage &amp; BiL</td>
<td>Secondary current, taps if applicable</td>
<td>Secondary voltage, taps if applicable</td>
</tr>
<tr>
<td>Metering class and rated burden</td>
<td>Window, bar, or wound primary type</td>
<td>L-L or L-G connected</td>
</tr>
<tr>
<td>Protection/relay class</td>
<td>Gapped core, remanence control</td>
<td>Primary fuses</td>
</tr>
<tr>
<td>Frequency (if other than 60 Hz)</td>
<td>Continuous current rating factor (RF)</td>
<td>Thermal capacity – VA (for light power use)</td>
</tr>
<tr>
<td>Operating ambient temperature (if other than 30OC)</td>
<td>Short-time thermal &amp; mechanical ratings</td>
<td>Over-voltage ratings, continuous and short-time duty, IEEE Group class</td>
</tr>
<tr>
<td>Mounting orientation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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IT product lines for utility applications
LV applications (600 V)

600 V metering
- Current and voltage transformers
- Encapsulated in thermoplastic rubber (TPR)
- Available in current and voltage designs
- Used for secondary revenue metering
- AccuRange high accuracy extended range (HAER) CTs

600 V plastic case ITs
- Offered in a variety of internal window diameter sizes
- Used in switchgear and outdoor vacuum breaker applications (R-Mag)
IT product lines for utility applications
MV applications (5 – 34.5 kV)

Outdoor medium voltage
Utilized in utility substations
  – Designed for metering and relaying on outdoor circuits
Materials
  – HCEP (hydrophobic cycloaliphatic epoxy)
  – PUR (polyurethane)
AccuRange high accuracy extended range (HAER) CTs
ResiVolt VFT resistant VTs
Combination CT/VT ITs
Station post CTs
IT product lines for utility applications
Station post CTs – metering and protection

LG and LGX
• 15 – 34.5 kV, 110 – 200 kV BIL
• Window (4.5-8.75” ID) and bar type designs
• Metering accy 0.3 & 0.15S (AccuRange CT), relaying to C800
• CEP tube

KOTD-110, -150, -200
• 15 – 34.5 kV, 110 – 200 kV BIL
• Window (4-5” ID) and bar type designs
• Metering accy 0.3, relaying to C800

KOT-60, -75, -11, -15
• 15 – 34.5 kV, 110 – 200 kV BIL
• Window (3.25” ID) and bar type designs
• Metering accy 0.3, relaying to C200

Marketing message
• Optimizing pricing to promote business across station post CT product family
• Working to develop better selection guide for these ITs
IT product lines for utility applications
MV & HV applications

Bushing current transformers (indoor)

- Ring-type current transformers
- Polyester or cotton tape wrap
- Typical applications include high voltage circuit breakers and power transformers

Bushing current transformers (outdoor)

- Urethane insulation
- Basic impulse level: 0.6 kV
- 15 kV – 765 kV Application:
  - Slips over the primary bushing of power transformers and oil-filled breakers
  - Substation metering and protection
IT product lines for utility applications

Generator applications

**Generator CTs – metering and protection**

Indoor and outdoor
Board mounted (155°C insulation, up to 32” ID) and resin cast (130°C insulation, up to 51” ID)
Basic impulse level: 0.6 kV
Extensive product offering of proven designs with decades of field experience
Durable design against water intrusion and vibration
Highly customizable

Application:
- Mounted over generator bushing
- 2000 amperes to 50,000 amperes
- Proprietary shield windings to prevent stray flux interference
- IEEE/IEC designs sold worldwide
IT product lines for utility applications
Split core, retrofit applications

Split-core CTs – monitoring, metering and protection

- Metering accuracy to 0.3 class
- Relaying accuracy to C800
- Convenient mounting around primaries which cannot be opened – common for retrofit solutions
- SP window sizes up to 41"
- CO window sizes of 2½", 5½", 9", sq. (custom sizes available)
IT product lines for utility applications

Submersible VTs

VIL-95/95S and VIL-12/12S – control power, relaying, or metering applications.

- Indoor VT for use in a subsurface installation
- VIL-95/12
  - Designed with secondary junction box for intermittent submersible operation where VTs are not permanently submerged under water
- VIL-95/12
  - Designed with secondary wires directly encapsulated into the polyurethane for a water-tight connection allowing installation where they me permanently submerged
- Uses dead-front elbow connectors for primary
IT product lines for utility applications
Ferroresonance mitigation

**FSR-983 outdoor saturable reactor**
- 600V class
- Matched to specific PT
- Ideal for retrofit applications to passively damp circuit to avoid resonance

**VT Guard Pro**
- Ideal for active elimination of ferroresonance risk in new deployments
- Used in open-delta connection of three single-phase VTs
- Requires additional LV winding on PT
### Other IT products not commonly used by utilities

Other specialty designs

<table>
<thead>
<tr>
<th>Indoor medium voltage</th>
<th>Auxiliary CTs and PTs</th>
<th>Control power transformer</th>
<th>Zero sequence CTs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typically used in switchgear and metal clad enclosures for primary revenue metering and protection</td>
<td>An Auto transformer</td>
<td>Control Power Transformers (CPT)</td>
<td>BYZ-863/865</td>
</tr>
<tr>
<td></td>
<td>Change the overall ratio of main current transformer</td>
<td>Available from 2.5kV to 15kV</td>
<td>Used for ground fault detection</td>
</tr>
<tr>
<td></td>
<td>Can be used as VT</td>
<td>From 5kVA, 10kVA &amp; 15kVA</td>
<td></td>
</tr>
</tbody>
</table>
ABB AccuRange technology
Extended range high accuracy current transformer technology

- 600 V to 34.5 kV voltage classes
- ABB was the original developer of this technology
- Accuracy of +/- 0.15% from 1% of the rated current to the rated factor
  - Exceeds the highest accuracy 0.15S IEEE accuracy class
- Increase revenue, most prominently on MV products
- Reduce part numbers and inventory, MV and LV
- Reduce meter multiplier diversity – simplify operations with less chance of billing errors
ABB AccuRange technology
Extended range high accuracy current transformer technology

Excellent linearity over wide dynamic range

Field study of ABB Pinetops, NC facility

How it works – increase current flowing into the meter
Benefits – more current leads to increased revenue

<table>
<thead>
<tr>
<th>CT Type</th>
<th>KWH</th>
<th>% improvement</th>
<th>Add'l revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>High accuracy</td>
<td>8,384,070</td>
<td>0.82%</td>
<td>$8,404</td>
</tr>
<tr>
<td>Standard accuracy</td>
<td>8,315,880</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$8,400 in additional annual revenue for a minor increase in CT selling price – use this in value added selling
ResiVolt technology

World’s first dry-type voltage transformers designed for very fast transient (VFT) resistance

Enhanced withstand to VFT overvoltages
- Common in renewable and frequent line switching installations
- Near reclosers, solar/wind farm interconnections, etc.

Optimized using advanced mechanical and electrical modeling for field performance
- ABB testing exceeds IEC 61869-3, class 7.2.3 and CAN/CSA 411.1, class 6.6 requirements for basic impulse and fast impulse transient withstand
- Large multi-year global effort to investigate models and designs to mitigate the effects of VFT
- Collaboration within ABB globally and with a Swiss university to create the software model which had not previously existed
- Multiple aspects of design changes – design details are trade secret and cannot be shared

Improved safety
- Withstand VFT without insulation degradation, reducing the chance of catastrophic failure

Unparalleled reliability
- Minimizes failures at critical interconnection or metering points

Extended factory warranty (36 months instead of normal 12/18 months) included on all ResiVolt VTs

For more information on the VFT phenomenon – contact the factory
Voltage transformer type designations that end in “R” are part of ABB’s ResiVolt product family

©ABB
ResiVolt technology
Product offered with and without ResiVolt™ certification

Same body style offered in both standard offering (similar to competition) and with ResiVolt™
- Needed to replace legacy portfolio – some locations or customers may not require or desire ResiVolt™ VFT resistance
- Many design enhancements don’t directly affect VFT resistance
- ResiVolt™ versions include design variant testing and certification and include an extended warranty by default (additional value proposition)

WHY use same physical body and most of design same with a ResiVolt™ variant?
- Efficiency in factory production
- Avoided having to create both non-ResiVolt™ and ResiVolt™ designs
- Allows competing more effectively in applications not prone to VFTs without devaluing ResiVolt™ offering
- Increases understanding and belief that our design has something unique in the design for VFT mitigation
ResiVolt Technology
Building belief and grabbing mindshare

Evidence backed explanation of field issues
Demonstrate ABB leadership in addressing issue
Gain acceptance not just an ABB product issue
Join with customers in mindset of solving industry challenge TOGETHER
Grab mindshare by showing
- Building the first VFT capable impulse generator in the United States, only 1 other in North America
- Collaborative investigation and conclusion with utility – co-authored whitepaper
- ABB investing heavily in the technology – evidence presented with new building and impulse tester
- Build belief in issue and technology through industry groups
- Differentiated mindshare through trademark (ResiVoltTM) and design certification process (with applied sticker – visual reminder of value)
CVC combination ITs

Application benefits

Streamlined footprint
- Lighter weight, less complicated 3 phase installations – safer, simpler, more fool proof
- Significant operational savings
- Lightest combination units in the industry

HCEP encapsulant
- Superior to all other HCEP and CEP in market
- ABB helped invent HCEP and has a special formulation that is the best in the industry

Application variety
- Standard accuracy – metering + protection/relaying
- HAER – high accuracy on CT with extended range current capability for metering only

CVC-150 and -200 are currently only offered in PUR, -150 HCEP will be released in 2020 and -200 HCEP in late 2021
CVC combination ITs

Improving safety, assembly and reliability in primary metering units (PMU)

Traditional configuration of CTs and VTs

Streamlined configuration of CVCs

Streamlined, smaller footprint
Substantial reduction in assembly time
Fewer connections, less cable for fewer potential failure points
Safer assembly - No more cantilevered or upside-down units!
Primary metering units
Pre-configured and flexible options

- 5 – 34.5 kV, 60 – 200 kV BIL
- Pre-configured configurations available
  - Three-phase, four-wire (3CTs & 3VTs, or 3CTs & 2VTs)
  - Three-phase, three-wire (2CTs & 2VTs)
- Other configurations available upon request, can also include sensors
- Any CT/VTs can be used
- Pole-mount or padmount cabinet options are available
  - Both are growing areas of interest in the market and we are continuing to expand our portfolio
Sensors for utility applications
Advanced primary measurement solutions responding to emerging challenges

25+ years old technology
Use solid state components and little or no ferromagnetic material in circuit
Lack of magnetic core – very low energy output – cannot typically transfer power to secondary
Numerous form factors for indoor and outdoor applications (voltage only, current only, combination)
Wide variety of outputs – from 0-10 V, 120V and 600 A
# Sensors for utility applications

## Features

<table>
<thead>
<tr>
<th><strong>Hybrid Rogowski coil</strong></th>
<th><strong>Low-power CTs</strong></th>
<th><strong>Resistive voltage dividers</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rogowski coil with some iron in magnetic circuit</td>
<td>Current transformer based on iron core with optimized output power</td>
<td>Accurate voltage sensing provides 3-10 V or 120 V outputs</td>
</tr>
<tr>
<td>Accurate current sensing provides a 10 V output</td>
<td>1A output for real-time reading of the current waveform</td>
<td>Voltage sensing 0.5% to 1% accuracy, depending on design</td>
</tr>
<tr>
<td>Current Sensing 1%-2% accuracy depending on design</td>
<td>Current Sensing 1%-2% accuracy depending on design</td>
<td>Compatible with wide selection of intelligent electronic devices</td>
</tr>
<tr>
<td>Compatible with wide selection of intelligent electronic devices</td>
<td>Compatible with wide variety of controllers</td>
<td></td>
</tr>
</tbody>
</table>

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Benefits of sensors vs traditional ITs

**Safety** – One of the most important benefits

- Low voltage, low energy output signals
- No need for primary fuses on voltage sensors
- Secondary can be left open (current sensor) or short-circuited (voltage sensor)
- Increased safety for personnel during testing/ operation

**WARNING!!!** The secondary circuit of traditional CTs should never be opened or left open when current is flowing in the primary. If the secondary circuit is open, the primary current will drive the core to saturation, inducing abnormally high and possibly lethal PEAK voltages.
Key benefits of sensors vs traditional ITs

- Reduced chances of failure – simpler construction, less internal failure points
- Reduced footprint - lighter weight, smaller form factors
- More linear response, esp. when harmonics present
- Simplified installations – less wiring, smaller footprint, lighter weight (e.g. PT drawout trays in switchgear may be avoided)
- Reduced energy use, esp. in tight compartments (Example MV voltage sensor over life: 0.040 kWh loss vs 7,500 kWh!)
- Flexibility toward varying load flow – linear response, extensive dynamic range (no core saturation)
- Typically, no risk of ferroresonance (voltage sensor vs PT)
- Upgrade of switchgear parameters without additional costs
  - Indoor sensors can often be retrofitted in existing structures with new relays
- Standardization - one sensor covers full voltage or current range of traditional IT family
  - Improved inventory management
  - Change-out flexibility
  - Simpler documentation
## Sensor challenges

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cabling</strong></td>
<td>May be sensitive to magnetic fields</td>
</tr>
<tr>
<td><strong>Lack of power transfer to secondary to power devices</strong></td>
<td>Lack of power transfer to secondary to power devices</td>
</tr>
<tr>
<td><strong>Percentage error still not comparable to traditional ITs</strong></td>
<td>Lack of standardization in IEEE</td>
</tr>
<tr>
<td><strong>Lack of standardization in IEEE</strong></td>
<td>Limited selection today of meters and relays compatible with sensors</td>
</tr>
<tr>
<td><strong>General understanding of sensors is less as opposed to ITs</strong></td>
<td>General understanding of sensors is less as opposed to ITs</td>
</tr>
</tbody>
</table>

©ABB
Sensors

Standards for ANSI markets

ITs are primarily covered by IEEE C57.13-2016; this standard does not cover sensors

- IEEE standards / guides for current & voltage sensors
- IEEE PSIM Working Group formed recently to work on an IEEE Guide that will be focus on testing of end-to-end sensor systems
- IEEE C37.92-2005 - Standard for Analog Inputs to Protective Relays From Electronic Voltage and Current Transducers

Recent switchgear standards (IEEE C37.20.2-2015) explicitly address the use of current & voltage sensors

However, this should not limit your applications

- IEC standards cover sensor physical device characteristics and is likely to be referenced in forthcoming IEEE guides

<table>
<thead>
<tr>
<th>Current sensors</th>
<th>Voltage sensors</th>
</tr>
</thead>
</table>
Sensors for utility applications

ABB DistribuSense® MV sensor offering

**VLS**
Voltage sensor
Voltage output

**KLS**
Current sensor
Current output

**VKS**
Current sensor
Voltage output

**VCS**
Combination – voltage and current
Voltage outputs

**WLS**
Combination – voltage and current
Current and voltage outputs
VLS – voltage sensor
15kV, 25kV and 34.5kV

Weight:
- 15kV: 10 pounds
- 25kV: 15 pounds
- 34.5kV: 21 pounds

Installs live
Lightweight, simple retrofit
3-10V or 120V output
1% accuracy

Used for
- FDIR – reclosers/distribution switches
- VVO/VVC/CVR – capacitor banks
- Outage management – padmount switchgear
**VCS-110 current and voltage combination sensor**

15kV

Voltage sensing 1% accuracy, <1.5° phase error
Current sensing 1% accuracy, <1° phase error with LEA output
Weight: 35 pounds
Line sag and current crosstalk immune
120V or 3-10V output for voltage
10V output @ 600A current (Includes voltage clipping to protect controller)
Acts as a line post insulator, allowing for easy installation without primary taps or cutting the line
Options with fault current measurement to 12kA and improved harmonic response to 33rd harmonic
Primary cable capture feature – “V design” is easier to install the cable
Larger creep than competitive designs for this voltage class
ABB assisted in development of HCEP with Huntsman and has the longest experience in the industry with this material

**Combo sensor**

**Used for**

FDIR (fault detection, isolation and recovery)
VVO/CVR – capacitor banks, independent feeder monitoring, distribution switches

25 kV, 34.5 kV – planned
VKS-110 is the current only equivalent of VCS
Sensors for utility applications

RSS-1 - submersible current sensor

Introducing the world’s first **truly hermetically sealed**, rustproof, waterproof submersible, split core current sensor

- **True hermetic sealing** – no exposed metal parts, truly submersible without degradation
- **Low energy output** – no safety risk from open circuit
- **Voltage clipping** – output limited in faults to protect receiving device from damage, yet gives enough magnitude for fault indication
- **Crosstalk mitigation** – unique winding structure to ensure accuracy without degradation from current “cross talk” from adjacent conductors
- **Easy install** – quick “tools free” install, easy to deploy even with PPE typical in the application

### RATINGS SUMMARY
- 600A : 10V
- Accuracy 1%
- RF 2.0 cont.
- NEMA Type 6P/IP68W compliant (2 meters depth)
- 5.5 lbs (10 lbs with 75 ft cable)
Utility applications
Outdoor apparatus – fuse cutouts and disconnectors

Fuse cutouts for distribution applications

3 Types
- ICX, fuse holder interchangeable with S&C, Cooper, ..
- ICX LBU, fuse switch application (breaking chamber)
- NCX, non interchangeable fuse holder (ABB type only)
- Ratings
  - 15, 27, 38kV
  - Up to 200A , ...20kA
- Insulators types; porcelain, silicon rubber, polymer concrete.
- Protection of overhead lines (laterals) and loads such as distribution transformers
- Protection and visible break

Overhead disconnect switches

Up to 38kv, ..900A ,..25kA
- SID, single insulator disconnect
- LSID, load break single insulator disconnect
- DCD, double insulator single phase disconnect switch
- RBD, single phase by-pass disconnect switch
- Sectionalize and isolate OHL or equipment for maintenance
- Isolating CBs, etc. reclosers by-pass
## Utility Applications

**Products and Solutions**

<table>
<thead>
<tr>
<th>Protection relays</th>
<th>Communication devices</th>
<th>Test switch and accessories</th>
<th>Arc fault protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microprocessor relays are programmable and the characteristic and behavior can be programmed. Multi-function relays for device protection, switch control, arc flash protection, sync and load shedding applications.</td>
<td>Used when connecting protection relays to wired communication media (fiber-optic, galvanic), to convert between communication protocols or between communication systems.</td>
<td>Designed and manufactured to allow quick and easy multi-circuit testing of switchboard relays, meters and instruments by any conventional system. They have been especially designed for the measurement of potential elements, current elements and make-before-break short-circuit elements related to Current Transformer (CT) circuits.</td>
<td>Solutions designed to detect an internal arc in 1.5 ms and eliminate it in less than 4 ms, improving safety and availability of the power system. Operating the network with a conventional solution with an operating time of 80 – 100 ms results in cable fire and copper and steel melting.</td>
</tr>
</tbody>
</table>
Battery Energy Storage System (BESS), Utility & Commercial

Sold to Utilities, Developers, Municipalities, EPCs and their distributors
Battery Energy Storage applications

Applications

Renewables
ESM (Energy Storage Module) aligns solar and wind generation peaks with demand peaks.

Utility distribution grid
ESM balances fluctuating demand without oversizing equipment.

Industrial loads
ESM provides back up power, improves load factor and manages demand peaks.

Residential and commercial
ESM lowers energy costs and provides backup power for critical loads.

Electrification of transportation
ESM reduces demand on grid and enables fast DC charging without increasing demand.
Energy storage solutions
Scope of a typical energy storage module (ESM)

Enclosure options for wide array of site conditions:
- Compact secondary substation (CSS), EcoFlex eHouse or skid
- Modular design for tight or complex spaces

Productized solution for improved delivery and startup time

Proven ABB technology
- Power conversion system (PCS)
- Medium voltage/low voltage switchgear
- Transformer
- Energy Management System (EMS) and local HMI

Ratings
- Power: starting at 25kW (not residential)
- Energy: configurable by battery parallel connection
- Grid connection voltage: up to 40.5kV

Typical customer base is utilities, industrials, EV, buildings
The global need for energy storage is growing at a rapid rate driven by items such as economic growth, increasing solar and wind resources, the electrification of transportation and backup power needs.

Energy storage modules (ESM) from ABB offer an integrated engineered and tested system solution for a wide variety of applications across industry, infrastructure, residential and utility sites.

Choosing ABB solutions with proven technology enables:

- **Fast project completion** - System engineering, factory system testing and reduced or eliminated site preparation costs, lowers schedule risk and improves project benefits.

- **Reliable solutions** - Internal arc tested MV equipment to IEC standards for safety, enclosure offerings for harsh environments and years of global installed base experience provide peace of mind.

- **Communication** - From local monitoring and control to dynamic optimization of resources, the platform supports a wide range of monitoring and control needs and will support advancements over the life of the equipment.
Selecting the correct energy storage solution

5 steps – major questions to consider

Step 1: Required standard?
- IEC/ANSI

Step 2: Required power and energy, and its application?
- Required power [kW]
- Required energy [kWh]
- Application (examples: load shifting, backup power, etc.)

Step 3: Network connection voltage?

Step 4: Site conditions?
- Installation in public domain
- Indoor access to equipment for maintenance
- Seismic requirement
- Transportation and site work condition
- Temperature and altitude
- All-in-one or modular type

Step 5: Control system?
- EMS (Energy Management System, which has control algorithm in ESS) without HMI (display, report, data storage)
- EMS with HMI
- External SCADA communication
- Integration with renewable or other system
Energy Storage Module Package Selection

Selection logic

1. Standard
2. Power/Energy
3. Voltage
4. Enclosure
Typical Style Nr.

Start

IEC Or ANSI

...100KW...
250KWh
...300KW...
300KWh
...1MW...
1MW
1.0-1.8MW
1.0-1.8MWh
...4.6MW...
configurable

...40.5KV

LV

LV

LV

LV

...40.5KV

Indoor Cabinet

CSS

CSS

CSS

Modular: Skid + EcoFlex

Modular: EcoFlex + EcoFlex

EECM10102VP

EECM10102VP

EECM10102VP

EECM10102VP

EEC17172VH

EEC17172VH

EEC17172VH

EEC17172VH

EECM234K2LH

EECM234K2LH

EECM234K2LH

EECM234K2LH

EECDP2K4K2VE

EECDP2K4K2VE

EECDP2K4K2VE

EECDP2K4K2VE

Product

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Slide 53
Energy storage module other auxiliary selections
Overview of optional selections available for all the packages

A. Power electrical
Different electrification technologies can be selected

<table>
<thead>
<tr>
<th>Products</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>MV transformer</td>
<td>Oil or dry SafeRing SafePlus</td>
</tr>
<tr>
<td>Low voltage Breakers</td>
<td></td>
</tr>
</tbody>
</table>

B. Control system
PLC options
Comm600 controllers
ZEE600 controller with the EMS

ESM control system can be monitored and controlled by SCADA system for ease of interface between all the electrical equipment

It can then connect through existing 3G/4G broadband

C. Ancillary equipment
eHouse or EcoFlex:
– Natural cooling
– HVAC cooling
– Fan cooling
– Fire detection and suppression

Control power and battery connection panel (BCP) for protection and control

UPS for protection and control power

D. ABB Ability™
All the packages can be ABB Ability enabled

The whole system can be monitored, controlled, and commanded from remote locations
**Energy storage form factor module package selection**

Enclosure type and features to consider

<table>
<thead>
<tr>
<th>Skid</th>
<th>EcoFlex container</th>
<th>Compact secondary substation (CSS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open air secondary skid unit is an ideal power conversion solution system for a high-power Energy Storage Module with outdoor equipment design.</td>
<td><strong>The metal enclosed</strong> EcoFlex is utilized for mid and high-power energy storage, and is a modular design, type tested to withstand internal arc according IEC 62271-202.</td>
<td>CSS is ideal for low power Energy Storage. Available in multiple materials: metal or new innovative <strong>glass reinforced polyester (GRP)</strong>, and type tested to withstand internal arc according IEC 62271-202.</td>
</tr>
<tr>
<td>Pre-engineered solution reduces delivery time</td>
<td>Stackable, expandable ISO standard enclosures</td>
<td>Pre engineered solution to minimize project engineering</td>
</tr>
<tr>
<td>Economical and fast installation solution</td>
<td>Easy to ship, load and offload</td>
<td>Available in multiple configurations, and a variety of sizes and materials to cover all requirements</td>
</tr>
<tr>
<td>Pre assembled and tested single piece solution</td>
<td>Robust and scalable solution</td>
<td>Simple and quick installation</td>
</tr>
<tr>
<td>Easy to install and operate</td>
<td>Relocatable solution can be adapted for temporary power</td>
<td>Relocatable solution can be adapted for temporary power</td>
</tr>
</tbody>
</table>

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Slide 55

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# Energy Storage Module Packages

## Overall offering

### Low-power offering

<table>
<thead>
<tr>
<th>ESM Type</th>
<th>Community Energy Storage (CES)</th>
<th>CES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>Up to 100kW</td>
<td>Up to 300kW</td>
</tr>
<tr>
<td>Energy</td>
<td>Up to 250kWh</td>
<td>Up to 300kWh</td>
</tr>
<tr>
<td>Enclosure type</td>
<td>Indoor panel</td>
<td>CSS</td>
</tr>
<tr>
<td>Layout</td>
<td><img src="image" alt="SLD" /></td>
<td></td>
</tr>
</tbody>
</table>

**Key feature**

- One-piece delivery
- Compact design, simple indoor installation
- One-piece delivery
- Internal arc tested for safety, metal and GRP option

### Mid-Power offering

<table>
<thead>
<tr>
<th>ESM Type</th>
<th>Distribution Energy Storage (CES)</th>
<th>DES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>Up to 1.0MW</td>
<td>Up to 1.8MW</td>
</tr>
<tr>
<td>Energy</td>
<td>Up to 1.0MWh</td>
<td>Up to 1.8MWh</td>
</tr>
<tr>
<td>Enclosure type</td>
<td>CSS</td>
<td>EcoFlex</td>
</tr>
<tr>
<td>Layout</td>
<td><img src="image" alt="SLD" /></td>
<td></td>
</tr>
</tbody>
</table>

**Key feature**

- One-piece delivery
- Internal arc tested for safety, metal and GRP options
- One-piece delivery
- Robust for easy transportation and installation
## Energy Storage Module Packages

### Overall offering

#### High-power offering + complete solutions

<table>
<thead>
<tr>
<th>ESM Type</th>
<th>Connection Energy Module (CEM)</th>
<th>CEM</th>
<th>DES</th>
<th>DES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>Up to 4.6MW</td>
<td>Up to 4.6MW</td>
<td>Up to 4.6MW</td>
<td>Up to 4.6MW</td>
</tr>
<tr>
<td>Energy</td>
<td>N/A (w/o battery)</td>
<td>N/A (w/o battery)</td>
<td>Configurable (with battery)</td>
<td>Configurable (with battery)</td>
</tr>
<tr>
<td>Enclosure type</td>
<td>Skid</td>
<td>EcoFlex</td>
<td>Skid(CEM) + EcoFlex(Battery)</td>
<td>EcoFlex(CEM) + EcoFlex(Battery)</td>
</tr>
<tr>
<td>Layout</td>
<td><img src="image" alt="SLD" /></td>
<td><img src="image" alt="SLD" /></td>
<td><img src="image" alt="SLD" /></td>
<td><img src="image" alt="SLD" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key feature</th>
<th>Economic solution, ease of installation</th>
<th>Robust for easy transportation and installation Internal arc tested</th>
<th>Scalable solution Economic solution, ease of installation Internal arc tested</th>
<th>Scalable solution Robust structure for easy transportation and installation Internal arc tested</th>
</tr>
</thead>
</table>

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## Energy Storage Module
Community energy storage - indoor

### Electrical specifications

<table>
<thead>
<tr>
<th>DC input</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC operating voltage range</td>
<td>633-822 V (at PF=1)</td>
</tr>
<tr>
<td>Max. DC operating current</td>
<td>1200A</td>
</tr>
<tr>
<td>DC grounding</td>
<td>Floating only</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AC output</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output power (S)</td>
<td>100kVA</td>
</tr>
<tr>
<td>Output energy</td>
<td>250kWh</td>
</tr>
<tr>
<td>Nominal voltage</td>
<td>up to 690V</td>
</tr>
<tr>
<td>Frequency</td>
<td>50/60Hz</td>
</tr>
<tr>
<td>Power factor range</td>
<td>4-quadrant, 0 to 1</td>
</tr>
</tbody>
</table>

### Description

Energy storage module for low voltage connection.

This equipment is integrated into an enclosure suitable for use in indoor conditions including the fans, HMI, control and communication equipment for local and remote operation.

### Values

- High reliability with extensive risk and failure mode analysis
- Maximize the return of investment with pre-engineered and factory tested solution
Energy Storage Module
Community energy storage (CSS)

**Electrical specifications**

<table>
<thead>
<tr>
<th>DC input</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC operating voltage range</td>
<td>633-822 V (at PF=1)</td>
</tr>
<tr>
<td>Max. DC operating current</td>
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<td>DC grounding</td>
<td>Floating only</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AC output</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output power (S)</td>
<td>300kVA</td>
</tr>
<tr>
<td>Output energy</td>
<td>300kWh</td>
</tr>
<tr>
<td>Nominal voltage</td>
<td>up to 800V</td>
</tr>
<tr>
<td>Frequency</td>
<td>50/60Hz</td>
</tr>
<tr>
<td>Power factor range</td>
<td>4-quadrant, 0 to 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enclosure</td>
<td>CSS</td>
</tr>
<tr>
<td>Transformer type</td>
<td>N/A</td>
</tr>
<tr>
<td>Medium voltage switchgear</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Description**

Energy storage module for low voltage connection with CSS enclosure in multiple materials with metal or new innovative glass reinforced polyester (GRP). The enclosures are designed to protect the equipment from external environmental influence and to be located in public areas. The different versions of the pre-engineered and industrialized ESM allow scalability, reduction of installation costs, high reliability and reduced project execution times.

**Values**

- Internally arc tested, and electrically compartmentalized to provide improved safety
- Available in multiple configurations, sizes and materials
- Maximize ROI with pre-engineered and factory tested solutions
- Simple and quick installation
Energy Storage Module
Distribution energy storage (DES)

### Electrical specifications

<table>
<thead>
<tr>
<th>DC input</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DC operating voltage range</td>
<td>633-822 V (at PF=1)</td>
</tr>
<tr>
<td>Max. DC operating current</td>
<td>1200A</td>
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<tr>
<td>DC grounding</td>
<td>Floating only</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>AC output</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Output power (S)</td>
<td>1000kVA</td>
</tr>
<tr>
<td>Output energy</td>
<td>1000kWh</td>
</tr>
<tr>
<td>Nominal voltage</td>
<td>up to 40.5V</td>
</tr>
<tr>
<td>Frequency</td>
<td>50/60Hz</td>
</tr>
<tr>
<td>Power factor range</td>
<td>4-quadrant, 0 to 1</td>
</tr>
</tbody>
</table>

### Equipment

<table>
<thead>
<tr>
<th>Enclosure</th>
<th>CSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transformer type</td>
<td>Oil-filled, dry type</td>
</tr>
<tr>
<td>Medium voltage switchgear</td>
<td>ABB SafeRing/SafePlus</td>
</tr>
</tbody>
</table>

### Description

Energy storage module for medium voltage connection with CSS enclosure in multiple materials with metal or new innovative glass reinforced polyester (GRP). The enclosures are designed to protect the equipment from external environmental influence and to be located in public areas. The different versions of the pre-engineered and industrialized ESM allow scalability, reduction of installation costs, high reliability and reduced project execution times.

### Values

- Internally arc tested, and electrically compartmentalized to provide improved safety
- Available in multiple configurations, sizes and materials
- Maximize ROI with pre-engineered and factory tested solutions
- Simple and quick installation
Electrical specifications

**DC input**
- DC operating voltage range: 845-1096 V (at PF=1)
- Max. DC operating current: 2400A
- DC grounding: Floating only

**AC output**
- Output power (S): 1800kVA
- Output energy: 1800kWh
- Nominal voltage: up to 40.5V
- Frequency: 50/60Hz
- Power factor range: 4-quadrant, 0 to 1

**Equipment**
- Enclosure: EcoFlex
- Transformer type: Oil-filled, dry type
- Medium voltage switchgear: ABB SafeRing/SafePlus

Description

Energy storage module for medium voltage grid connection with EcoFlex enclosure. The enclosures are designed to protect the equipment from external environmental influences and to protect operation personnel. The different versions of the pre-engineered and industrialized ESM allow scalability, reduction of installation costs, high reliability and reduced project execution times.

Values

- Internally arc tested, and electrically compartmentalized to provide improved safety
- Easy to ship, load and offload
- Robust and scalable solution
- Maximize ROI with pre-engineered and factory tested solutions
- Relocatable solution adaptable for temporary power needs
**Energy Storage Module**
Connection equipment modules with skid

### Electrical specifications

<table>
<thead>
<tr>
<th>DC input</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC operating voltage range</td>
<td>ABB’s connection equipment module (CEM) is a packaged power conversion system for energy storage applications that performs the bidirectional AC/DC energy conversion between the grid and the battery system.</td>
</tr>
<tr>
<td>Max. DC operating current</td>
<td>The secondary skid unit is an economical way for high-power energy storage with outdoor equipment design.</td>
</tr>
<tr>
<td>DC grounding</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>AC output</strong></td>
<td></td>
</tr>
<tr>
<td>Output power (S)</td>
<td></td>
</tr>
<tr>
<td>Output energy</td>
<td></td>
</tr>
<tr>
<td>Nominal voltage</td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td></td>
</tr>
<tr>
<td>Power factor range</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enclosure</td>
<td>Easy to install and operate</td>
</tr>
<tr>
<td>Transformer type</td>
<td>Optimized solution to maximize ROI</td>
</tr>
<tr>
<td>Medium voltage switchgear</td>
<td>Pre-engineered solution reduces delivery time</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| DC input                              |                                                                           |
| DC operating voltage range            | 680 to 1500V (at PF=1)                                                    |
| Max. DC operating current             | 2400A                                                                      |
| DC grounding                          | Floating only                                                              |

| AC output                              |                                                                           |
| Output power (S)                       | Up to 2300kVA                                                             |
| Output energy                          | N/A                                                                        |
| Nominal voltage                        | up to 40.5V                                                                |
| Frequency                              | 50/60Hz                                                                    |
| Power factor range                      | 4-quadrant, 0 to 1                                                         |

| Equipment                              |                                                                           |
| Enclosure                              | Skid                                                                       |
| Transformer type                       | Oil-filled, dry type                                                       |
| Medium voltage switchgear              | ABB SafeRing/SafePlus                                                      |
## Energy Storage Module

Connection Equipment Modules with EcoFlex

### Electrical specifications

<table>
<thead>
<tr>
<th><strong>DC input</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DC operating voltage range</td>
<td>680 to 1500V (at PF=1)</td>
</tr>
<tr>
<td>Max. DC operating current</td>
<td>2400A</td>
</tr>
<tr>
<td>DC grounding</td>
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</table>

<table>
<thead>
<tr>
<th><strong>AC output</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Output power (S)</td>
<td>Up to 2300kVA</td>
</tr>
<tr>
<td>Output energy</td>
<td>N/A</td>
</tr>
<tr>
<td>Nominal voltage</td>
<td>up to 40.5V</td>
</tr>
<tr>
<td>Frequency</td>
<td>50/60Hz</td>
</tr>
<tr>
<td>Power factor range</td>
<td>4-quadrant, 0 to 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Equipment</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Enclosure</td>
<td>EcoFlex</td>
</tr>
<tr>
<td>Transformer type</td>
<td>Oil or dry type</td>
</tr>
<tr>
<td>Medium voltage switchgear</td>
<td>ABB SafeRing/SafePlus</td>
</tr>
</tbody>
</table>

### Description

ABB’s Connection Equipment Module (CEM) is a packaged power conversion system for energy storage applications that performs the bidirectional AC/DC energy conversion between the grid and the battery system.

The enclosures are designed to protect the equipment from external environmental influences and operation personnel. The pre-engineered solution allows scalability, reduction of installation costs, high reliability and reduced project execution times.

### Values

- Internally arc tested, and electrically compartmentalized to provide improved safety
- Easy to ship, load and offload
- Robust and scalable solution
- Maximize ROI with pre-engineered and factory tested solutions
- Relocatable solution adaptable for temporary power needs
### Description

ABB’s Energy Storage Module is a packaged solution that stores energy for use at a later time to maximize system efficiency. The different versions of the pre-engineered and industrialized ESM allow scalability, reduction of installation costs, high reliability and reduced project execution times. This design utilizes a Connection Equipment Module and battery modules for a complete solution.

### Values

| Improvised safety with arc tested equipment | Flexible with modular concept to allow ease of scalability in power and capacity |
| Maximize ROI with pre-engineered and factory tested solution | High reliability with extensive risk and failure mode analysis |
## Wind solution

Integrated energy storage with solar/wind generation

<table>
<thead>
<tr>
<th>Customer challenges</th>
<th>Application</th>
<th>Value</th>
<th>Typical equipment</th>
</tr>
</thead>
</table>
| Solar/wind power hard to properly forecast | Battery energy storage system with solar/wind power generation | **One-piece delivery**  
- Simple installation | V switchgear  
Distribution transformer  
Renewable integration  
Local control |
| Renewable generation not aligned with the demand | Peak shaving, supplement power quality, store excess power | **Factory assembled and tested**  
- Reduce site testing and commissioning. | |
| Renewable mandates and incentives | | **Safety**  
- Mitigate site safety risk. | |
| Tax benefit for storage systems | | **Capacity firming**  
- Increase reliability and improves efficiency of the renewable plant | |
| | | **Tax and regulatory incentives**  
- Potential tax benefits or incentives for clean grid technology | |
## Large-scale utility solution
Scalable energy storage for grid utility customer

### Customer challenges
- Economic and population growth leads to increasing demand for power
- Coal plant retirements, reducing baseload power capacity
- Growth in renewables, reducing reliability on the electrical grid
- New power generation plant costs too much and takes long time
- Economic power generation by load leveling

### Application
- Scalable energy storage with modular system
  - Continuity and power resilience

### Value
- **Pre-engineered solution**
  - Schedule improvement
- **Scalability**
  - Modular design
- **Transportation**
  - Robust structure (EcoFlex)
- **Factory assembled and tested**
  - Reduce site commissioning
- **Safety**
  - Mitigate site safety risks
- **Frequency regulation**
  - Increases reliable operation
- **Load leveling**
  - Postpone investments in grid

### Picture
- Scalable energy storage for grid utility customer
  - July 30, 2021 Slide 66
Why choose ABB for your energy storage solution needs

Value proposition

<table>
<thead>
<tr>
<th>Trustworthy partner</th>
<th>Maximize the return of investment</th>
<th>High reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>World leader in digital industries to serve customers</td>
<td>Pre-engineered and industrialized products with reduced project engineering</td>
<td>Protected equipment from environmental influences</td>
</tr>
<tr>
<td>Pioneering technology leader focused on digital industries</td>
<td>Reduced installation and transportation costs</td>
<td>Factory tested solution</td>
</tr>
<tr>
<td>Strong global team</td>
<td>Maximized uptimes due to factory assembled and tested solutions</td>
<td>Designed to withstand severe environmental conditions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Undergone extensive risk and failure mode analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Advanced and efficient temperature control provided for the inverter and battery system.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IEC compliant</td>
</tr>
</tbody>
</table>
Why choose ABB for your energy storage solution needs
Value proposition

**Flexible**

- Modular concept to allow ease of scalability in power and capacity
- From low-voltage to a wide range of AC medium-voltage levels
- Engineered footprint to optimize customer’s requests
- Different options of MV switchgear from ABB’s SF6 gas-insulated secondary switchgear portfolio (also available with air-insulated switchgear)
- Performs all energy storage applications in given power range

**Safe and easy to install and operate**

- Internally arc tested for public and service personnel
- No live parts accessible
- Locking system for all enclosure doors prevents unauthorized entry of personnel
- Local and remote monitoring and control, easy integration to customer SCADA and ABB Ability™
- Ease of transportation due to standardize solutions
- Pre-assembled and tested at ABB premises to reduce on-site times
Industrial and utility products: switchgear battery chargers

Integritas wall chargers
- Large capacity (20-150A), small footprint
- Modular with hot-swappable rectifiers
- Only 3 Phase 480V wall mounted charger in industry
- Markets:
  - Utility substation and switchgear control-renewables
  - Pumping station and motor operation

Integritas floor chargers
- Large capacity (20-800A), small footprint
- Configurable distribution
- Modular with hot-swappable rectifiers
- Markets:
  - Utility substation and switchgear control-renewables
  - Heavy industrial, marine, off-shore
  - Power generation and distribution

Infinity industrial
- Configurable communication DC system
- Configurable distribution
- Modular with hot-swappable rectifiers
- Markets:
  - Utility communication systems-renewables
  - Power generation control power
  - Oil and gas communication and control
# Wall mounted battery chargers

## General features / options

- Modular design for easy upgrade and maintainability.
- Advanced controller with secure protocols (SNMPv3, HTTPS, SSL, SSH), MODBUS, IPv6, NERC compliance with full remote access. DNP3 and IEC61850 options.
- Input and output surge protection and ground fault detection.
- -40°C to 75°C operation.

## Single phase chargers (infinity based)

- Modular rectifier constructions.
- Nominal input: 120 – 277 VAC.
- Input AC type: 1F, 3F unbalanced Delta (3PH,G) or WYE (3PH,N,G).
- Outputs:
  - 24V: 21 – 29VDC; 100A modules.
  - 48V: 42 – 58VDC; 50A modules.
  - 125V: 95 – 160VDC; 20A modules.

## True three-phase chargers (GP based)

- Modular rectifier constructions.
- Input Voltage: 380 – 480 VAC.
- 3F Delta (3W+G).
- Outputs:
  - 24V: 21 – 29VDC; 100A modules.
  - 48V: 42 – 58VDC; 100A modules.
  - 125V: 95 – 160VDC; 50A modules.

## Info

- **Dimensions and mounting**
  - H: 28.25” (718mm) W: 17.5 – 23” (356 - 584mm) D: 14” (356mm).
  - Reversible mounting brackets for wall or rack mount.
- **Battery support / monitoring**
  - Complete suite for capacity and battery health testing.
  - VRLA, lead calcium and NiCad support.
Floor mounted battery chargers

General features and options:
- Modular design for ease upgrade and maintainability
- Multi-voltage operation to support controls, fire systems and equipment drives
- Designated advanced controller with secure protocols (SNMPv3, HTTPS, SSL, SSH), MODBUS, IPv6, NERC compliance with full remote access per Charger Group
- Sectionalized input surge protection with AC breakers
- Output distributions with surge protection and ground fault detection
- Remote and local emergency shutdown
- -40°C to 75°C operation

Outputs and capacities:
- Each 1RU shelf can provide the following output capacity:
  - 24V – 300A
  - 48V – 150 to 225A
  - 125V – 60A
- Sample P&W LM6000: two independent 24V systems with 600A capacity and one 125V system (5 shelves) with 375A capacity.
- Configurable output distribution with up to 12 breaker outputs per row of distribution

Configurable parameters:
- Input and output voltages
- Output capacity and type
- Battery connectivity
- Output distribution for field configurations
- Motor starter
- Input transformer for wider range operation
Infinity-S dual voltage

Features:
• Low cost
• High density
  - -48V 800A +300A +24V
  - +24V 800A +240A -48V
• Flexible distribution – 1 or 2 panels, 26 selectable voltage positions each
• Flexible growth scenarios
• Universal power shelf
• High efficiency
• ECO priority ready
• Advanced controller features

Rectifiers:
• NE050AC48TEZ – 50A, 48V
• NE100AC24TEZ – 100A, 24V
• 96-97% efficiency

Converters:
• NE030DC48 – 30A, 48V
• NE075DC24 075A, 24V
Wind farm construction and connection components
Sold to Wind industry distributors, installers and contractors
Utility applications: power-plant products
Construction, connection and protection components

Construction Solutions
- Blackburn: ground connectors and lugs
- Joslyn: MV capacitor switches, 15-38KV
- Fisher Pierce: indicators, sensors and controls
- Kindorf: cobra clamp, metal framing and strut
- PMA: fittings, conduits and strain relief
- Elastimold: MV connectors
- Elastimold: MV surge arrestors
- Elastimold: MV overhead terminations
- Elastimold: MV multi-point junctions
- Elastimold: MV molded vacuum interrupters
- Ocal: conduit; straight, elbows
- OPR: external lightning protection
- Kindorf: strut and pre-engineered framing
- Hi-Tech: MV current limiting fuses, 15KV, 35KV
- Joslyn: lightning and surge protection
Lugs and wire termination

Color-Keyed Battery Smart Tool Dieless Crimper

- Dieless Crimper
- #8-750kcmil
- (2) Milwaukee Tool batteries
- 30% faster than previous model

Color-Keyed Connectors for Aluminum/Copper Code Conductor
- Designed and Approved for Use with Either Aluminum or Copper Conductors
- Temperature rating of 90 °C
- Filled with oxide-inhibitor compound
- Rated for 600V to 35kV applications
- Material: High-conductivity wrought aluminum
- Finish: Electro-plated tin

Color-Keyed Connectors for Copper Code Conductor
- Designed and Approved for Use with Copper Conductors
- Rated for 600V to 35kV applications
- UL® Listed for flex strandings
- Color coded to help installer select the proper application dies
- Material: High-conductivity wrought copper
- Finish: Electro-plated tin
ABB in the growing renewables market – Wind & Battery Energy Storage
Solutions Low to Medium Voltage- Products, systems, software and services

Allen Austin
Sr. Market Development Manager-Americas
Renewable Energy & Power Generation
Electrification business

ABB Inc.
3645 Marketplace Blvd. Suite 130-153
Atlanta, GA 30344(USA)
Phone: +1 940 235 2407
E-Mail: allen.austin@us.abb.com
Website: www.abb.com/solar

Customer Service: 1 888-862-3290
Email: abb.support@tnb.com
Technical Support: 1 888-385-1221
Email: eppc.support@us.abb.com