Wind Generation Best Practices
Agenda and Speakers

1:00-2:20 - Electrical balance of plant panel discussion moderated by Benny Nyberg

Matthew Vaughn
Business Development, Substations

Khundmir Syed
Technical Sales and Applications Engineer, Power Conversion Systems

Pat Hayes
Business Development, Energy Storage

2:20 – 2:40 – Break

2:40-3:00 – Life cycle management

Jeff Peterson
Global Product Line Manager - Wind Service

Marzio Zambetti
Global Renewable Segment Manager, Electrification Products
Part 1: Power Grid Integration

Electrical balance of plant
Technologies and best practices
Collector Substation Challenges and Pitfalls

- Overall substation construction lead-times.
  - Developers often under estimate the time and logistics required to execute the substation portion of the project.
  - Time required to fully execute the substation can be equal to or even longer than the time to complete that actual renewable facility.
  - This is very common in the solar industry due to highly efficient methods of design and install in the solar market.
Goal:
Highlight pitfalls of renewable projects that developers and EPC’s commonly stumble into, which can be avoided with some up front awareness & planning, and avoid catastrophic schedule issues that could potentially endanger your PPA back feed dates.
Interconnection / collector substation
Project execution pitfalls

Overall substation construction lead-times

- Developers often under estimate the time and logistics required to execute the substation portion of the project.

- Time required to fully execute the substation can be equal to or even longer than the time to complete that actual renewable facility.

- This is more common in the solar industry due to highly efficient methods of design and install.
Interconnection / collector substation
Project execution pitfalls

Substation site location

- **Logistics** - Consider access of large and heavy equipment to be shipped to site..

- **Site conditions** - Some investigation and a small shift in site location can save 100’s of thousand in site preparation and shorten overall lead-time.
  - Note: If you see large visible rock sticking out of the ground, please try to relocate the substation site!

- **Utilities** – Remote Sites can require long lead-times for utility access.
Interconnection / collector substation
Project execution pitfalls

Engineering will take longer than you think!

- Required engineering studies require time and information from the developer/ EPC and utility.
- The equipment used within the Wind/Solar system impacts everything inside of the substation.
- Equipment selection early is crucial to maintaining the schedule.
- Changing equipment during the preconstruction stage could trigger the requirement of a new system study and delay the delivery of your substation as well as add significant cost.
  - Example: Inverter selection affects power quality and will likely change the capacitor bank sizing, reactor sizing and controls
- Substation require a multi-layered engineering review cycle from many parties.
  - Examples: Developer / EPC / Serving Utility / Locality issuing permits.
- Reviews and approvals require a minimum of 10 days to approve PER LEVEL OF APPROVAL
Interconnection / collector substation
Project execution pitfalls

Local permitting

- Depending on the locality and their relationship to the project this can be an easy process or become bureaucratic nightmare.

- Consider that the level of review and lead-time involved will vary greatly from location to location and consider a contingency for this potential delay.

- Substation engineering deliverables will be required to meet the localities requirements.
Part 1: Power Grid Integration

Wind Grid Integration Technologies
Reactive power compensation at POI
Challenges facing project developers

- Guidelines to connect wind farms or solar plants are implemented throughout the world
- Level of complexity vary by country and/or by region
- In some cases, advanced wind turbine converters or solar inverters can satisfy grid requirements
- In other regions, dynamic reactive power control is needed
- Typical requirements include:
  - HVRT or LVRT
  - Power Factor Control
- Need to complete a system impact study and understand what requirements your wind farm must meet to safely connect to the grid
Example Interconnection Requirements
HVRT & LVRT

Comparison of HVRT and LVRT Requirements
PREPA’s Voltage Ride-Through Requirements

Courtesy: National Renewable Energy Laboratories (NREL) and Puerto Rico Electric Power Authority (PREPA)
Voltage Regulation System (VRS):

- Wind Generation facilities must have a continuously variable closed loop control VRS.

- VRS set-point shall be adjusted between 95%-105% of rated voltage at POI. Set-point shall be controllable by SCADA.

- Voltage droop shall be adjustable between 0 to 10%.

- The VRS dead band shall not exceed 0.1%.
Example Interconnection Requirements
Reactive Power Capability

- Wind Generation Facility shall be able to smoothly ramp the reactive power from 0.85 lagging to 0.85 leading at the point of interconnection (POI).

- A part of that power factor range is usually expected to be dynamic. This dynamic range is generally determined based on studies.

- The requirement of MVAR capability at maximum output shall be sustained throughout the complete range of the WGF as shown in the adjacent figure.
Dynamic reactive power control

What is a STATCOM?

- A member of the Flexible Alternating Current Transmission Systems (FACTS) family of devices used on alternating current electricity transmission networks

- Is a power electronic based device (also referred to as a voltage-source converter)

- Acts as either a SOURCE or SINK of reactive AC power to an electricity network for purpose of controlling voltage or power factor
STATCOM – Major Components

AC Step-Up Transformer
- From 480 V to MV

Power Converters
- IGBT power electronic ‘switches’
- Controls and Aux Power

DC Capacitor
Principle of Operation

\[ Q = \frac{V_1 V_2}{X_{12}} \sin \phi (\delta_1 - \delta_2) - \frac{V_2^2}{X} \]

Power flow \( P \) from \( V_1/\delta_1 \) to \( V_2/\delta_2 \)

If \( V_{\text{conv}} > V_2, Q \) Capacitive

If \( V_{\text{conv}} < V_2, Q \) Inductive

\( V_{\text{conv}} \)

\( Q \)

STATCOM

SVC

SC TCSC

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May 24, 2018 | Slide 17
STATCOM V-I CHARACTERISTICS

- Inductive
- Capacitive

Slope

Vref
STATCOM V-I CHARACTERISTICS

Weaker grid
Stronger grid

STATCOM V-I CHARACTERISTICS

System (Grid) Voltage
Statcom Current (PU)

INDUCTIVE
CAPACITIVE
STATCOM V-I CHARACTERISTICS
## Applications of STATCOMs
Voltage control and reactive power management

<table>
<thead>
<tr>
<th>Renewables</th>
<th>Utilities</th>
<th>Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Enables grid code compliance in wind and solar plants</td>
<td>- Utility grid compensation for fluctuating loads, particularly in remote locations</td>
<td>- Industrial grid support and power quality enhancement</td>
</tr>
</tbody>
</table>
ABB’s STATCOM Solution Applied
Naguabo, Puerto Rico

- A Puerto Rican wind farm required dynamic reactive compensation support for power factor and voltage control

- System comprised of 13 x 1.8 MW wind turbines connected to a 34.5 kV collector grid for a total capacity of 23.4 MW

- Dynamic simulations showed the ABB STATCOM voltage control system was able to meet PREPA’s Minimum Technical Requirements
ABB’s STATCOM Solution Applied
PREPA Performance Requirements

- All generation to remain online and be able to ride-through faults down to 0.0 per-unit

- The total power factor range shall be from 0.85 lagging to 0.85 leading.

- STATCOM system control is coordinated with the wind park power controller
ABB’s STATCOM Solution Applied
Naguabo, Puerto Rico

- ±12 MVAR ABB STATCOM
- 1 x 5 MVAR Switched Capacitor Bank
- 1 x 4 MVAR Reactor
- STATCOM system provided reactive power and voltage control
- Automatically used its rapid speed of response and overload to assist in LVRT and HVRT
Renewable Plant

Solving problems in the Wind Farm . . .
- Grid Interconnection Requirements
- Fault Ride Through (LVRT & HVRT)
- Power Factor (voltage regulations)
- Power Quality (harmonics)

Statcom

Grid

And solving problems on the grid . . .
- Prevent grid system instability & network imbalances
- Provide frequency and voltage control
- Reactive power control
- Active power regulation
Part 1: Power Grid Integration

Battery Energy Storage in Wind Farms
Applications and case studies
EssPro™ Energy Storage Capabilities

- Residential loads
- Solar power
- Industrial loads
- Microgrids
- Wind power
- Power Station

- Peak Shaving
- UPS
- Load Levelling
- Capacity firming
- Frequency Regulation
- Voltage Support

24 May 2016
ABB Energy Storage Experience
Saft / Cowessess Nation / SRC

Customer needs
- 400 kW / 744 kWh BESS
- Wind Integration.
- Customer wanted BESS to smooth out wind turbine output.
- Demand Response
- Demonstrate Anti-Islanding functionality

Project Details
- Li-ion batteries
- Installed in 2012

ABB Scope
- 400 kW PCS including (2) x 200 kW Indoor units
- Includes inverters, dc contactors, ac circuit breakers, control and external isolation/step-up transformer to 23kV grid

Saft’s IM 20E Container
(1) X 200 kW / 372 kWhr

(Inside)
ABB Energy Storage Experience
Saft / Cowessess Nation / SRC BESS

GRID  25kV PCC  LOAD

Customer Communication & SCADA / PCC INFORMATION

ABB Vantage Controller

ABB EssPro PCS

ABB EssPro PCS
ABB Energy Storage Experience
Saft / Cowessess Nation / SRC

Courtesy of SRC
Case study results: Canadian wind facility Energy storage & power conversion system

Field Results - Smoothing

- Volatility was reduced by 64%
- Smoothing algorithm based on user settable ramp rate limitations (i.e. 10% over 1 minute)
- Ramp rates were shown to be limited by a factor of 20
- Improved capacity factor and availability
ABB Energy Storage Experience
SCE, LG Chem 8 MW / 9 MVA PCS

Customer needs
- DOE Smart Grid Program
  - ARRA funds

ABB Scope
- (2) x 4 MW / 4.5 MVA PCS100 for BESS
- EssPro Vantage Controller
- DC Bus and Protection Circuit Breakers
- Mini-PCS System (100kW Indoor) w/ Site Energy Control
- System Models, RTDS and Simulations
- Commissioning, Training and Installation Supervision
- Li-Ion Batteries
- Installed in 2013
ABB Energy Storage Experience
SCE, LG Chem 8 MW / 9 MVA PCS

12–66 kV transformer

Battery building

PCS units
ABB Energy Storage Experience
SCE, LG Chem 8 MW / 9 MVA PCS

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| Slide 35
ABB Energy Storage Experience
SCE, LG Chem 8 MW / 9 MVA PCS

8 MW / 32 MWhr Tehachapi Storage Project
ABB Energy Storage Experience
SCE / LG Chem BESS
ABB Energy Storage Experience
SCE, LG Chem 8 MW / 9 MVA PCS

EssPro Vantage Controller
- Multiple Protocols
- Data Management
- Metering

Modes of Operation (8)
- Voltage Support / Grid Stabilization
- T-Line congestion mitigation
- Load Shifting
- RE Capacity Firming, Ramp Rates
- Frequency Regulation
- Spinning Reserve
- Energy Price Arbitrage

Courtesy of SCE
ABB Energy Storage Experience
BESS Integrator / PJM (20 MW PCS)

Customer needs
- PJM Regulation Market

Project Details
- Li-ion batteries
- Installed in 2014

ABB Scope for Project Containing:
- (4) x 5000 kW Outdoor PCS / 35kV
- Includes inverters, dc circuit breakers, ac circuit breakers, control, protection and external isolation / step-up transformer to 35kV grid
- Metering / Data Management
- Noise suppression

(1) X 5000 kW PCS
ABB Energy Storage Experience
BESS Integrator / PJM (20 MW PCS)

(4) X 5000 kW PCS
Questions?
Break
AWEA 2016
Turbine Retrofit/Upgrades
AWEA 2016
Agenda – ABB Wind Turbine Retrofit/Upgrades

- ABB Company Overview
- Fixed Speed Turbine Retrofit
- Other Wind Services
ABB in the Wind Power Industry
Full Electrical-only Supplier

Collection grid products

Power systems consulting

Oil home HVDC* converter station

Asset management

Substation automation and power quality optimization solutions

HVAC* cables

Turbine control and protection products

HVDC* Light, HVDC* cables

Converters

Substation for onshore wind power plants

PLC*

Control and network management: SCADA*, EMS*, GMS*

Motors

Hybrid generation microgrid

Switchgears

Offshore AC substation

Collection grid products

HVDC* cables

Commifion Solutions, wind power plant control

Generators

Substation for onshore wind power plants

Offshore HVDC* converter station

HVDC* cables

Conversers

HVDC: High-voltage Direct Current

PLC: Programmable Logic Controller

SCADA: Supervisory Control And Data Acquisition

EMS: Energy Management System

GMS: Generation Management System

HVAC: High-voltage Alternating Current

24 May 2016
ABB Wind Retrofit
Enable your fixed speed turbine to work at variable speed, increasing efficiency and lifetime
ABB Wind Retrofit
Offering Description

- ABB can improve the wind performance and lifetime of an old turbine by using new components and technologies
- Upgrade from stall/pitch controlled fixed speed to stall/pitch controlled variable speed
- Wide power range: 200kW to 1300kW+
- Available for all turbine trademarks
ABB Wind Retrofit
Constant vs Variable Speed

\[ P_w = \frac{c_p(\lambda, \delta)}{2} \cdot A_r \cdot v_w^3 \]

Usable wind power

- **variable speed**
- **constant speed**

Parameter:
wind speed \( v \)

Switch-over to another pole number

\( v = 13 \text{ m/s} \)
\( v = 12 \text{ m/s} \)
\( v = 11 \text{ m/s} \)
\( v = 10 \text{ m/s} \)
\( v = 9 \text{ m/s} \)
\( v = 8 \text{ m/s} \)
\( v = 7 \text{ m/s} \)
\( v = 6 \text{ m/s} \)
\( v = 5 \text{ m/s} \)
\( v = 4 \text{ m/s} \)
\( v = 3 \text{ m/s} \)

power maxima at different wind speeds \( v \) demand variable speed operation for maximum energy yield

### ABB Wind Retrofit

**Increase efficiency and turbine lifetime**

### Scope

- Analysis
- Consulting
- Engineering
- Design
- Project management
- Field commissioning

### Extend Life of Turbine

- Refurbish and upgrade existing electrical and mechanical components
- Add full power converter that reduces mechanical stress on drivetrain

### Delivery

- Flexible packages for older generation turbines
- Improve efficiency and reliability
- Meet grid code compliance

24 May 2016
ABB Wind Retrofit
Full Power Converter System

Frequency Converter

\[ P = T \cdot \omega \]
\[ I \sim T \]
\[ P \sim n_{\text{wind}}^3 \]

Drive

INU

DC

ISU

INU control

Fieldbus adapter

Wind turbine control

\[ P_{\text{act}} = \sqrt{3} U_{\text{line}} I \cos \varphi \]
\[ Q_{\text{act}} = \sqrt{3} U_{\text{line}} I \sqrt{1 - \cos^2 \varphi} \]

\[ P_{\text{ref}} = f (U_{\text{DC,ref}} - U_{\text{DC,act}}) \]

\[ Q_{\text{ref}} \]

\[ T_{\text{ref}}, Q_{\text{ref}} \]

U_{\text{line}} \text{ denotes line-to-line voltage, } I \text{ phase current}

gearbox
brake
rotor bearing
Pitch drive

medium voltage switchgear
line coupling transformer

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| Slide 50
ABB Wind Retrofit

Full power converter concept (FPC) – Overview

**Full power converter concept**
- Decouples the generator from the grid
- All generated power flows through converter to the grid
- Enables full reactive power production @ desired PF
- Improved output power quality
- Converter provides generator’s torque and speed control
- Noise reduction by avoiding harmful resonance frequencies to the mechanical structure

**Advantages compared to fixed speed turbines**
- Satisfies grid code compliance
- Increased production (kWh) in terms of efficiency by taking advantage of low and medium speed winds
- Reduction in mechanical shocks and stresses on turbine
ABB Wind Retrofit
Reference – Before Retrofit
ABB Wind Retrofit
Reference – After Retrofit
Reference

NTR, Northern Ireland: 1 x V29 225 kW Retrofit
  • Electrical Retrofit and Full power converter installation
  • Superior control system from DEIF
  • Generator refurbishment
Reference

Jofemar, Spain: 1 x V25 (150 kW) retrofit for micro grid application

- Electrical Retrofit and Full power converter installation
- Superior control system from ABB
- Generator refurbishment
- Integration in micro grid (solar, EV charging, etc.) done by others
Chile Chico, Chile: 3 x V44 turbines (600 kW)

- Electrical Retrofit and Full power converter installation
- Mechanical Retrofit
- Superior control system from DEIF
- 3x switch-rooms containing the MV switchgear and transformer (13.3 kV/690V) from ABB (pull-through)
ABB Wind Retrofit

Conclusions

- Extend the life of your orphan turbines (NegMicon, Bonus, Vestas)
- Bring older turbines in to compliance with local grid codes
- Remove/minimize maintenance on ancillary grid support equipment
- Additional side benefit of potential power production by maximizing power curve
Abb Wind Drive Upgrade
Optimize your ACS800-67 performance
ABB Wind Drive Upgrade
Service offering

- Increase the availability of your ACS800-67 by adding new components reducing its maintenance costs and improving its efficiency
ABB Wind Drive Upgrade Service offering

- Brake Chopper upgrade
- Contactor upgrade
- NDCU Upgrade
- NETA-01 to -21
- Carbon Dust Exhaust
- Future Upgrades
ABB Wind HW Upgrade
Contactor kit

Reduce maintenance costs and increase reliability of the grid coupling

**Benefits**

**Increased operational lifetime:** With contactor kit you increase the circuit breaker lifetime beyond the turbine lifetime.

**Optimized maintenance costs:** Avoid extra costs of the circuit breaker replacement.

**Increased operational reliability:** Contactor and circuit breaker will perform for what they have been designed.
ABB Wind HW Upgrade
Brake chopper kit

Improve LVRT performance of your ACS800-67

Benefits

**Improved performance:** better ride-through capabilities

**Increased operational reliability:** Reduces the quantity of overvoltage converter shut off

**Optimized maintenance costs:** Avoid the component aging and damaging caused by converter trips.
ABB Wind HW Upgrade
NDCU 33-CX

NDCU 33-CX replaces the NDCU 32/33 solution that was originally shipped with converter.

**Benefits**

**Increased operational reliability** with the latest control board and the new software.

**Increased operational lifetime.** The new control board increases the NDCU lifetime beyond the operational lifetime of the wind turbine.

**Improved performance:** The new processor, real time clock and optimized software, allows the NDCU-33CX to perform better and faster than its predecessor.

**Better converter capabilities** with lots of new parameters such as AC & LVRT signals, system control inputs, crowbar stats…
ABBB Wind HW Upgrade
NETA 21

NETA 21 replaces the NETA 01 solution and enables the real-time Condition Monitoring.

**Benefits**

**Real-time Condition Monitoring:** Prevent failures and their consequences.

**Improved performance:** Easier and faster communication.

**Increased customizing:** Create custom events and reports
ABB Wind HW Upgrade  
Carbon dust exhaust pipe  

Keep your nacelle clean by installing the exhaust pipe  

Benefits  

**Increased Reliability:** Keeping the nacelle clean means that there is no dust that can damage the mechanical or electrical components in the long term.  

Better safety and healthy conditions
Generator Replace and recycle

ABB Wind Care – Generators: Replace & Recycle Concept
ABB Wind Care
Wind power generator: Replace and recycle concept

- When a wind power generator faces a damage, it causes downtime up to 20 weeks and production losses.

- To help our customers to overcome this problem, we have created two storages for rapid replacement, one in Denmark for 50 Hz, and one in USA for 60 Hz generators. We store few different generator types of the largest fleets.

- The “recycle” means that we require the damaged ABB generator for exchange, we repair and refurbish it, if possible and feasible, and return it to the storage. If they are not feasible to be repaired, we shall manufacture a new one for the storage.

- If you want to guarantee the availability of the replacement generator, you can buy them and make a hosting agreement with ABB.
Wind service
Electrification Products & Service
EP – Service
Main Pillar

Product Portfolio
- Replacement
  - ABB to ABB
  - ABB to Competitors
- Spara parts
  - Consumable
  - Components
- LCM
  - Retrofitting

Documentation
- Value Proposition

Go to Market
- OEM
  - Vestas
  - Gamesa
  - SWP
- System Integrator
  - DMDR
  - Ingeteam
- ISP
- Utilities
- Distributors

Connection among Distributors and Utilities
Circuit Breakers & Switches - Service
Maintenance: Why Maintenance? Why Service?

- Health & Safety Risks
- Production Loss
- Reduced Life Time of Equipment
- Management of Urgency
- Energy Consumption
Circuit Breakers & Switches – Service Life Cycle Management

**Active**
- Normal production,
- Sales and Development phase,
- Standard Go to MaRket

Product is released for sale

**Classic**
- Product maintenance phase

Lifecyle announcement

**Limited**
- Limited production and guaranteed availability of spares

Lifecyle announcement

**Obsolete**
- Reduced availability of components and supports

Lifecyle announcement
Circuit Breakers & Switches – Service Life Cycle Management

- Active
  - Emax 2
  - AF Contactor
- Classic
  - New Emax
  - PR122/P
- Limited
  - New Emax: Active until end of June 2017
  - Classic from 1st July 2017
  - EK 370 -1000
- Obsolete
  - EH 370 – EH 1200
  - EHDB 520-960
  - MEGAMAX
  - ISOMAX up 800 A

Granted Product Support → Limited Product Support
Electrification Products – Service Maintenance

- Component failure due to lack of maintenance
- Miss-used

Corrective Maintenance

Preventive Maintenance

EMAX and NEW EMAX
Mechanical Components
Aging Chambers
Acting and main contacts
Operating Mechanism
Hocking in/out device (for withdrawable circuit breakers)
Auxiliary Contacts
Main circuit - Busbars connection
Terminals
Auxiliary Connections
Auxiliary Contacts
Electrical and mechanical accessories
Gapped motor
Undervoltage release
Shunt opening release
Shunt closing release
Circuit-breaker locked in the open position (with key or padlocks)
Circuit-breaker auxiliary contacts
Locking devices for circuit-breakers connected and disconnected
Interlocking devices between circuit-breakers mounted side by side and/or on top of another
Optional Performances
Thermographic check
Insulating resistance
Electrical components
Protection trip unit

Legend
I (Inspection): Inspections and tests, corrective actions and, if required, replacement of the component.
P (Performance): Tests, measurements and any "maintenance", "repair" or "replacement" activity, if required, aimed at improving the product life.
(R) (Replacement under condition): Any replacement of component suggested by ABB qualified technician after Ordinary and/or Extraordinary Preventive Maintenance Inspections.
P (Performance under condition): Tests performed only if provided for contract and/or deemed necessary by ABB qualified technician.
(R) (Replacement): Obligatory replacement of component during preventive maintenance activity (never provided for this circuit-breaker).
Ordinary Maintenance (cleaning & greasing)
- Visual Inspection
- Trip Test
  - Ekip T&P (new Emax)
  - PR010/T (old Emax)
- Check the contact wear and arc chambers
- Electrical test of the accessories (YO, YU, AUX, gear motor, etc..)
- Device locking, open-close the key locks
- Manual opening-closing of Emax (10 operations)

- Manual 1SDH000460R0002

Old Emax / New Emax

Contactor AF range

Ordinary Maintenance (cleaning & greasing)
- Visual Inspection
- Check the contact wear and arc chambers
## Maintenance: Check List MCCBs < 630A- ISOMAX S7

### TMAX < 630 A
- Visual Inspection
- Manual opening-closing operation (5 times)
- Trip Test:
  - TMD: trip test by push button
  - ELT: trip test by ekip T&P (or PR010/T for Isomax)
- Electrical testing of accessories (YO, YU, AUX, gear-motor, etc..)
- Tightening of the screws and cables

### ISOMAX S7
- Ordinary maintenance (cleaning & greasing)
  - Visual Inspection
  - Trip Test by PR010/T
  - Electrical testing of accessories (YO, YU, AUX, gear-motor, etc..)
  - Device locking, open-close the key locks
  - Opening-closing operation (10 times)
Circuit Breakers & Switches – Service Trainings

Online trainings
- Products and Features
- Where to find material/documents

Ordinary maintenance
- Getting into Service
- General Inspections
- Preventive Maintenance

Extraordinary maintenance
- Replacement of critical components (mechanism, poles,..)
- ABB Technicians Only
Breakers and Contactors

Breakers

Contactors

1. Terminal bar
2. Moving contact
3. Fixed contact
4. Operating coil
5. Armature
6. Core
7. Coil terminals
8. Arc chutes
9. Shading coil
Kits and testing equipment

**Maintenance Kit & Greasing Kit**

**Test Equipment**

- **Ekip T&P** (New Emax – Tmax)
- **PR010T** (Old Emax - Isomax)
Circuit Breakers & Switches – Service

Retrofitting

Original Busbars

Existing Busbar

Retrofill Kit
WARNING! SAFETY DIRECTIVES

Before carrying out any maintenance work, it is necessary to complete the following procedures:

- Ensure that incoming and outgoing sections are no longer energized
- Switch off the circuit breaker
- Rack the circuit breaker in "DISCONNECTED" position
- For extraordinary maintenance move the circuit breaker downwards of the nacelle to ensure safe and easy access to it
- Put into safety conditions in compliance with the standards and laws in force

ABB accepts no liability for damage to property or personal injury due to failure to comply with the instructions contained in this document.

MOVING PART SERVICING PROCEDURES

General inspection and cleaning of the exterior

Check that there is not dust, dirt or carbon traces on the circuit-breaker. If present, remove dirt, oil traces or exceeding grease, with a clean dry cloth.

Remove grease or dust from plastic components with a clean dry cloth, alcohol and not aggressive products suitable for plastic components.

Check that the labels showing the technical characteristics of the circuit-breaker are present.

Clean circuit-breaker labels with a clean dry cloth.

Check that there are not overheating traces on the circuit-breaker isolation parts. These parts should be light grey in color.

Check that the circuit breaker contacts are intact. These contacts should be silver in color, with no traces of erosion or smoke.

Check the number of operations carried out

Operating Mechanism

Remove circuit breaker front cover

Remove coils holder

Discharge closing springs by closing and opening the circuit breaker

Dismantle Operating Mechanism and coupling pin

Remove grease or dust and, if present, oil traces or exceeding grease from internal components with clean dry cloth and laminated diluting

Clean and lubricate the opening and closing shafts, the hooks and other moving parts with grease type Exxon Mobil Mobilgrease 28

Check that all safety rings are in their place and that they are correctly installed

In case of excessive wear of any part replace the operating mechanism with a new one

Install operating mechanism lubricating coupling pin with grease type Exxon Mobil Mobilgrease 28

Check that screws of Operating Mechanism are tightened.

Check that the pin between operating mechanism and contacts rod is in place with its safety washer in place

Measure release close effort on closing button board

Measure release open effort on opening button board

Check that antipumping device works properly

Check the correct opening hook stroke

Check the correct charge springs pawl stroke

Check the correct knee-pad hook stroke

Check lubrication of the moving parts: Lubricate the bearings of the drive shaft with Exxon Mobil Mobilgrease 28 grease, including those on the circuit-breaker sides
## EP Service
### Extended Warranty

<table>
<thead>
<tr>
<th>Products</th>
<th>Whom</th>
<th>Extend Warranty</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Emax 2</td>
<td>Anyone can access to the Extended Warranty dedicated tool:</td>
<td>+1 year free of charge if end user and site details are indicated in the WEB based tool</td>
<td>The extended warranty covers the circuit breaker and the accessories ordered already mounted on the circuit breaker from ABB factory.</td>
</tr>
<tr>
<td>- New Emax</td>
<td>1) ABB Local sales Units</td>
<td>a total number of warranty years = 2 years</td>
<td>To activate the extension of warranty is mandatory to register the product in the WEB based Extended warranty tool.</td>
</tr>
<tr>
<td>- Tmax (from T4 to T8)</td>
<td>2) ABB Sales Partners: Panel Builder, Original Equipment Manufacturer (OEM), Wholesaler, Utility, System Integrator, EPC, Service Provides, etc...</td>
<td>+3 years with a fee a total number of warranty years = 4 years</td>
<td></td>
</tr>
<tr>
<td>- Tmax XT</td>
<td>3) End users</td>
<td>+4 years (at the same +3 years) price if end user and site details are indicated a total number of warranty years = 5 years</td>
<td></td>
</tr>
</tbody>
</table>

The extended warranty covers the circuit breaker and the accessories ordered already mounted on the circuit breaker from ABB factory.

To activate the extension of warranty is mandatory to register the product in the WEB based Extended warranty tool.
Power and productivity for a better world™
Electrification Products—Service
US Wind Installed Base

Country Analysis
Location of WP and shares of OEMs

Gulf of Alaska
Canada
Gulf of Mexico
Caribbean Sea
Pacific

Country
- UAE
- UK
- Ukraine
- Uruguay
- US

ABC Country
- U

MW

Total Amount of Turbines
46.30 Tsd.
Total Amount in MW
65.87 Tsd.

Total Maximal ABB Share (Amount of Turbines)
71.01%
Total Maximal ABB Share (Amount of Turbines)
32.88 Tsd.

Operator
- 3D Metals
- 71 Ranch, Oversi...
- Acciona
- Adams Electric C...
- AES Wind Genera...
- AG Land Energy L...
- Air Force Center f...
- Airforce
- Akron-Westfield ...
- Akugo Ennerov

ABB
Electrification Products – Service
US Distribution of ABB products