Agenda

Introduction - ABB Ability™

What is Digital Substation

ABB Digital Substation offering
- Grid management, automation and control
- Primary equipment's technology (GIS and AIS)
- Digital MV switchgears

Digital Substation benefits

ABB reference cases
ABB Ability™: industry-leading digital solutions

Our expertise
- Information
- Technology
- Know-how

ABB Ability™:
Digitally connected products & services

Customers
- Uptime
- Speed
- Yield
- Safety
- Security
Unlocking the ABB potential in digital

ABB Ability™: industry-leading digital solutions built on a common set of standard technologies

- Open access, intelligent cloud
- New end-to-end digital solutions
- Systems to master process control
- Closing the loop with connected devices
Utilities

Reduced installation time (<40%), maintenance costs (<50%) and outage time (<50%)

<table>
<thead>
<tr>
<th>Asset performance management</th>
<th>Distributed energy resource management</th>
<th>Maintenance workflow management</th>
<th>Energy market trading system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated digital substation</td>
<td>Standard IP communications</td>
<td>Microgrids</td>
<td></td>
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</tbody>
</table>
Electric power system of the future
Core themes defined by Cigré

- Bi-directional energy flow
- Application of „Smart Metering“ and major need for information exchange.
- More power electronics for AC and DC.
- Storage for grid stability.
- New market design and market rules & regulations.
- New grid protection concepts in order to cope with characteristics of renewable generation.
- New environmental and energy efficiency regulations.
- Increase capacity and efficiency of assets.
- Involvement of stakeholders in the development of adequate grid infrastructure to cope with future requirements.
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Substation evolution
Evolution of a substation
From wired to optical communication

Past

Present

SA with process bus
Gateway
Optical communication network
IEC 61850 Station bus
to other bays
IEC 61850 Process bus
Bay cubicle
Sensors, actuators

SA with station bus
Gateway
Optical communication network
IEC 61850 Station bus
to other bays
SA conventional
Control room
SCADA
Distribution, protection, control
Bay cubicle
Copper cables

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| Slide 9
Evolution of current and voltage transformer
From conventional CTs and VTs to NCITs*

New applications like combined current and voltage NCITs for metering and protection

Standardized integration of protection, control and metering with IEC 61850

*NCITs = Non-Conventional Instrument Transformers
ABB Digital Substations
Transmission portfolio and architecture
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**ABB solution for digital substations**

Monitoring and Diagnostics for switchgear, transformers and IEDs

- Integrated Monitoring and Diagnostics
- Switchgear, transformers and IEDs
- Communication via IEC 61850 and other standards
- Connected to station monitoring and network level system

From time based to condition/risk maintenance
End-to-end integration for reduced OPEX
Asset Health with online monitoring

Asset Health Center benefits

- Prevent failures
- Optimize maintenance
- Support asset renewal prioritization
- Provides situational awareness
- Supports maintenance and capital replacement decisions
- Indicates early warning signals of potential failures
- Improves asset utilization
- Improves workforce efficiency
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Instrument transformers with NCIT (sensors)

NCITs: Non-conventional instrument transformers

IEC 61850-9-2LE

Merging Unit

FOCS sensor head and electronics

Combined Current & Voltage sensor
### ABB Digital substation offering

Less space required, “One bay one footing” concept

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<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong> Reduce needed space with DCB, Disconnecting Circuit Breaker</td>
<td></td>
</tr>
<tr>
<td><strong>2.</strong> Minimize the footprint even further with integrated optical CT</td>
<td></td>
</tr>
</tbody>
</table>

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**ABB Digital substation offering**

- Disconnector Circuit Breaker
- Conventional current measurement

**ABB Digital Substation**

- DCB+FOCS
- Fiber-optic current sensor
- Disconnecting circuit breaker

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ABB Digital substation offering
PASS with motor drive™ 1.4

PASS (Plug and Switch System) with Motor Drive™ 14
- Digitally controlled motor drive for CB operation
- Drastically reduction of moving party enables highest reliability
- Local control of all switching objects in PASS
- IEC 61850 interface for integration in protection and control system
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ABB Digital substation offering

UniGear Digital: The smart solution for Distribution

- UniGear Digital switchgears for up to 24kV
- Non-conventional current and voltage sensors
- 615 series IEDs exchange GOOSE and IEC 61850-9-2 sampled voltage values on station bus within the switchgear
- IEDs can act as publisher and receiver of sampled values
- Only voltage values are exchanged
Sensors for UniGear Digital

...are smaller, lighter, have much lower losses and are easy to handle

Current transformer  Voltage transformer
1 piece = 18 kg  1 piece = 27 kg

Current sensor  Voltage sensor
1 piece = 0.5 kg  1 piece = 2 kg

3 x 18 + 3 x 27 = 135 kg
3 x 0.5 + 3 x 2 = 7.5 kg
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Digital substation

Main benefits

*Based on a typical conventional 400kV double bus bar AIS substation compared to a modern variant using SAM600 process bus IO system and FOCS integrated in disconnecting circuit breakers.

“Potentially eligible for “iperammortamento” under the “industria 4.0” law for fiscal incentives, once duly interconnected and in accordance with the law.”
Digital substation
Main benefits: increased personal safety

Reduced risk of electrical shock

- Handling of current transformer circuits and signaling voltage poses a threat to life and equipment
- Process bus eliminates the galvanic connection between protection and control panels and the switchyard.
- Eliminates CT and VT circuits in the protection & control panels
- Replaces conventional 110/220VDC indications with fiber optics
- No risk of fire or explosion
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# ABB’s Digital Substation

References: installations with process bus IEC61850-9-2

## Pilot Projects
- **Braemar, AU**
  - GIS NCIT, 670series
- **SvK, SE**
  - GIS NCIT, 670series, REB500
- **Nehden, DE**
  - GIS NCIT, 670series, REB500
- **Millenaran, AU**
  - GIS NCIT, 670series, REB500
- **Loganlea, AU**
  - GIS NCIT, 670series, REB500
- **Vattenfall, SE**
  - GIS NCIT, 670series, REB500
- **SPEN, UK**
  - GIS NCIT, 670series, 3rd party
- **CNE, UK**
  - GIS NCIT, 670series, 3rd party

## Real Projects
- **Loganlea, AU**
  - GIS NCIT, 670series, REB500
- **Millmerran, AU**
  - GIS NCIT, 670series, REB500
- **Braemar, AU**
  - GIS NCIT, 670series, REB500
- **SPEN, UK**
  - GIS NCIT, 670series, 3rd party
- **DTB with FOCS**
  - GIS NCIT, 670series, 3rd party

## Timeline

<table>
<thead>
<tr>
<th>Year</th>
<th>Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>Pilot installation Laufenburg, CH&lt;br&gt;GIS NCIT, 670series, REB500</td>
</tr>
<tr>
<td>2010</td>
<td>Real installation Loganlea, AU&lt;br&gt;GIS NCIT, 670series, REB500</td>
</tr>
<tr>
<td>2011</td>
<td>Pilot installation CH&lt;br&gt;GIS NCIT, 670series, 3rd party</td>
</tr>
<tr>
<td>2012</td>
<td>Real installation Braemar, AU&lt;br&gt;GIS NCIT, 670series, REB500</td>
</tr>
<tr>
<td>2013</td>
<td>Real installation TW&lt;br&gt;SAM600, 670series, 3rd party</td>
</tr>
<tr>
<td>2014</td>
<td>Pilot installation UK&lt;br&gt;GIS NCIT, 670series</td>
</tr>
<tr>
<td>2015</td>
<td>Pilot installations CN&lt;br&gt;DCB with FOCS&lt;br&gt;3rd party</td>
</tr>
<tr>
<td>2016</td>
<td>Pilot Installation US&lt;br&gt;DTB with FOCS, SAM600, 670series</td>
</tr>
<tr>
<td>2017</td>
<td>With 3rd party content</td>
</tr>
<tr>
<td>2018</td>
<td></td>
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</tbody>
</table>

Pilot projects are installations to verify technology and compare to traditional systems.
Real projects are installations without traditional backup.
Engineering Optimisation
Reducing physical footprint and materials and improving safety

Targeted areas of improvement and optimisation in conventional design

- Steelwork Foundations: 15%
- Building Foundations: 10%
- Cubicles: 10-30%
- Copper replaced with fibre: 80%
- Relay Room: 10%
**Asset Health Center**

Asset management solution

**Case study**

Situation and challenge:
- Critical assets to be analyzed: 3,500 substations, 8,667 transformers, 10,737 breakers, 274 batteries; 33% transformers over 50 yrs old; 18% over 60 yrs
- How can AEP prevent failures, optimize maintenance and prioritize renewals?

Solution:
- ABB Asset Health Center
- Consolidated SCADA, sensor & maintenance data analyzed via industry-leading asset performance models

Benefits:
- Target 15% savings on O&M
- Automatic alerts, action recommendations & priorities
  - Prevented at least three transformer failures
- Consistent prioritization of asset replacements