Renewable Systems Grid Integration
The ABB success history
Guillermo Fuentes, Marketing & Sales Manager, System Integrations
ABB - GI present in most relevant markets
System Units all around the world

PGGI - power integration
≈ 40 countries
≈ 2200 employees

ABB - PGGI Values
Safety & integrity
Customer focus & quality
Innovation & speed
Ownership & performance
Collaboration & trust
Grid Integration

Generation expansion: New Challenges

Before

Industry  Grid

After

Windfarm  Solar

Impact-transformation

Technical
- Grids codes adaptation
- Ancillary Services
- Grid integration
- Control of the plants
- Digitalization & smart grid

Commercial
- Fast track installations
- New business setups
- Competition with other energy sources
- Demand Management
Grid Integration - Power Consulting

Grid Impact Due to Renewable Integration

**Before**

- Conventional Grid

**After**

- Windfarm
- Solar

**Impact**

System Inertia Issues, LVRT, HVRT and Power Quality issues
### Grid Integration - Power Consulting

#### Harmonics

<table>
<thead>
<tr>
<th>Before</th>
<th>After</th>
<th>Impact</th>
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<tbody>
<tr>
<td><img src="image1.png" alt="Industry" /></td>
<td><img src="image2.png" alt="Grid" /></td>
<td><img src="image3.png" alt="New loads like VFD’s, furnace, rolling mills added" /></td>
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<tr>
<td><img src="image4.png" alt="Harmonic Overvoltage leads to equipment damage" /></td>
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</tbody>
</table>

New loads like VFD’s, furnace, rolling mills added

Harmonic Overvoltage leads to equipment damage
### Why ABB as grid integrator

**Our vision**

<table>
<thead>
<tr>
<th>Why, Grid integration ABB</th>
<th>How,</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Integrate Wind and Solar has many challenges.</td>
<td>1. Focus on main technical parameters</td>
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<tr>
<td>2. The substations a key element of the plant.</td>
<td>2. We strive toward the highest quality and safety</td>
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<tr>
<td>3. The total LCOE of the plant will be reduced</td>
<td>3. Global organization/ local focus</td>
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<table>
<thead>
<tr>
<th>Our Vision</th>
<th>What,</th>
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<tr>
<td>1. Best supplier for the renewable market.</td>
<td>1. We deliver high quality turnkey substations</td>
</tr>
<tr>
<td>2. Allowing minimum LCOE, fast tracking delivery, new technologies, optimizing risk and policies, service included in added value</td>
<td>2. Engineering packages</td>
</tr>
<tr>
<td></td>
<td>3. FACTS devices/ Systems</td>
</tr>
<tr>
<td></td>
<td>4. Energy Storage Systems</td>
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</table>

**Why do we exist?**
ABB delivers from A to Z to the wind industry

Wind power generation, integration and transmission

ABB is present in all the value chain, but independent
## Added value

Simple questions difficult to answer

### Some challenges, that together, we can solve

<table>
<thead>
<tr>
<th>Compliant with Grid Codes?</th>
<th>Are you looking for local suppliers?</th>
<th>Are you considering service?</th>
<th>Are you optimizing the transformer or MV cabling?</th>
<th>Is the earthing system taken into account?</th>
<th>Do you need a fast track substation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABB reactive and active compensation systems to comply with grid codes. Studies and recommendations available.</td>
<td>ABB can help you identifying potential local partners. By having an early involvement we secure lowest LCOE.</td>
<td>ABB can support you with service and maintenance of the Substation and asset management programs.</td>
<td>ABB can help you in optimizing the transformer design adapted to the production regime.</td>
<td>ABB can give advice and design earthing system.</td>
<td>ABB is aware of the need of fast delivery. We implement special strategies to deliver on fast track.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Have you think about safety? And about Cyber security?</th>
<th>Have you consider other technologies to optimize LCOE?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety is one of the most important topics for ABB, safety is a about hazard but is about production and efficiency as well</td>
<td>AIS, hybrid or GIS, ABB can compare technologies from a life cycle perspective</td>
</tr>
</tbody>
</table>

The grid connection of the plant can reduce systemically your LCOE
System optimization. Optimizing power transformer

Various optimization criteria

The transformers may be optimized to some various application specific criteria

- Ambient conditions (temperatures, seismic, …)
- Loading cycle vs overloading (short-time, long-time, emergency)
- Specific technical parameters (low losses, low noise)
- Cooling mode (natural vs forced)
- General arrangement and footprint / dimensions / weights
- Transport limitation (size & weight)
- Energy efficiency
- Environmental requirements
- Fire hazardous
- Purchasing price vs costs of losses
- Total Ownership Costs
- Life time

How much does a transformer cost? Are you considering the operation?
System optimization. HV and substations engineering
Site and grid requirements and substation design

- Transformers and overall engineering optimization
- Pre-engineered substations – Fast Track Solutions
- Different design and safety codes, site conditions and grid characteristics does require some particular engineering studies:
  • Insulation co-ordination and shielding
  • Grounding
  • Current Transformers specification
  • Clearances, safety and working distances
  • Adapted civil engineering (bearing capacity, draining conditions, chemical and geotechnical composition)

Right engineering save you time and cost
HV Products
Full Scope – Full expertise

Complete portfolio of HV 72-800 kV Product Solutions for all standards - IEC, ANSI ++

- Ultra Compact / pre-tested
  - Small footprint for challenging sites

- Wide range of Environments
  - Wide temperature range
  - Resists pollution, corrosions, earthquakes and high altitudes

- Modular designs with proven reliability
- Low environmental impact and lifecycle costs
- Reduced installation and commissioning time
- High safety and quality standards
- Advanced features for digital substations
- Global Service Support Organization – Local Everywhere
**HV Products**

Full Scope – Full expertise

**Power Quality - Voltage levels up to 36 kV, power to 14.4 MVAr**

- Compliance with Standards and Regulations THD & Harmonic limits
- Designed for low voltage and medium voltage systems up to 36kV (Trough step-up transformer)
- Proven harmonic compensation solution in wind farm applications (Brazil, Europe, Australia)
- MECB solution for wind farm reactive power compensation
- Switchable from the windfarm control system
- Synchronous switching solutions available (ideal for connection to weak networks)
Grid integration solutions: Pre-engineered substations

IEC based solutions

**Based on HIS PASS M0**

- Rated voltages 123 - 170 kV
- Rated total output from 15 to 200 MW
- “Modular & extendable approach” to cover many variants, most of them compatible ones

**Main layouts**

- “1L+1T”: 1 line/trafo bay
- “1L+2T”: Single busbar
- “2L+2T+1BC”, “H” with circuit breaker coupler
- “2L+2T+1BS”, “H” with disconnector coupler

**Automation ABB solution**

- Based on IEC 61850
- All SCADA, communication and gateway functions
- but easy customization to different HMI interfaces, line protections and metering specifications

Based on HIS PASS M0 Main layouts Automation ABB solution
System Optimization - MV cabling and switchgear

Cables and Switchgear optimization

- Selection will be driven by short-circuit and load flow analysis.
- Experience: Cable feeders are limited by short circuit requirements.
- Switchgear specify to meet short-circuit, including dynamic requirements.
- Power losses should be weighted based on wind statistic distribution:

\[
\eta_c = \frac{p_{l1} \cdot h_1 + p_{l2} \cdot h_2 + \cdots + p_{l_{25}} \cdot h_{25}}{p_{nom1} \cdot h_1 + p_{nom2} \cdot h_2 + \cdots + p_{nom1} \cdot h_1 + \cdots + p_{nom2} \cdot h_{25}} \times 100
\]

- MV losses are related with cable features and operation structure. Higher improvement margin.
- Cable sizes optimized with software tools, taking into account layout conditions, influence of nearby conductors, losses.
- Cable root optimization X constructive characteristics of MV Circuits
ABB Medium Voltage products in Wind

From the tower to the grid connection

**MV Switchgears**
- Gas insulated up to 40.5 kV

**Compact Secondary Substations**
- Steel, concrete and GRP up to 40.5 kV

**Protection & Control Relays**

**MV Switchgears**
- Air and Gas insulated up to 40.5 kV

**Reclosers**
- up to 38 kV

**Outdoor live tank circuit breakers**
- up to 40.5 kV

**Outdoor dead tank vacuum circuit breakers**
- up to 38 kV
Power Consulting

Renewable energy studies

- Renewable Energy Studies
  - Wind
    - Grid Integration
    - Power Evacuation
    - Stability Studies
  - Solar & Others
    - Grid Code Studies
    - Insulation Co-ordination
    - Other EMTP Studies
    - Reactive Power requirement
    - Fault Ride Through
    - Harmonic, Flicker
The power system fault will lead to voltage dip on WTs. To maintain the grid stability, wind farm is required to keep connected in the power system for a defined time period under grid fault, this is called FRT. Actually, the voltage is not always dip to zero, it can be just a voltage sag. So many researchers put their efforts to deal with the so called low voltage ride-through problem. The main differences in FRTs requirement of different countries are the depth of voltage drop, the time period and the boundary where WTs can be tripped. New FRT needs not only the WTs keep on grid but also can provide voltage support or generator reactive power to the power system. So nowadays, the FRT researchers care even more subjects. How to protect the converter and DC bus of WTs, how to control the generator to generate reactive power and how to increase the voltage under grid fault are the three main study directions.

Guillermo Fuentes | 12/04/2017
Power system studies and optimization

Renewable integration

Supporting solar power

Making solar electric power affordable - A competitive Levelized Cost of Energy (LCOE)

In order to obtain a low LCOE - Focus on minimizing total investment and operating costs:

- consumer oriented system reliability and power quality
- optimized network configuration and intelligent use of modern automation equipment

Developers must reduce the risk of solar power projects. More investors/capital are interested in funding renewable energy projects.

Compliance, optimization and bankability are the keys to successful solar power generation

Renewable studies

- Feasibility studies (AC vs. DC connection)
- System layout and dimensioning of equipment
- Grid compliance
- System stability studies (interaction with public grid)
- Determination of required compensation
- Reliability analyses
- Grounding and network protection concepts
- System perturbation (harmonics, flicker, voltage drops)
- Lightning protection design
- Economic efficiency considerations
- Battery storage requirements
Global Service organization

Optimizing the performance and return of your investment

**Service & Maintenance adapted to the operator or owner needs**

- Total lifecycle support at every stage for any solar installation
- Tailored service contracts that cover all equipment and solutions
- Help customers achieve maximum return on investment through improved capacity, efficiency and reliability
ABB Service
From solar plants to the home plug-ins...

Power generation  Electric transmission  Electric distribution  Control technology  Robots & electric drives  LV products

engineering  training  inspections  maintenance  support  consulting  migration  replacements  modernization

commissioning  installation  spare parts  retrofit

ASEA + BBC  merger 1988  Zürich  HQ  140,000 employees  39.8 bn. revenues 2014
Substation reliability assessment

Reliability centered maintenance for the most critical asset in the wind plant

1. Substation Assessment
   Risk modelling and recommendations:
   - Condition
   - Importance: FMEA

2. Life Stretch
   Life extensions and retrofits alternatives risk modelling and benchmarking based on a multi-objective tailored criteria

3. Substation Care
   Maintenance plan based on substation risk profile and a tailored multi-object criteria
ABB Service - Capabilities

Comprehensive portfolio of services
Renova Energia - Brazil

Alto do Certao I.
Around 230MW x WTG (GE 1.7MW);

ABB designed a 34.5 kV MV solution on OHL, with reclosers, IEC 61850 relay and distribution transformers 0.6/ 34.5 kV as the first project;

ABB solution for eBoP as engineering, PM, complete portfolio of products, erection, training, commissioning and startup

Hundreds of OHL (34.5kV), 2 x Step Up Tx SS 34.5/ 69 KV and 2 x SE 34.5/ 230 kV, OHL (69kV and 230 kV), Connection bays in the local utility.
Renova Energia - Brazil

Alto do Certao II.

ABB designed a 34,5 kV MV solution on OHL, as reclosers (184 units), IEC 61850 relay and distribution transformers 0.6/ 34.5 kV;

ABB solution for eBoP as engineering, PM, complete portfolio of products, erection, training, commissioning and startup.

Delivery time 12 months: hundreds of OHL (34.5 and 69 kV), 5 x step up SE (12 x transformers) and 5 Connection Bay in the local utility.
Eólicas do Sul 400 MW- Brazil

Project in the South (Uruguay Bordering).

400 MW (Gamesa and Impsa 2.0 MW each);

ABB designed in 34,5 kV MV a solution underground (~900 km of MV cables)

ABB solution for eBoP as engineering, PM, complete portfolio of products, erection, training, commissioning and startup

2 x step up SE 34,5/ 138 KV and 1 x SE 138/ 525 kV, OHL in138 kV (30 km).

Delivery Time: 18 months
Enel Fonte dos Ventos - 105 MW - Brazil

Project in the Northwest (Tacaratu - PE).
80 MW (GE 2.35 MW each x 34 WTG);
ABB solution for SS and Bay Connection, PM, complete portfolio of products, erection, training, commissioning and startup
4 x 35MVA step up (single phase) SE 34.5/230 KV.
Delivery Time: 12 Months
Latest success stories

Morro do Chapeu (ENEL GP), Brazil - SS 34,5/ 230 kV, OHL 34,5 kV, Connection Bay

Customer’s need

- Investor experienced in the Power Sector (main utility co.) but weak knowledge of the Wind Business in Brasil. Customer needed to participate in a Governmental Wind Auction where projects need to be very competitive.

ABB’s response

- Full support before auction happened. ABB did not know if the developer would be awarded with the project, but we created a partnership. ABB putted in place an expert to develop optimized Grid Connection solutions. Early partnership.
- We gather knowledge about the customer team and way of work to give us a better idea about the Project/ solution and accelerate the process reaching our customer expectations .

Customer’s benefit

- Best price in the auction - got awarded with the project
- Customer and ABB defined a process to replicate success stories
- Contract frame agreement to accelerate offering process
- Full utility compliance that allowed low risk under operation