Microgrid for Commercial and Industrial (C&I) sites
Pablo Astorga, Global Marketing Manager & Regional Sales Manager Europe
Presenter Introduction
Pablo Astorga, Global Marketing Manager & Regional Sales Manager Europe

- Over a decade of extensive international experience in renewable energy
- Global Marketing Manager & Regional Sales Manager Europe for ABB's Microgrids & Distributed Generation business
- Responsible for microgrid sales and efficiently integrating renewable energy systems into new and existing fossil fuel-based generation
- A real supporter of clean energy in his personal and professional life
- Board Member at ARE, the Alliance for Rural Electrification
- Based in Madrid, Spain
Agenda

- ABB Grid Automation overview
- Overview of Commercial and Industrial sites
- How microgrids create value in C&I sites
- What ABB has to offer
- Microgrid for C&I business case
- Summary
Grid Automation

Leading the world of grid automation since 1905


ABB's first electro-mechanical relays introduced

IEC founded
ABB is a leading member

ABB introduces COMBIFLEX electronic relays

ABB's first optical FOX link installed on HV lines with integrated teleprotection

ABB develops integrated protection and control
First distributed busbar protection – REB500

ABB's first fully integrated analog and digital Power Line Communication (PLC)

ABB introduces the Relion® family of IEC 61850 compliant relays and compliant substation automation systems

ABB launches its pioneering Standalone merging unit - SAM600

ABB acquires Tropos Wireless Networks
National Grid Saudi Arabia partners with ABB to introduce IEC 61850 Substation Automation Systems

ABB launches its first digital substation in the UK
ABB partners with Microsoft's Azure Cloud based platform to launch ABB Ability

ABB installs first Power Line Communication (PLC) and protection Signaling Equipment

ABB introduces first SCADA and network management systems
ABB launches Micro-processor based relays

ABB introduces EMS, GMS and DMS applications
ABB introduces first computer based substation control system

First redundant RTU supporting Ethernet communication (RTU500 series)
First NCIT installations in ABB substation automation systems

ABB introduces SCADA system for renewables

ABB pioneers Wide Area Monitoring System (WAMS)

Between 2010 – 2011 ABB acquires Ventyx & Mincom
ABB's first IEC 61850-9-2 digital substation installation - Loganlea, Australia

ABB introduces worlds first Asset Health Center solution
100,000th RTU sold

ABB sells its 100,000th Relion® 670 unit
ABB sells its 10,000th MicroSCADA Pro license

ABB launches its pioneering Microgrid enabling product - PowerStore Battery
ABB recognized for the world's first conformance tested system engineering tools
## Power Outage Issues for C&I plants

Outages, costs and generator ownership

<table>
<thead>
<tr>
<th>Region</th>
<th>Share of firms experiencing outage (%)</th>
<th>Annual total outage duration - impacted businesses only (hours)</th>
<th>Associated losses (% of annual sales)</th>
<th>Share of firms owning / sharing a generator (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle East &amp; North Africa</td>
<td>57</td>
<td>1,832</td>
<td>7</td>
<td>41</td>
</tr>
<tr>
<td>South Asia</td>
<td>66</td>
<td>1,615</td>
<td>11</td>
<td>45</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>80</td>
<td>570</td>
<td>8</td>
<td>52</td>
</tr>
<tr>
<td>India</td>
<td>55</td>
<td>331</td>
<td>4</td>
<td>47</td>
</tr>
<tr>
<td>East Asia &amp; Pacific</td>
<td>46</td>
<td>253</td>
<td>3</td>
<td>33</td>
</tr>
<tr>
<td>LatAm &amp; Caribbean</td>
<td>61</td>
<td>66</td>
<td>3</td>
<td>26</td>
</tr>
<tr>
<td>High income: OECD</td>
<td>28</td>
<td>15</td>
<td>1</td>
<td>11</td>
</tr>
</tbody>
</table>

Overview of business recorded power outages, associated costs, and backup generation

*Source: Bloomberg/World Bank (2010-2017)*
Businesses view on energy management
Reducing electricity cost and consumption

- Companies get more comfortable with self-generating their electricity supplies and procuring renewable energy from third parties.

- 80 percent of businesses view reducing electricity costs as essential to staying competitive from an image perspective.

- 84 percent of businesses view reducing electricity consumption as essential to staying competitive from a financial perspective.

Businesses take control with renewables
Have on-site electricity generation

- 2017
  - 43% No
  - 57% Yes
Microgrid
Generation at the point of consumption and always available

Microgrid definition
Distributed energy resources and loads that can be operated in a controlled, coordinated way either connected to the main power grid or in “islanded”* mode.

Microgrids are low or medium voltage grids without power transmission capabilities and are typically not geographically spread out.
Poll Question 1
### How microgrids create value in C&I sites

Increasing renewable penetration requires enhanced microgrid control capabilities

<table>
<thead>
<tr>
<th>Protection options</th>
<th>Key elements</th>
<th>Interruption time</th>
<th>Efficiency (on-grid)</th>
<th>Benefits and drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grid only</td>
<td></td>
<td>hours</td>
<td>100%</td>
<td>Zero additional/capital cost, No backup during outage</td>
</tr>
<tr>
<td>Diesel Generator + Grid</td>
<td></td>
<td>~10-30s</td>
<td></td>
<td>Low capital cost, 15 sec delay, CO2 &amp; local emissions, noise</td>
</tr>
<tr>
<td>BESS + Grid</td>
<td></td>
<td>&lt;150ms</td>
<td></td>
<td>No disconnection, BESS services, Voltage sag; Limited backup time</td>
</tr>
<tr>
<td>BESS + PV + Grid</td>
<td></td>
<td>(effective for most loads)</td>
<td>99%</td>
<td>No disconnection, BESS services, cost &amp; CO2 savings, Voltage sag; Limited duration in low solar condition</td>
</tr>
<tr>
<td>BESS + PV + Diesel Generator + Grid</td>
<td></td>
<td></td>
<td></td>
<td>No disconnection, BESS services, cost &amp; CO2 savings, Voltage sag</td>
</tr>
<tr>
<td>UPS + Grid</td>
<td></td>
<td>No interruption</td>
<td></td>
<td>Power quality, Limited duration, low efficiency, no grid services</td>
</tr>
<tr>
<td>UPS + Diesel Generator + Grid</td>
<td></td>
<td>(highly sensitive loads)</td>
<td>96%</td>
<td>Power quality, Low efficiency, no grid services</td>
</tr>
<tr>
<td>UPS + PV + Diesel Generator + Grid</td>
<td></td>
<td></td>
<td></td>
<td>Power quality, cost and CO2 savings, Low efficiency, no grid services</td>
</tr>
</tbody>
</table>

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What ABB has to offer

ABB - global microgrid solution partner

Leading global expertise

- 25+ years experience
- 40+ executed projects
- Innovation, technology & productization leadership
- Global sales & service network

Broad portfolio of products & services

- Renewable power
- Conventional power
- Microgrid control system
- Energy storage and grid stabilization
- Power distribution and protection

Consulting
Service
3rd party financing
What ABB has to offer in microgrids

Global references with 40+ successfully executed microgrid projects
Industrial and commercial sites
Longmeadow, PowerStore/PV/Diesel

About the Project

- **Project name:** Longmeadow
- **Location:** South Africa
- **Customer:** Longmeadow Business Estate
- **Completion date:** 2016

The resulting Microgrid system consists of:
- PowerStore Battery (1 MW/380 kWh)
- Microgrid Plus Control System
- Solar PV (1 x 750 kWp)
- Diesel (2 x 600 kW)
- Remote Monitoring

Solution

- Stabilizing the grid for reliable and stable power supply
- Optimized renewable energy contribution to the facility
- Seamless transition from grid connection to islanding in case of an outage
- CO₂ reduction: over 1,000 tons/year
- Up to 100% renewable energy penetration

Customer Benefits

The microgrid solution is for the 96,000 sqm facility in Johannesburg that houses both ABB South Africa’s headquarters, as well as a manufacturing facility employing close to 1,000 employees
ABB microgrids deliver ~30% fuel reduction

Future projects benefit from lower PV prices

Decreasing Solar PV costs to improve future business cases

Global Large Commercial PV system prices (1 to 5MW) USD/ Wp

- PV prices have reduced over 30% in past 2 years and continue to fall globally
- Commercial and utility scale systems reducing faster than household solar with the $1/Wp already reached for utility scale\(^1\)

ABB references already show ~30% fuel reduction possible with subsidies

- Johannesburg, PowerStore/ PV/ Diesel
  - ~30% reduction in electricity bills and fossil fuel consumption

- International Committee of the Red Cross (ICRC) Logistics Center, PowerStore/ PV/ Diesel
  - Powering the largest logistics hub of the ICRC through a state-of-the-art microgrid, delivering reliable power for the first time in a region exposed to frequent outages and power quality issues

Source: IHS PV Demand Market Tracker - Q2 2017
\(^1\) https://www.greentechmedia.com/articles/read/Sunshot-1-Per-Watt-Solar-Cost-Goal-Mission-Accomplished-Years-Ahead-of-S
Microgrid business case – C&I site connected to a weak grid
Various solar and storage scenarios tested using HOMER\(^1\) optimization tool

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**Example: glass manufacturing in India**

**Power System**
- 15 MW average load
- Critical load: 1 MW peak, 0.5 MW average
- 2 x 0.6 MW backup diesel generators
- Grid energy price: $0.15/kWh

**Outages**
- 260 x 1hr power interruptions per year
- $800USD cost per outage

**Business Case**
- Delivered Fuel Cost: $1 USD/l
- Solar installed cost: $1 USD/Wp
- Average cost of capital: 11%
- Subsidies: none

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**Goal of the study**
Determine when the Levelized Cost of Energy (LCOE) of 3 scenarios is lower than the diesel only base case
- Diesel & Storage
- Diesel & Solar PV
- Diesel & Solar PV & Storage

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1 HOMER: [http://www.homerenergy.com/](http://www.homerenergy.com/), a simulation and optimization tool for energy systems
Poll Question 2
Power Outage Impacts on C&I Plants

Plant activities and operations have a big impact on outage costs

Power outage impacts

- Shutting off or malfunction of the machinery
- Damage to equipment and products
- Decrease in productivity

Modelled outage costs for C&I plant

Hidden costs can add up for a manufacturer experiencing 260 outage events in a year

<table>
<thead>
<tr>
<th>Cost line item</th>
<th>Cost per event</th>
<th>Cost per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disrupted production line</td>
<td>Idle workers</td>
<td>$350</td>
</tr>
<tr>
<td>Lost product</td>
<td>$350</td>
<td>$91'000</td>
</tr>
<tr>
<td>Lost efficiency</td>
<td>$100</td>
<td>$26'000</td>
</tr>
<tr>
<td>Annual total cost</td>
<td>$800</td>
<td>$208'000</td>
</tr>
</tbody>
</table>
**Microgrid for C&I - Business Case**

Incremental hybridization options analyzed

1. **Base case – Diesel**
   - Generator system (0.6 MW each), both required during power outage
   - Generators kept off while grid-connected to save on fuel costs
   - Facility undergoes outage every time the grid goes down

2. **Diesel + BESS**
   - BESS provides seamless transition to island state
   - BESS provides required ramping and reduces need for generators
   - BESS can delay or eliminate the need to start up a generator during short term outages

3. **Diesel + Solar PV**
   - Requires generator spinning reserve equivalent to 75% of the maximum solar PV output to account for shading

4. **Diesel + BESS + Solar PV**
   - All the benefits of Diesel + BESS case, as well as Diesel + Solar PV case
   - BESS provides required ramping for solar and thus during daylight hours all generators can be shut down

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## Microgrid for C&I - Business Case

Up to 45% reduction in fuel possible when combining diesel with BESS and Solar PV

<table>
<thead>
<tr>
<th></th>
<th>Base case – Grid + Diesel</th>
<th>Grid + Diesel + BESS</th>
<th>Grid + Diesel + Solar PV</th>
<th>Grid + Diesel + BESS + Solar PV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel consumption (kL)</td>
<td>44.5</td>
<td>43.6</td>
<td>28.5</td>
<td>24.5</td>
</tr>
<tr>
<td>Investment ($M)</td>
<td>0.55</td>
<td>0.97</td>
<td>1.5</td>
<td>3.0</td>
</tr>
<tr>
<td>IRR (%)</td>
<td>-</td>
<td>35%</td>
<td>20%</td>
<td>26%</td>
</tr>
<tr>
<td>LCOE ($/MWh)</td>
<td>203</td>
<td>177 (-12.8%)</td>
<td>190 (-6.4%)</td>
<td>163 (-19.7%)</td>
</tr>
<tr>
<td>Payback (years)</td>
<td>-</td>
<td>2.7</td>
<td>4.5</td>
<td>3.6</td>
</tr>
</tbody>
</table>
Sensitivity analysis – Key driver of LCOE saving

Outage cost the largest single driver of LCOE savings, followed by PV price

<table>
<thead>
<tr>
<th>Sensitivity driver</th>
<th>Low case</th>
<th>Base case</th>
<th>High case</th>
<th>Microgrid LCOE impact (pp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outage Cost (k$/year)</td>
<td>104</td>
<td>208</td>
<td>416</td>
<td></td>
</tr>
<tr>
<td>Installed PV price (USD/Wp)</td>
<td>0.5</td>
<td>1</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Grid energy price (USD/kWh)</td>
<td>0.1</td>
<td>0.15</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Diesel price (USD/L)</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>Installed battery price excl. converter ($/kWh)</td>
<td>300</td>
<td>400</td>
<td>500</td>
<td></td>
</tr>
</tbody>
</table>
Microgrid for C&I - Business Case

Recommended microgrid system configuration and LCOE reduction

**Configuration sensitivity to prices**

**MG LCOE sensitivity to prices**

- Solar PV price (USD/Wp)
- MG LCOE price (USD/kWh)
- Solar PV size (MW)
- BESS size (MWh)

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Summary: 20 – 30% energy related savings possible for C&I facilities

BESS + Solar PV benefits for a C&I facility with a weak grid

20-30% LCOE savings possible across many scenarios

Outage costs a critical driver of total C&I energy related costs

Outage related costs and PV price the biggest drivers of LCOE saving
Developing a microgrid project from concept to commission

The project lifecycle

**Microgrid Project Lifecycle**

- **Concept**
- **Feasibility study**
- **Detailed engineering**
- **Supply**
- **Installation & commissioning**
- **Operations & Maintenance**
- **Optimization**

**Main business drivers**

<table>
<thead>
<tr>
<th>Social &amp; Environmental</th>
<th>Economic &amp; Operational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data collection</td>
<td></td>
</tr>
<tr>
<td><strong>Technical</strong> Site conditions, solar, wind, generation and load</td>
<td><strong>Financial</strong> Subsidies, OpEx Costs, Fuel price</td>
</tr>
<tr>
<td><strong>Analysis</strong></td>
<td><strong>Financial analysis</strong></td>
</tr>
<tr>
<td><strong>Technical viability</strong></td>
<td></td>
</tr>
<tr>
<td>Business case</td>
<td></td>
</tr>
</tbody>
</table>

Different tools are required for each stage of the project lifecycle
- HOMER Quickstart (http://quickstart.homerenergy.com/)
- Financial model
- HomerPro (Energy flow)
- Powerfactory, PSSE, PSCAD (Loadflow, Stability, Protection)
- MatLab (Tuning)

Each tool has its own specific application
Poll Question 3
Microgrid for C&I sites

Key takeaways

How C&I sites will benefit from microgrids

- Fuel saving (and associated reduction in CO2 emissions & maintenance costs)
- Reduced Levelized Cost of Electricity (LCOE)
- Attractive Internal Rate of Return on investments (IRR)
- Improved power quality
- Increased energy independence
Get in touch with us

ABB Microgrids

To know more about our solutions, please visit: www.abb.com/microgrids

If you have any specific questions about our microgrid solutions, please e-mail me at pablo.astorga@es.abb.com