Microgrid for Commercial and Industrial (C&I) sites

Hamideh Bitaraf, Ph.D., Microgrid Advisor
Agenda

- 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
# 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](image_url)
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.

* Islanded mode: ability to provide power independently from the main power grid

Microgrids are low or medium voltage grids without power transmission capabilities and are typically not geographically spread out.

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*Islanded mode: ability to provide power independently from the main power grid*
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
Global installed base

Microgrids and BESS

Worldwide: 331 MW

Europe: 9.79 MW

Asia: 70.18 MW

Middle East: 200 kW

Australia: 75.28 MW

North America: 151.6 MW

South America: 20.18 MW

Africa: 3.95 MW
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

Customer Benefits
- 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

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>2.5</td>
</tr>
<tr>
<td>2015</td>
<td>2.0</td>
</tr>
<tr>
<td>2017</td>
<td>1.66</td>
</tr>
<tr>
<td>2019</td>
<td>1.5</td>
</tr>
<tr>
<td>2021</td>
<td>1.25</td>
</tr>
</tbody>
</table>

• 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

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
Microgrid business case – C&I site connected to a weak grid

Various solar and storage scenarios tested using HOMER 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
Plant activities and operations have a big impact on outage costs

Power Outage Impacts on C&I Plants

- 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></td>
<td></td>
</tr>
<tr>
<td>Idle workers</td>
<td>$350</td>
<td>$91,000</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 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
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 ($M)</td>
<td>0.55</td>
<td>0.97</td>
<td>1.53</td>
<td></td>
</tr>
<tr>
<td>IRR (%)</td>
<td>-</td>
<td>35%</td>
<td>20%</td>
<td>26%</td>
</tr>
<tr>
<td>LCOE ($/ 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) vs Base case MG LCOE savings = 19.7%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outage Cost (k$/year)</td>
<td>104</td>
<td>208</td>
<td>416</td>
<td>High case: 10.3, Low case: 14.4</td>
</tr>
<tr>
<td>Installed PV price (USD/Wp)</td>
<td>0.5</td>
<td>1</td>
<td>1.5</td>
<td>High case: -10.4, Low case: 10.3</td>
</tr>
<tr>
<td>Grid energy price (USD/kWh)</td>
<td>0.1</td>
<td>0.15</td>
<td>0.2</td>
<td>High case: -4.3, Low case: 3.0</td>
</tr>
<tr>
<td>Diesel price (USD/L)</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
<td>High case: 0.5, Low case: 0.5</td>
</tr>
<tr>
<td>Installed battery price excl. converter ($/kWh)</td>
<td>300</td>
<td>400</td>
<td>500</td>
<td>High case: 0.5, Low case: 0.5</td>
</tr>
</tbody>
</table>
Microgrid for C&I - Business Case

Recommended microgrid system configuration and LCOE reduction
Summary: 20 – 30 % energy related savings possible for C&I facilities

BESS + Solar PV benefits for a C&I facility with a weak grid
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
Microgrid Market Analysis
- Trends in energy price, tariffs
- Drivers for energy storage as peak shaving, self-consumption vs feed-in, and energy arbitrage.
- Market participation revenues

Microgrid economic Analysis
- Optimum size and operation of DER
- Cost of energy, ROI, and payback
- Fuel savings and environmental impacts
- Sensitivity analysis on drivers
- Value stacking
- Ownership models

Microgrid technical Analysis
- Stability and dynamic studies
- Contingency analysis
- Power quality and reliability
- Frequency and voltage ride through
Contact Information

Dr. Hamideh Bitaraf
Microgrid Advisory Consultant

ABB Enterprise Software
1601 Industrial Blvd, Sugar land, TX, USA

Email: hamideh.bitaraf@us.abb.com