Microgrids and renewable energy integration

ABB solution and offering overview
Global energy challenges
Significant forecasted demand in emerging economies

Global energy challenges
Social, economic and environmental

Access to electricity and water
• For all, including in remote locations
• At an economically viable cost
• For an increasing global population

Reduce levelized cost of energy
• Increase renewables contribution
• Hedge against fuel price volatility
• Reduce dependence on imported fuel

Climate change and protection
• CO2 reduction goals
• Sustainable power generation
• Energy efficiency

Significant infrastructure investments are needed to provide sustainable access to energy in high growth emerging countries
Microgrids and renewable energy integration
Decentralized, self-sufficient power networks
Microgrids and renewable energy integration
Microgrid market segments and drivers

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<th>Segments</th>
<th>Typical customers</th>
<th>Social</th>
<th>Economic</th>
<th>Environmental</th>
<th>Operational</th>
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<td>Off-grid</td>
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<td>Islands</td>
<td>(Local) utilities</td>
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<td>Remote research centers</td>
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<td>Rural electrification</td>
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<td>Weak grid</td>
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<td>Industrial and commercial</td>
<td>Mining companies / IPPs / Oil &amp; Gas companies / Hotels &amp; resorts</td>
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Sustainable access to electricity anywhere
Microgrids powered by renewable energy sources

Microgrids achieve secure power generation with grid-quality electricity while integrating renewable energy
Renewable energy integration challenges
Managing power output fluctuations

- Inherent volatility of renewable energy (RE) can compromise grid stability
- The RE integration solution must address requirements traditionally fulfilled by diesel generation (base load)
  - Frequency and voltage control
  - Sufficient spinning reserve
  - Sufficient active and reactive power supply
  - Peak shaving and load levelling
  - Load sharing between generators
  - Fault current provision
- RE generation capacity should be sized to maximize ROI and fuel savings
# ABB microgrids and RE integration

## Technology overview

<table>
<thead>
<tr>
<th>Microgrid Plus system</th>
<th>PowerStore</th>
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</thead>
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<tr>
<td>Specially designed networked control system responsible for coordinating the operation of hybrid power stations</td>
<td>Grid stabilizing system that offers real and reactive power to enable intermittent renewable energy to be integrated into grids</td>
</tr>
</tbody>
</table>

- Maximizes fuel savings
- Optimizes use of renewable energy
- Guarantees optimum loading and spinning reserve in fossil fuel generators
- Distributed logic enhances reliability and scalability for future system expansions

- Can be used in isolated grids or in grid support mode
- Maximizes fuel savings through highest possible renewable penetration
- Ensures high power quality by stabilizing renewable energy generation
Renewable Integration Challenges
High penetration leads to maximized fuel savings

Low renewable energy (RE) contribution

- **Control system:** none/simple
- **Grid frequency:** within operational limits

High renewable energy (RE) contribution

- **Control system:** sophisticated
- **Grid frequency:** stable
Microgrid Plus System
Efficient and reliable power flow management

PV plant MGC600-P
Wind Turbines MGC600-W
M+ Operations Local and remote
Communication Network

Diesel Generator MGC600-G
Grid connection MGC600-N
Grid Stabilising System MGC600-E

Distribution feeder MGC600-F
Residential
Industrial & commercial

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Microgrid Plus System
Typical example of isolated PV / diesel microgrid
The PowerStore consists of:
- **Flywheel** energy storage
- or
- **Batteries** energy storage
- Power converter system
- Operator interface

The PowerStore is able to operate in:
- Grid Support Mode (GSM) for large networks
- Virtual Generator Mode (VGM) for isolated microgrids
PowerStore
Flywheel energy storage

• The flywheel is a robust and proven mechanical device used in UPS solutions
• It is failsafe, utilizing its own energy to supply the lifting magnets

Flywheel Performance Data

- Net. energy content 18 MWs
- Max Input/output power 1650 kW
- Speed range 1800 to 3600 rpm
- Total weight 6000 kg
- Rotor weight 2900 kg
- Idling losses 10 kW
- Greasing frequency 5 years
- Bearing service life 8 years
PowerStore
Ensuring a stable microgrid electricity network
**PowerStore**
**Virtual generator mode – 100% renewables**

**Diesel-off / Virtual generator mode:**
- The PowerStore operates as the only generator on the grid.
- Max RE penetration = 100%

**Benefits:**
- Increased annual RE contribution
- Reduced diesel generator running time

**Additional considerations:**
- Diesel-off functionality is to be studied case by case
- Business case is optimal when:
  - Daily load with peaks during PV peak
  - High price of fuel
  - Expected increase in fuel price
ABB microgrids and RE integration
Five comprehensive solutions

- Hybrid Power plant
- Integrated Wind or PV Plant
- Optimized microgrid integration
- Renewable to grid connector
- Grid stabilizer
ABB microgrid and RE integration
Turnkey solution for a greenfield microgrid project

Hybrid Power plant

- Integrated Wind or PV Plant
- Optimized microgrid integration
- Renewable to grid connector
- Grid stabilizer

Providing a complete solution for a greenfield project
- Lowest LCOE
- Grid stability and utility grade electricity
- Maximum availability
# ABB microgrids and renewable energy integration

## Our offering and some references

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<td>Ancillary power system services</td>
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### What is it?
- Turnkey solution for a greenfield microgrid project
- Integration of renewable energy into fuel-based microgrids (HFO, diesel, gas etc.)
- Stabilization and flow optimization of renewable energy integration
- Stabilization of on-grid renewable energy plants connected to a weak grid
- Providing virtual inertia, grid stabilization, as well as other ancillary power system services

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- Carnegie (wave)
- Kalbarri (wind)
- SP Ausnet (GESS)
- Leinster Mine (peak lopping)
- Endesa (grid connection)
- REE (grid connection)
Upgrading an existing fuel-generation based microgrid with RE generation

- Maximized fuel savings
- Increased security of supply
- Ensured grid stability

Hybrid Power plant

Integrated Wind or PV Plant

Optimized microgrid integration

Renewable to grid connector

Grid stabilizer
# ABB microgrids and renewable energy integration

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Optimizing the performance of an unstable microgrid with existing RE and fossil fuel generation

- Maximized fuel savings
- Optimized production of RE
- Ensured grid stability
# ABB microgrids and renewable energy integration

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Enforcing a compliant grid connection for wind and solar power plants

- Increased power quality and reliability
- Maximized utilization and ROI of renewable energy plant

Hybrid Power plant
Integrated Wind or PV Plant
Optimized microgrid integration
Renewable to grid connector
Grid stabilizer
# ABB microgrids and renewable energy integration

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ABB microgrid and RE integration
Virtual inertia as an ancillary power system service

- Hybrid Power plant
- Integrated Wind or PV Plant
- Optimized microgrid integration
- Renewable to grid connector
- Grid stabilizer

Grid support through active and reactive power injection
  - Fast response to grid frequency disturbance events
  - Ensured grid stability
## ABB microgrids and renewable energy integration

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Customer requirements
Reduce the peak load of a newly installed winder by 1MW so that the total power demand is kept within the contractual limits with the IPP.

ABB solution
Install a 1MW PowerStore device that provides the 1MW to the winder and recharges when the total demand is within the contractual limits.

Customer benefits
Reduction of peak demand by 1MW
Reduction of spinning reserve by IPP of 1MW
For microgrids, especially in remote areas, it is critical to maintain constant power supply and have access to technical support 24/7.

ABB technology enables remote access, monitoring and control of all microgrid assets.

ABB can perform routine service checks, regular maintenance and unscheduled service remotely, with minimal operational impact on the Microgrid.

ABB service
A trusted partner through the microgrid’s lifecycle
PV Electrical Balance of Plant

Optimized electrical system solutions to secure your large-scale PV project
ABB PV plant references
Local expertise, global presence, >900MWp.
ABB value proposition in the PV industry
Engagement in the entire project life-cycle

Development stage

- Project development
  - ABB support and engineering expertise
    - Project design and optimization
    - Yield and PR calculation
    - Grid Connection, substation capacity

- Construction
  - eBOP electrical system integration
  - Performance guarantee for electrical system
  - Turn-key EPC executed by one of our tier-1 partners

- Operation
  - Full O&M service
  - ABB products and equipment lifetime services
Electrical Balance of Plant from ABB
From the back of the panels to grid connection

**Turn-key**

**eBOP**
Vertically Integrated solution based on reliable and proven ABB products, including erection, commissioning, O&M and performance guarantee

Consultancy

Plant automation

Protection

Transformer centers

Cables

DC boxes

Inverters

Transformers

Switchgears

Substation

Panels

Structure
ABB products in PV used in the eBOP Applications: Utility >1000 KW

1. Trackers

Low voltage products:

2. Contactors: GAF series
3. Direct current string boxes
   Switchboards: Gemini series
   Consumer units: Europa series
   Junction boxes
   Fuse disconnectors: E90 PV
   Fuses: E 9F PV
   Surge protective devices: OVR PV
4. Switch-disconnectors: OTDC series
   Miniature circuit-breakers disconnectors: S800 PV-M
   Switch-disconnectors: Tmax PV
5. Moulded-case circuit-breakers: Tmax
   Miniature circuit-breakers: S200
6. Contactors: A and AF series
7. Energy meters: DELTAplus
8. Residual current devices: F202 PV B and F204B
   Residual current devices: RD3
9. Air circuit-breaker: Emax
10. Switch-disconnectors: OT
    Switch-disconnectors: E200
11. Surge protective devices: OVR T1 / T2

Solar inverters:

12. Central inverters: PVS 800
    Remote monitoring portal
13. Megawatt station

Medium voltage products:

14. Dry type transformers
15. Liquid filled transformers
16. Secondary switchgears
17. Primary switchgear
18. Compact secondary substations
19. Substations
Electrical Balance of Plant from ABB
Inverter station – Proven reliability & performance

Features:
- Indoor Solution based on Power module with more than 100GW in references worldwide.
- From 500 kW to 2,4MVA
- EcoDry type transformer
- From 6,6 to 36 kV
- Up to 45° Ambient Temperature
- Monitoring services
- Grid Code Compliance service
- Pretested ready to plug and play.

Benefits:
- All ABB proven and reliable components
- Compact, modular and robust design, easy transportability, reduced downtime
- Best in class efficiency, high ROI
Service for PV plants
Tailored according to customers’ needs

<table>
<thead>
<tr>
<th>PV plants service offering</th>
<th>Service features</th>
<th>ABB service packages</th>
</tr>
</thead>
</table>
| Advanced services          | - PV energy production forecast  
                            | - Financial analysis tool | Recommended for optimal O&M |
| Remote services            | - Remote monitoring  
                            | - Reporting |  |
| Preventive and corrective maintenance | - Scheduled / unscheduled maintenance of the complete PV plant | Typical FULL O&M by ABB, with guaranteed PR and availability |
| Basic PV plant maintenance service | - PV module cleaning  
                            | - Vegetation control etc. |  |

ABB added value
Solar plant automation
Scalable architecture for managing large plants and the MV transformation centers

Remote Management of Plants
- Real time monitoring of assets
- Power production management from Remote Control Center
- Plant maintenance planning from Remote Service Center
- Diagnostics algorithms to support maintenance activities

Plant Monitoring & Control System
- SCADA system to monitor all relevant field signals
- Real time control system to manage the production of the plant
- Grid code compliant functions for controlling active and reactive power, frequency and voltage

Transformation Center Control
- Monitors and controls the inverters
- Monitors the String Boxes and/or the tracking systems
- Coordinates the production in the transformation center
- Interfaces with the upper level Section Controller
Main Features
NEREO+

- Power Regulation
- Maximum Ramp
- Power Factor Adjustment
- Hourly Based Forecast
- Daily Based Forecast
Plant Control
NEREO+
Solar power automation
Nereo+. Forecasting of power production

**Hours ahead forecasting**

- Based on Artificial Neural Network algorithm
- Uses historical data for training and real time plant data to improve the forecasts accuracy
- Makes use of weather forecasts in the area where the plants are located
- Hourly values for a horizon of 6 hours
- Daily values for a horizon of 7 days
Assumptions:

- The movement of the cloud is from West to East at constant speed of 6m/min ~ 0.1 m/sec
- No deformation of the cloud
- ~ 66% of shadowing of the plant
- GHI ramp rate 50 W/m²/Δt
- Inverters operating @ MPP
Partial shadowing over the PV plant – Behaviour of inverters

Inverters 1, 2, 3 & 4 are affected by shadowing. The answer of inverters 3 & 4 is delayed over the inverters 1 & 2.

The inverters 5 & 6 are not affected by the cloud and remain producing at maximum point.
Partial shadowing over the PV plant – Behaviour of inverters

The production of inverters 5 & 6 remains high being almost not affected by the shadows of the cloud.

The production of inverters 1, 2, 3 & 4 drop nearly to 95% (~30 min).
The loss of production is a consequence of the shadows over inverters 1, 2, 3 & 4. The inverters 5 & 6 remain producing at maximum level and they are maintaining the power output of the plant.

The loss of production is ~ 50% during shadowing.
Power and productivity for a better world™