MAY 2017

Microgrid

Enabling resilient and cost effective access to power

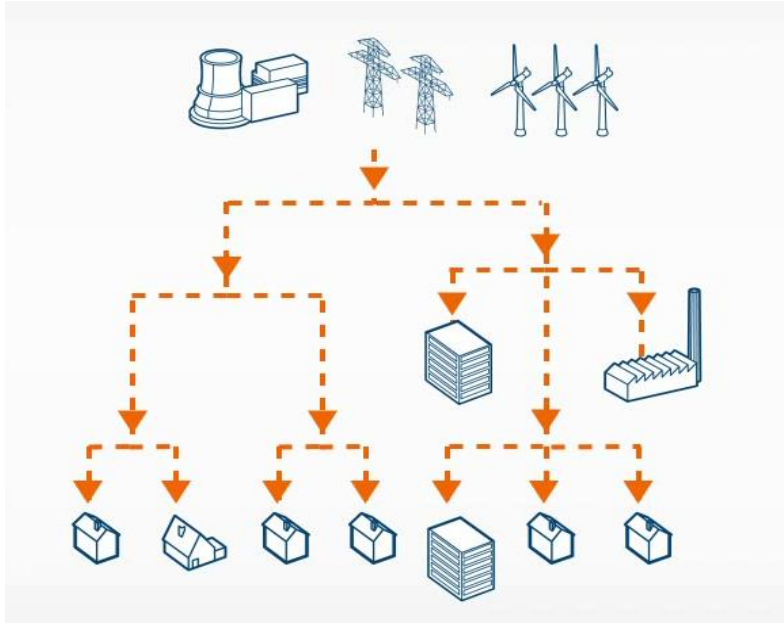
Maxine Ghavi, Head of Microgrid Program

www.abb.com/microgrids

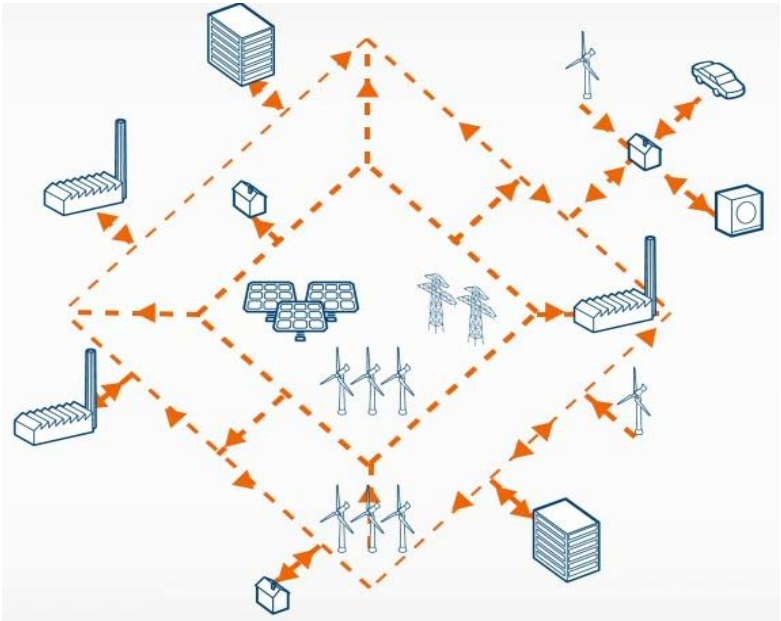
Energy and grid transformation

Transition from a centralized to a distributed grid

Traditional grid



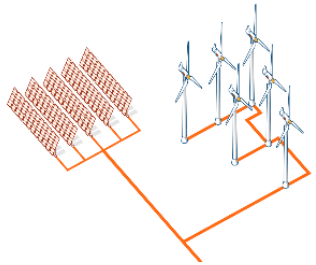
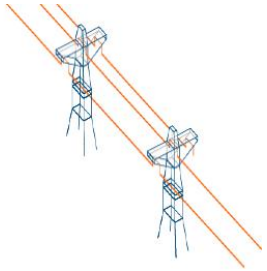
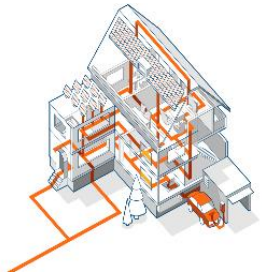
New grid



New developments are accelerating the transition

Energy and grid transformation

Global trend – Big shift in the electrical value chain

Generation mix		Renewable share: ~40% of capacity by 2035 Greater volatility, less predictability More feed-in nodes
Power transmission and distribution		Increasing complexity Control/ information flow is key value driver Transmission: Longer distances, higher voltages
Micro-/ Nano-grids		On-and off-grid Control/ automation on “local” level Energy storage is key

DER: Distributed Energy Resources

Microgrid segments and main drivers

Covering a diverse range of applications

Off-grid / Weak grid / Grid-connected

Segments	Typical customers	Main drivers: Social – Access to electricity	Economic – Fuel & cost savings	Environmental – Reduce CO2 footprint	Operational – Fuel independence	Operational – Uninterrupted supply
Island utilities	(Local) utility, IPP*		✓	✓	✓	(✓)
Remote communities	(Local) utility, IPP, Governmental development institution, development bank	✓	✓		✓	
Industrial and commercial	Mining company, IPP, Oil & Gas company, Datacenter, Hotels & resorts, Food & Beverage		✓	(✓)	✓	✓
Defense	Governmental defense institution		(✓)	(✓)	✓	✓
Urban communities	(Local) utility, IPP			(✓)		✓
Institutions and campuses	Private education institution, IPP, Government education institution		(✓)			(✓)

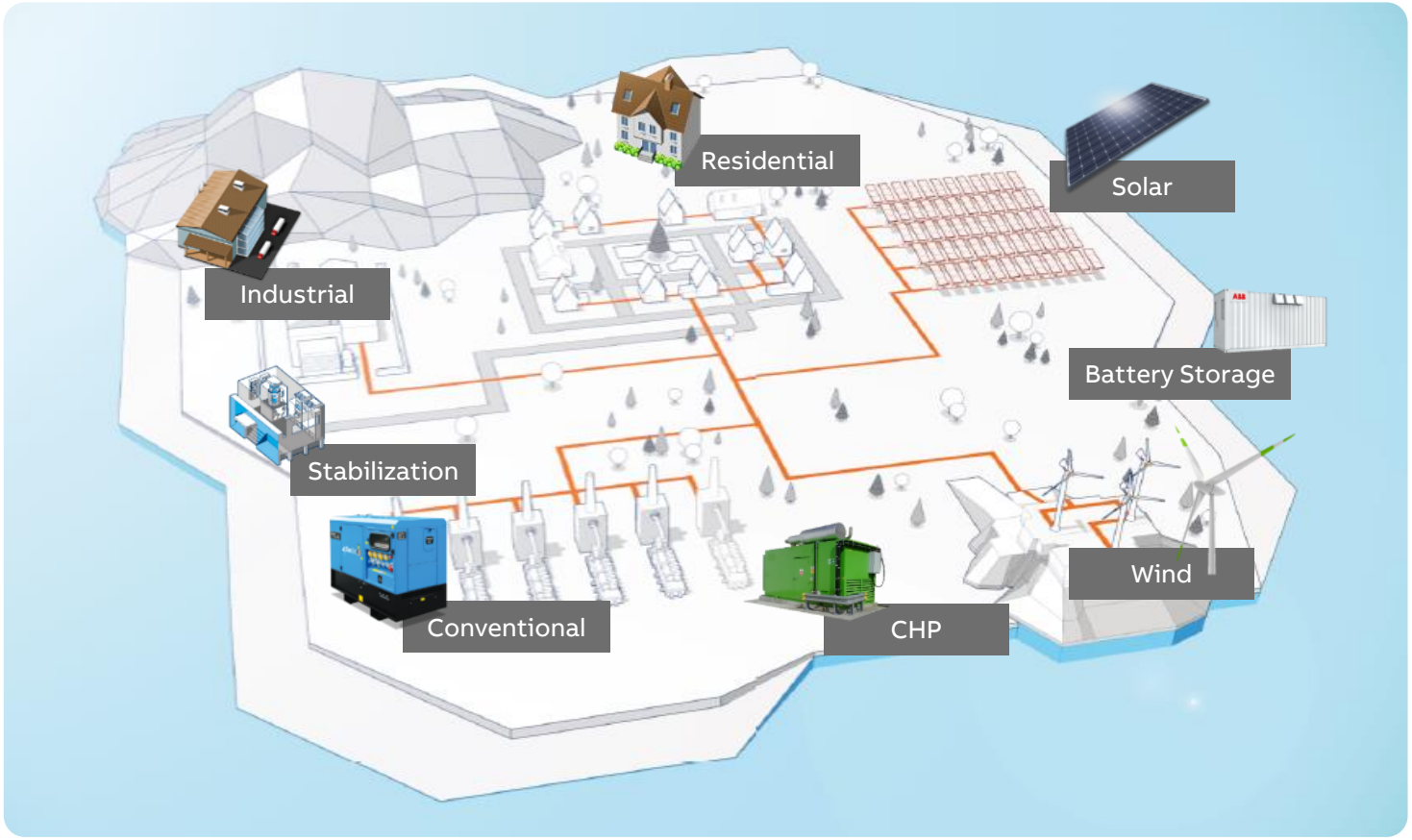
IPP: Independent Power Producer

✓ : Main driver

(✓) : Secondary driver

Hybrid or Islanded Microgrid

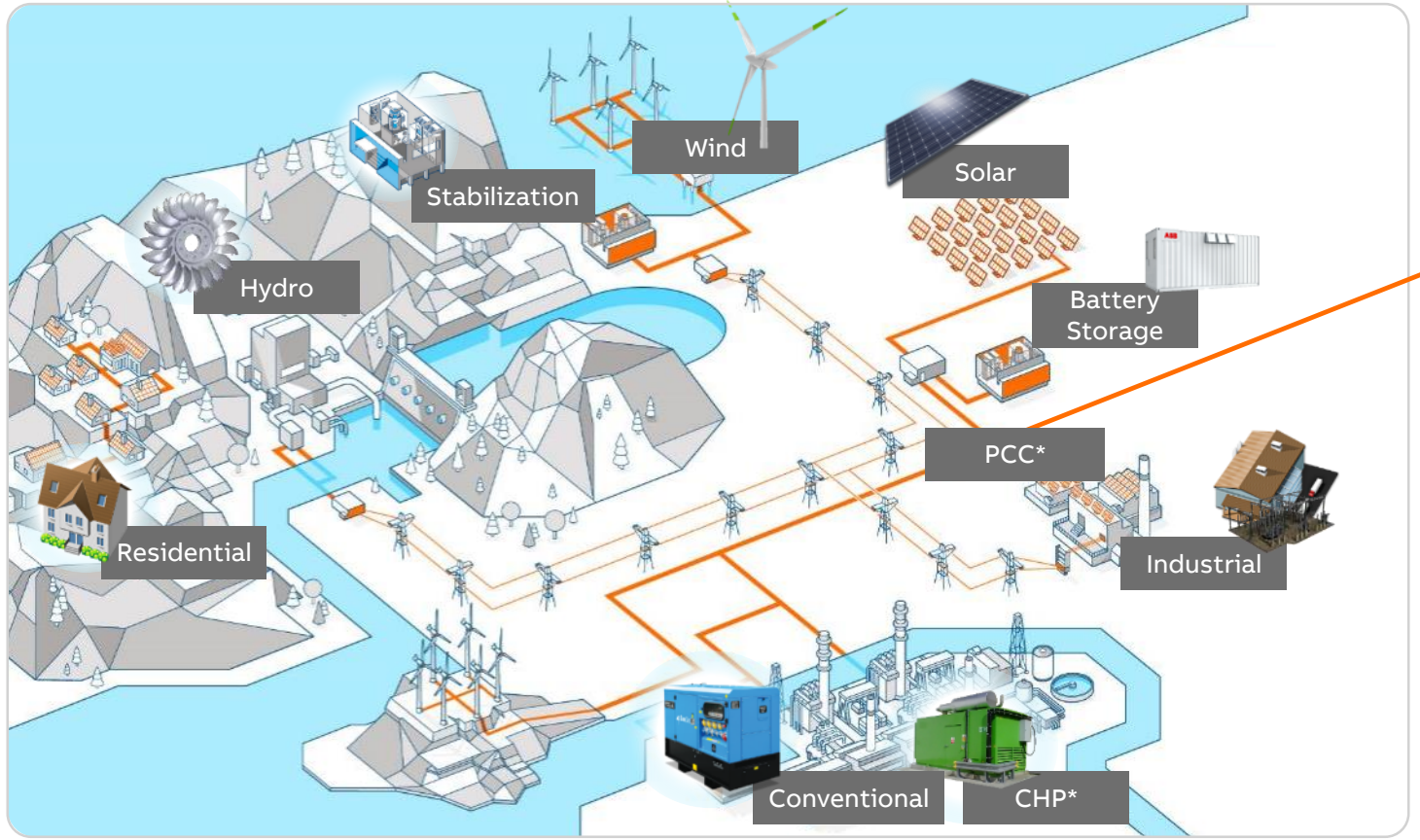
Access to power in remote locations, power quality plus lower cost and environmental impact



CHP: Combined Heat and Power

Grid connected Microgrid

Grid resiliency, power quality, self consumption and lower environmental impact

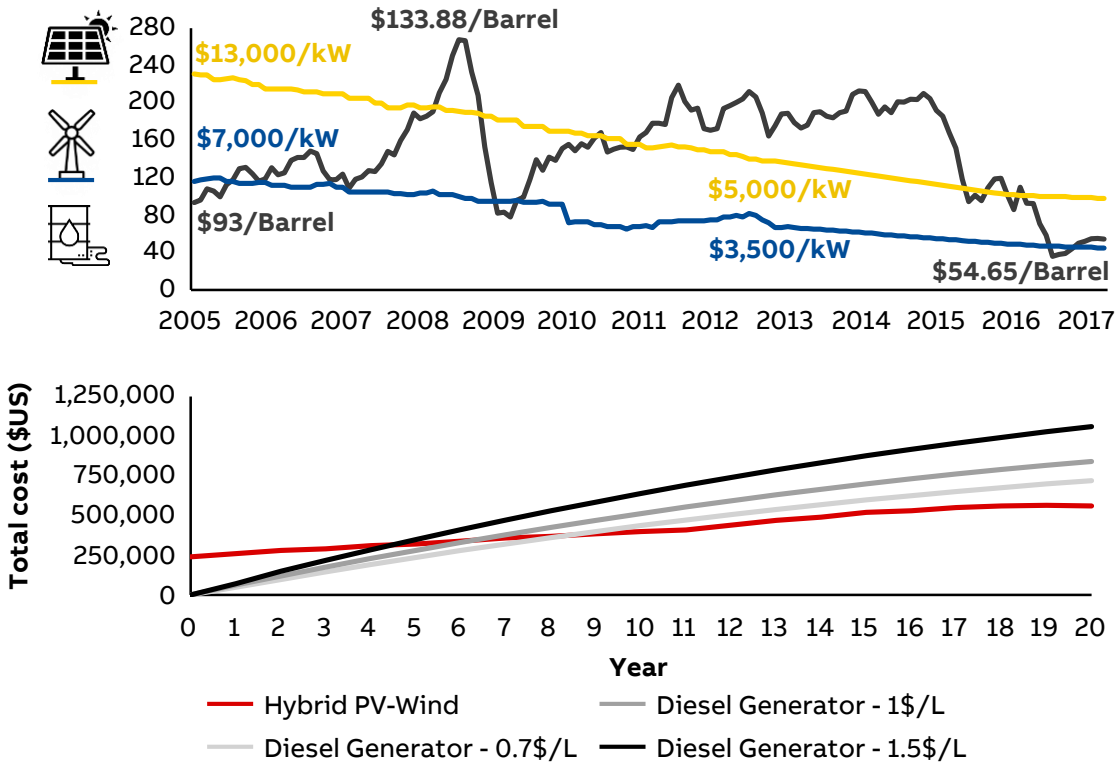


PCC: Point of Common Coupling, CHP: Combined Heat and Power

Driver: Fuel independence and lower LCOE

Secure power generation and fuel cost savings

Average Oil price USD$/Barrel is volatile



LCOE: Levelized Cost of Electricity

Fossil fuel cost is volatile

Steady decline of renewable energy cost, making it economically viable

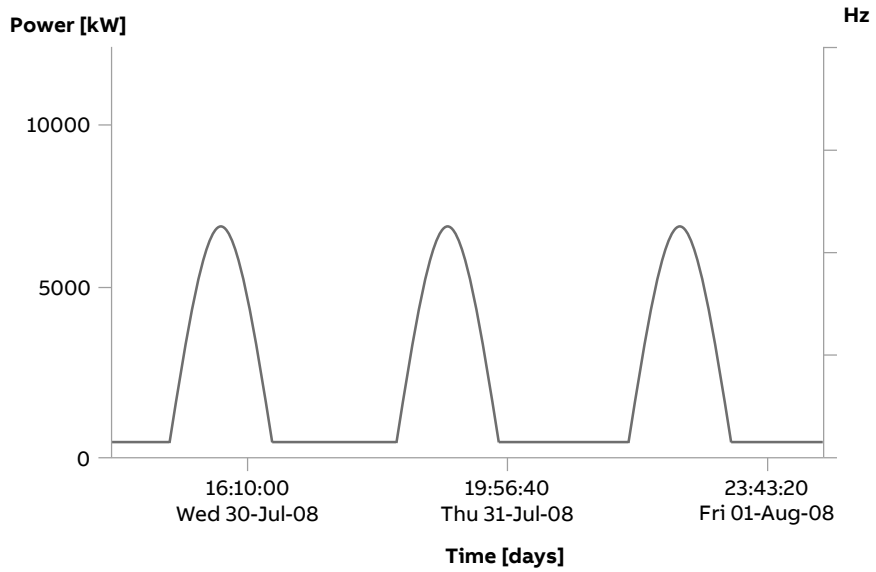
An optimized energy mix leads to a lower cost of electricity

Sources:
1. US Energy Information Administration – Independent Statistics and Analysis
2. Alliance for Rural electrification (ARE). Projections made from a case study based in Ecuador with real natural conditions

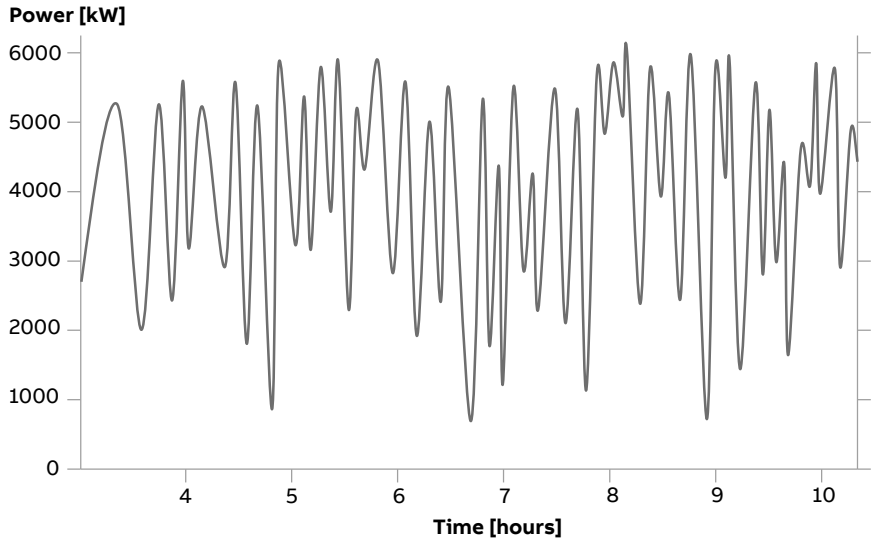
Driver: Uninterrupted power supply

Managing power fluctuations from renewables

Solar power variations



Wind power variations



Inherent volatility of renewables can compromise grid stability

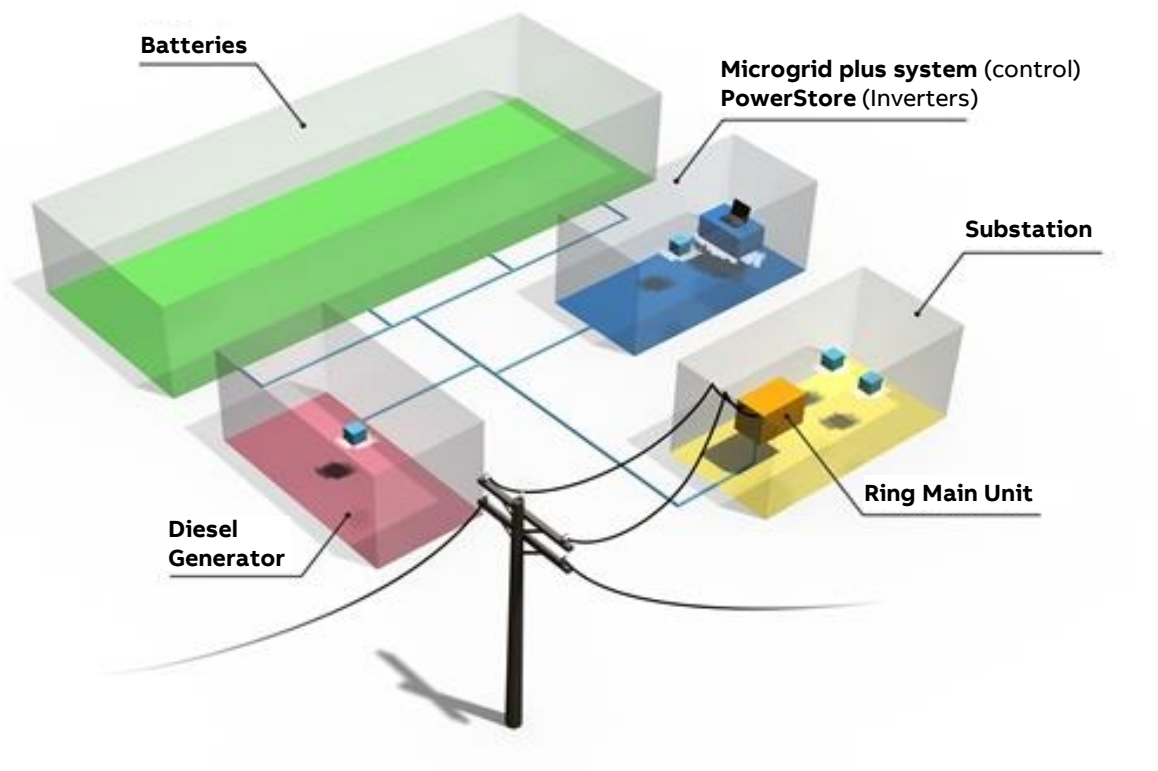
Grid stability requirements are traditionally fulfilled by diesel generation (base load)

Optimized microgrid solution maximizes ROI* and fuel savings

ROI: Return of Investment

Driver: Strengthening distribution grids

Maximizing capital efficiency



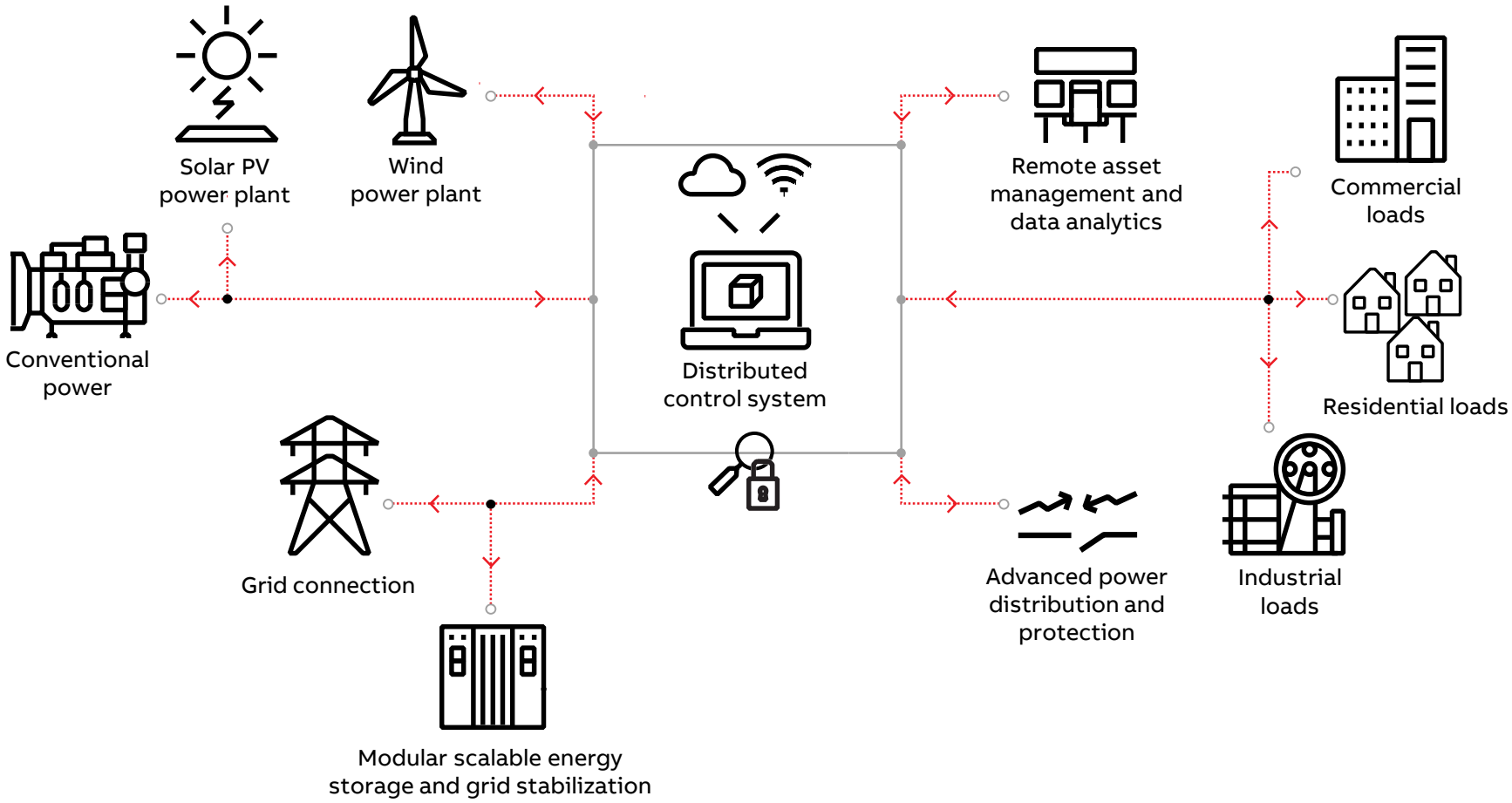
Microgrids can remove load from the power grid to avoid or defer new power capacity investments by:

- Reducing peak demand
- Reducing system load growth

While simultaneously improving network reliability and availability, and lowering consumer rates.

Microgrid

Generation at the point of consumption and always available

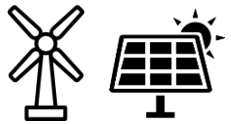


Microgrid operational goals and power system functions drive choice of technology

Operational goals

- Access to electricity
- Maximize reliability
- Uninterrupted supply
- Reduce environmental impact
- Maximize renewable energy contribution
- Fuel & cost savings
- Fuel independence
- Provide grid services

Renewable power



Microgrid control system

Energy storage and grid stabilization

Power system functions – “8S”

1. Stabilizing
2. Spinning reserve
3. STATCOM (static synchronous compensator)
4. Seamless transition between islanded and grid-connected states
5. Standalone operation
6. Smoothing
7. Shaving
8. Shifting

Key microgrid technology: energy storage

8S application response times and energy and power requirements

	Application	Time frame	Energy requirement	Power requirement
S1	Standalone	milliseconds	low	high
S2	Seamless transition	milliseconds/seconds	low	high
S3	Stabilize (V & f support)	seconds	low	high
S4	Statcom (power quality)	seconds	zero	high
S5	Spinning reserve	seconds/minutes	medium	high
S6	Smoothing	minutes	medium	medium
S7	Shaping (Peak lopping/shaving)	minutes/hours	medium	low
S8	Shifting (load leveling)	hours	high	low

ABB in Microgrid

ABB - the global microgrid solution partner

ABB the leading provider of microgrid products and end-to-end microgrid solutions

Leading global expertise

25+

25+ years experience
40+ executed projects

Innovation, technology & productization leadership

Global sales & service network

AND

Broad portfolio of products & services

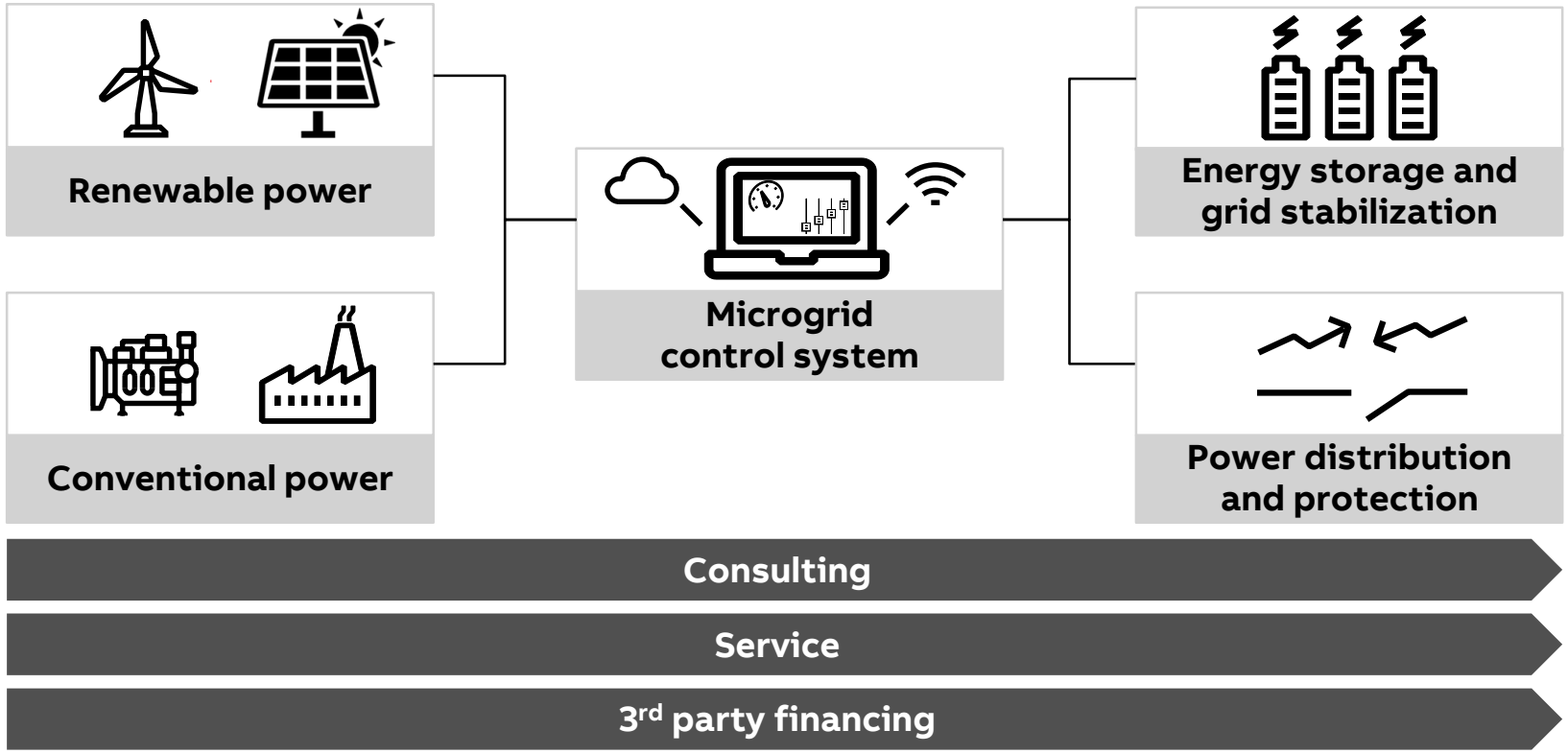


ABB in Microgrid

Consulting

Consulting and design tools

Our experience, capabilities and tools enable our customers to plan and operate the Microgrid reliably and at maximum economic benefit.

Consulting is offered throughout the complete lifecycle of a project with the goal to find the optimal solution that maximizes the value of the assets and financial investment.

- Feasibility studies and simulations
- Grid studies
- Renewables engineering

ABB in Microgrid

Electrical balance of plant

Plant electrification, automation, power distribution and protection

Comprehensive scope of plant electrification and automation systems

- Solar inverters
- Plant automation, optimization and control and remote monitoring
- Control systems, drives, instrumentation, power converters and inverters

Low and medium voltage products and solutions for protection, control and measurement meeting the demands from all types of power distribution grids.

- Switchgears
- Transformers
- Circuit Breakers
- Substations
- Protection and control
- Measurement and monitoring

ABB in Microgrid

Grid stabilization and energy storage

PowerStore

Containerized plug-and-play solution in various ratings

Fully productized and scalable to address all market segment applications.

- Seamless transition from grid connected to islanded mode
- Stabilizes against voltage and frequency variations
- “Virtual Generator” can form the grid, integrating up to 100% of renewable energy
- Microgrid Plus Controller
  - Maximizes fossil fuel savings and 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

ABB in Microgrid

Integrated solar PV solutions

For remote communities and small industries

Operations include off-grid, in parallel with diesel generators or weak grids

Key components

- Solar inverter
- Power converter
- Protections
- Control system
- Remote monitoring
- Batteries

PowerStore Hybrid; > 60kW
(integrated battery)

MGS100; 20kW-60kW
(external battery)

ABB in Microgrid

PV/Diesel kit

Cost-effective kit optimized for hybrid solar PV-diesel applications

A kit, solar inverter plus microgrid controller, for off-grid and grid-connected applications

Simple and cost competitive

- "out-of-the-box" solution
- No application engineering needed

Flexible and scalable

- Fully compatible with ABB solar inverters (TRIO, PVS800) and diesel genset controllers from leading vendors
- Can be integrated with ABB SCADA system

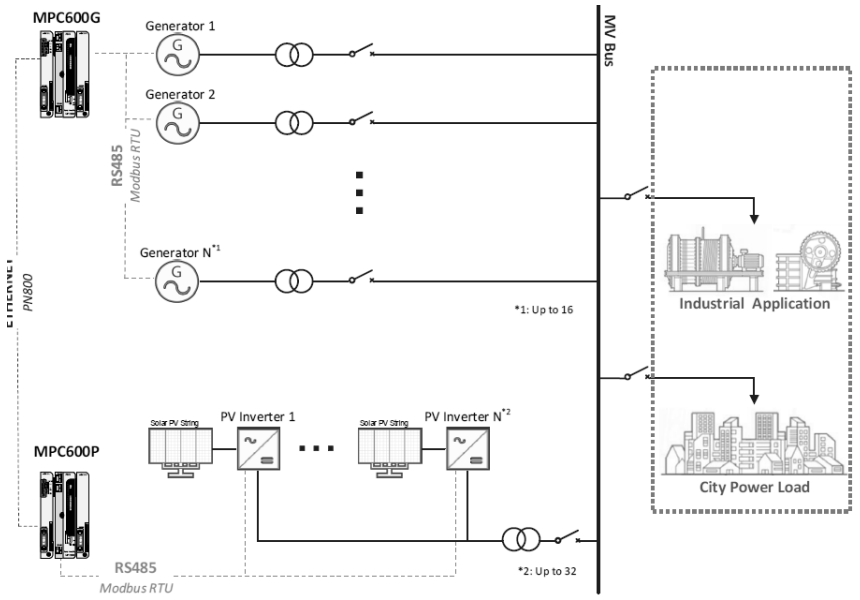


ABB in Microgrid

The circuit breaker with integrated microgrid control

Advanced protection: Emax 2

The first intelligent circuit breaker to protect and optimize low voltage Microgrids.

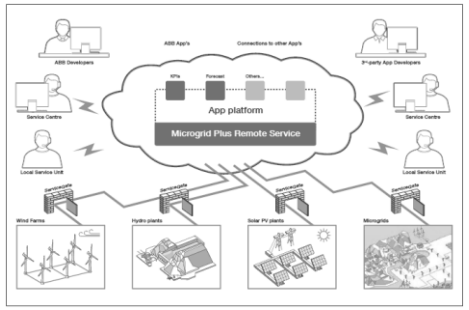
- Embedded Microgrid control algorithm
- Optimizing utility power, solar, diesel generation, loads and energy storage
- Complete series of embedded protections to satisfy both on grid and off grid systems
- Ensuring protection for loads and generators without using external devices
- Plug and play, scalable logic to interconnect and coordinate devices
- Embedded sensors release data enabling remote monitoring

ABB in Microgrid

Remote monitoring a key component in lifecycle management

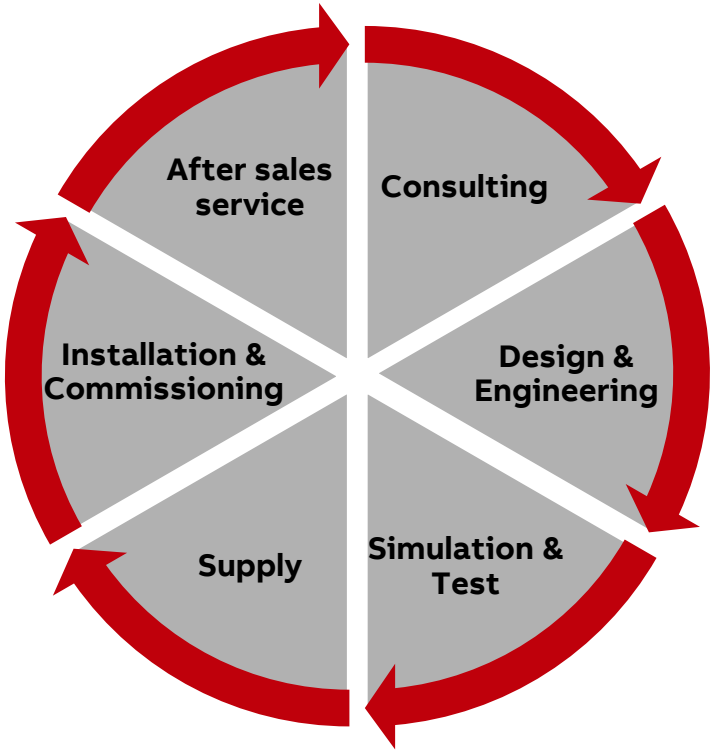
Remote services for operation and maintenance

A comprehensive solution for unattended sites to increase productivity, improve energy efficiency and reduce operational costs.



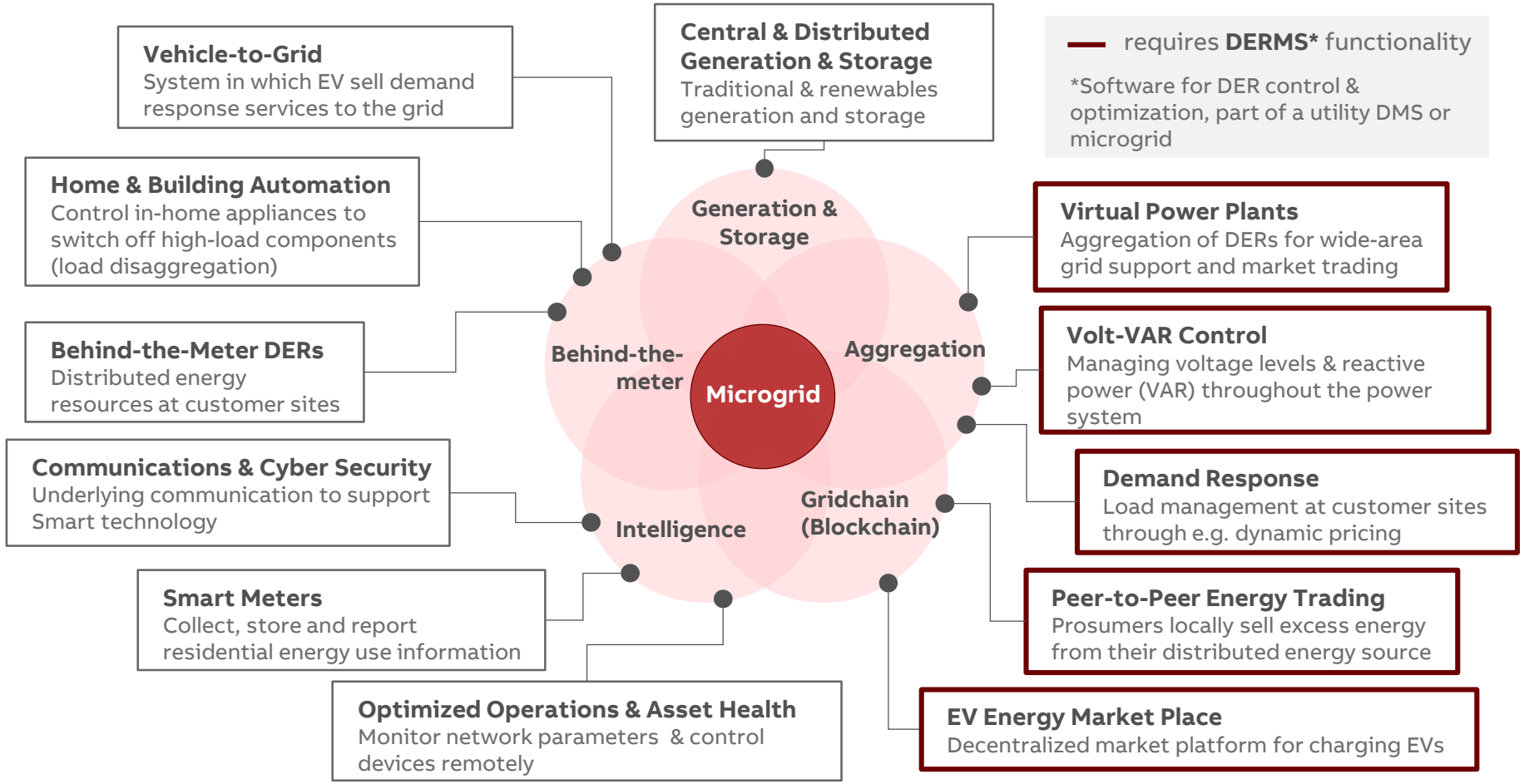
Management of customers and plants from the same web portal, providing

- Energy production reports
- Interventions
- Energy production forecasts
- Real time data production
- List of customers and plants



Grid transformation and emerging technologies

Enabling new applications & services redefining microgrid



EV: electric vehicle / DERMS: distributed energy resource management system
DER: distributed energy resource / DMS: demand management system

ABB in microgrid - References

Hybrid power plant

Marble Bar, PV/Diesel

Project name

Marble Bar

Country

Western Australia, Australia

Customer

- Horizon Power
- Government of WA

Completion date

2010

ABB solution

Turnkey solution for a greenfield Microgrid project

PV/diesel Microgrid with PowerStore grid-stabilizing technology and Microgrid Plus System

The resulting Microgrid system consists of:

- Diesel (4 x 320kW)
- PV (1 x 300kW)
- PowerStore-flywheel (1 x 500kW)
- Microgrid Plus System

Customer benefits

Minimize diesel consumption, 405,000 litres of fuel saved annually

Minimum environmental impact, 1,100 tonnes CO2 avoided annually

Reliable and stable power supply

60% of the day time electricity demand is generated by the PV plant

About the project

Marble bar and Nullagine are the world's first high penetration, solar photovoltaic diesel power stations

Integration of renewables

Kodiak Island, PowerStore/Wind/Hydro/Diesel

Project name

Kodiak Island

Location

Alaska

Customer

Kodiak Electric Association (KEA)

Completion date

2015

ABB solution

Two PowerStore flywheels act in parallel to shave off peak load and to reduce the stress placed on an existing battery energy storage system

The resulting Microgrid system consists of:

- PowerStore Flywheel (2 MW/ 33 MWs)
- Wind (6 x 1.5 MW)
- Hydro (3 x 11 MW)
- Diesel (1 x 17.6 MW, 1 x 9 MW, 1 x 3.6 MW, 1 x 0.76 MW)

Customer benefits

Stabilizing - frequency regulation

Provide frequency support for a new crane

Help to manage the intermittencies from a 9 MW wind farm

Reduced reliance on diesel generators

About the project

Two PowerStore Flywheels act in parallel in order to deliver optimal grid stabilization on Kodiak Island

Reliable power in presence of a weak grid

Johannesburg, PV/diesel/Storage and grid

Project name

Longmeadow

Location

South Africa

Customer

Longmeadow Business Estate

Completion date

2016

ABB solution

PV/diesel Microgrid with battery-based system to maximize solar contribution and ensure security of power supply at ABB's premises in Johannesburg

The resulting Microgrid system consists of:

- 750 kWdc rooftop PV plant, including ABB PV inverter
- 1 MVA/380 kWh battery-based PowerStore
- Microgrid Plus System

Customer benefits

Reliable and stable power supply

Optimized renewable energy contribution to the facility

Ability to island from the grid in case of an outage

CO2 reduction: over 1,000 tons/year

Up to 100% renewable energy penetration

About the project

The Microgrid solution is for the 96,000 sqm facility houses hosting ABB South Africa's headquarters as well as manufacturing facilities with around 1,000 employees. The innovative solution will help to maximize the use of solar energy and ensure uninterrupted power supply.

Reliable power in presence of a weak grid

Red Cross Logistics Center (Kenya), PV/diesel/Storage and grid

Project name

Red Cross Logistics Center

Location

Nairobi, Kenya

Customer

International Committee of the Red Cross

Completion date

2017

ABB solution

Supply, installation and commissioning supervision of a PowerStore-battery.

The resulting Microgrid system consists of:

- PowerStore Battery (150 kW/100kWh)
- Microgrid Plus Control System
- Solar PV (1 x 30 kW_p)
- Diesel (1 x 150 kW)

Customer benefits[1]

Reliable and stable power supply despite outages and power quality issues.

Reduced fuel costs and carbon footprint

About the project

"Reliable power is essential for our staff to continue their life-saving work uninterrupted in the field. (…) the ABB microgrid solution is in line with the ICRC's goal to use environmentally friendly technologies. Solutions like this are proof that cooperation between the corporate and humanitarian sectors is not only possible, but imperative"

Peter Maurer, ICRC President

Ancillary power system services

AusNet Services, grid energy storage system

Project name

SP AusNet GESS

Country

Victoria, Australia

Customer

SP AusNet

Completion date

2014

ABB solution

Design, engineering, installation and testing of PowerStore-Battery, transformer and diesel generator

Microgrid Plus System for overall system management

Based on transportable containerized solution

Customer benefits

Manage peak demand – Active and reactive power support during high demand periods

Transition into isolated/Off-grid operation on command or in emergency cases without supply interruption

Delay of power line investments

About the project

First Embedded Generation system with Battery Grid Energy Storage for distribution network support in Australia

Integration of renewables

Finolhu Villas Resort, off-grid PV/diesel/storage microgrid

Project name

Finolhu Resort

Country

Gasfinolhu, Maledives

Customer

Club Med

Completion date

2014

ABB solution

Provision of 40 TRIO-27.6 kW solar inverters for the 1MW solar PV plant installed in the Finholhu Villas island resort.

ABB supplied the inverters to T&D, a system integrator.

Customer benefits

Minimize diesel fuel expenditure – return on investment of the solar PV plant plus storage is less than 8 years

Branding as the first 100% sustainable resort in the Maledives

- 100% renewable energy production
- Waste management and recycling system also in place

About the project

First 100% sustainable resort in the Maledives. The PV panels were integrated into the resort's architecture from the design phase.

Integration of renewables

AGIBA, PV/diesel hybrid microgrid for oil extraction

Project name

AGIBA Solar

Country

Aswan, Egypt

Customer

ENI

Completion date

2013

ABB solution

100 units solar inverter PVI-10.0-TL for the 100kW solar PV plant installed at an oil extraction site.

Customer benefits

Minimizing operational expenses derived from diesel fuel use

About the project

Nine out of ten exploratory wells are over 15,000 ft deep. Crude pumping is an energy intensive activity whose costs have been reduced thanks to microgrid technology.