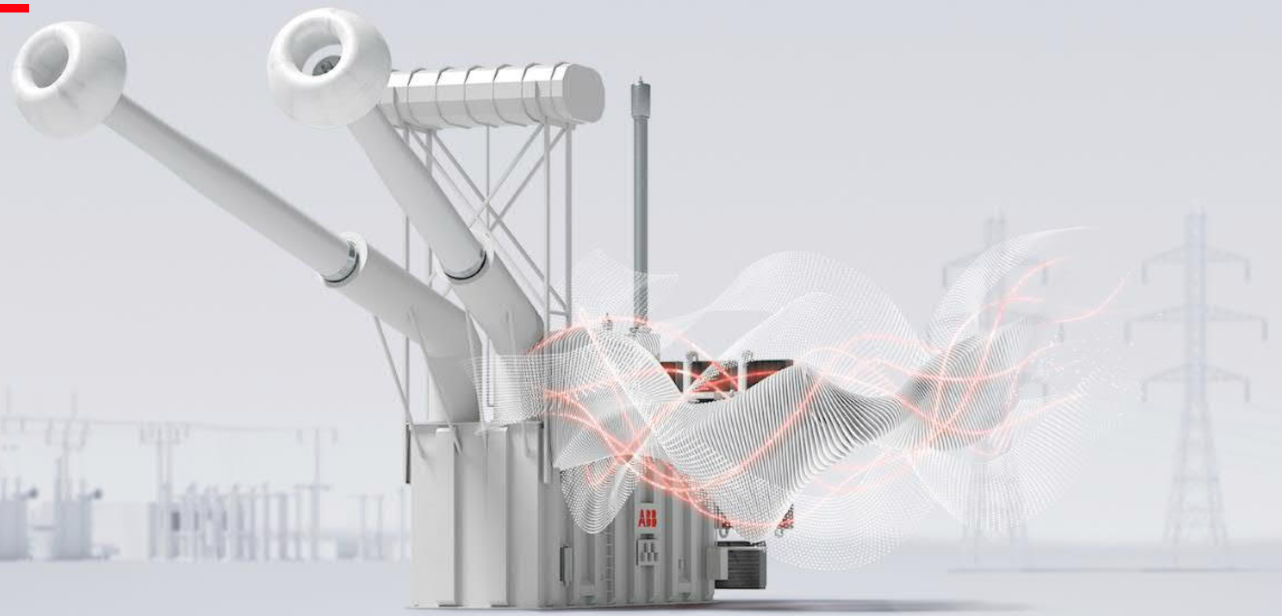


PABLO ASTORGA, ABB MICROGRIDS & DISTRIBUTED GENERATION, JANUARY 28, 2019

Advanced microgrids

Concepts and experience

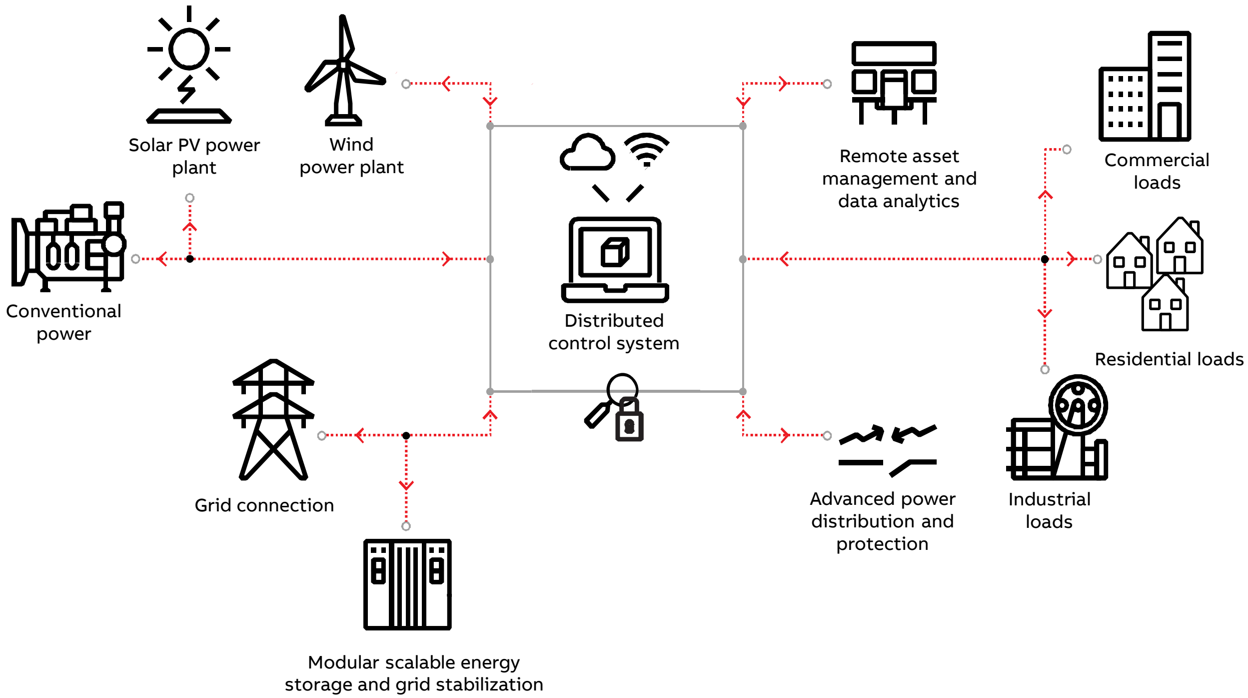
Microgrids

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.



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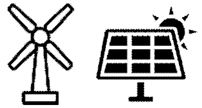
Operational goals and power system functions

Designed-in flexibility and control

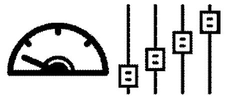
Operational goals

- Maximize reliability
- Resilience in the face of severe weather or natural disasters
- Resilience in the face of a weak, unreliable grid
- Meeting environmental targets
- Maximizing penetration of renewable energy sources
- Minimizing operating expenditures
- Energy independence
- Participation in regulation or ancillary services markets

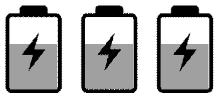
Renewable power



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

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The rise of the EV

- EV charging stations increasingly considering a microgrid composed of grid + PV + BESS + EV chargers
- Opportunities
  - Solve capacity limitations of existing grid connections by avoiding expensive grid infrastructure upgrades
  - Resource optimization via technologies such as v2grid
- Challenges
  - Lack of historical data for EV charger load profile
  - Proper sizing for simultaneous use of fast EV chargers

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Urban communities

Vestec, PowerStore/Solar/EV

About the Project

- **Project name:** Vestec microgrid
- **Location:** Vestec, Czech Republic
- **Customer:** CEZ

Solution

The resulting Microgrid system consists of:

- ABB Ability^{TM} PowerStore Battery (280 KW/280 kWh)
- Microgrid Plus control and automation system
- Remote monitoring
- Solar PV (50 kWp)
- EV chargers (3x 50 kW)

Customer Benefits

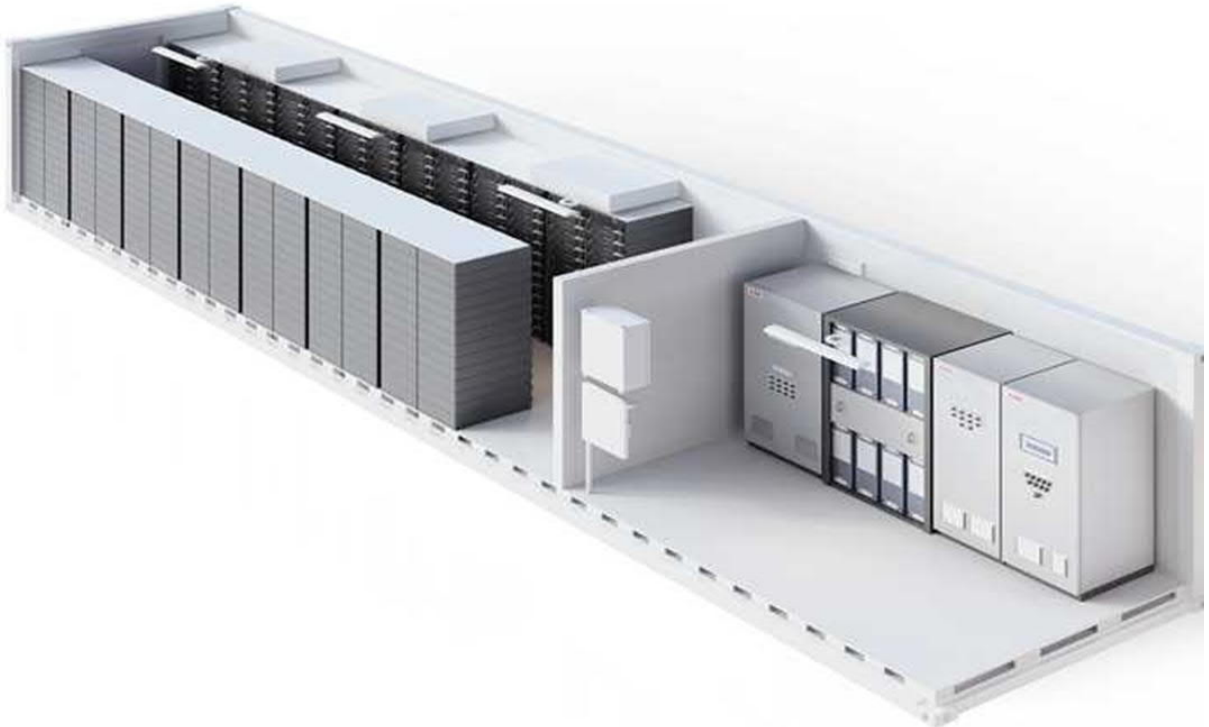
- Integration of renewables into overall facility
- Avoid upgrade of existing grid infrastructure
- Peak shaving and load shifting to optimize ESS use and EV charger use
- Seamless transition to island mode in case of grid failure

First-of-its kind solar-powered EV charging stations with ability to seamlessly transition into island mode in case of grid failure

Advanced microgrids

Beyond batteries

- Battery technology, especially Li-Ion, is under continuous improvement (both technically and commercially)
- Still, and depending on the application, often times other energy storage technologies might be a better fit than batteries. Projects need to be analyzed case-by-case
- In some cases, different energy storage technologies should be combined to offer the best solution (e.g. batteries and flywheels)
- Early planning and system studies are key to a successful specification



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Island utilities

Kodiak Island, PowerStore/Wind/Hydro/Diesel

About the Project

- **Project name:** Kodiak Island
- **Location:** Alaska, United States of America
- **Customer:** Kodiak Electric Association (KEA)

Solution

The resulting Microgrid system consists of:

- PowerStore Flywheel (2 MW/ 33 MWs)
- Battery (3 MW / 750 kWh)
- 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 (high cycling)
- Help to manage the intermittencies from a 9 MW wind farm
- Reduced reliance on diesel generators

Press Release
Infographic
Video

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

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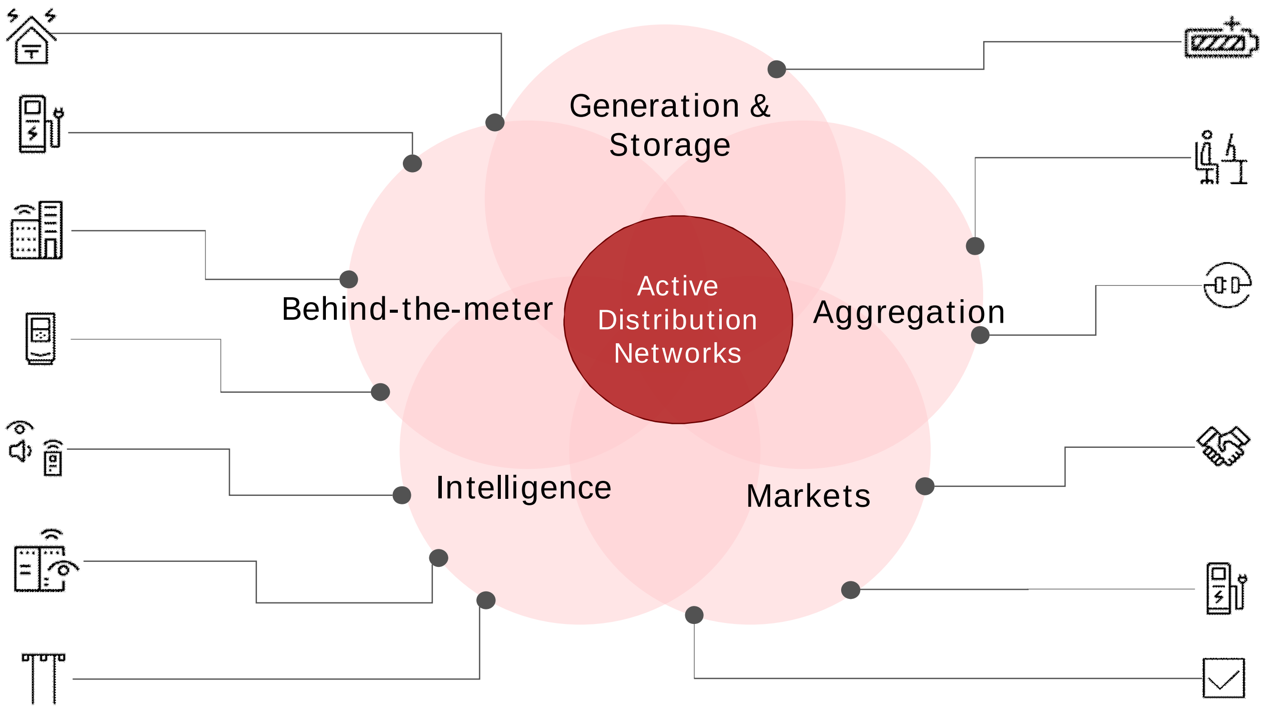
Advanced microgrids

Grid-connected microgrids: the case for optimization

- Market participation of end customer resources
  - Demand response
  - Weather forecast and day-ahead optimization
  - Load scheduling
  - Energy trading
  - Frequency support and other ancillary services
- Multiple POIs increase optimization complexity
- Optimization based on
  - CO_2 emissions
  - Energy purchase from the grid
  - Overall System OPEX
- Optimization typically achieved via software layer on top of control/automation system



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Urban communities

Odd soccer club's Skagerak Arena, PowerStore/Solar

About the Project

- **Project name:** Odd soccer club's Skagerak Arena
- **Location:** Skien, Norway
- **Customer:** Skagerak Energi

Solution

The resulting Microgrid system consists of:
- ABB Ability™ PowerStore Battery (800 KW/1000 kWh)
- Microgrid Plus control and automation system
- Remote monitoring
- Rooftop solar

Customer Benefits

- Power stadium floodlights during soccer games
- Meet the annual power consumption of the stadium - 375,000 kWh
- Provide electricity to 15 homes in the stadium's neighborhood
- Facilitate utility to gather insights on prosumers' power production and consumption pattern

Skagerak Energi

Press Release

First-of-its kind solar-powered energy lab that will use microgrid solution coupled with a battery energy storage system to power a soccer stadium, as well as gather insight about power grids of the future

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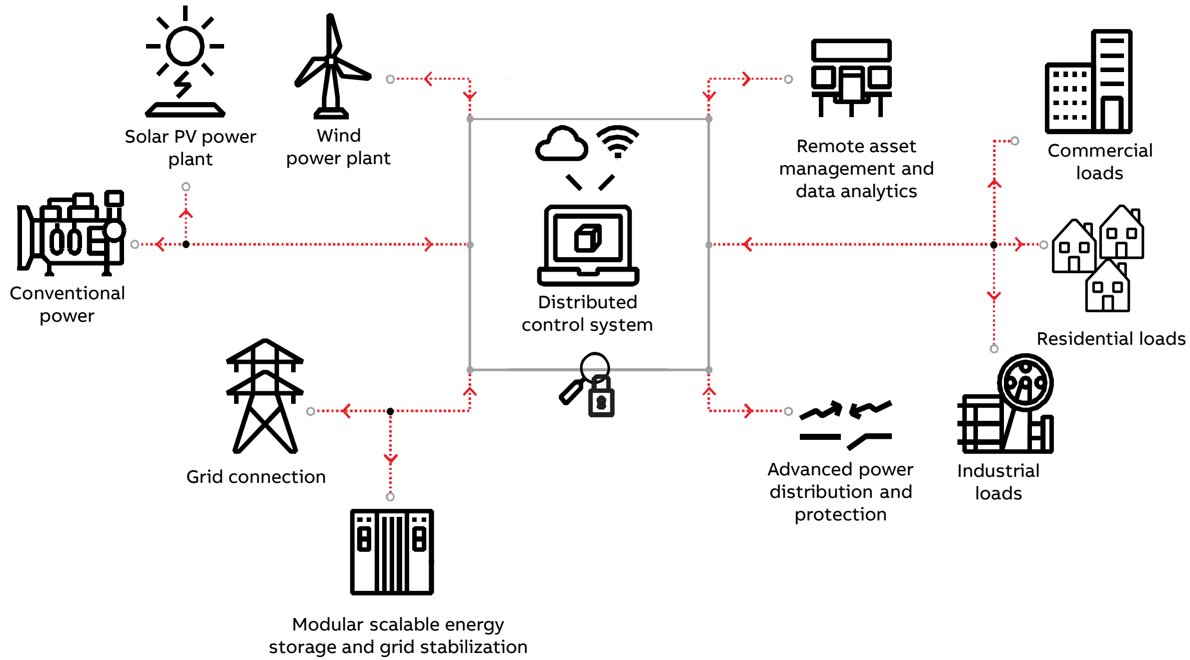
Advanced microgrids

Key aspects and main takeaways

- Early planning and project-specific design are key
- Flexibility in terms of technology can provide access to optimal solutions
- Modular, distributed architectures offer the most effective solution
- Standard interfaces and communication protocols are a must-have to integrate equipment from multiple vendors
- Software optimization offers many opportunities (and growing)



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