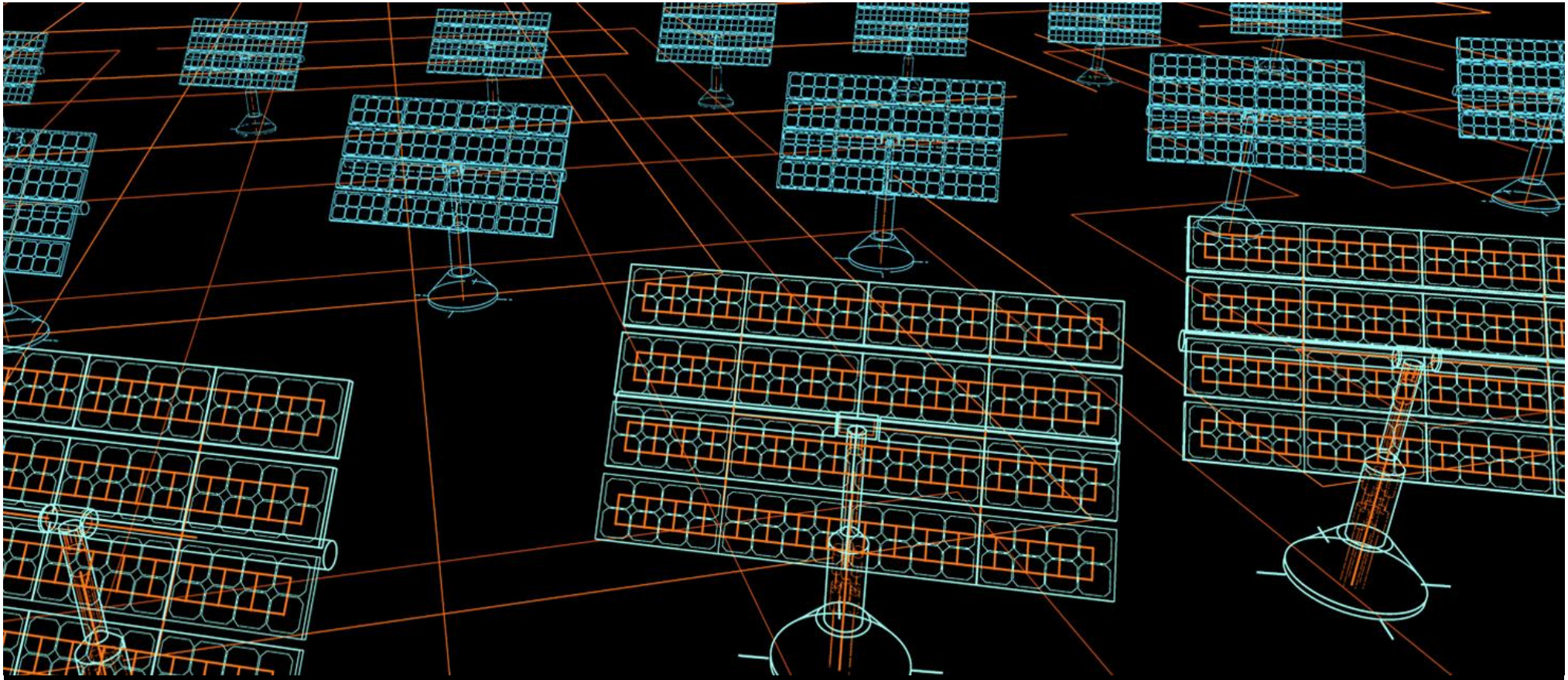


Celia Roldan, ABB PS, Microgrids & Renewable Energy Integration, RENISLA 2014.

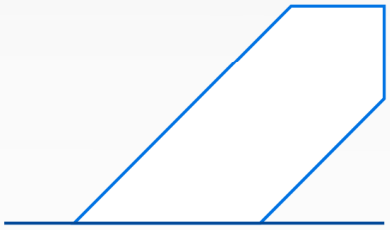
High Penetration in an islanded grid – How to overcome grid Instability

Agenda

1. Overall introduction of ABB
2. Microgrid Challenges
3. Islanded power systems key technologies
4. References
5. Conclusion

A global leader in power and automation technologies
Leading market positions in main businesses

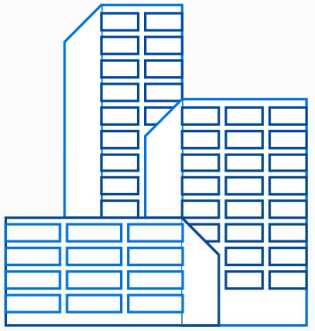
~150,000 employees



$42 billion
In revenue (2013)

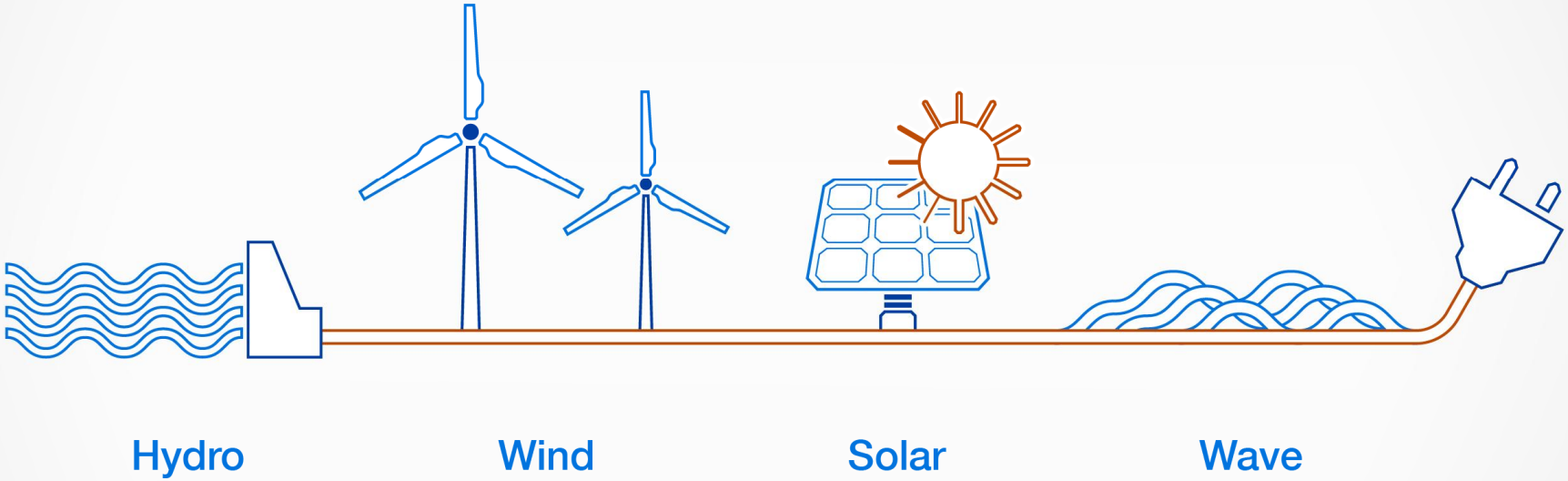
Present in +100 countries

Formed in 1988

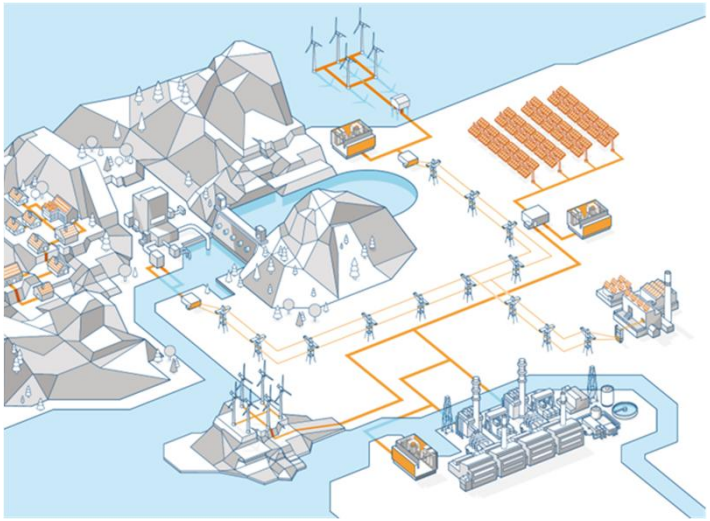


merger of Swiss (BBC, 1891) and Swedish (ASEA, 1883) engineering companies

Renewable energy
Key growth driver for both power and automation



Microgrid Overview
Challenges of islanded power systems



Current Situation

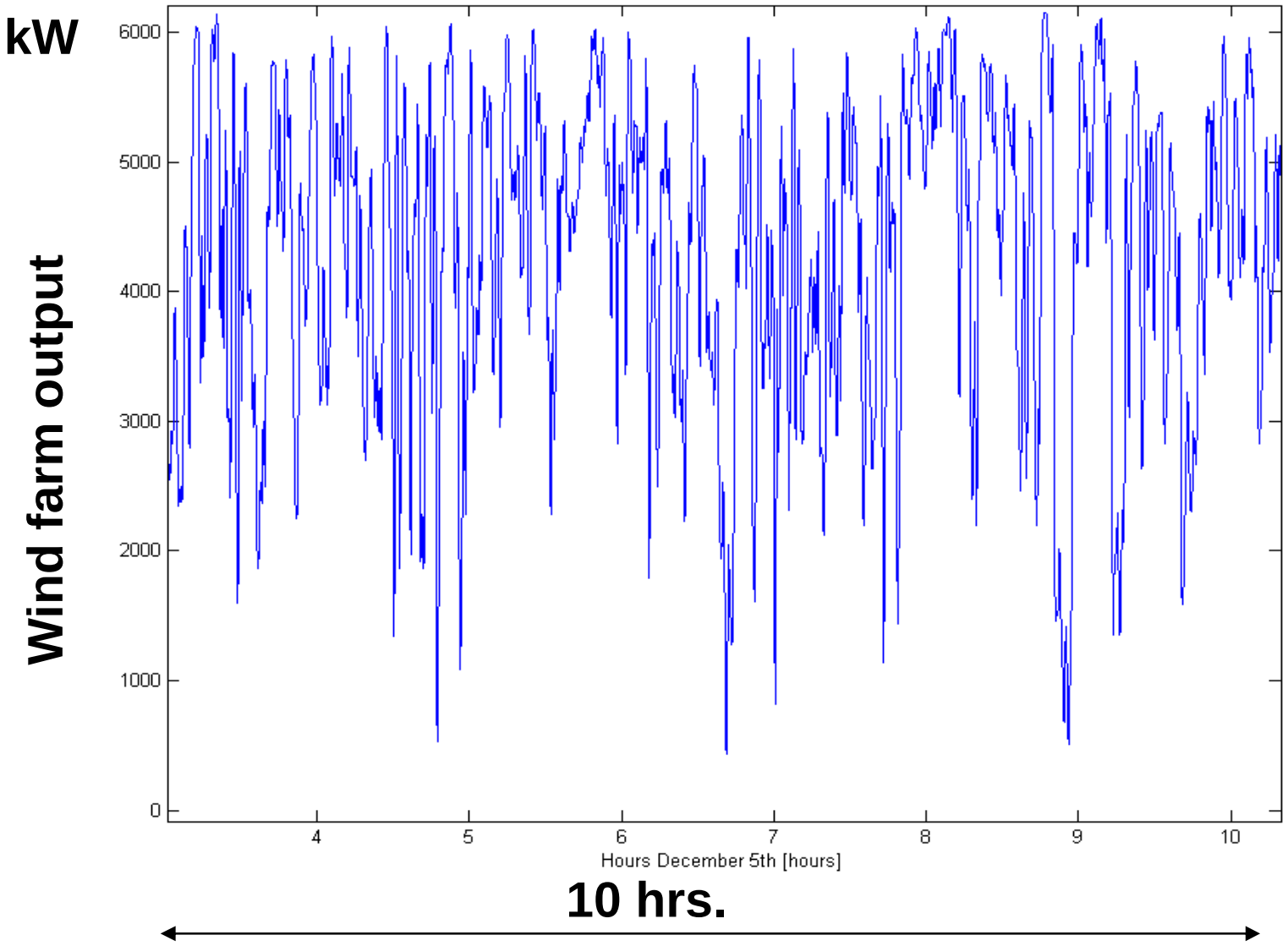
- Areas with low population density
- Few Industrial consumers
- Weak grid infrastructure
- High dependency on fossil fuel and oil price
- Often good renewable sources
- Impacts of Renewable integration

Requirements

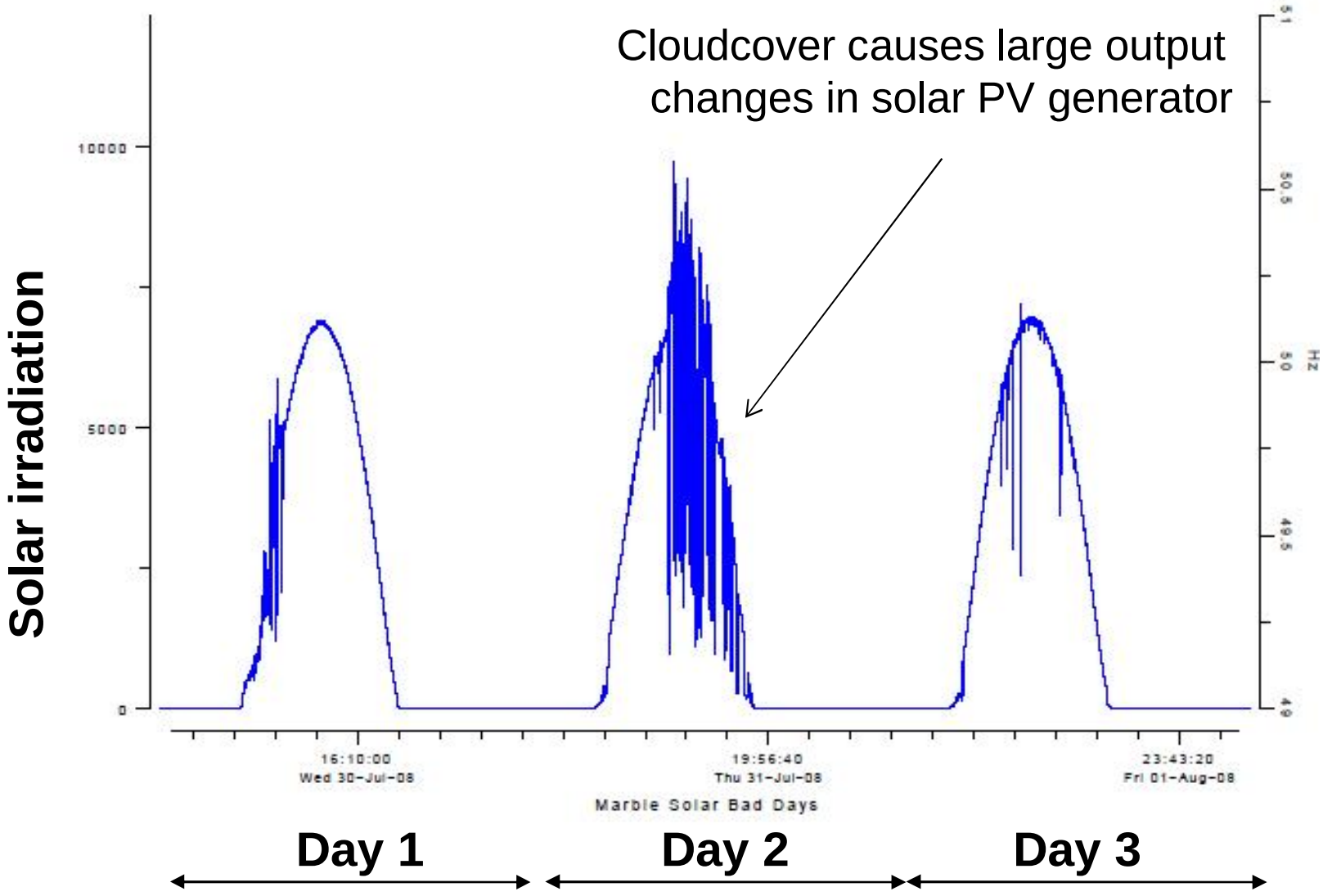
- Stable frequency and voltage
- Sufficient active and reactive power
- Electrical power production at lowest cost
- Power access, whenever required (24/7)
- Safe operation of plant, short circuit power
- Taking care of fluctuations of renewable plants

With maximum renewable energy contribution

Renewable energy integration challenges
Managing power output fluctuations - wind



Renewable energy integration challenges
Managing power output fluctuations - solar



Islanded power systems key technologies
Smart islanded power systems

1. Power System Modelling

2. Automatic dispatch and control of RE & Thermal Plant

3. Grid stabilisation

4. Automated demand response

5. Long term energy storage

Islanded power systems key technologies
Power System Modelling

Input
Sol_rad(t)

→

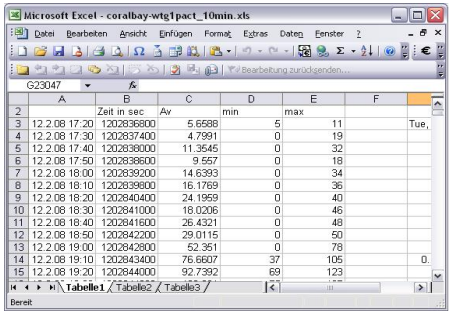
Power System
Dynamic Model

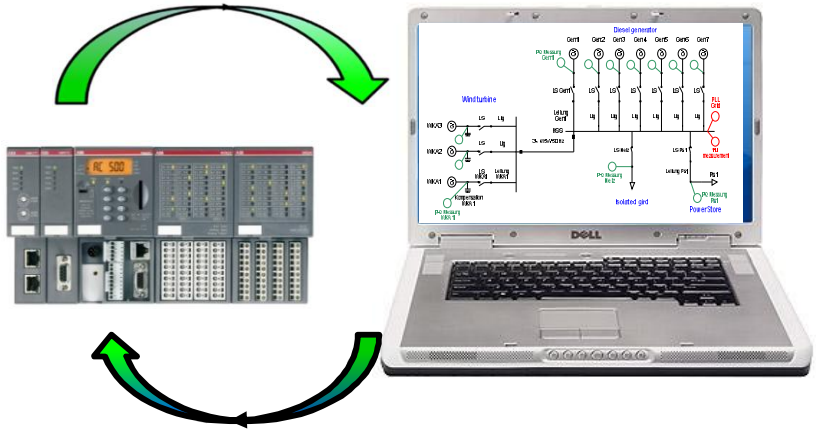
→

Output:
U(t), f(t), ...

Recorded data

from real system:

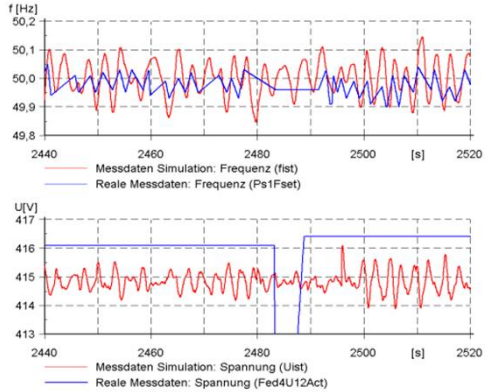




Hardware in the Loop
Power System Simulation Tool

Output of Simulation

(Voltage, Frequency, etc)



- Showing expected frequency & voltage variations
- Control algorithm verification for automated dispatch and control system

Islanded power system key technologies
Automated dispatch and control system

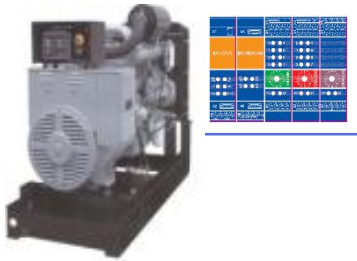
PV/CPV Generation

Wind Farm

Industry Consumers

Cooling/Heating Loads

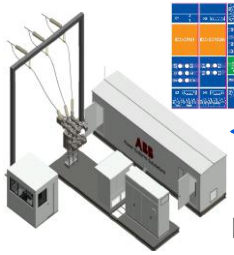
Thermal Generator



Control Center

Isolated Power System

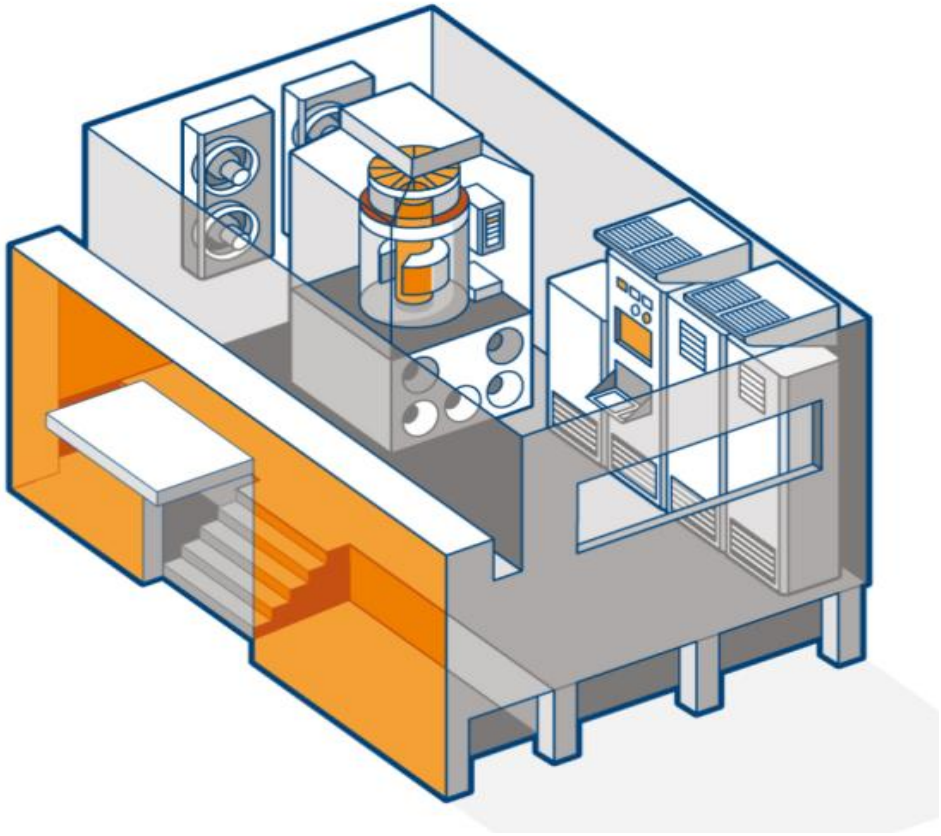
Local consumers



Energy storage system (long-term)

Grid stability system

Islanded power system key technologies
PowerStore Solution:Flywheel based Grid Stabilisation



Functionality

- Parallel with conventional generators
- Frequency control, like a generator
- Voltage control, like a generator
- Active and reactive power supply
- Run stand-alone as virtual generator (Frequency and voltage reference)

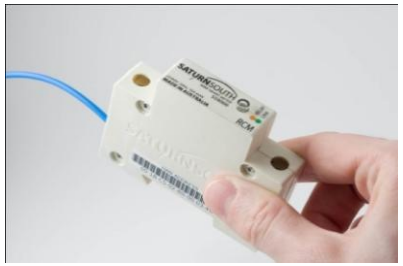
Applications

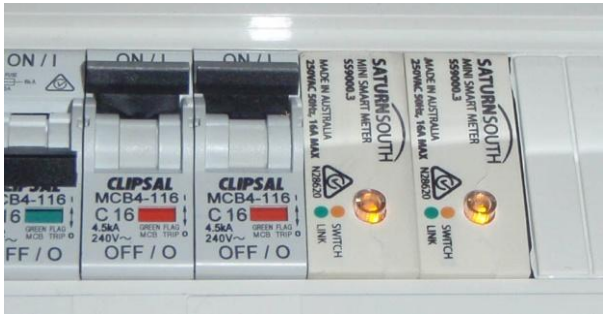
- Grid Stability
- Renewable smoothing
- Provide fault current
- Peak Lopping

Islanded power system key technologies
Automated demand response

Multiple Sites:

House, Industrial, Commercial





Site Platform

Mini Smart Meters
Mini CT Meters

Zigbee on site communication

ES-Box

Ethernet Connection

Communication WAN

Aggregation into automated dispatch system

Advanced Hybrid Power Station

Smart Grid Control Centre

Database Server

Operator Interface

DRAS Server

Ethernet Connection

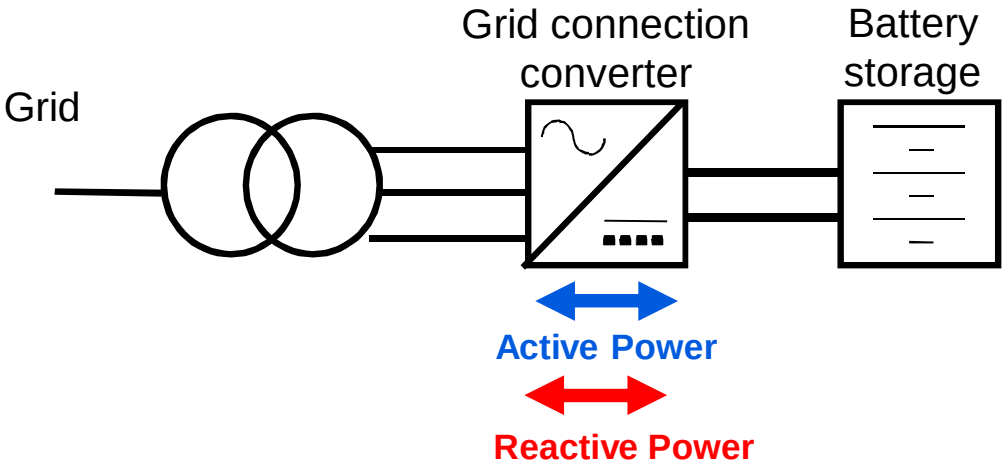
OPC Server

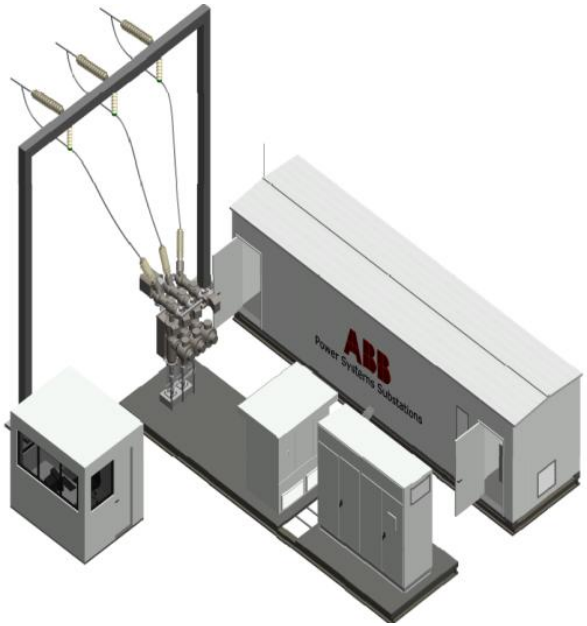
AB-PLC

Power Station Control System

<1s

Islanded power system key technologies
Long term energy storage systems





Advantages

- Medium term power contribution and consumption (from minutes to hours)

Applications

- Overnight storage
- Peak shaving and load leveling
- Active and reactive power supply

Islanded power systems
Summary of key technologies and benefits

Typical Project Phases	Annual renewable energy contribution	Peak renewable power penetration	Grid stability	Control System
Integrate renewables energy sources	7%	20%	☺	None
Installation of automated dispatch system	10%	30%	☹	Simple
Inclusion of grid stabilization	50%	100%	☺	Advanced
Automated demand response	60%	100%	☺	Sophisticated
Energy storage	100%	100%	☺	Sophisticated

References
Flores Island, wind/hydro/diesel

Project name
Flores Island PowerStore
Country
The Azores, Portugal
Customer
Electricidade dos Acores (EDA)
Completion date
2005

ABB solution

- Supply, install and commission a Microgrid Plus System and a PowerStore-flywheel
- The system smooths out wind power fluctuations

Customer benefits

- Increased wind power penetration
- Minimized diesel consumption
- Reliable and stable power supply

About the project

100% renewable penetration – Diesel off mode

References
Ross Island, Wind/Diesel

Project name
Ross Island

Country
Ross Island, Antarctica

Customer
- New Zealand's Antarctic Division
- USA McMurdo Station

Completion date
2009

ABB solution

- Integration of wind turbines into the microgrid with PowerStore grid-stabilization and Microgrid Plus System
- Implement a frequency converter to connect a 50Hz network to a 60Hz one
- The resulting system consists of: Diesel (9 x 125kW), WTG (3 x 330kW), PowerStore-flywheel (1 x 500kW), Microgrid Plus System, frequency converter

Customer benefits

- Minimize diesel consumption
- Reduced environmental risk of transporting diesel
- 463,000 litres of diesel fuel saved annually
- 2,800 tonnes CO2 avoided annually
- Up to 70% wind power peak penetration

About the project

- Integration of the southernmost wind farm in the world into a dual 50 and 60Hz microgrid

References
Nullagine, PV/diesel

Australian Government
Department of Climate Change and Energy Efficiency

HORIZON POWER

Government of Western Australia
Office of Energy

Project name
Nullagine
Country
Western Australia, Australia
Customer
- Horizon Power
- Government of WA

Completion date
2010

ABB solution

- PV/diesel Microgrid with PowerStore grid-stabilizing technology and Microgrid Plus System
- The resulting system consists of:
  - Diesel (3 x 320kW)
  - PV (1 x 200kW)
  - PowerStore-flywheel (1 x 500kW)
  - Microgrid Plus System

Customer benefits*

- Minimize diesel consumption, 182,000 litres of fuel saved annually
- Minimum environmental impact, 1,100 tonnes CO2 avoided annually
- Reliable and stable power supply
- 60% of electricity consumed by the microgrid 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

*For both Marble Bar and Nullagine projects

References
La Gomera, grid stabilizing system

Project name
La Gomera PowerStore
Country
Canary islands, Spain
Customer
Endesa
Completion date
2014

ABB solution

- Supply, install and commission of a PowerStore-flywheel 500 kW grid stabilizing solution
- Solution upgradable to 1MW
- PowerStore adds inertia in the 22MW isolated power system of La Gomera

Customer benefits

- Reduced frequency and voltage deviations
- Reduced load shedding events

Conclusion

General Conclusions

- Smart power systems start with smart engineering
- Renewable penetration in islanded systems already reaches levels that require grid stabilisation
- All elements in a power system have to be part of a smart control system to:
  - Increase the use of renewable sources
  - Maintain stable supply of electricity
  - Allow safe operation of thermal power plants

Technology to become a smart power system is **already available** and **proven in many islanded power** systems around the globe reaching up to **100% penetration of renewable generation**

Power and productivity
for a better world™