MATTI VAATTOVAARA, VICE PRESIDENT, POWER GRIDS

Microgrids and Virtual Powerplants

ABB WEC seminar 25.2.2019

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The evolution of Energy management Systems

90’s Control system, **tens** of assets

Applications for SCADA

- Load forecasting
- Unit commitment
- Optimum power flow
- Automatic Generation Control
- Load shedding
- Telecommunication & **remote control**

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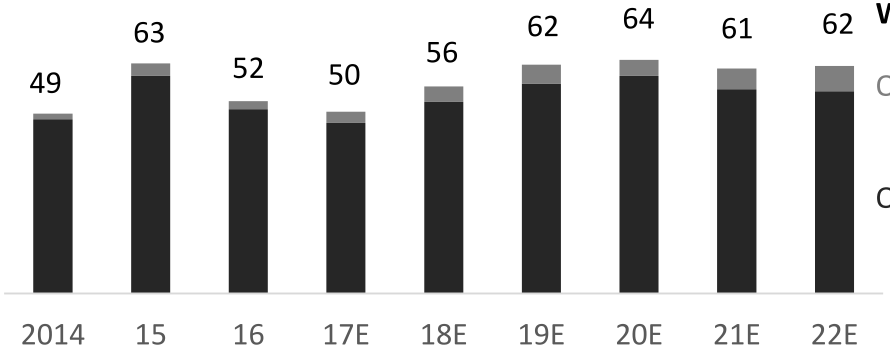
Renewable market development

Wind ramps up from 2018; Solar keeps high installation capacity level

Wind yearly additional capacity

In GW



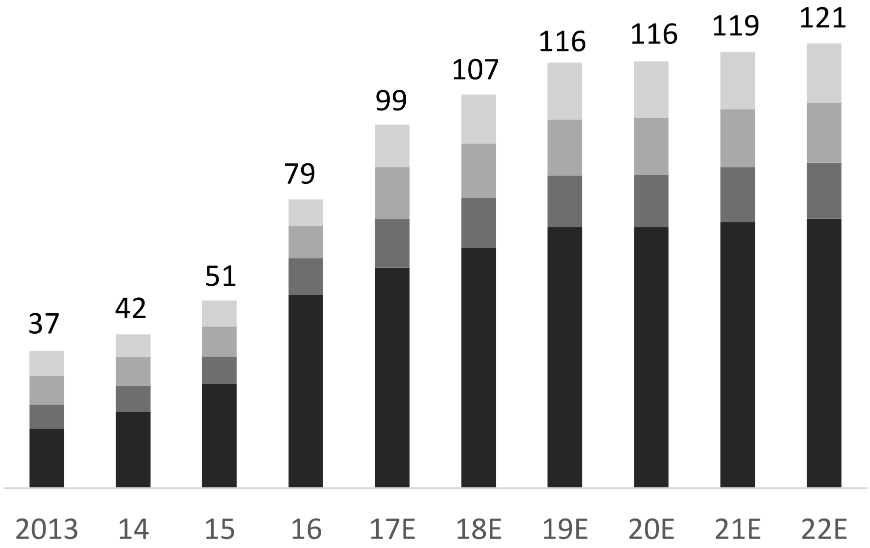
CAGR 2017-22

Wind	**4.6%**
Offshore	18%
Onshore	3.5%

Wind recovers from low capacity additions in 2017

Solar yearly additional capacity

In GW



CAGR 2017-22

Solar	**4.1%**
<20kW	7.0%
20kW-1MW	2.7%
1-5MW	2.9%
>5MW	4.1%

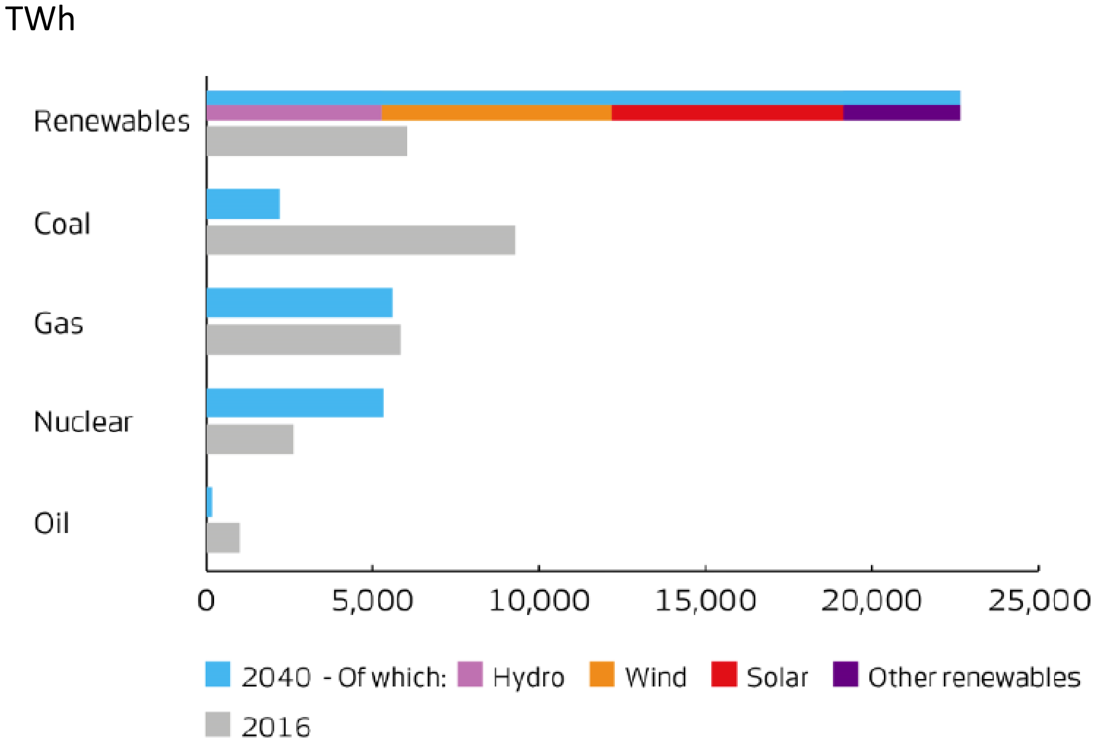
Solar additional installed capacity maintains > 100GW p.a. level

Sources: MAKE Consulting, GTM research

Future energy mix

Majority of future power generation investments on Renewables

Global electricity generation by source in 2016 and 2040



- Wind estimated at ~7% of overall electricity capacity in 2016*
- Wind accounted for ~20% of all new-build capacity in 2016*
- Renewables are expected to dominate future electricity generation, and wind will play an important role
- Two key drivers for future renewables demand:
  - OECD countries decommission conventional capacity driven by CO2 reduction targets and its financial end of life
  - Non-OECD countries increasingly to pursue renewables to cater for increasing electricity demand

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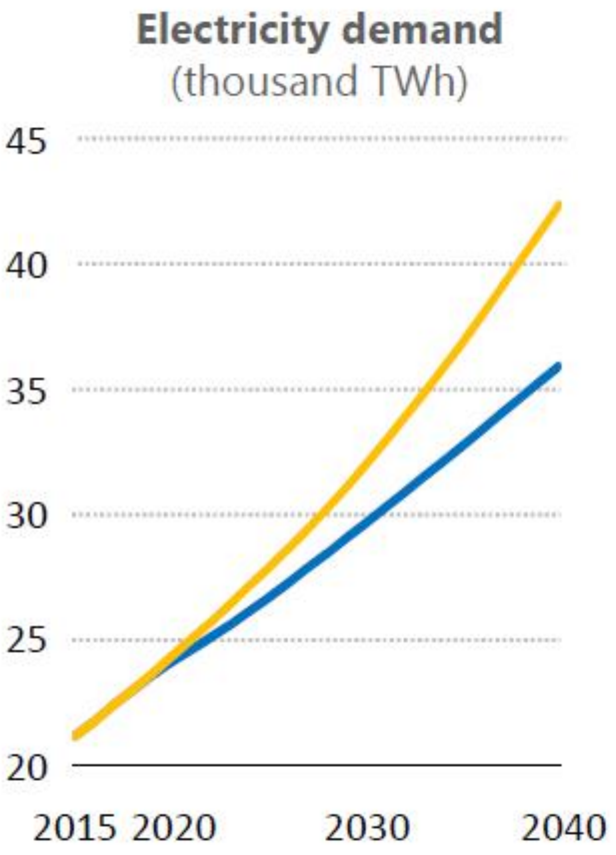
Source: International Energy Agency: Sustainable development scenario,World Energy Outlook 2017, November 2017 (Vestas fy2017 presentation)
* Source: Bloomberg New Energy Finance, New Energy Outlook, June 2017.

What if the future is electric?

World Energy Outlook 2018



Today, **24 %** of European energy is electricity

2050: over **60%**

→ Also consumption will electrify
→ Flexibility is necessary

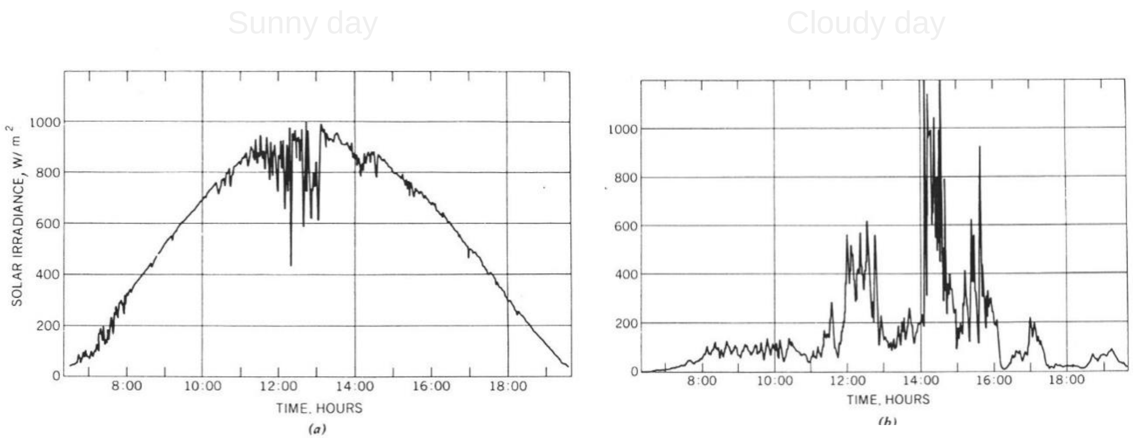
Increased electrification
related premature deaths,

© OECD/IEA 2018

Volatile power generation

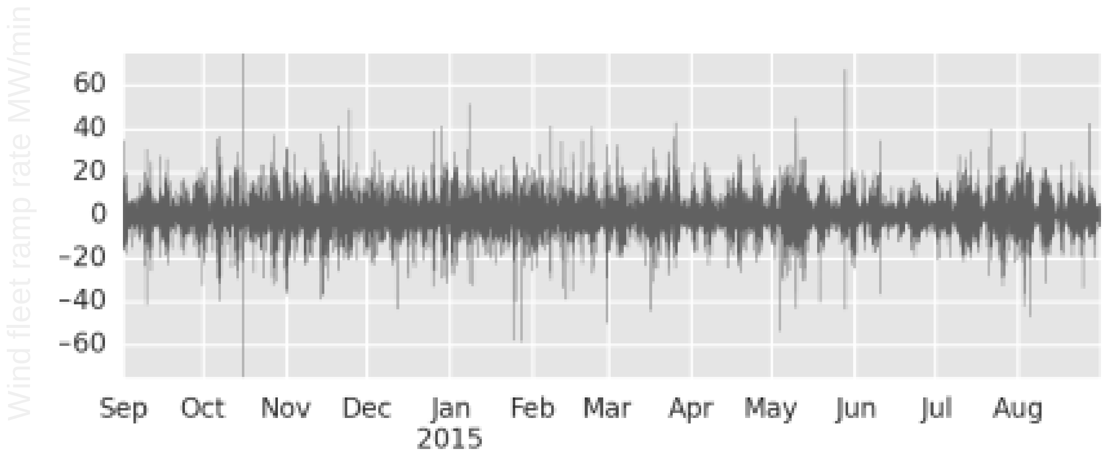
Wind and Solar PV: What's different?

Variation of the solar radiation



Source: Powerfromthesun.net

Wind power variation



Source: Statistical Analysis of a wind capacity factor in Australia

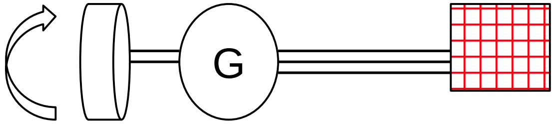
With the increase of renewable energies, the system stability and supply will mainly rely on volatile generation

Inertia response capability
What it means for the grid?

- Non-synchronous generation like solar and frequency variable windmills with power electronics become the major provider of energy in the grid
- The lack of a rotatory mass is missing to support the grid automatic frequency response (provided by inertia)
- Usual frequency control systems in the grid rely on the inertial response for primary frequency control

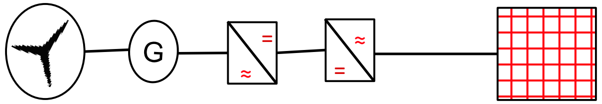
With less rotatory mass frequency stability and control become more challenging

Conventional power plants



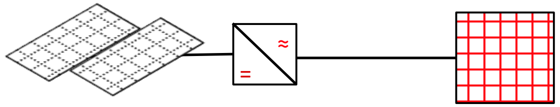
J = 4 – 6 s

Wind Power



J = ???

Solar PV

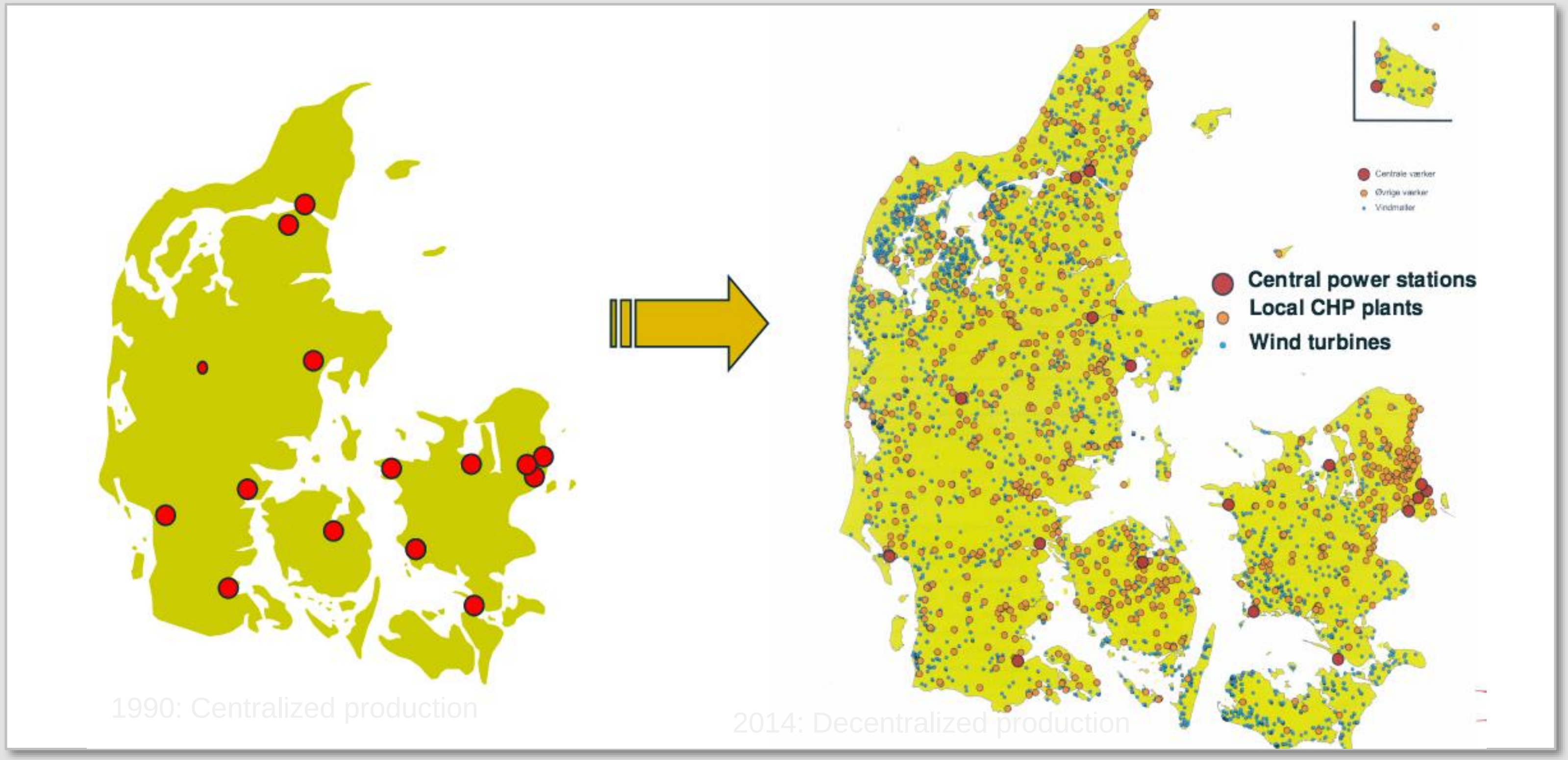


J = 0 -?

Modularity and distributed generation

What it means for the grid?

- Reverse flows & local voltage problems
- More measurements needed to know the network state
- Protection need to be upgraded
- Overdimensioning of network vs control of production



Distribution grids need enhancement to cope with the new task

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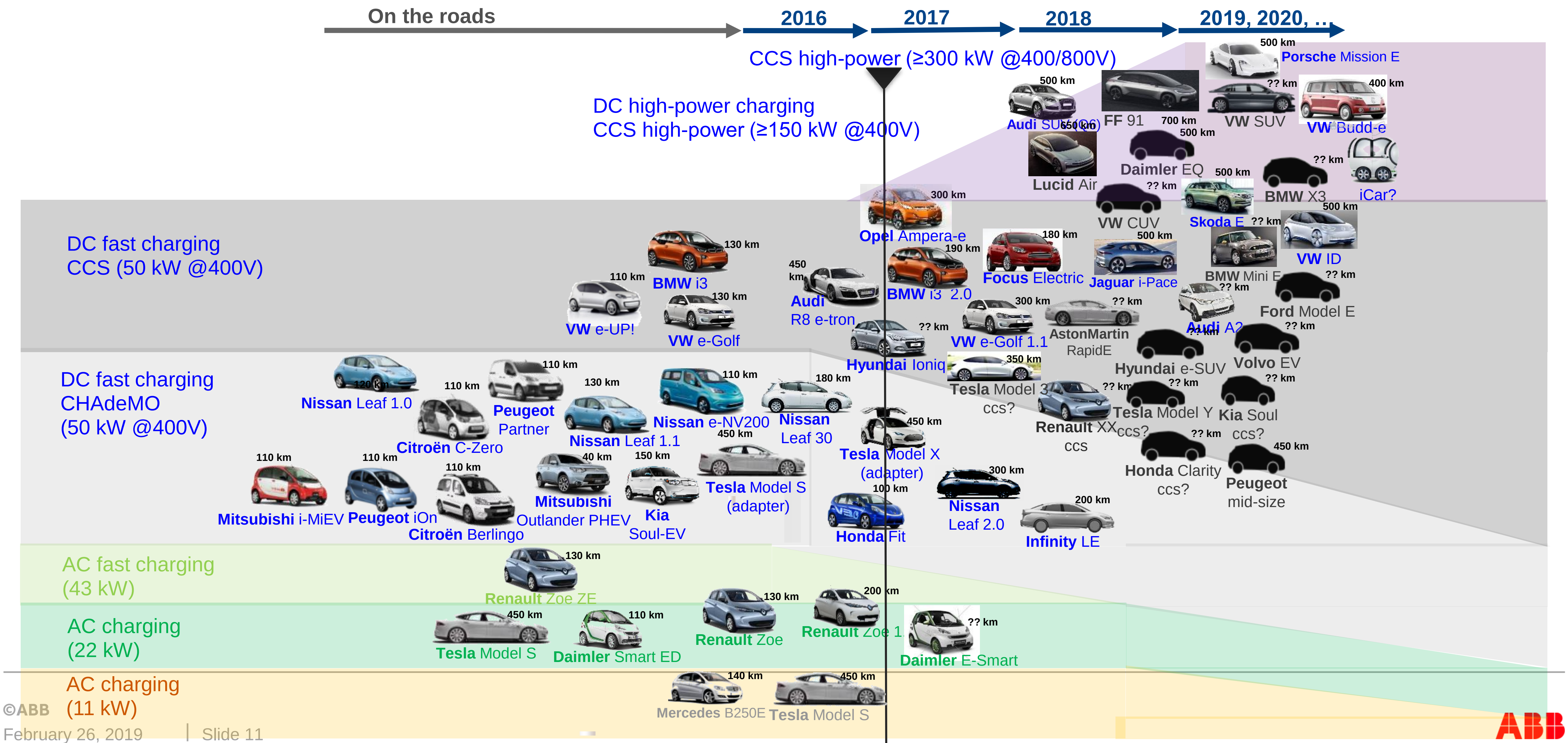
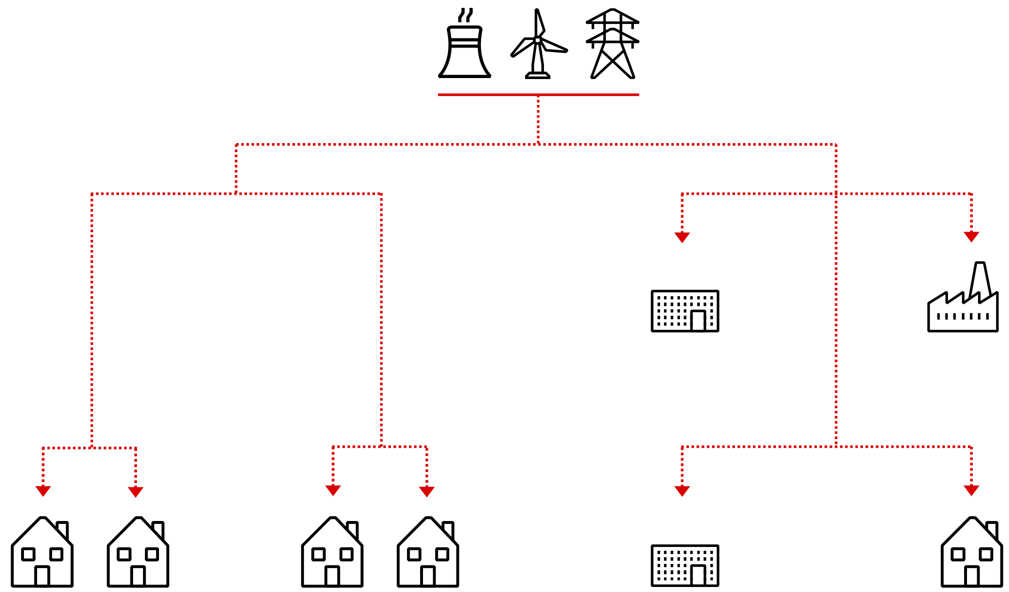
Follow the car through Europe: Which car, when?



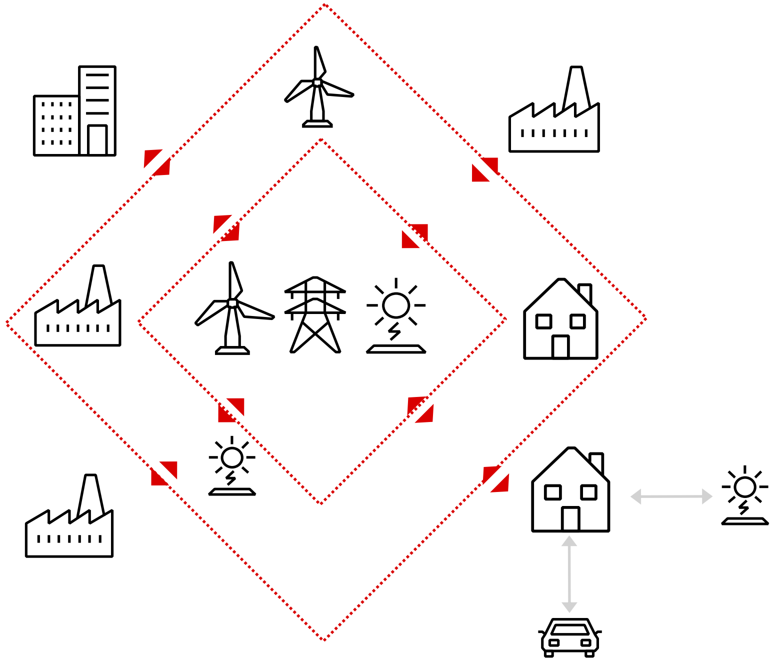
Energy and grid transformation

Transition from a centralized to a distributed grid

Traditional grid



New grid



New developments are accelerating the transition

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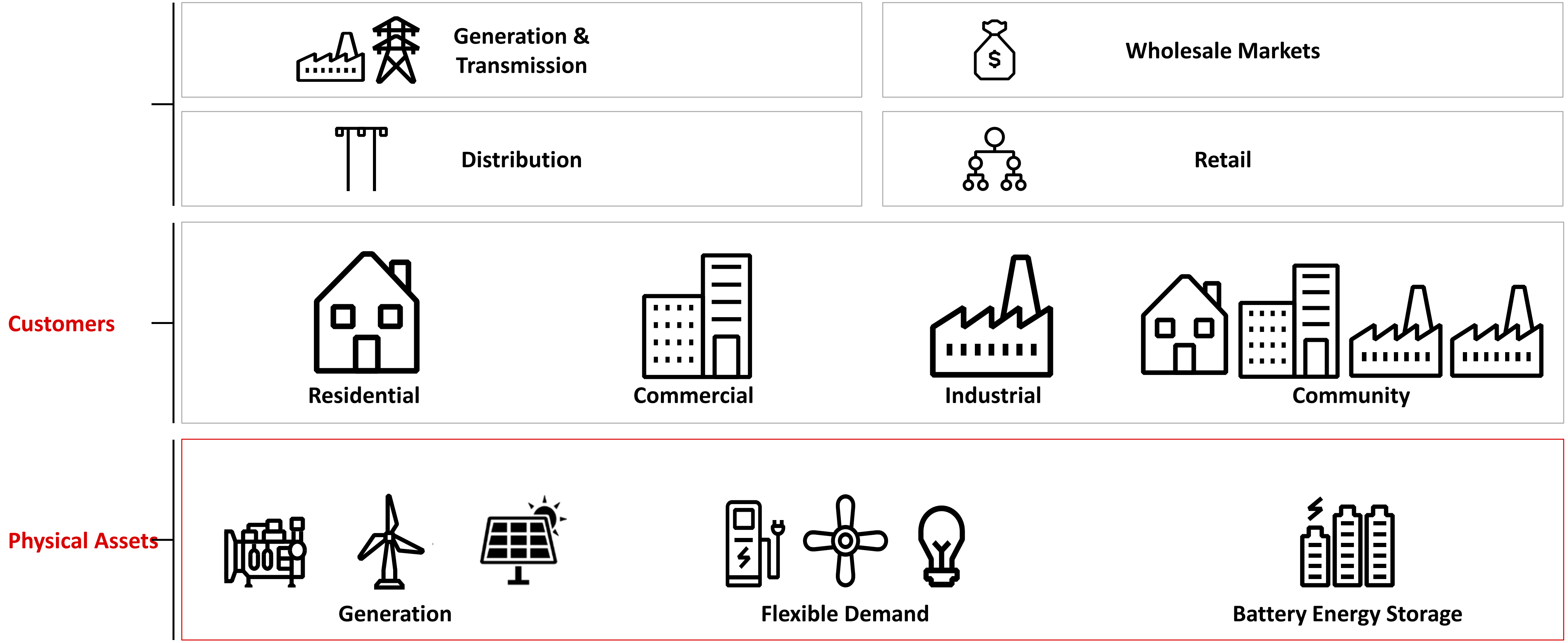
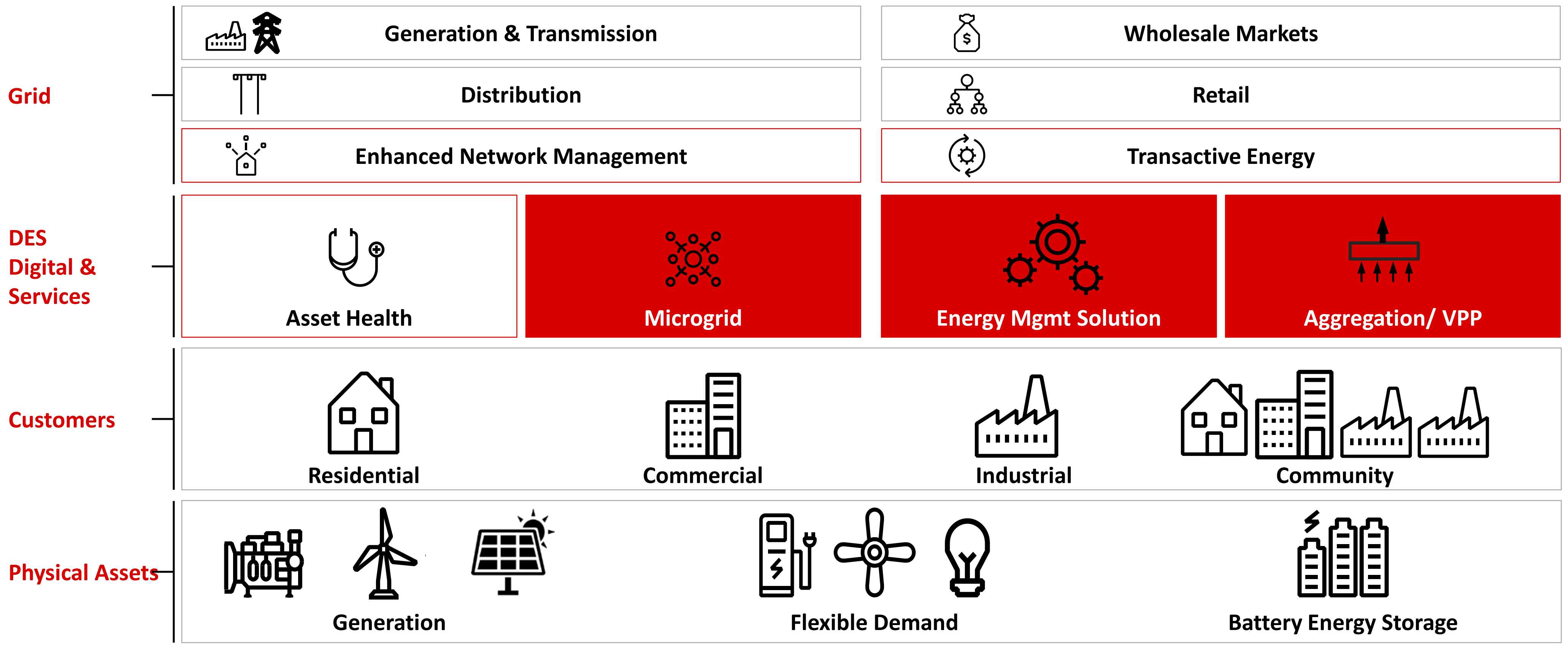
Growth in physical distributed assets



- Growth in DERs
- Bi-directional power and information flows
- Grid operators need to respond to a complex & distributed network
- Consumers become “prosumers”, want maximum value from their assets
- Energy provider landscape expanding with new business models

New solutions between grid and customers



Digital solutions enable

- Maximize customer value
- System performance optimization
- Grid reliability
- Energy services
- New business opportunities for energy providers

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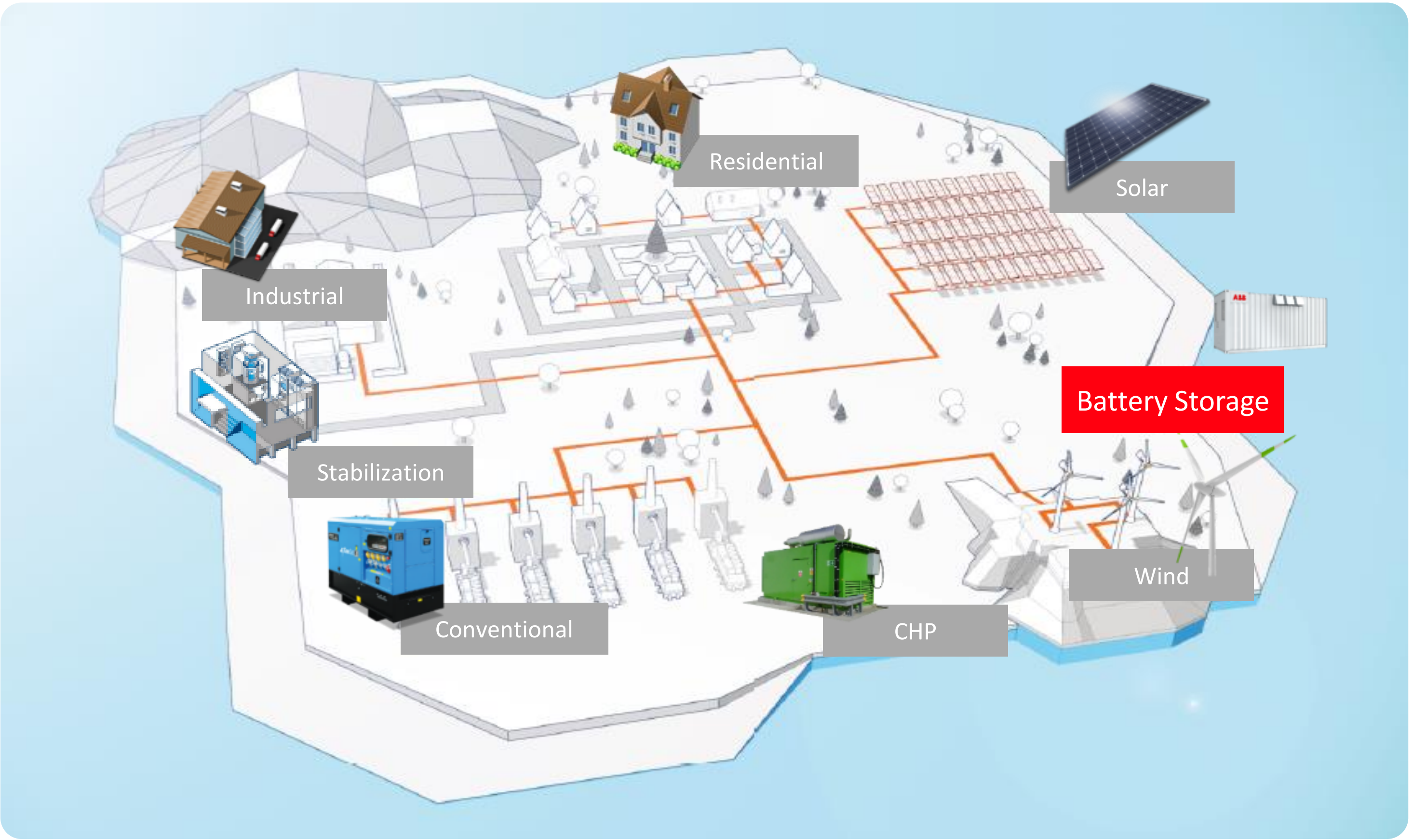
Microgrid

Generation at the point of consumption and always available

Microgrid tasks

- Energy storage
- Frequency control
- Balance demand and production
- Avoid fossil fuels by optimized use of generation capacity



CHP: Combined Heat and Power

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

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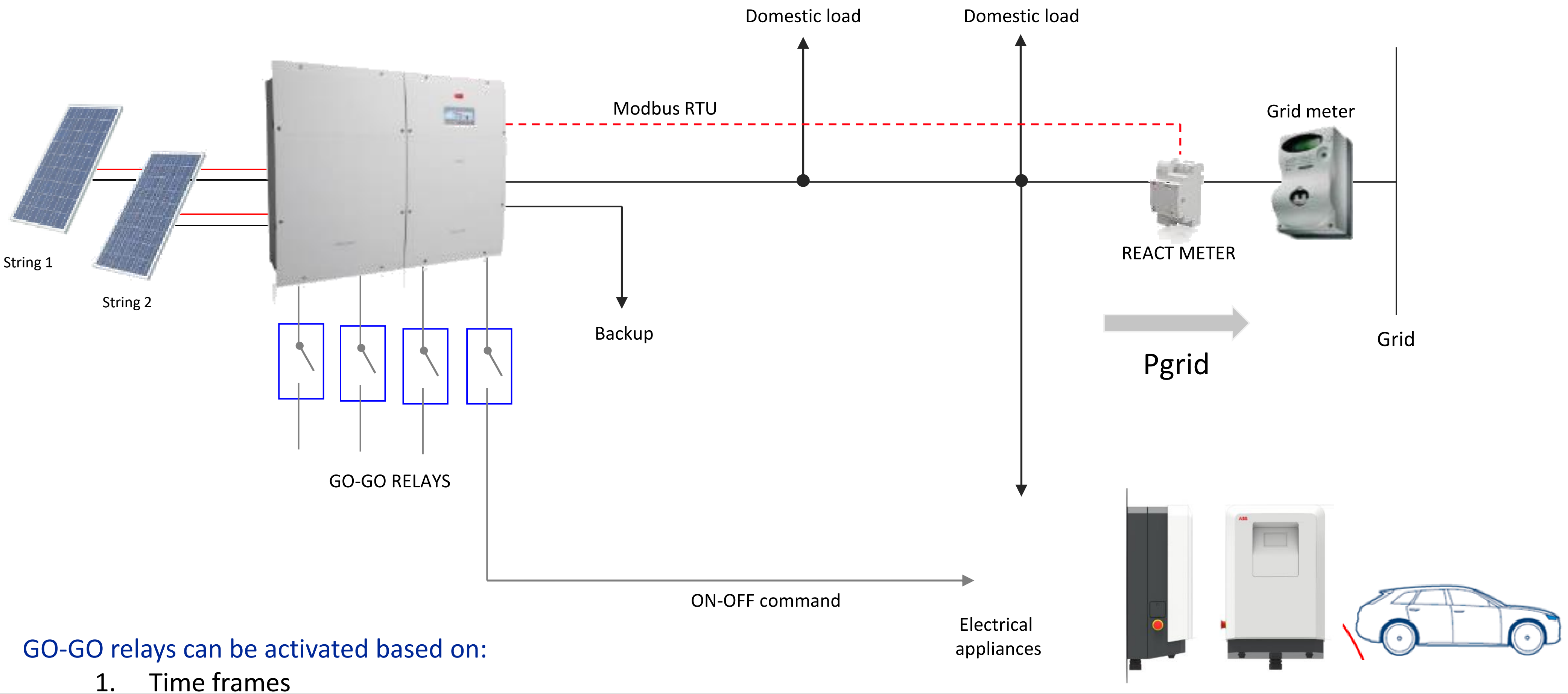
REACT – Combined Solar Inverter and Battery

Load management

Four independent relays to increase self-consumption



GO-GO relays can be activated based on:

1. Time frames
2. Power injected into the grid

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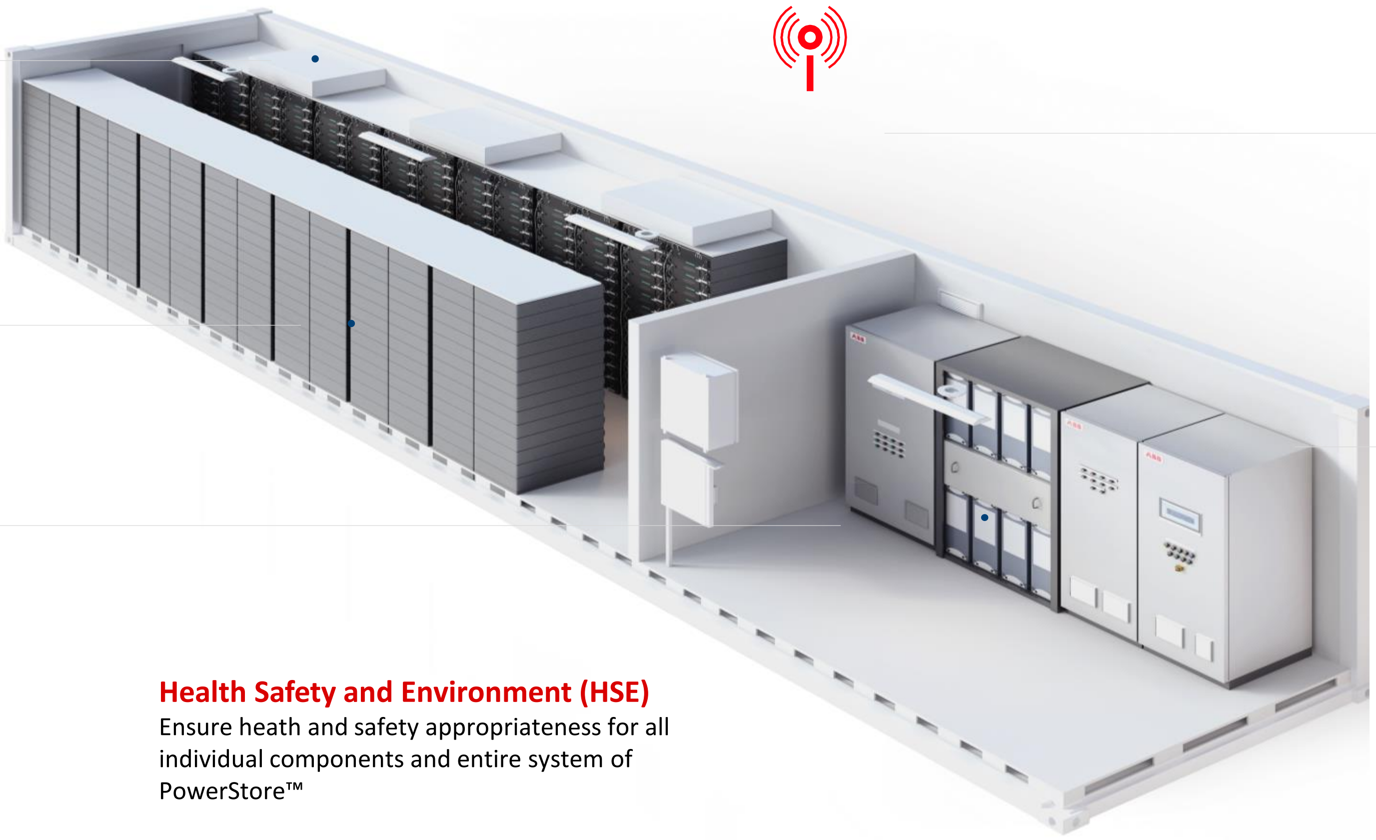
PowerStore™ Energy storage & controller for microgrids

"Plug and play" solution, easily configurable to adapt your unique needs

Climate Control
Maintaining temperature inside the container within an acceptable operating limit at all times

Lithium Ion Batteries
Battery module, Racks, and Battery Management System (BMS) Interface
- Easy maintenance
- Online replaceable
- Hot-swappable

PCS100
PowerStore™ Conversion System
- Scalable
- Modular
- Grid Forming
- Virtual Generator



Health Safety and Environment (HSE)
Ensure heath and safety appropriateness for all individual components and entire system of PowerStore™

Remote Monitoring
Comprehensive solutions for unattended sites to increase productivity.
- Key Performance Indicators
- Real-time & historical data trends
- Configurable data sampling rate
- Support predictive, preventive and corrective maintenance

Built-in PowerStore™ Automation
Dedicated Microgrid plus control system delivered pre-programed to meet the application needs

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Island Utilities

Kodiak Island, PowerStore/Wind/Hydro/Diesel → 99% renewable

About the Project

- **Project name:** Kodiak Island
- **Location:** Alaska, United States of America
- **Customer:** Kodiak Electric Association (KEA)
- **Completion date:** 2015

Solution

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**

Press Release

Infographic

Video

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

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Remote Communities

Marble Bar, PowerStore/PV/Diesel

About the Project

- **Project name:** Marble Bar
- **Location:** Western Australia, Australia
- **Customer:** Horizon Power, Government of WA
- **Completion date:** 2010

Solution

The resulting Microgrid system consists of:

- PowerStore Flywheel (500 kW/ 16.5 MWs)
- Microgrid Plus Control System
- Solar PV (1 x 300 kW_p)
- Diesel (4 x 320 kW)

Customer Benefits

- **Minimize diesel consumption** - 405,000 liters of fuel saved annually
- Minimum environmental impact - 1,100 tons CO_2 avoided annually
- Reliable and stable power supply
- 60% of the day time electricity demand is generated by the PV plant

Government of Western Australia Office of Energy

HORIZON POWER

Press Release

Video

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

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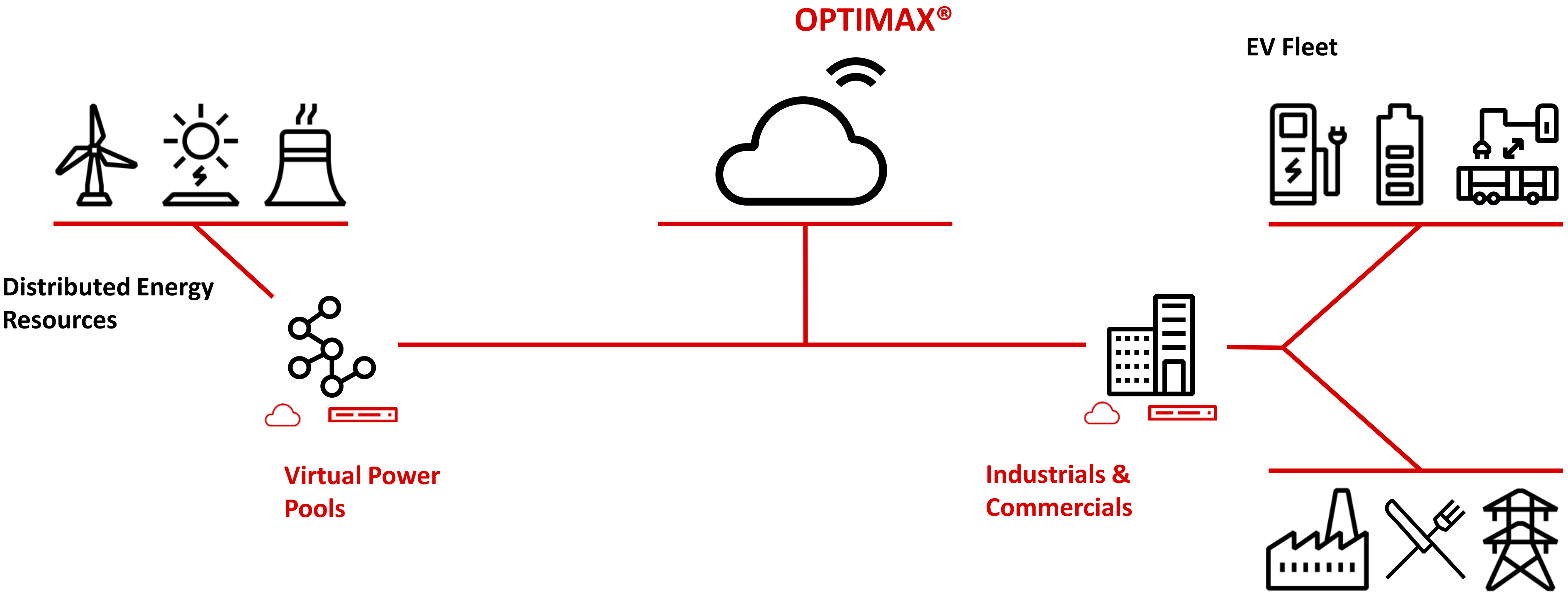
Virtual powerplants

Aggregates decentralized generation, flexible loads and storage systems to enable participation in energy markets

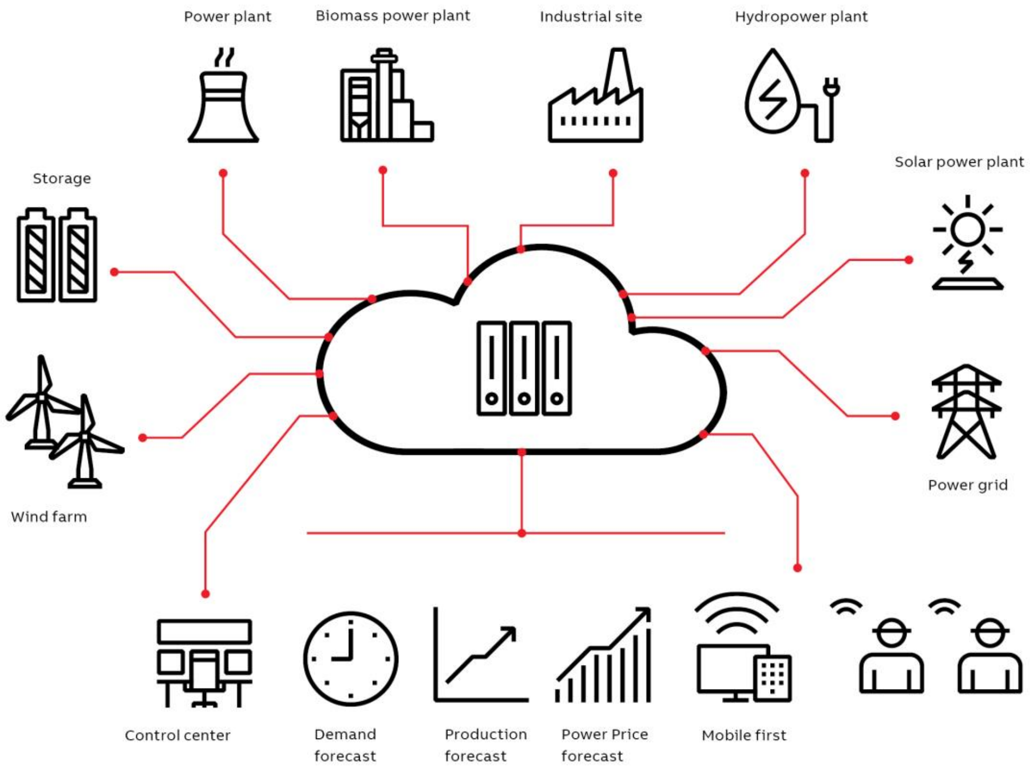


Virtual Power Plants

ABB Ability™ Energy Optimization for power producers

- Central **control and optimization** system
- Combine tens **or thousands of DERs**
- **Plan and adjust production** dynamically thanks to advanced **forecasting**
- **Trade** intelligently on the **energy market**
- **Sector coupling** for electricity, gas, heating & cooling, water and e-mobility

OPTIMAX®
Central control and optimization system



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DER: Distributed Energy Resource

Smart Farm

Very small system

Customer need

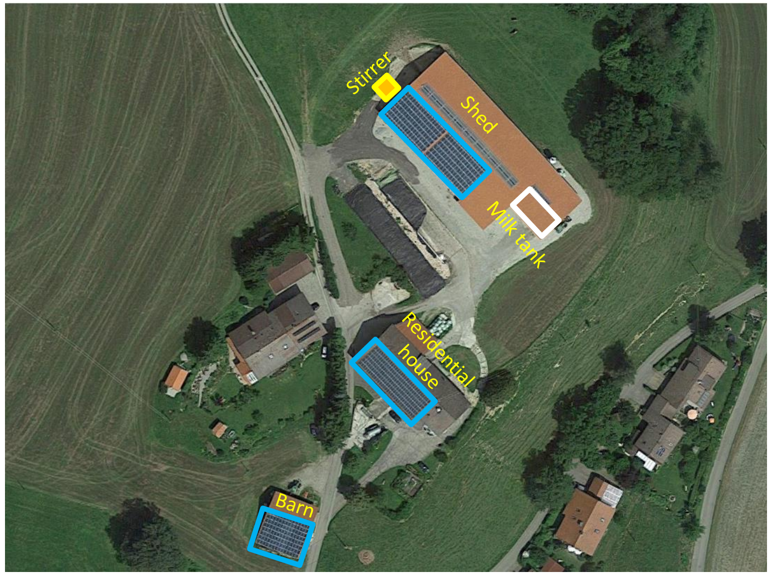
- **Maximization of internal power supply**
- PV, battery, e-tractor, milk tank, stirrer & grid connection
- Merger of several companies

ABB response

- Optimization
- Merger of several companies to participate in the trade

Customer benefits

	not optimized	optimized
Grid purchases	70 kW	32 kW
Self consum-ption rate	31,0 %	50,2 %



Customer: AÜW
Location: Kempten
Delivery: OPTIMAX®

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Next Kraftwerke

From a start-up to a Large-Scale Virtual Power Plant

Customer need

- Rapidly growing business
  (**7000 aggregated units with >6 GW**)
- Solar, Wind, CHP, Power-to-Heat, Emergency gensets, industrial loads…
- Direct access to energy markets & spot

Solution

- Central control system for virtual power plant
- Monitor and **forecast**
- Automated secondary **frequency control**
- Optimal distribution of balancing power calls
- Controls power producers and consumers, based on **day-ahead and intraday markets**

Customer: Next Kraftwerke
Location: Cologne
Delivery: OPTIMAX® PowerFit

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