Storage. A Watt Smarter!

Bosch Energy Storage Solutions
Smart integration of storage

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Bosch Energy Storage Solutions
Agenda

1. **Energy Storage: Business field of Robert Bosch GmbH**

2. Bosch Energy Storage Solutions: Introduction

3. Application cases for storage and references

4. Energy Management System: The brain of our solutions

5. Smart integration of storage into a micro-grid

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Robert Bosch GmbH
2015 key figures

Bosch Group	→ 70,6 billion euros in sales → 375,000 associates *	
Mobility Solutions	→ One of the world's largest suppliers of automotive technology	60% share of sales
Industrial Technology	→ Leading in drive and control technology, packaging, and process technology	
Energy and Building Technology	→ Leading manufacturer of security technology → Global market leader of energie-efficent heating products and hot-water solutions	40% share of sales
Consumer Goods	→ Leading supplier of power tools and accessories → Leading supplier of household appliances	

*01/16, preliminary figures

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Robert Bosch GmbH
Innovative energy technologies

Production	Components and systems	▪CHP/ORC systems
Infra-structure	Stationary Storage System Technology	▪ Stationary storage solutions for residential, commercial and industrial applications ▪ Projects in kW/MW-scale
Con-sump-tion/ Effi-ciency	Building Technology	▪ Highly efficient gas and oil boiler, thermal power station, heat pumps ▪ Solarthermics, thermal storage, geothermal energy
	Industrial Application	▪ Turn key optimization concepts ▪ Drive and control technology ▪ Industrial boiler for hot water and steam, CHP plants
Service / Net-working	Energy Services	▪ Decentral energy management ▪ Energy optimization for (mainly) commercial buildings ▪ Efficiency services
	Software Solutions	▪ Internet-based system- and service platform ▪ Diverse smart energy-applications (e.g. virtual power plants, smart metering, smart home/smart grid)

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Locations

Paris, France

Stuttgart, Germany Headquarter

Madrid, Spain

Palo Alto, US

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Project specific optimal dimensioning and operation

- Data & requirements analysis
- Bosch Planning Tool for **optimal sizing**

- **Cost-effective** storage solution, based on reliable, certified standardized **block**
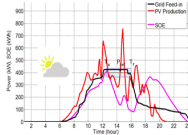
1 Service: Planning & consulting

2 System design, HW

3 Control SW

4 Construction & commissioning

5 Service: Lease/ rent O&M

- Support during operation
- Customized service modules for **highest operational yield**
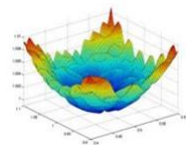- **Customized system guarantee**

- Grid friendly management system for storage and all energy assets (PV, wind,..) for **higher revenues and lower costs**
- Advanced **prediction and optimization algorithms** for superior performance

- **Experienced** project management for **seamless** & **fast** implementation
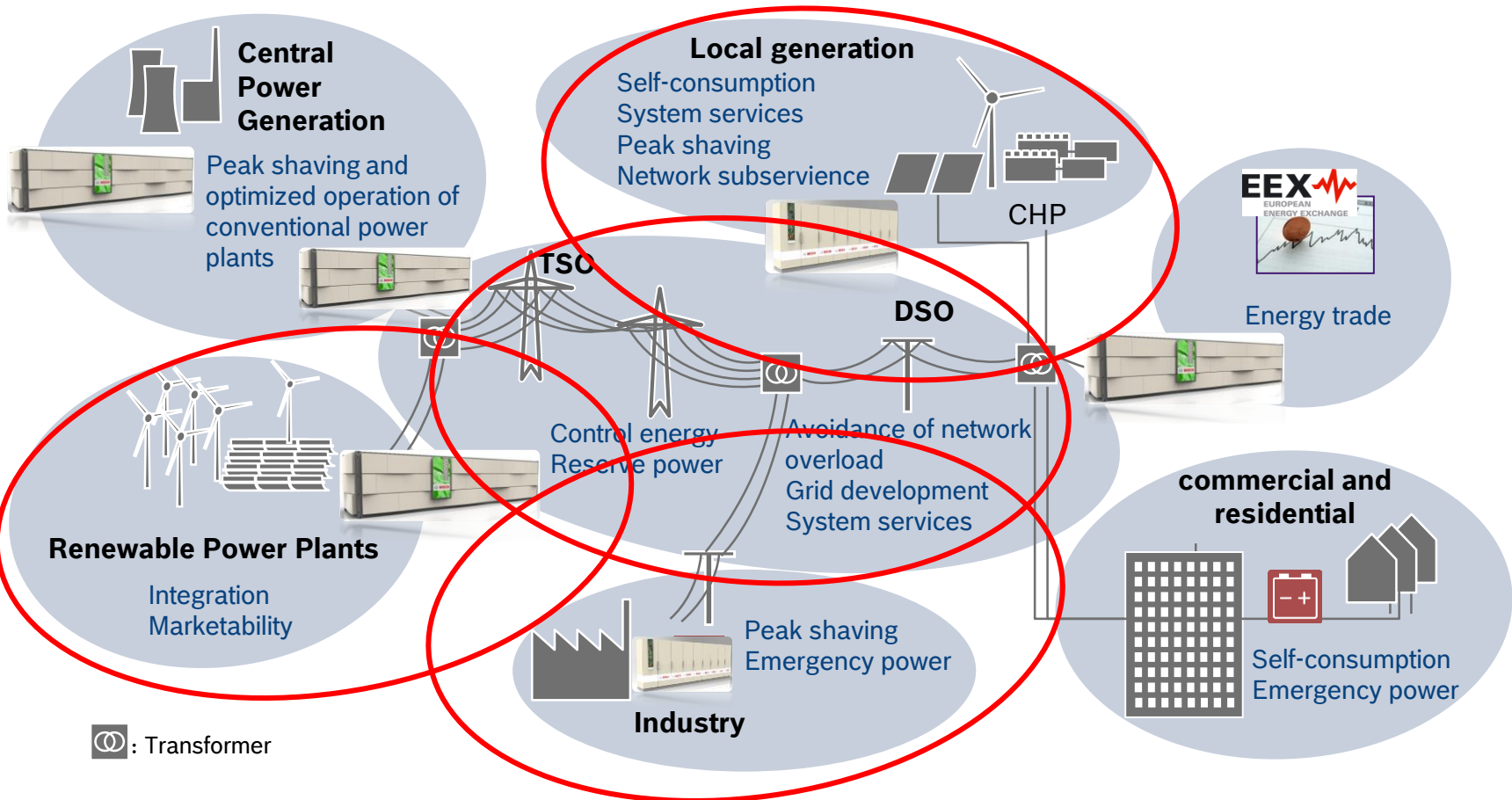- **Worldwide** support

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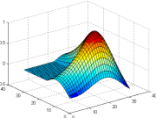
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Storage for several functions at all grid levels

Central Power Generation
Peak shaving and optimized operation of conventional power plants

Local generation
Self-consumption
System services
Peak shaving
Network subservience

CHP

EEX
EUROPEAN ENERGY EXCHANGE

Energy trade

TSO

DSO

Renewable Power Plants
Integration
Marketability

Control energy
Reserve power

Avoidance of network overload
Grid development
System services

commercial and residential

Self-consumption
Emergency power

Peak shaving
Emergency power

Industry

⊚⊚ : Transformer

TSO: transmission system operator   DSO: distribution system operators

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Our references

135 kWh Kelsterbach, DE, Community storage

1 MWh Braderup, DE, Avoidance wind curtailment

2,4 MWh Braderup, DE, Frequency regulation

20 kWh Hildburghausen, DE, PV own-consumption
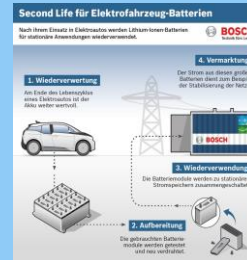
2 MWh Hamburg,DE, Frequency regulation

135 kWh Fort Bragg, US, Micro grid

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Controls architecture: maximized use of energy

Hierarchical Control Architecture

SW Components	Functions	Implementation
Energy Management System	• Planning of optimal use of ESS and other generation assets through reduction of energy costs or/and increase of revenues according to storage internal data (technical cost criteria, state of charge), states of other connected assets, and external drivers (grid tariffs, demand management requests)	IPC/Cloud
System SCADA/Monitoring	• Human-Machine Interface for monitoring of ESS and other components of energy system • Historization of variables and reporting of system performance • Communication interface with external world	IPC/Cloud
Energy Storage System controller (ESS)	• Control of power flow from ESS through inverter • Inverter regulation and safety functions • Control of ESS subsystems, monitoring of faults, generation of alarms	PLC
Battery Management System (BMS)	• Measurements of operating parameters of battery system • Estimation of SOC	BMU

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Energy Management System: Flexible platform for multiple applications
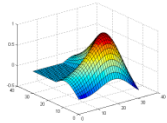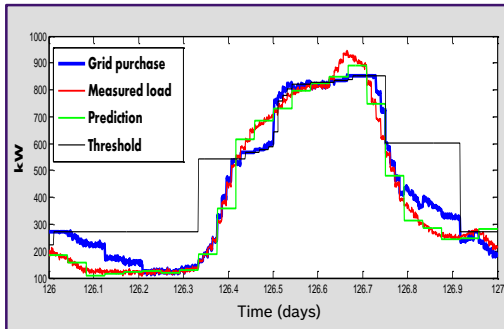

**Energy Management System**

> Optimized power commands to be implemented by ESS and other energy resources based on **forecasts** and **measurements**

Enabling SW components for complex applications:
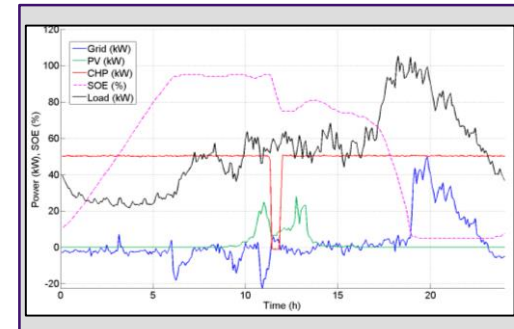
- Demand Charge Reduction
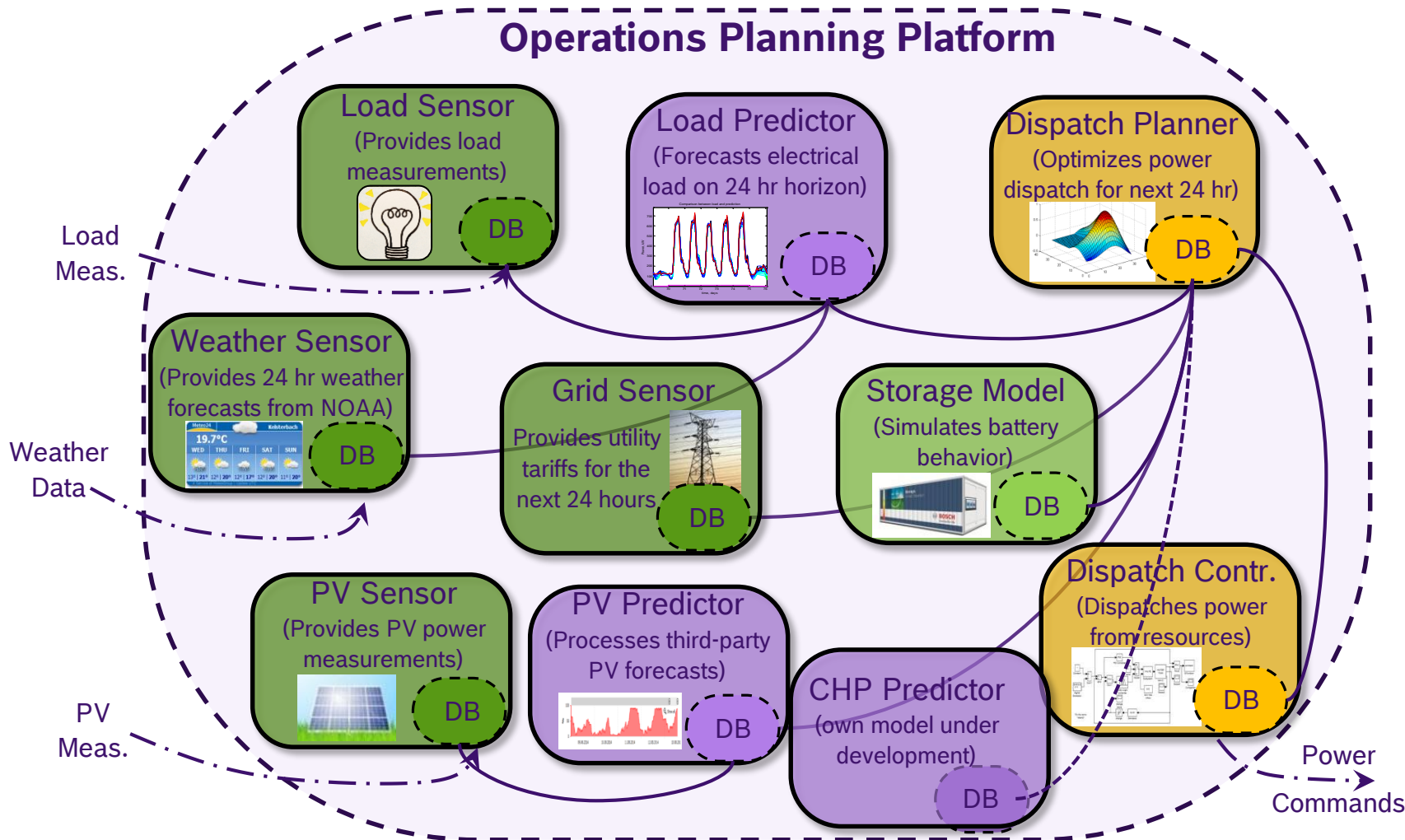 Monthly Bill = Energy Cost + Demand Charges

- Renewable integration subject to ramp up/down, call-power constraints (e.g. regulations in French islands)
- Balancing group optimization/ forecast accuracy increase
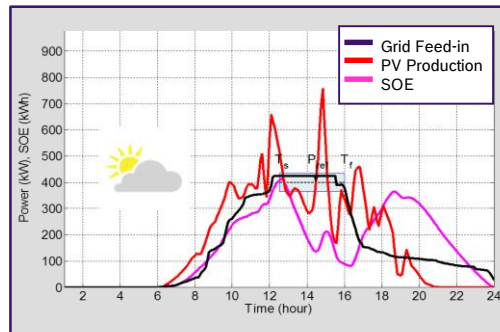
- Micro-grid with conventional and renewable generation resources and storage devices

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Operations Planning Platform

Load Sensor
(Provides load measurements)
DB

Load Predictor
(Forecasts electrical load on 24 hr horizon)
DB

Dispatch Planner
(Optimizes power dispatch for next 24 hr)
DB

Weather Sensor
(Provides 24 hr weather forecasts from NOAA)
DB

Grid Sensor
Provides utility tariffs for the next 24 hours
DB

Storage Model
(Simulates battery behavior)
DB

PV Sensor
(Provides PV power measurements)
DB

PV Predictor
(Processes third-party PV forecasts)
DB

CHP Predictor
(own model under development)
DB

Dispatch Contr.
(Dispatches power from resources)
DB

Load Meas.

Weather Data

PV Meas.

Power Commands

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Project Kelsterbach/Süwag: Micro grid - Self consumption

Storage system
- 50 kW / 135 kWh
- Lithium Ion batteries
- Modular 19" cabinet systems
- 7 battery cabinets
- 2 PCS + controls cabinets
- 3 phase system
- Coupled to CHP & PV
- Increase self consumption
- Operator: SÜWAG, Frankfurt-Kelsterbach
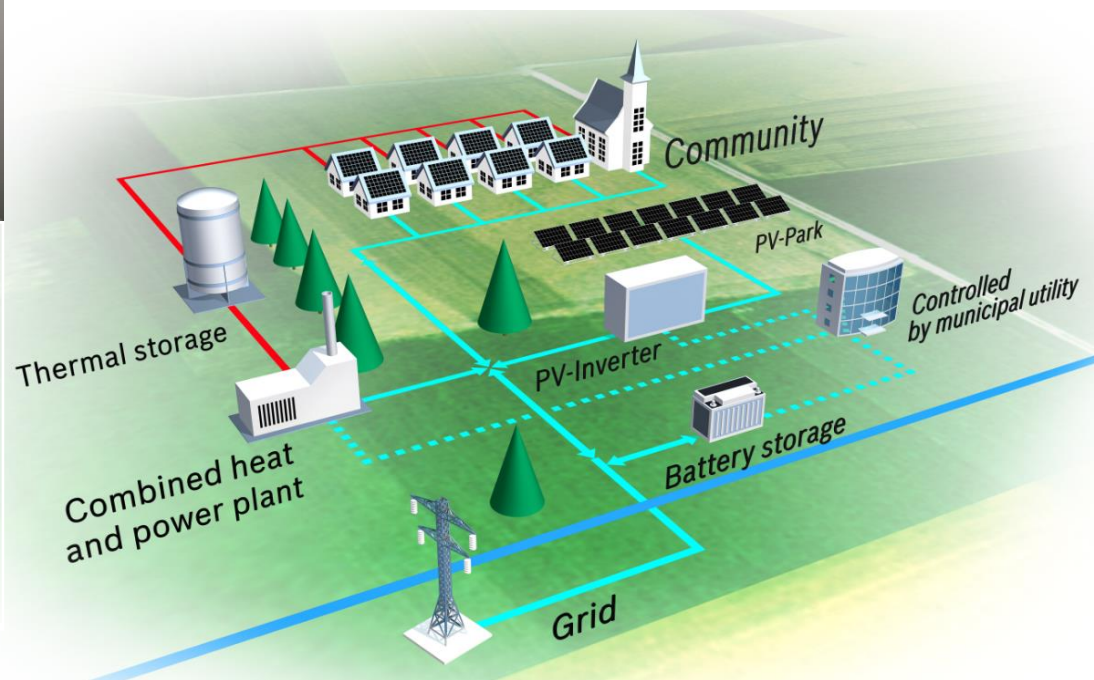
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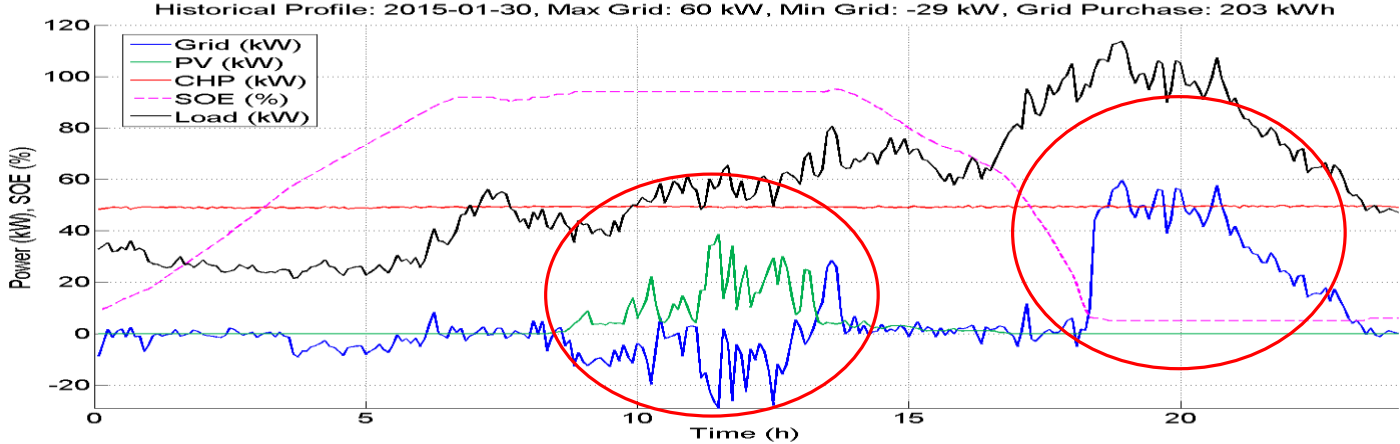
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Energy Management Goals

➔ <u>Objective</u>: "grid friendly" operation of the micro grid

    ➔ Minimize **grid energy purchase** (maximize self-consumption)

    ➔ Minimize **grid power purchase** spikes

    ➔ Minimize **grid power feed-in** spikes

➔ <u>Bosch Solution:</u> Model Predictive Control (MPC)

    ➔ Use forecasts for PV(and other RES), Load and in future CHP

    ➔ Stochastic optimization to control Storage and CHP

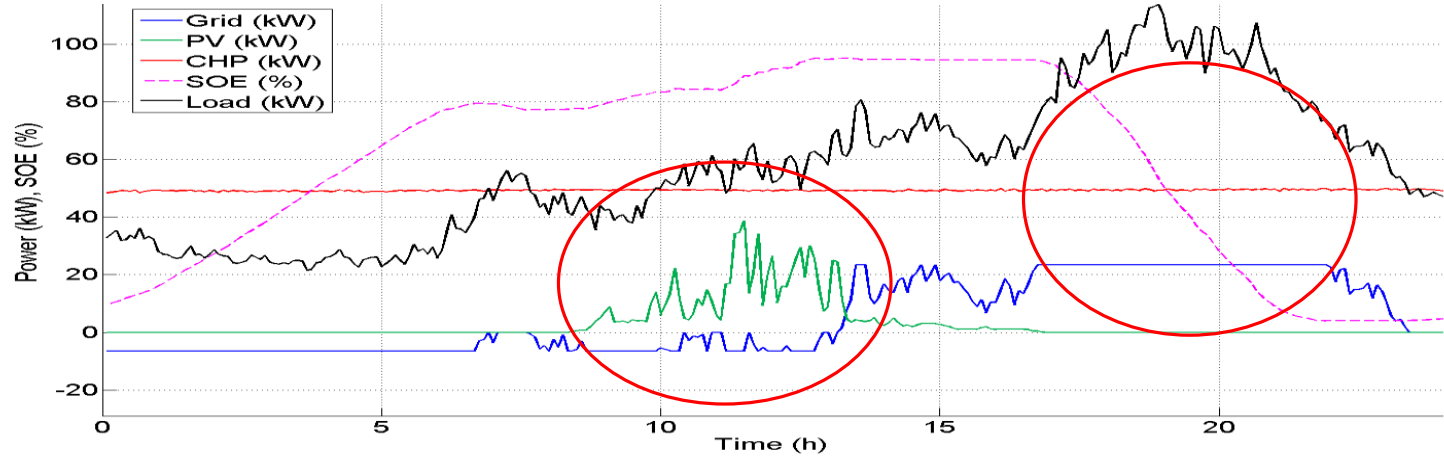   ➔ Self learning algorithms improve forecasts over time

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Bosch Energy Storage Solutions
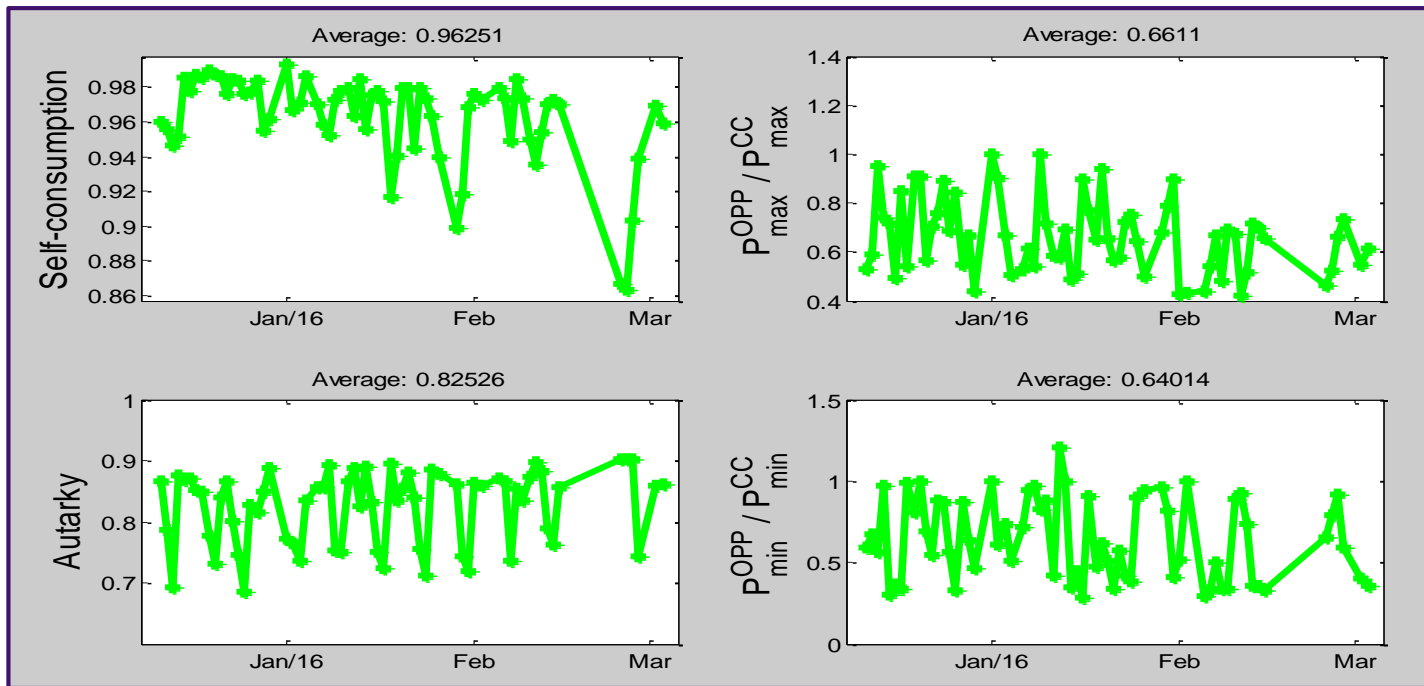## Predictive algorithms for optimized operation

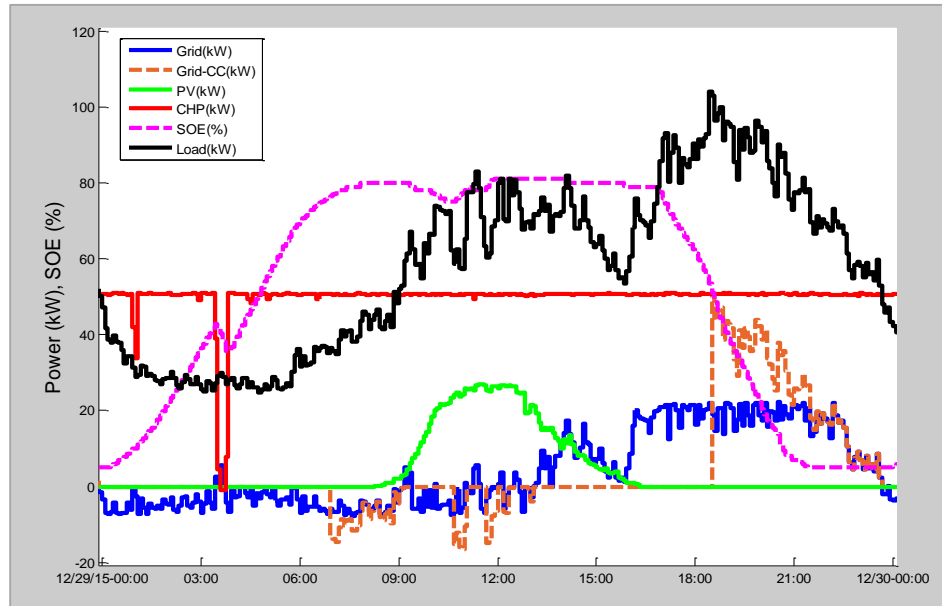**BOSCH**

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Results

➔ **KPIs, average since 10.12.15, Status 08.03.16:**

  ➔ Self consumption = 96.25% ; self sufficiency rate = 82.5 %;

  ➔ Reduction of peak load $P_{max}^{OPP}/P_{max}^{CC}$ = 0.66 ➔ 34 %

  ➔ Reduction of feed-in peaks $P_{min}^{OPP}/P_{min}^{CC}$ = 0,64 ➔ 36 %

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Representative good day (12/29/2015)

➔ KPIs:

  ➔ Reduction of feed-in peaks: 54%

  ➔ Reduction of grid purchase: 56%

  ➔ Self consumption: 96,2%

  ➔ Self sufficiency rate: 88,9%

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Summary: Storage advantages/ possible applications with RES

Advantages:

- Fast deployment
- moveable
- Can be used for multiple applications/ functions and services
- Modular extendable
- Fast and precise power regulation within whole power range (0- 100%)
- Combination of different generation assets (PV, Wind, CHP)
- Optimization through clever software

Possible applications:

- Improve forecast/ balancing group optimization
- Enable participation in reserve markets (PRM,SRL,MRL)
- Support grid service functions – reactive power supply; voltage support
- Peak shaving/ load shifting, smoothening

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Thank you for your attention!

Contact: Kevin.Schimschar@de.bosch.com
Please visit our homepage: http://boschenergystoragesolutions.com/en/
and our blog: http://boschenergystoragesolutions.com/en/blog

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