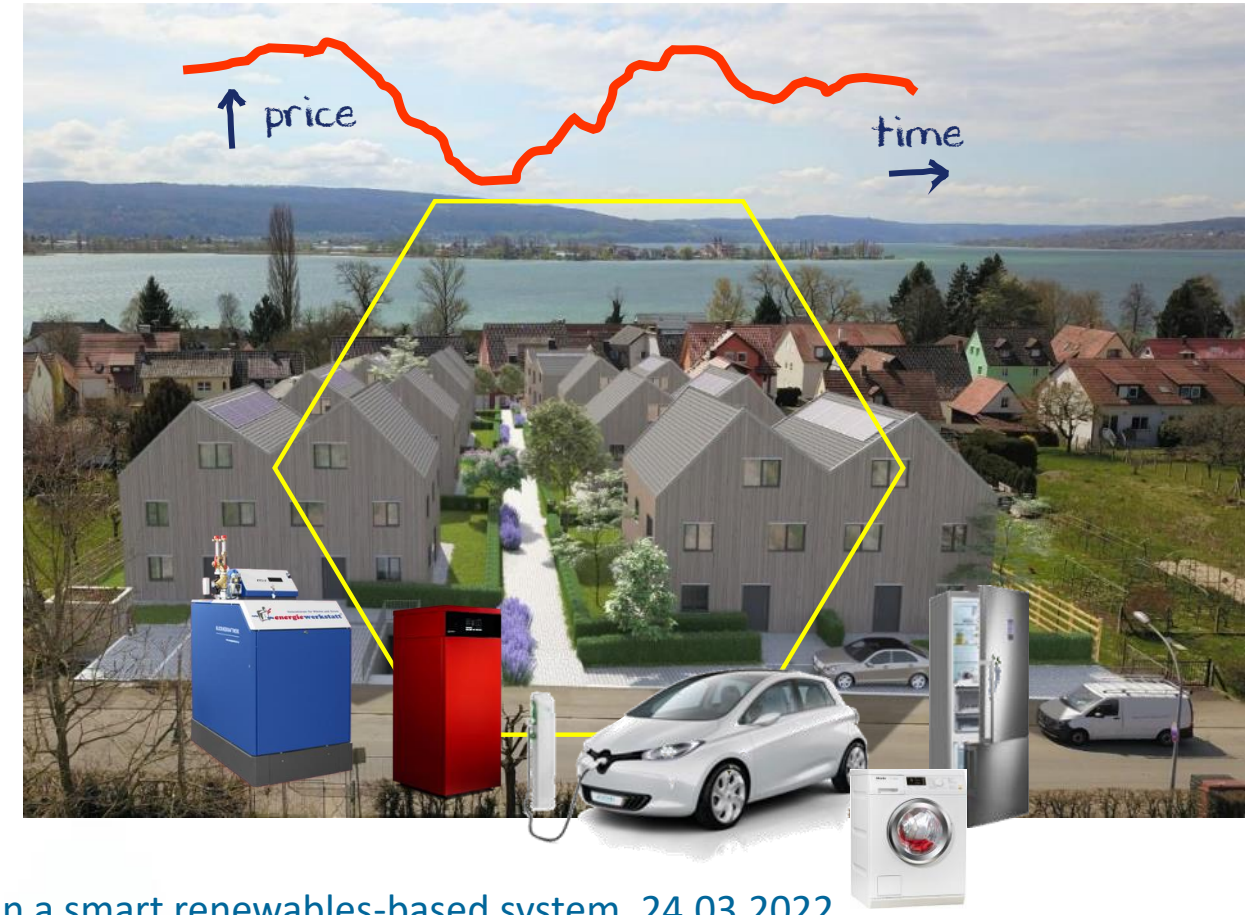
Project SoLAR

Successful Energy System Transition via Intelligent Sector Coupling: Real-time Pricing Based on Grid Status

Dipl.-Ing. Stefan Werner
Easy Smart Grid GmbH
Project Coordinator on behalf of ISC Konstanz



RGI Best Practice Webinar: Matching generation and consumption in a smart renewables-based system, 24.03.2022

Community Allensbach
A Blue Print Energy Concept

SoLAR
Smart Grid ohne Lastgangmessung Allensbach - Radolfzell

ALLENSBACH
am Bodensee

7084 inhabitants (2019)
area: 26,54 km²
267 inhabitants / km²

Climate Action Plan Allensbach
Scenario 2030 (-75% CO_2)

11 wind (external) 5 MW

PV (local) 13 MW
(0,5 % of community area)

CHP Σ 4 MW_{el}
heat pumps Σ 7 MW_{th}
EV charging stations Σ 11 MW
5% heat from wood, bio-gas etc.

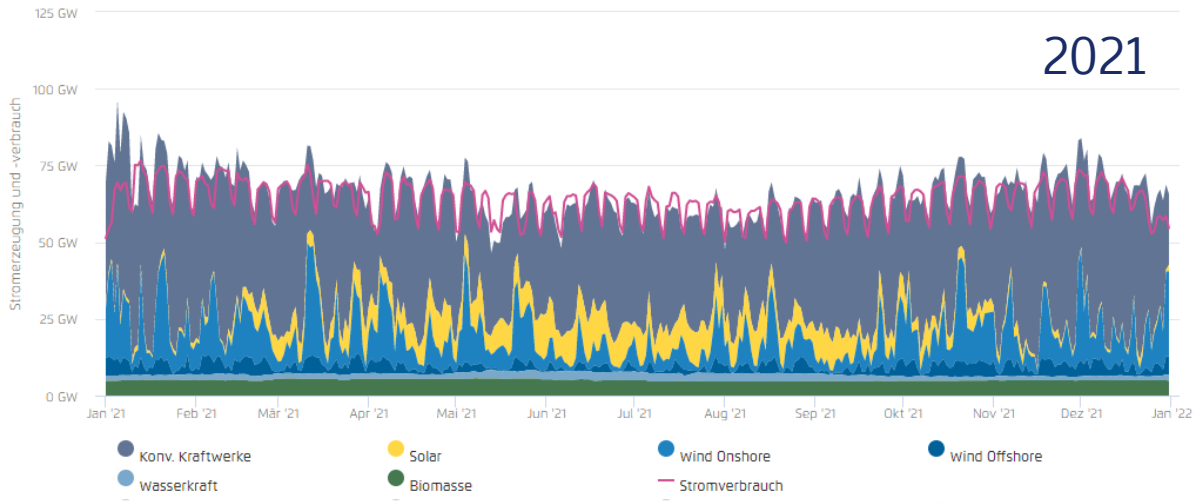
Lokale Agenda 21
Allensbach
Energie, Ressourcen, Klimaschutz

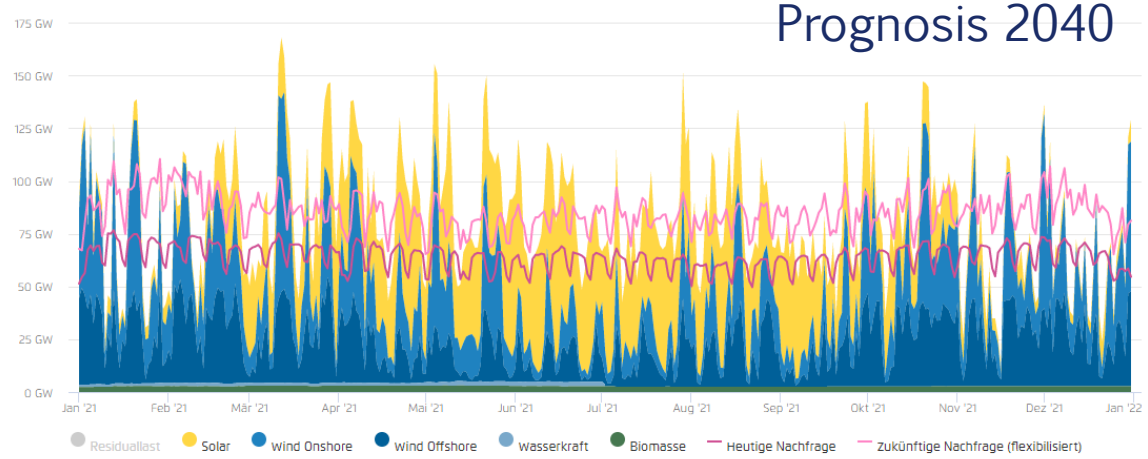
Award 2010
„Climate Neutral Community“

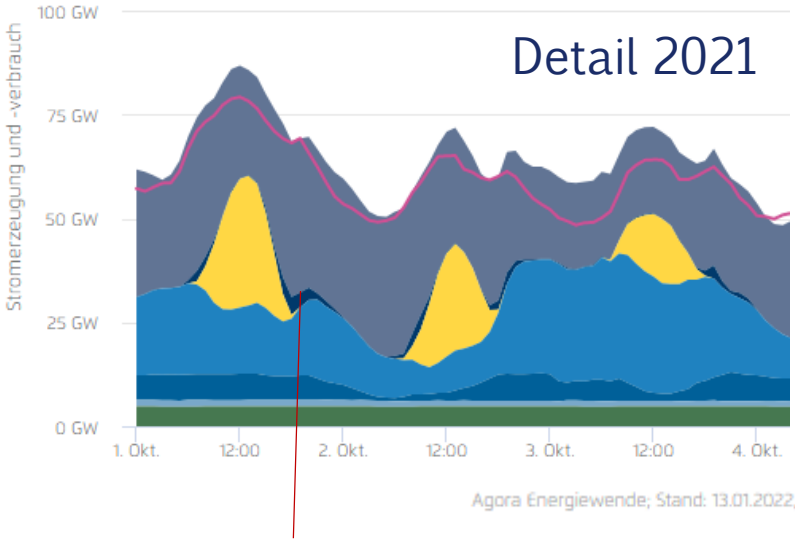
SINTEG C/Sells 2020
„Participation Cell“

Power Generation Germany 2021/2040
Storage Challenge of Energy System Transition

Smart Grid ohne Lastgangmessung Allensbach - Radolfzell



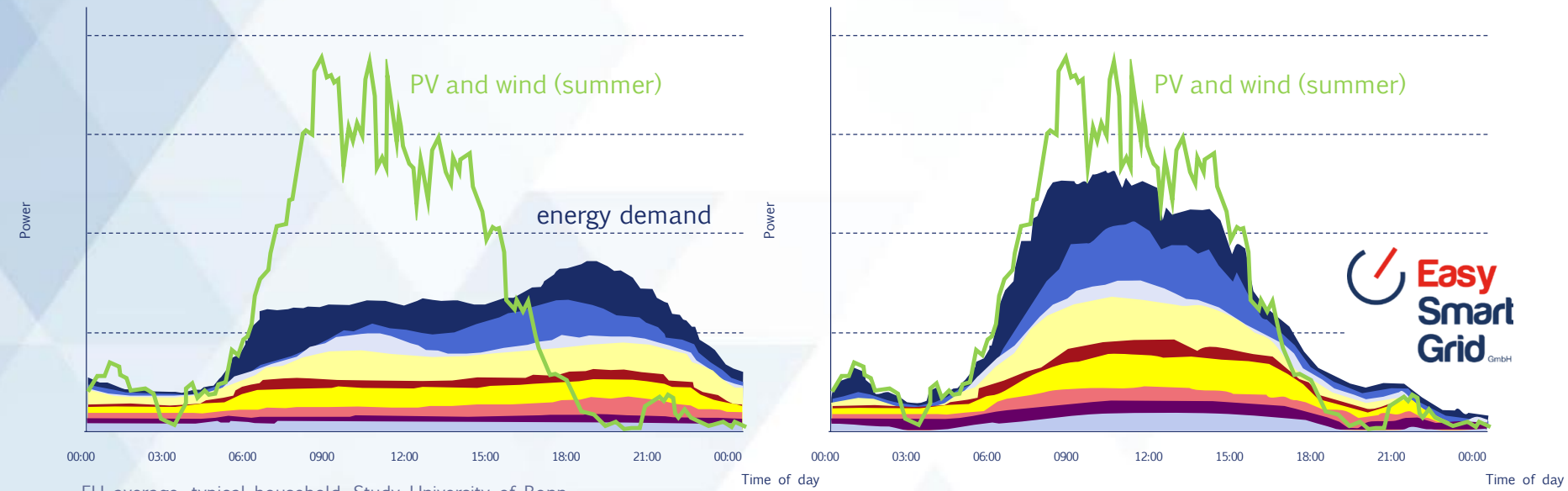




The energy stored by pump storage plants in a year (ca. 8 TWh), is almost neglectable, even as it is about 2000 (!) times larger than the current energy storage of batteries (app. 3 GWh).

Good News:
Wind and sun complement each other over the year

Electric Devices as „Virtual Batteries“ Example for Illustration



- water heater
- AC/ventilation
- oven/stove
- tumble dryer
- washing machine
- circulation pump
- dishwasher
- refrigerator
- freezer

Using existing flexibility to provide “virtual storage for free”.

EU average, typical household, Study University of Bonn
https://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/smart-a_synergy_potential_of_smart_appliances.pdf

Sector Coupling for more Efficiency – and more „Virtual Batteries“

+ Industrial Flexibility!

Combine! Consume or generate electricity while heating

Electric Devices
- Load shifting as „Virtual Battery“
- Control power possible

Heat Pumps
- Energy storage by heat
- 4 x more efficient than gas heating

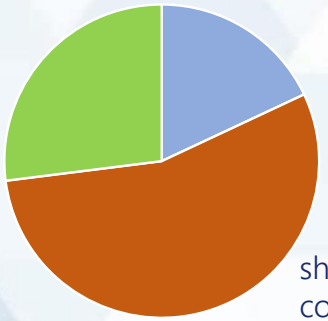
CHP and Fuel Cells
- Electricity and heat lead
- Efficient heat use
- High feed temperatures

Electric Vehicles
- 75% less energy consumption compared to gasoline and diesel
- Smart Charging - „Virtual Battery“

Electricity

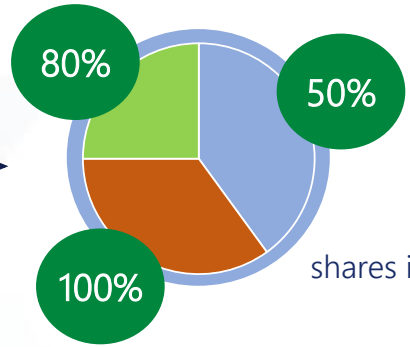
Heating/Cooling

Mobility



shares at current energy consumption

efficiency gains for heating and mobility



shares in electrified scenario

Flexibility Potential

in sum about 80%!

(80% of electric demand may be shifted in time using „virtual batteries“)

SoLAR - Living Quarter Energy Pilot
Achieving Maximum Self Sufficiency

SoLAR
Smart Grid ohne Lastgangmessung Allensbach - Radolfzell

Baden-Württemberg
MINISTERIUM FÜR UMWELT, KLIMA UND ENERGIEWIRTSCHAFT

Contract Partners Funded Project

ISC International Solar Energy Research Center Konstanz
eifer
kaufmann bau.com

Associated Partners

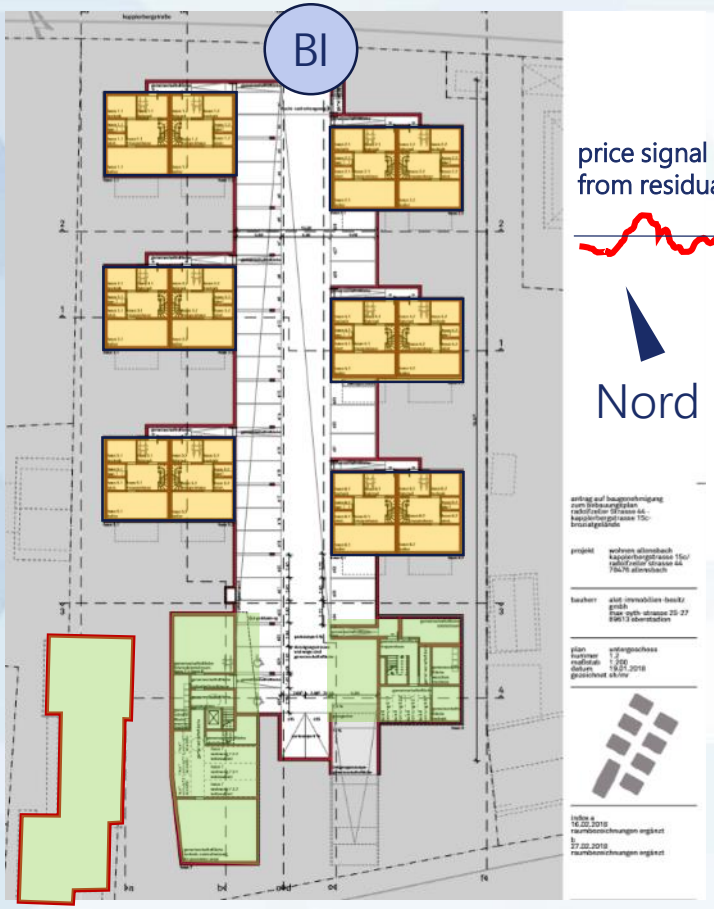
Easy Smart Grid
WEIDER WÄRMEPUMPEN
B/S/H/ BSH HAUSGERÄTE GMBH
Innovationen für Wärme und Strom energiewerkstatt
NaturEnergie von Energiedienst
stadtwerk haßfurt
SWT

Supporting Partners

ALLENSBACH am Bodensee
GEMEINDEWERKE BODANRÜCK
Miele
Buderus
E3/DC ENERGY STORAGE
inpuncto Küchen und Möbel
Netze BW
STADTWERKE RADOLFZELL immer vor Ort
TEC Technik
cfaed CENTER FOR ADVANCING ELECTRONICS DRESDEN
Hochschule Offenburg offenburg.university
SmartGridsBW Energien intelligent vernetzen.
Technische Universität München
TECHNISCHE UNIVERSITÄT DRESDEN

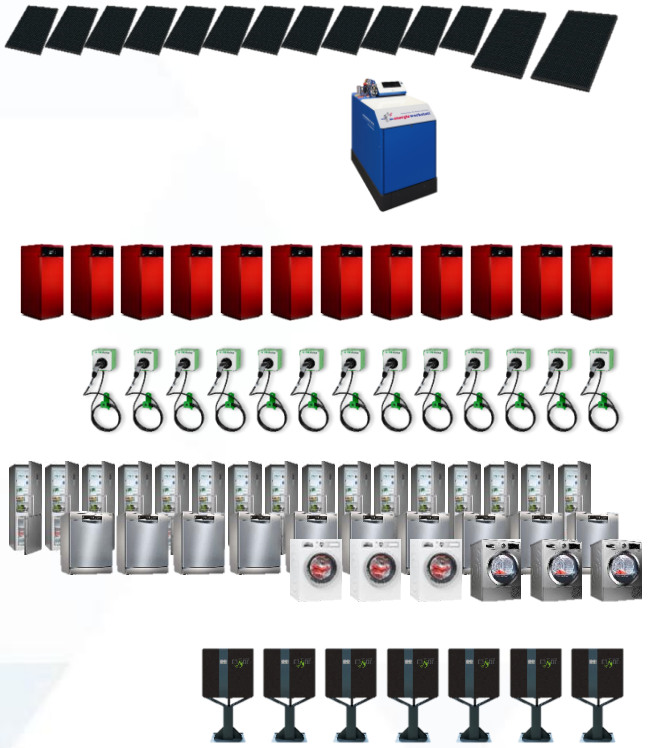
und weitere ...

SoLAR - Living Quarter Energy Pilot
Real Estate and Flexible Devices



existing building

Nord



62 flexible devices in planned extension stage of real demonstration

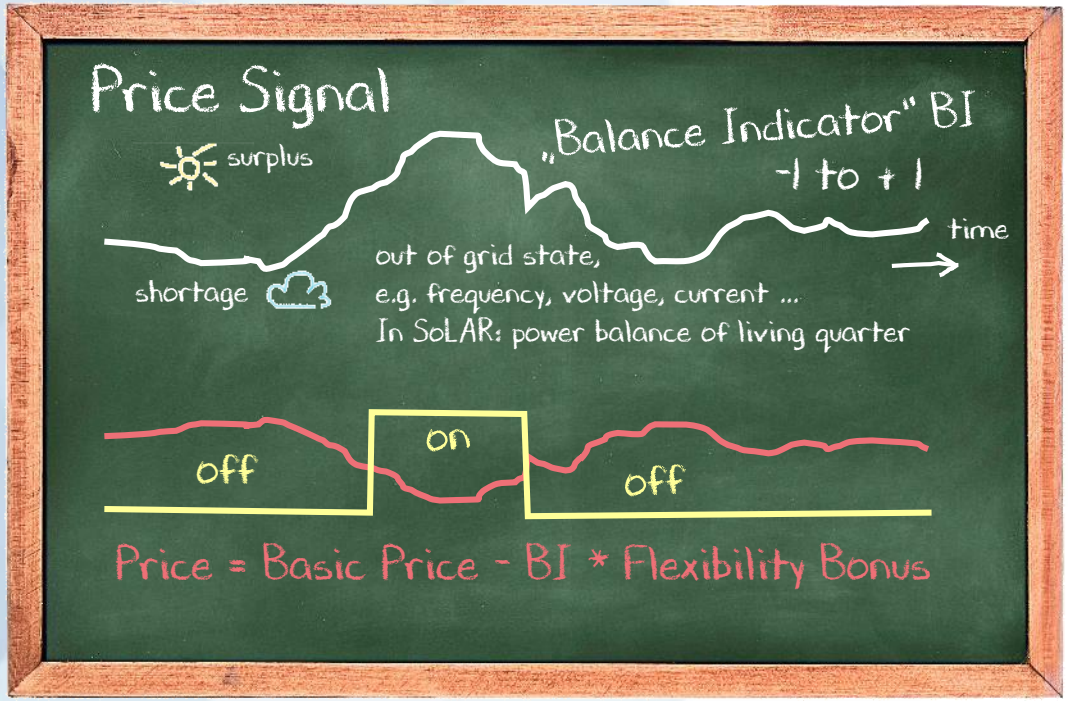
- 9 houses with 25 apartments
- KfW 40 insulation standard (new buildings)
- 14 PV plants (Σ 88 kWp)
- 12 heat pumps 5 kW_{th} (ground water)
- 1 CHP 21 kW_{el}, 46 kW_{th}
- charging stations for electric vehicles
- battery storages (SDH, KfW 40+)
- flexible home appliances for 25 apartments (e.g. washing machine, dishwasher, tumble dryer, refrigerator, freezer)

potential: > 130 controlled devices

business model: tenant power

research: real-time tariff

Easy Smart Grid: The Concept
Decentral Energy Management



data from extern, if appl.

„Smart Meter 2.0"

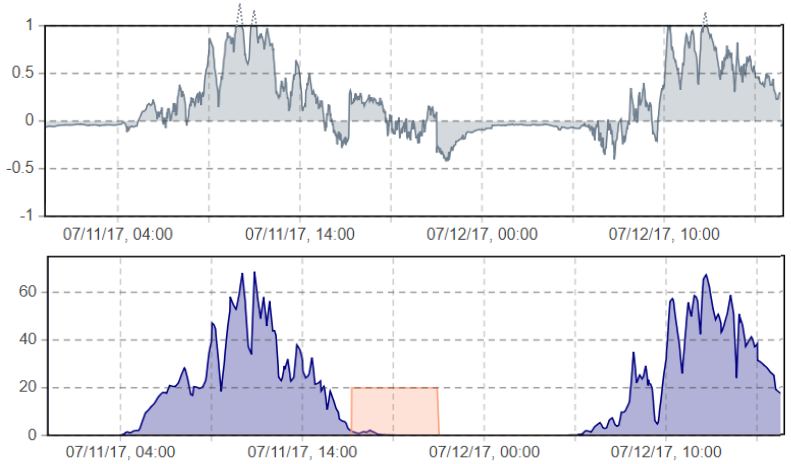
BI

target:
standardized
price signals
and use cases

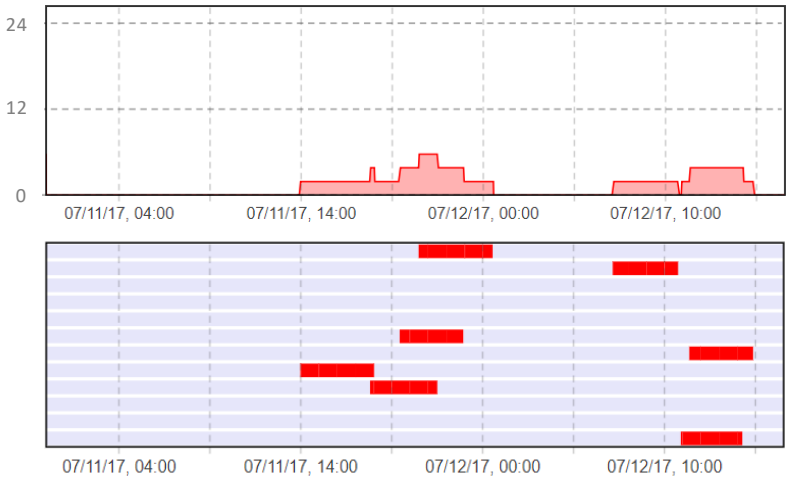
No data security problems!

A price signal BI is derived out of grid state and broadcast to the controls of flexible devices in real-time.
The devices react autonomously in a swarm.
Price feedback loop is realized over grid state.

Decentral Energy Management
Scenario Summer (only flexible heating devices)



heat lead



Balance Indicator

Calculated with power at grid connection point.
+1 = maximum feed
-1 = maximum supply

Generators

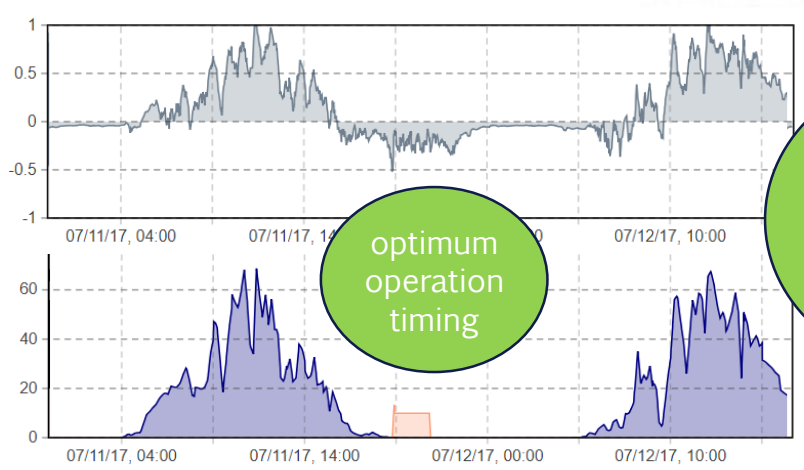
Electricity generation of PV plants ( ) and CHP ( )

Σ Heat Pumps

Sum of power consumption of the heat pumps in 12 private houses

Heat Pumps

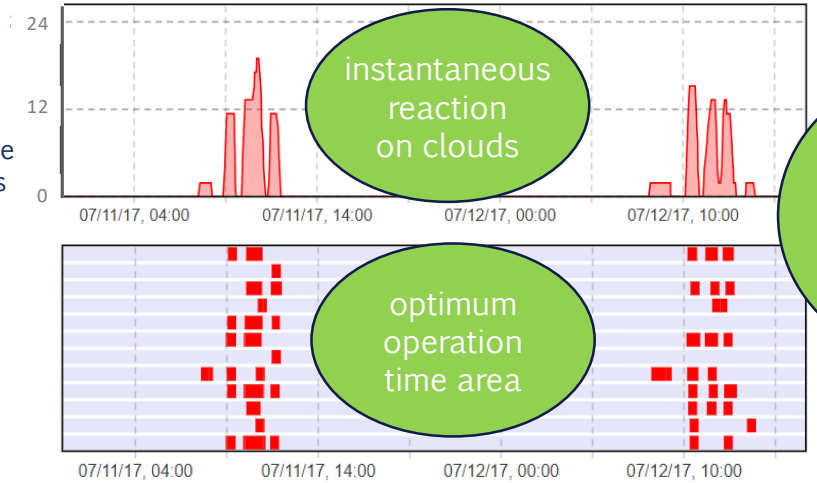
Switching decisions of the heat pumps in 12 private houses (warm water supply)



optimum operation timing

CHP
100%
self supply

Easy Smart Grid



instantaneous reaction on clouds

optimum operation time area

heat pumps
100%
PV energy

eifer

Inter-Sectoral Energy Management
Scenario Spring (activation of all flexibilities)

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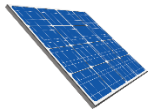
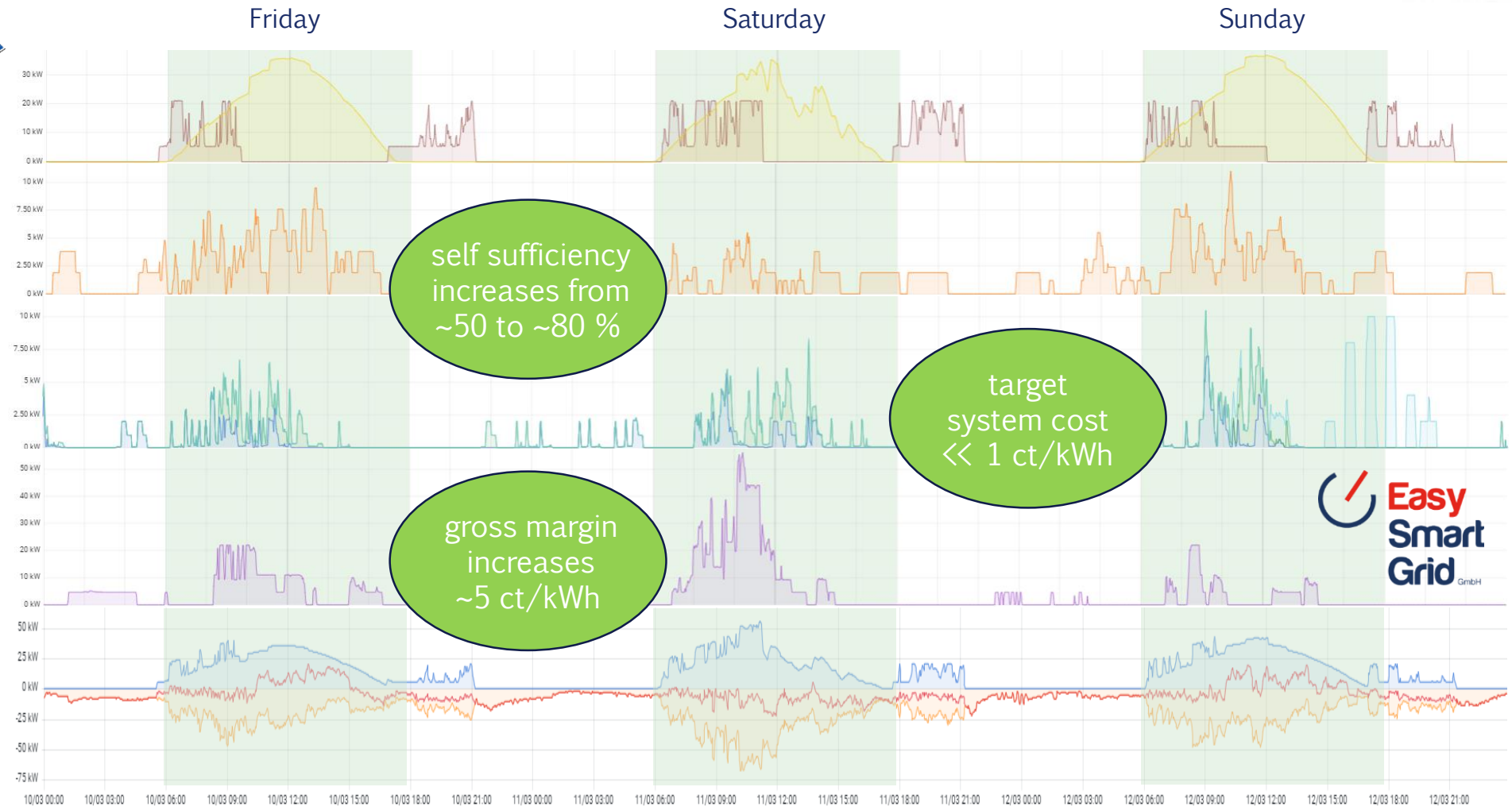




Σ



14 PV roofs

1 CHP

ISC International Solar Energy Research Center Konstanz

12 heat pumps

eifer

69 household appliances

dishwashers
washing machines
tumble dryers

13 EV chargers

generation

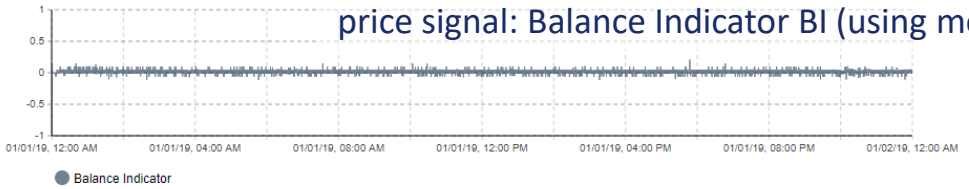
residual load → BI

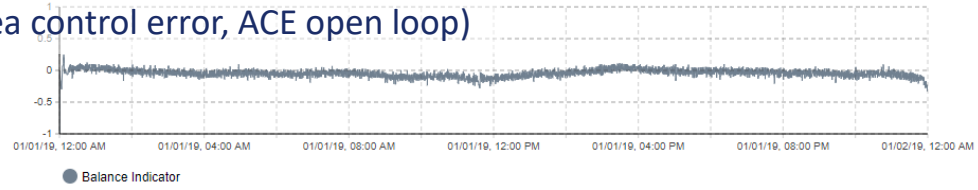
consumption

Using Household Fridges and Freezers to provide Control Power

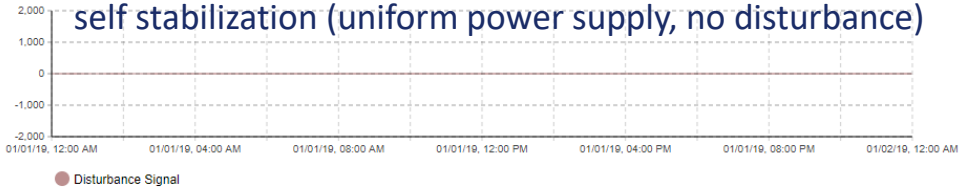
Smart Grid ohne Lastgangmessung Allensbach - Radolfzell

price signal: Balance Indicator BI (using model area control error, ACE open loop)

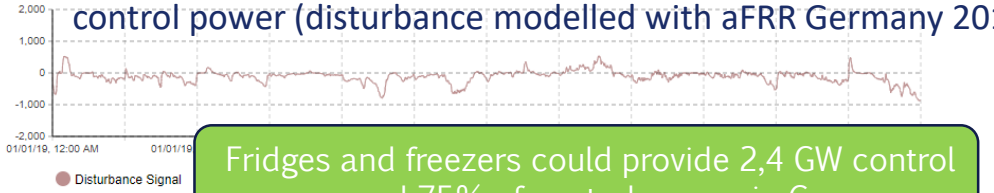




self stabilization (uniform power supply, no disturbance)

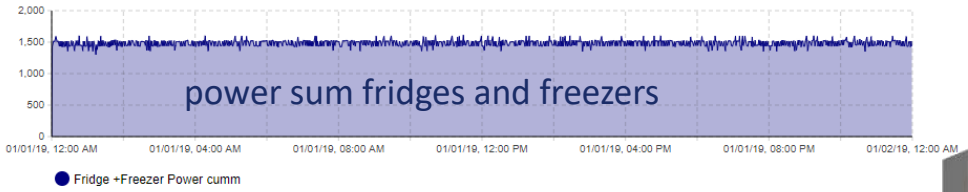


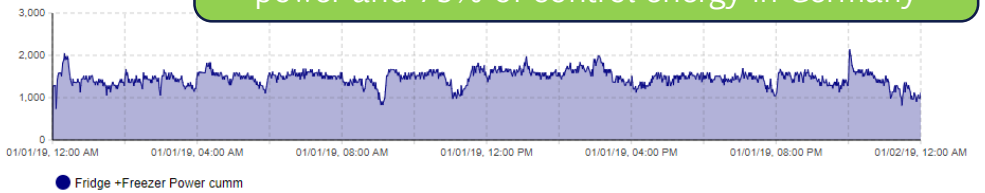
control power (disturbance modelled with aFRR Germany 2019)



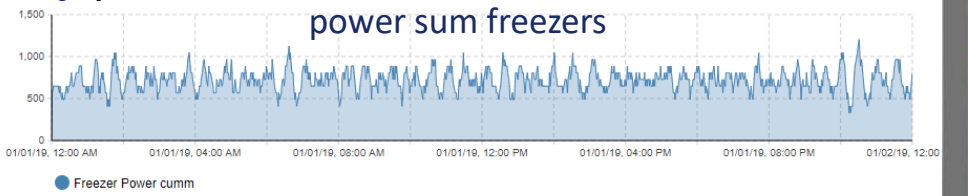
Fridges and freezers could provide 2,4 GW control power and 75% of control energy in Germany

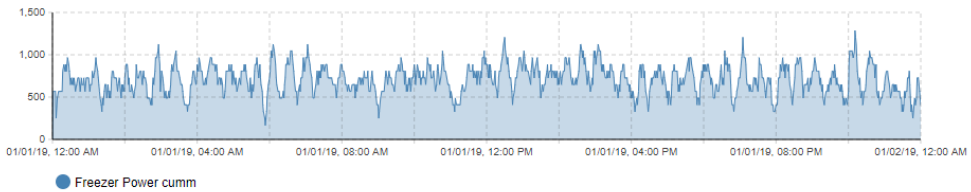
power sum fridges and freezers



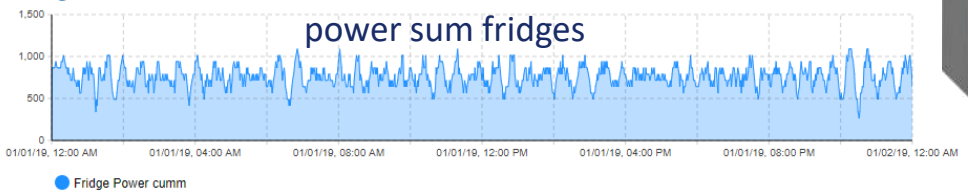


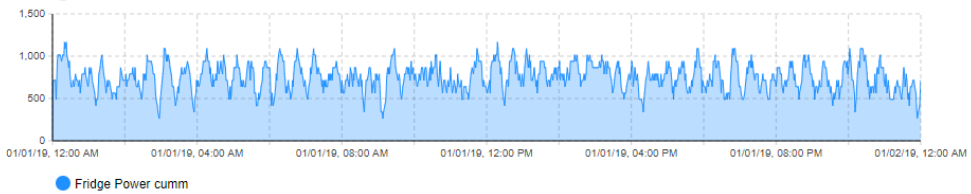
power sum freezers





power sum fridges





B/S/H/ BSH HAUSGERÄTE GMBH

Easy Smart Grid GmbH

eifer

From Demonstration to Living Lab of Energy System Transition

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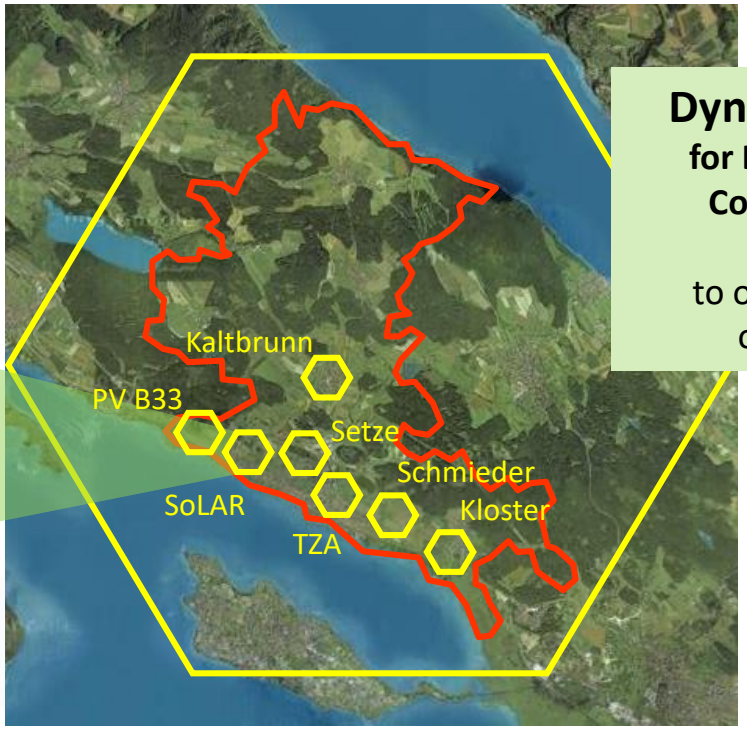
Local Green Tariff
New Heating
Electric Mobility
Smart Grid

Baden-Württemberg
MINISTERIUM FÜR UMWELT, KLIMA UND ENERGIEWIRTSCHAFT

SUNRISE



Dynamic Tariff
for Local Energy Communities

to optimize grid operation

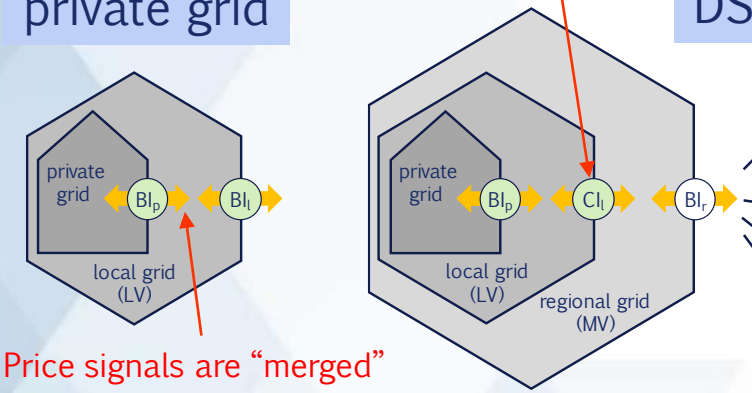
Bundesministerium für Wirtschaft und Klimaschutz

Energy System Transition Roadmap
DSO Market and Cell Scenario

Operation of sub cells in distribution grid with congestion indicator (CI) – voltage or section load

private grid

DSO



Price signals are “merged”

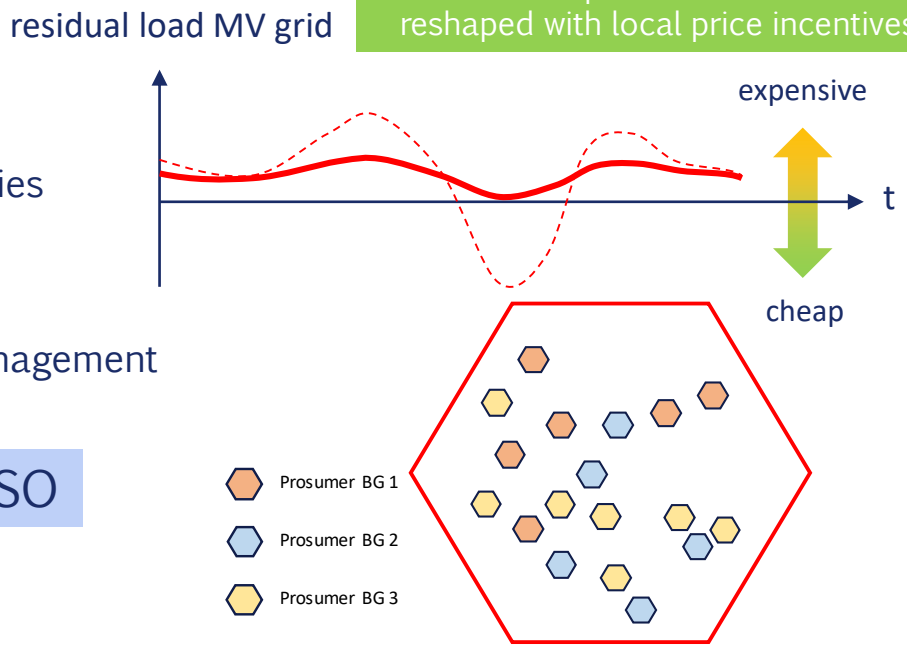
- Local Energy Communities
- DSO balance group management
- Control Power
- Redispatch 3.0

TSO

“smart quarters” (sub market)

“smart communities” (sub market)

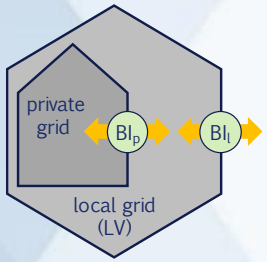
The cell load profile (DSO schedule) is reshaped with local price incentives.

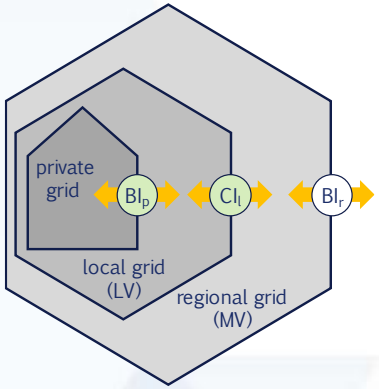


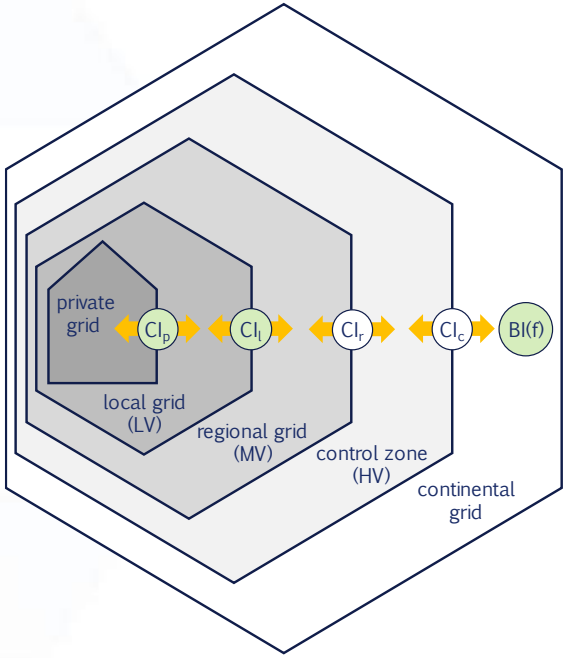
target:
DSO price signal to incentive flexible prosumers
Regional grid forms a unit subject to prequalification
(“flexible standard load profile”)

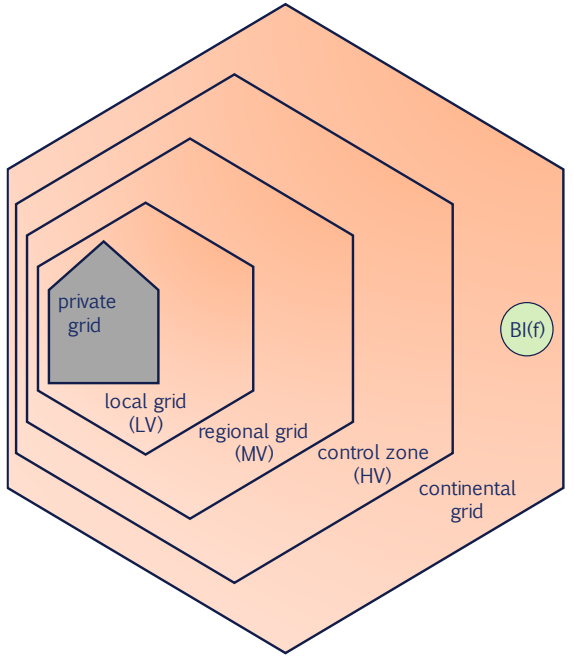
Energy System Transition Roadmap
Fully Integrated Market and Cell Scenario

BI/CI in green can be measured locally.
➔ high resilience and cyber security









"Smart Quarters"
(sub market)

"Smart Communities"
(sub market)

"Grid Pricing"
(integrated market)

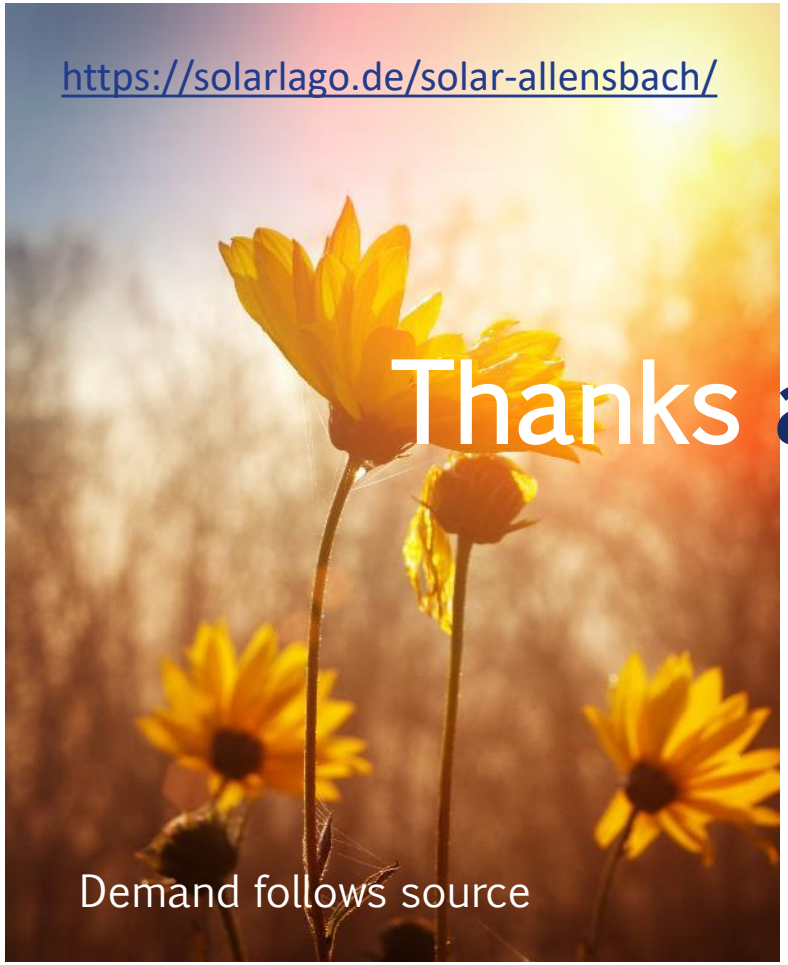
"Copper Plate Status"
(continental price zone)

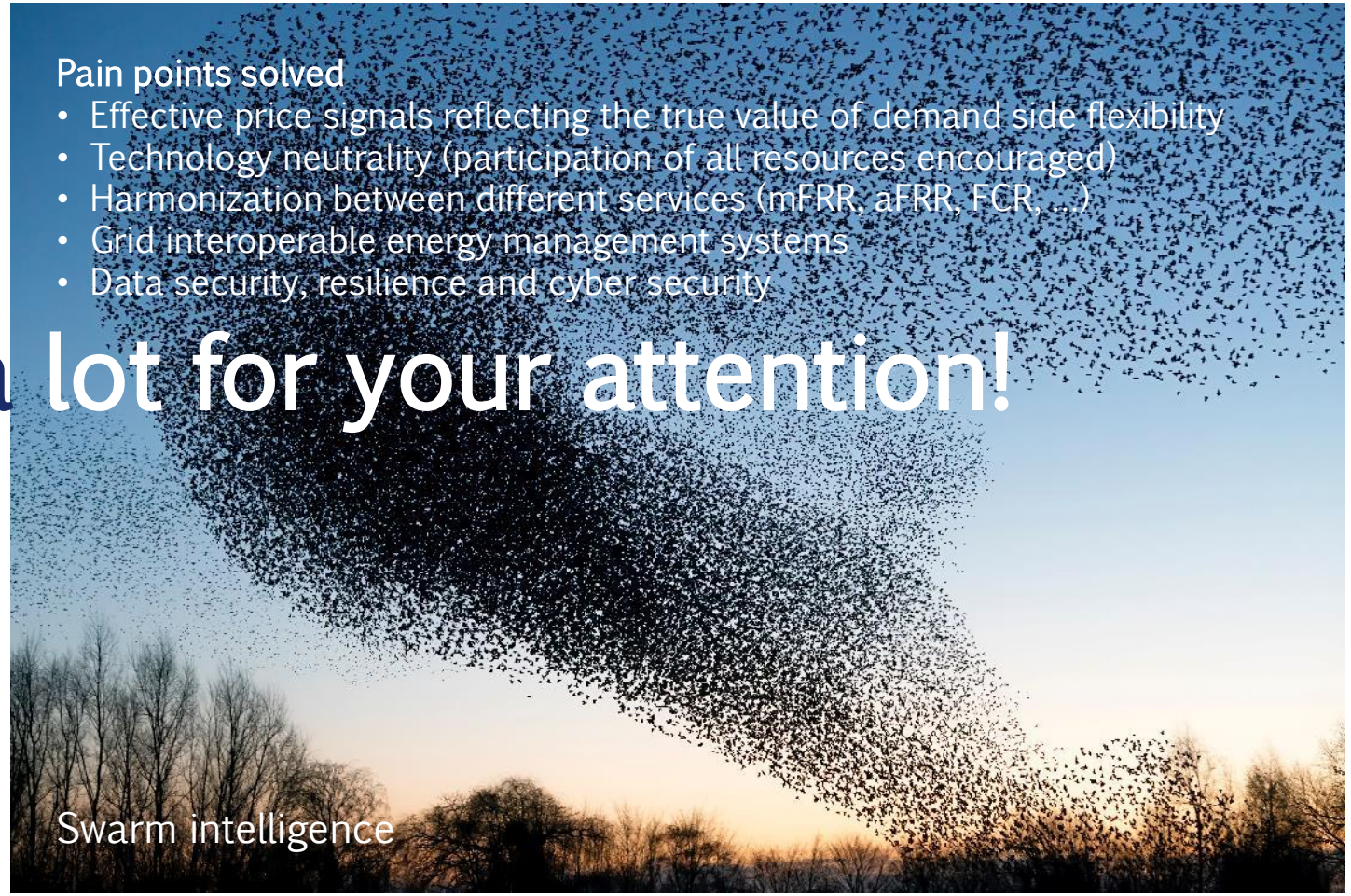
Using price signals at all cell levels, an integrated market platform for balance and congestion management can be formed.

In absence of congestions, CI values are zero and all cell levels have the same price signal BI(f).

Energy System

Energy System Transition





Thanks a lot for your attention!