IEA EGRD

The Role of Storage in Energy System Flexibility

Flexibility Option of the Demand Side

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Motivation for Demand Response

Need for flexiblity of the demand

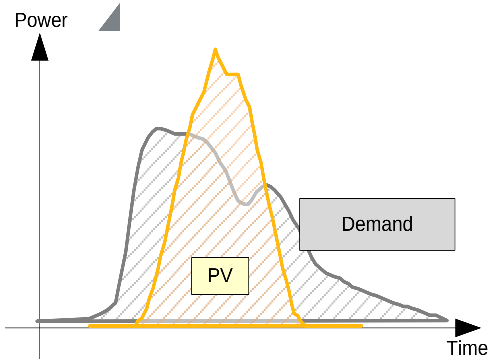
- Increase of (**local) distributed generation** (e.g..: PV, CHP, Wind)

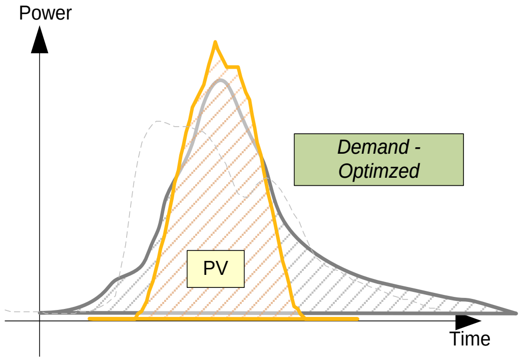
→ **PV: „grid-parity“**

→ **Impact on network: curtailment**
(Germany: since 2013: 60% Peak curtailment)

→ **Higher dynamics** in the power system

→ **Higher unbalance** due to forecast errors





DR as a possible alternative to energy storage

Demand Response Resources

- **Electro thermal** - thermal storage
  - Warm water boilers
  - Cooling / freezers
  - Heating (HVAC)
- **Electric vehicles** – electrical storage
  - Controlled charging
- **Public services** – load shifting
  - Water pumps
  - Waste water / sewage

- **Storages** → Buffer to meet energy constraint (comfort)
- **Load shifting** for network operation is already in place for many years (ripple control)
- **Aggregation** makes it more robust → Virtual Power Plant

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Potentials of DR

Technical and practical potentials in Germany

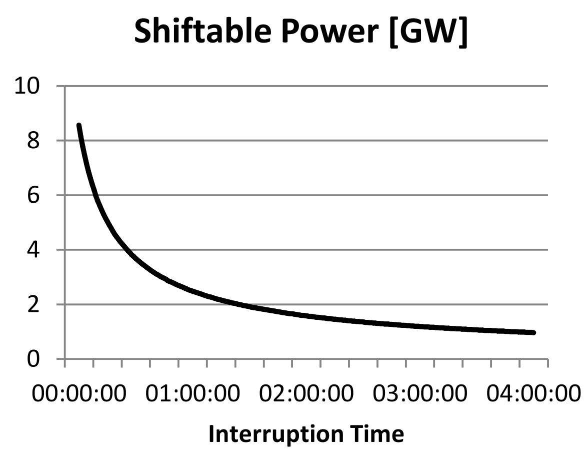
sectors	Techn. shiftable power	Displacable Energy
Household	2010: ca. 2,6 GW 2020: ca. 3,8 GW 2030: ca. 6,0 GW	2010: ca. 8,0 TWh per year 2020: ca. 12,4 TWh per year 2030: ca. 32,3 TWh per year
Tertiary sector	2010: ca. 1,4 GW 2020: ca. 1,7 GW 2030: ca. 1,8 GW	2010: ca. 5,0 TWh per year 2020: ca. 5,6 TWh per year 2030: ca. 9,7 TWh per year
Industry	2010, 2020, 2030 load shift potential of 2,8 GW to 4,5 GW	

9GW PSW, 40-70 GW load

7-15% total electricity consumption

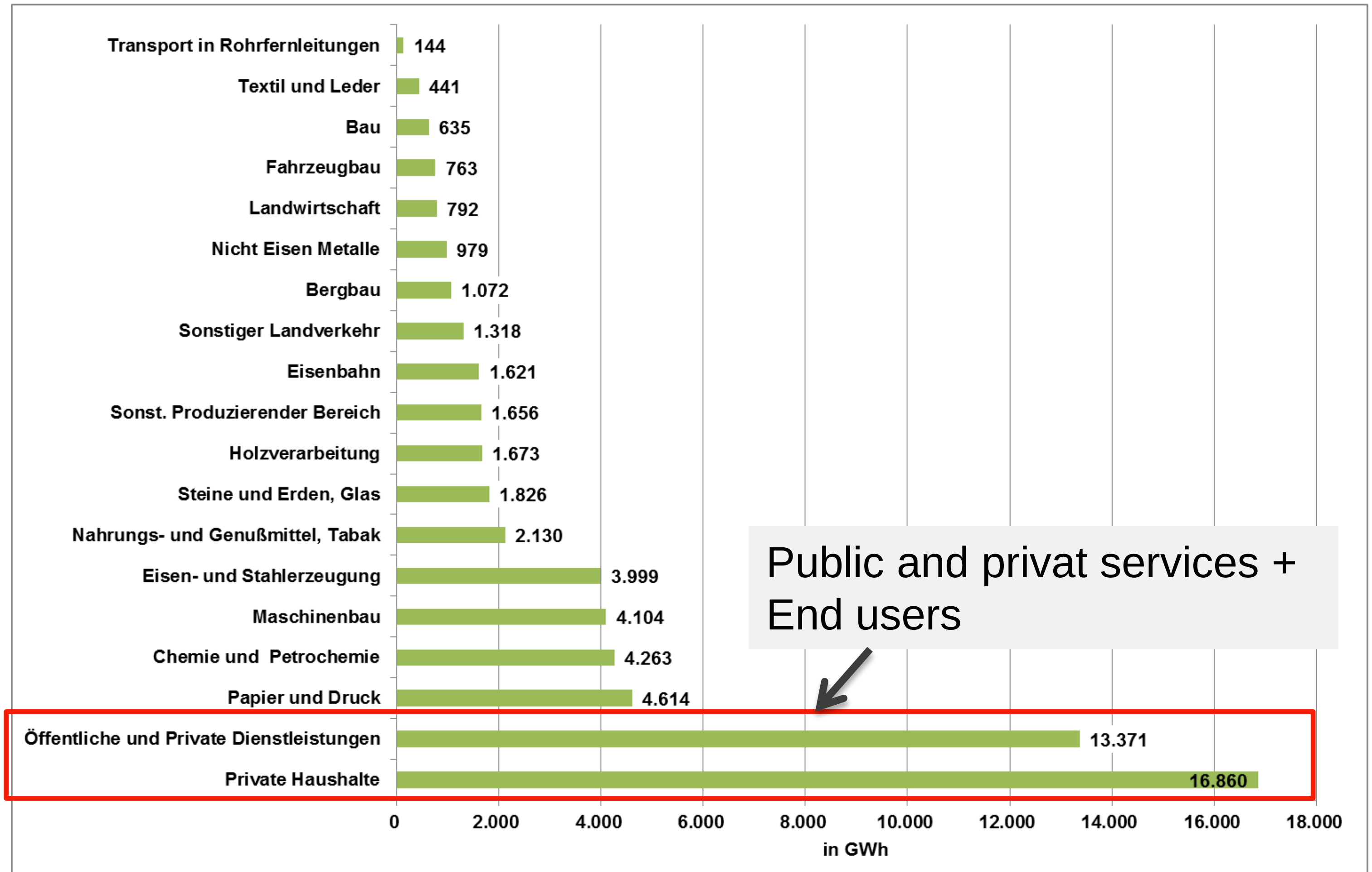
- 1,5 GW load shifting potential in Germany especially through thermal applications

Source: B.A.U.M Consult - Load shifting potentials in small and medium-sized businesses



Potentials of DR

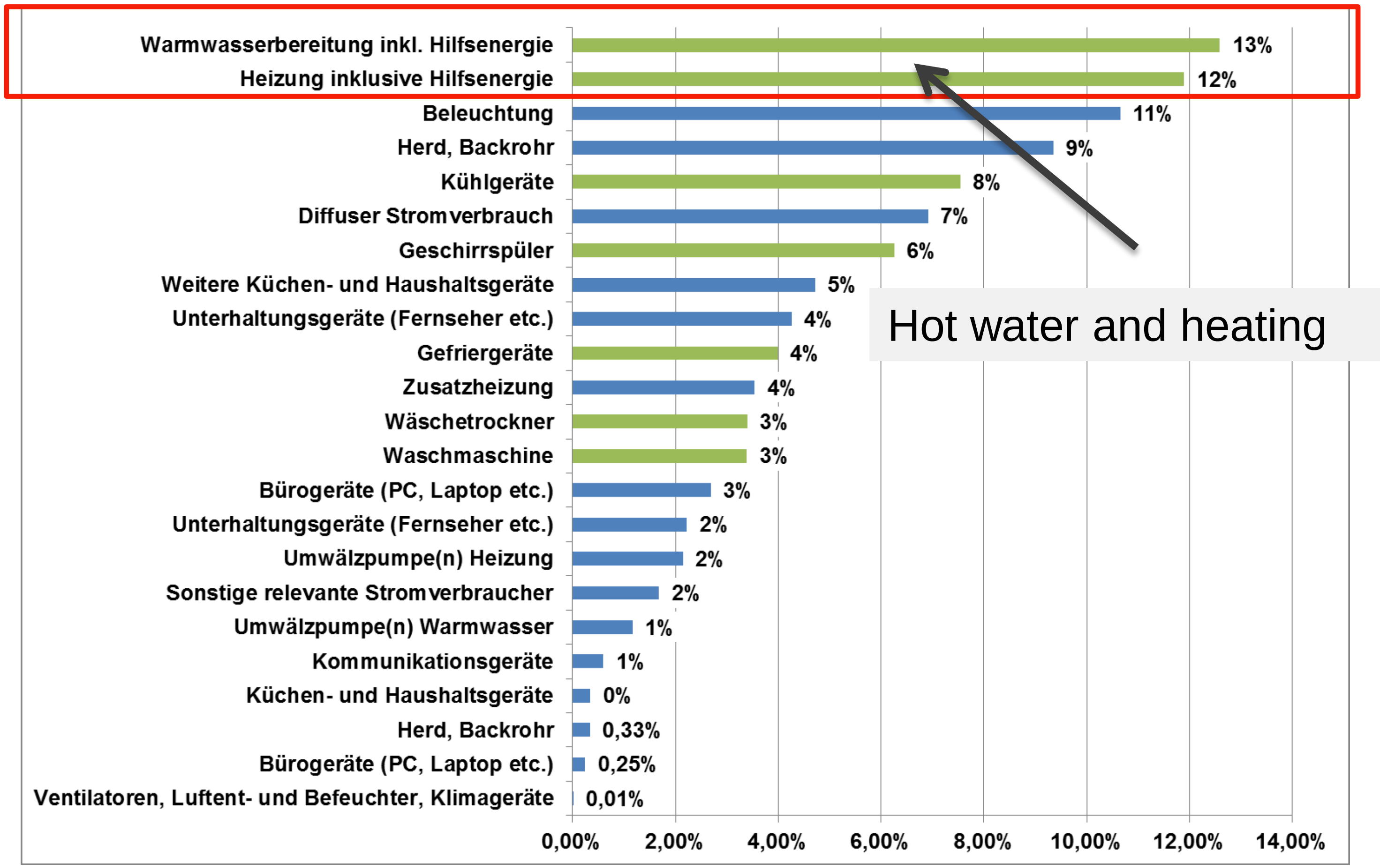
Sectorial electricity end use in Austria (2012)



Source: Statistik Austria, 2012

Potentials of DR

Categories of electricity use in households (2012)

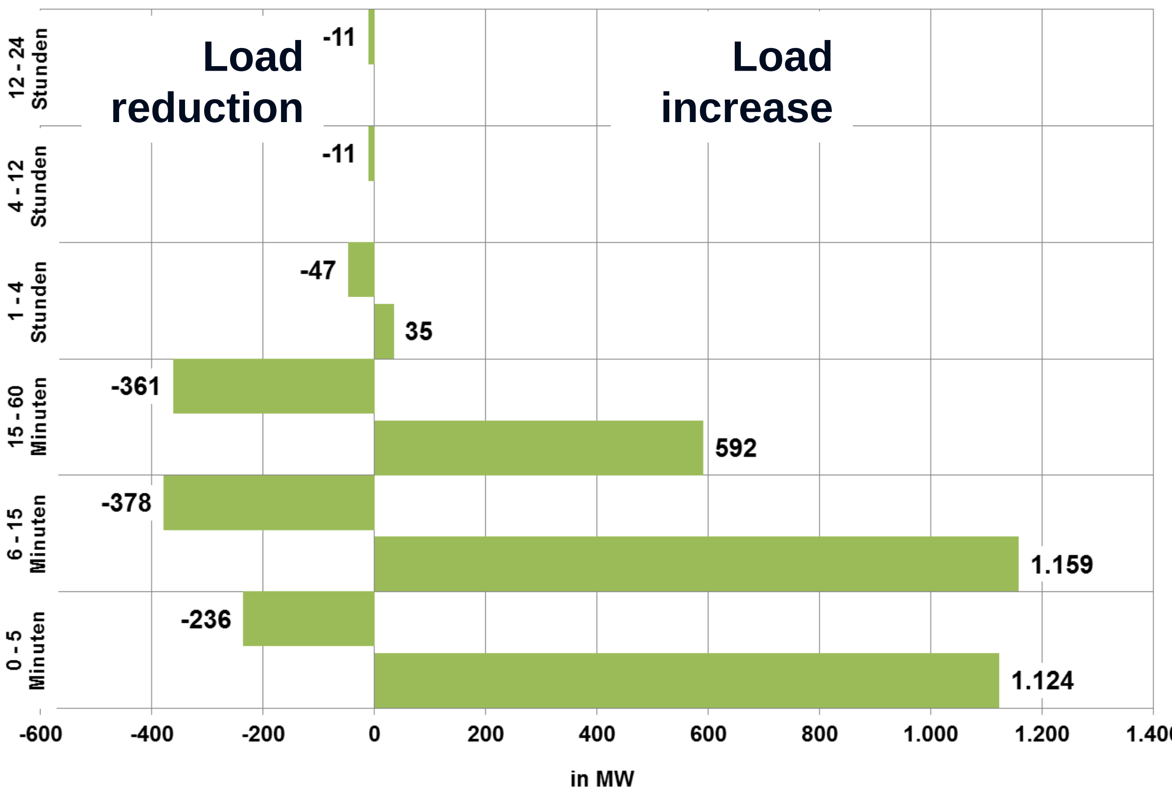


Source: Statistik Austria, 2012

Potentials of DR

Technical potentials in Austria

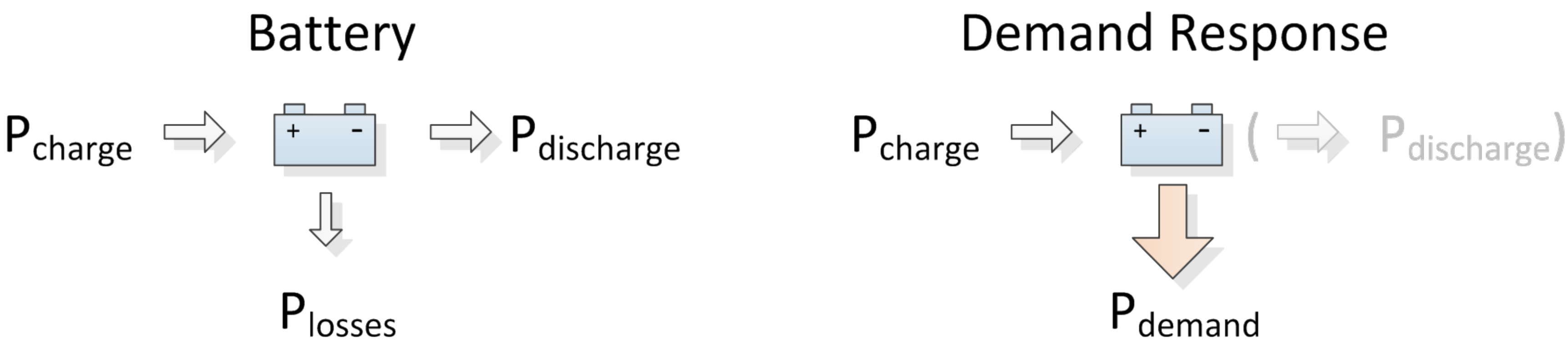
- Practical load shift demand at households in Austria



Source: Energieinstitut an der JKU Linz – Project „LoadShift“

Differences between DR and energy storage

Battery operation vs. Demand requirements



SOC = f (operation mode)

SOC = f (demand)

Differences between DR and energy storage

Battery operation vs. Demand requirements

	Battery	Demand Response
Operation	charging / off / discharging	(forced) charging / off
Self discharging	losses	losses = customer demand
SOC range	depends on previous operation	unknown free rest capacity
Rated power	charging = discharging	withdraw > charging
Storage time	short to long term	(short term) “shifting”
Availability	dispatchable	external factors (demand, T, …)
Purpose	dedicated system	part of demand side
Control	energy management system	simple control (e.g., thermostat)
Objective	storage of electric energy	shifting of energy
Scale	large / utility	settlement, building, households

Examples from pilots and field tests

Sharing best and bad practices and defining use cases

Project SGMS-HiT– Smart Grids Model Region Salzburg

Buildings as interative participants in the Smart Grids

SMARTGRIDS Modellregion Salzburg · Salzburg AG · Salzburg Wohnbau · cure center for usability research & engineering · SIEMENS

SGMS – HiT

Utilizing HVAC-Systems (heating, hot water)

- Separate **usage of energy** from **energy supply**

  → **Buffering** with thermal storages

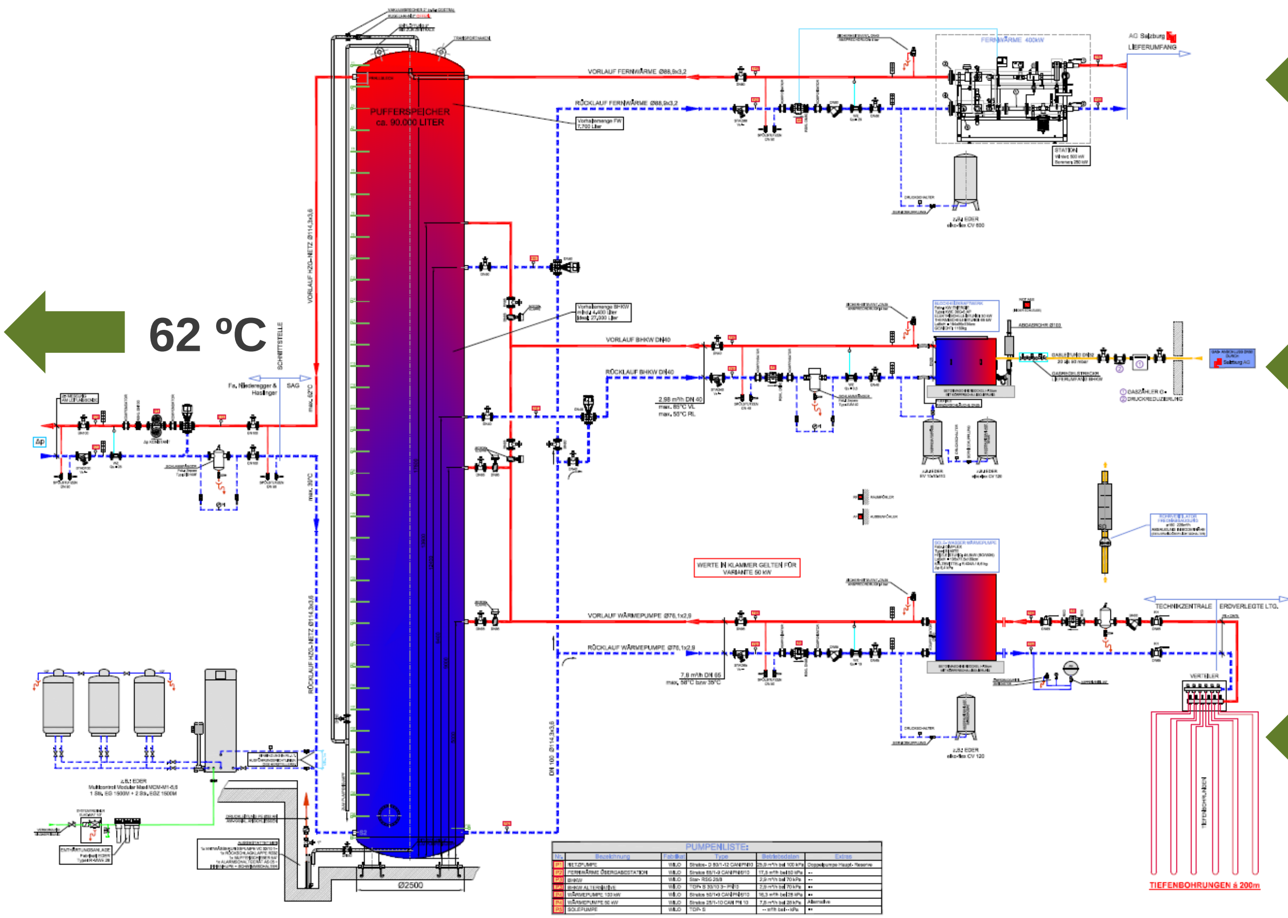
- Use **energy** which is most **efficient** for the grid
  - PV - Heatpump
  - Biogas (CHP)
  - Grid
  - District heating

  → **grid friendly building**

- **Comfort** must be **preserved**.

SGMS – HiT

Three heat sources feeding into one storage tank



62 ºC

District heating

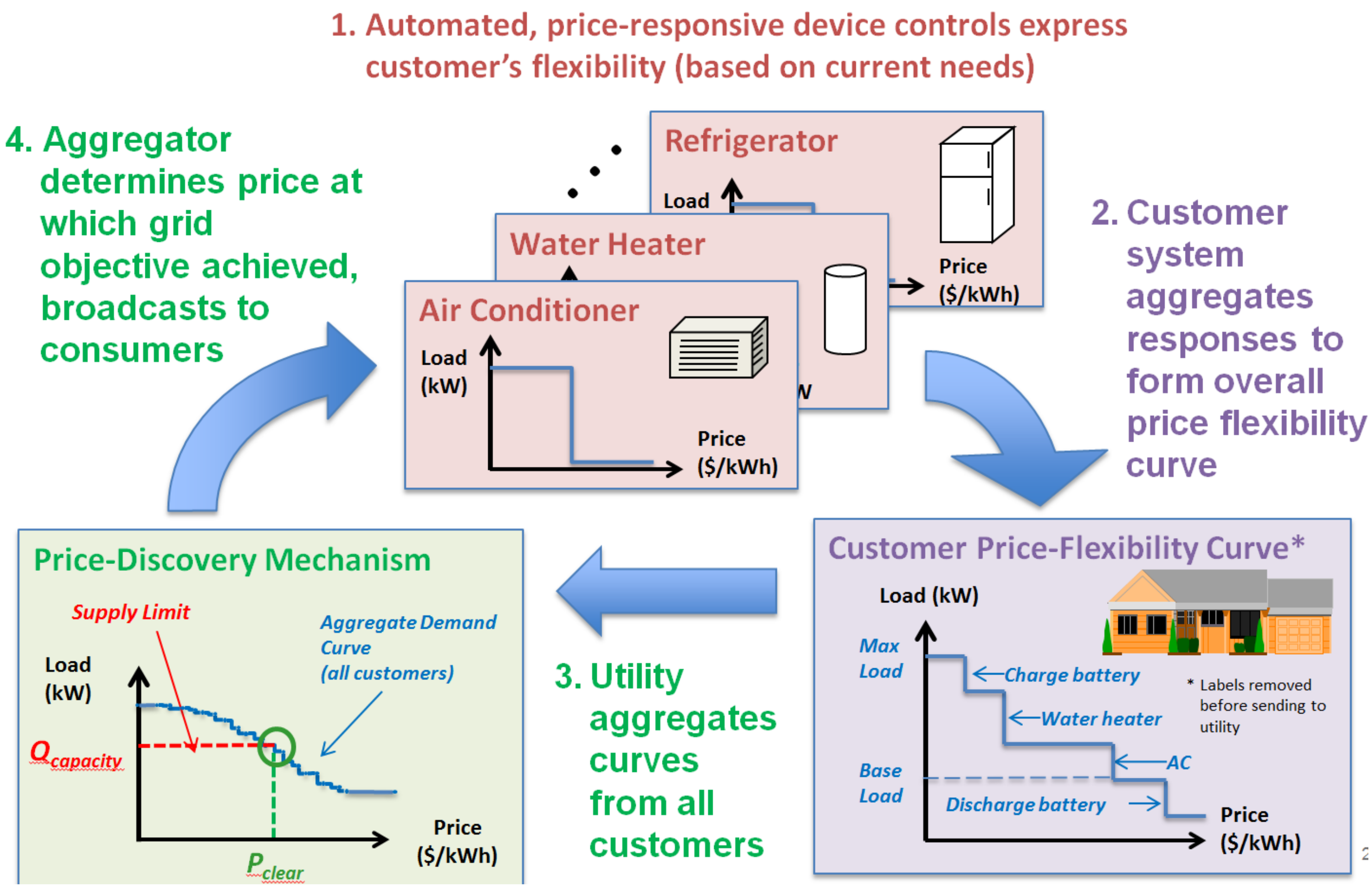
Combined heat and power plant
(68 kW therm, 30 kW elec)

Heat pump
(45 kW therm)

90m³ Hot water storage tank

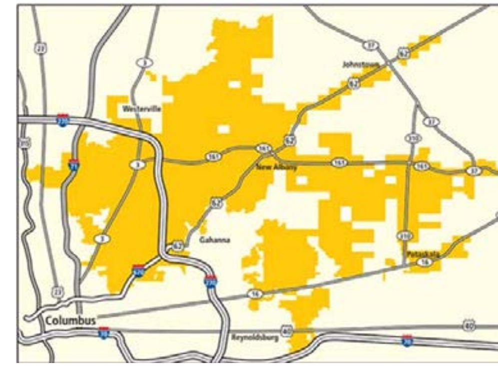
Project: gridSMART® - Residential Real-time Pricing

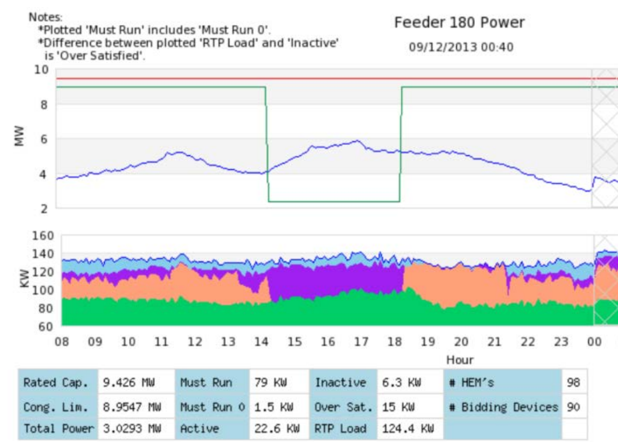
Overview – Transactive Grid Control



Project: gridSMART® RTPda Demo

- First **real-time market** at distribution feeder level with a tariff approved by the PUC of Ohio
- Value streams
  - Energy purchase benefit
  - Capacity benefits: e.g., peak shaving
  - Ancillary services benefits
- Uses **market bidding mechanism** to perform distributed optimization – **transactive energy**
  - ~200 homes bidding on 4 feeders
  - Separate market run on each feeder
  - “Double auction” with 5 minute clearing
- **HVAC automated bidding**
  - Smart thermostat and home energy manager
  - Homeowner sets comfort/economy preference
  - Can view real-time and historical prices to make personal choices

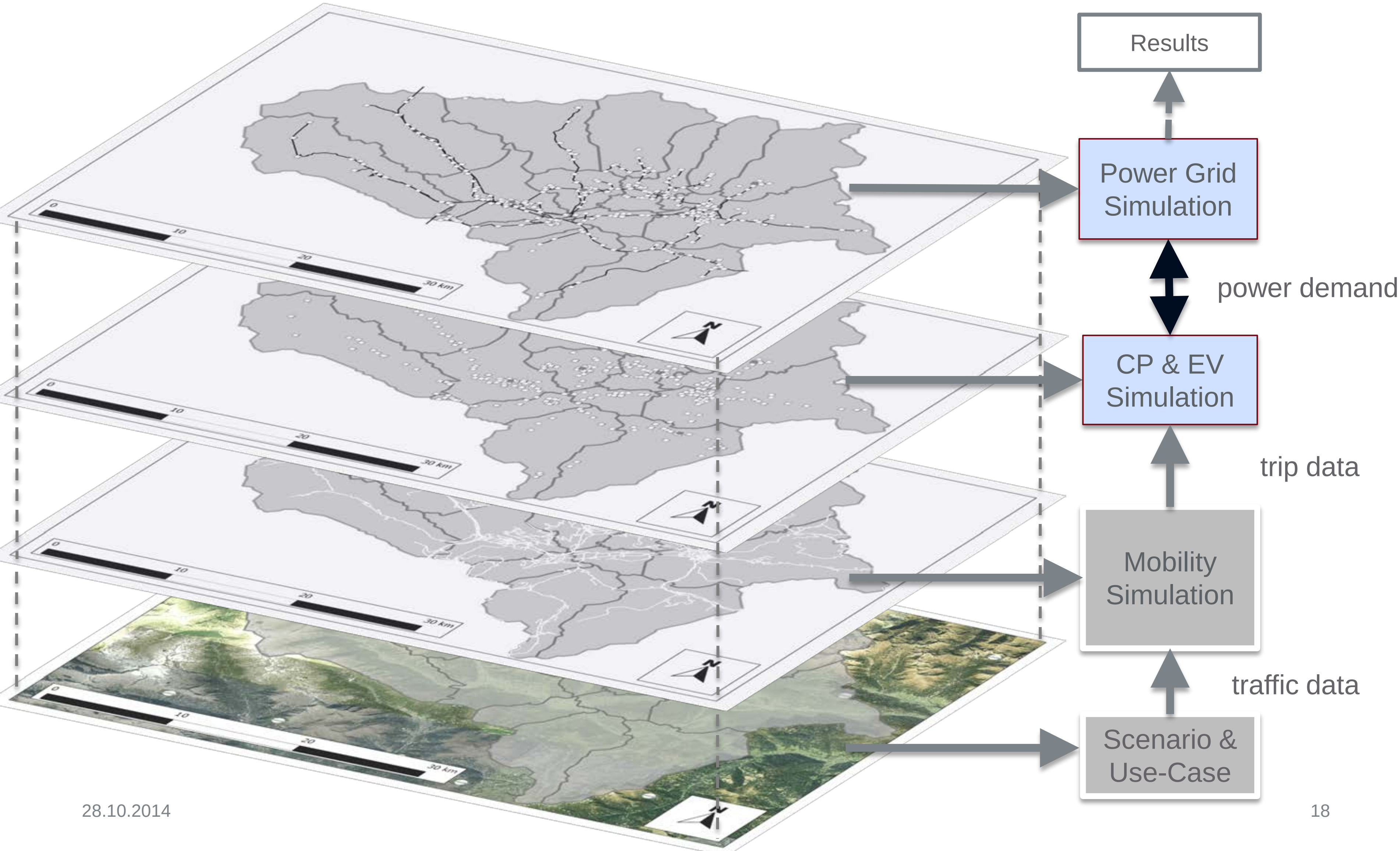




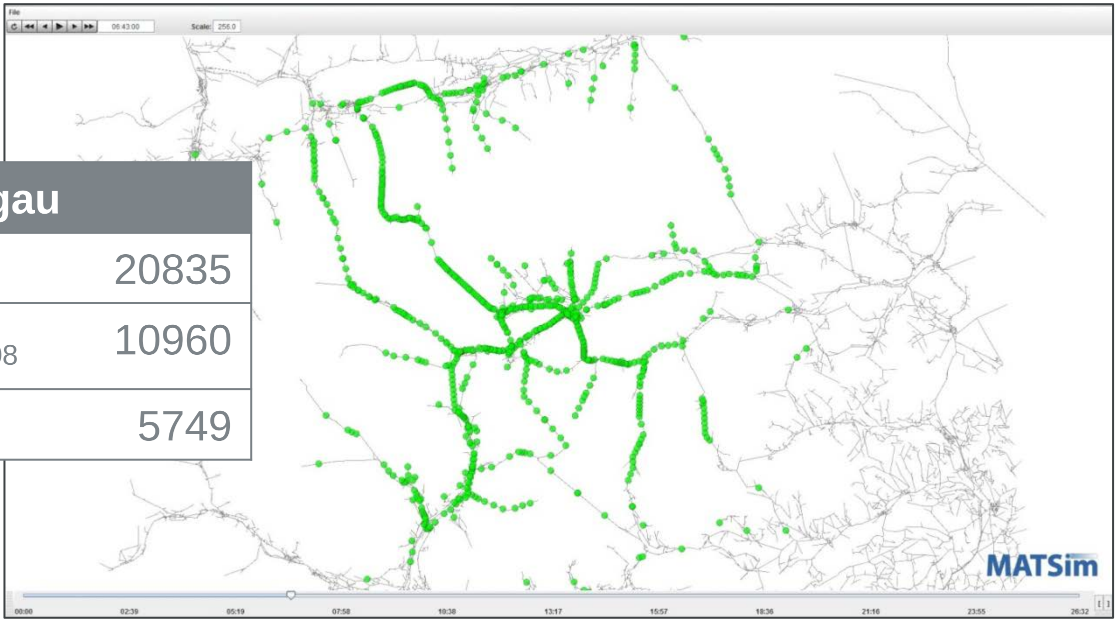
Electric Vehicles

Electric storage as a flexible resource to integrate renewables

EV Simulation Environment



Use-Case Description: Basic Data

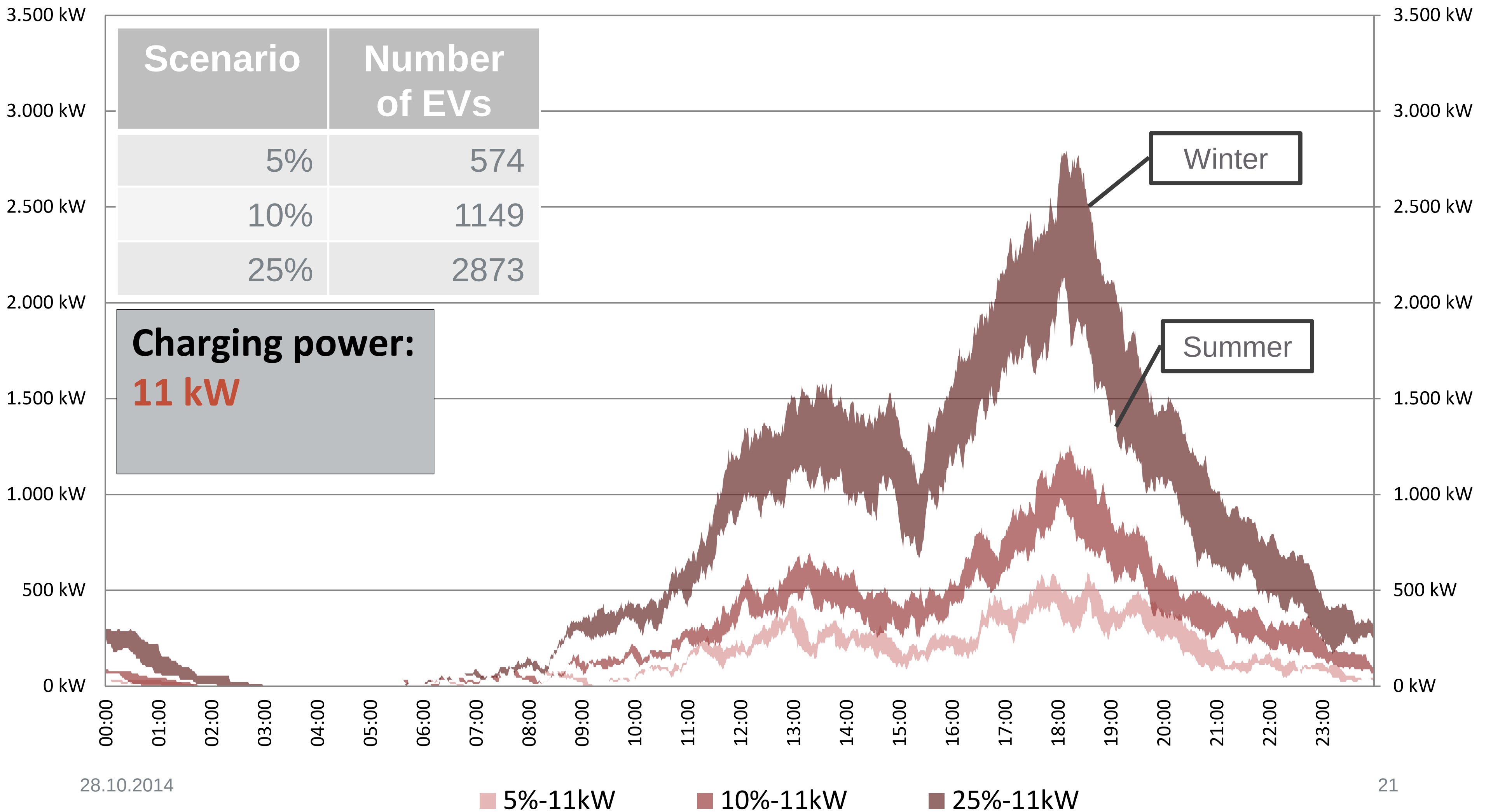


Data of District Lungau	
Population 2008	20835
Passenger vehicles Lungau 2008	10960
50% BEV/PHEV	5749

Vehicle	Battery [kwh]	Charging Specifications			Range [km]	Consumption [kWh/km]
		Amperage[A]	Voltage[V]	phases		
BEV	27,5	16	230	3	130	21,15
PHEV	10,5	16	230	1	60	17,50

Impact of different maximum charging power (11kW)

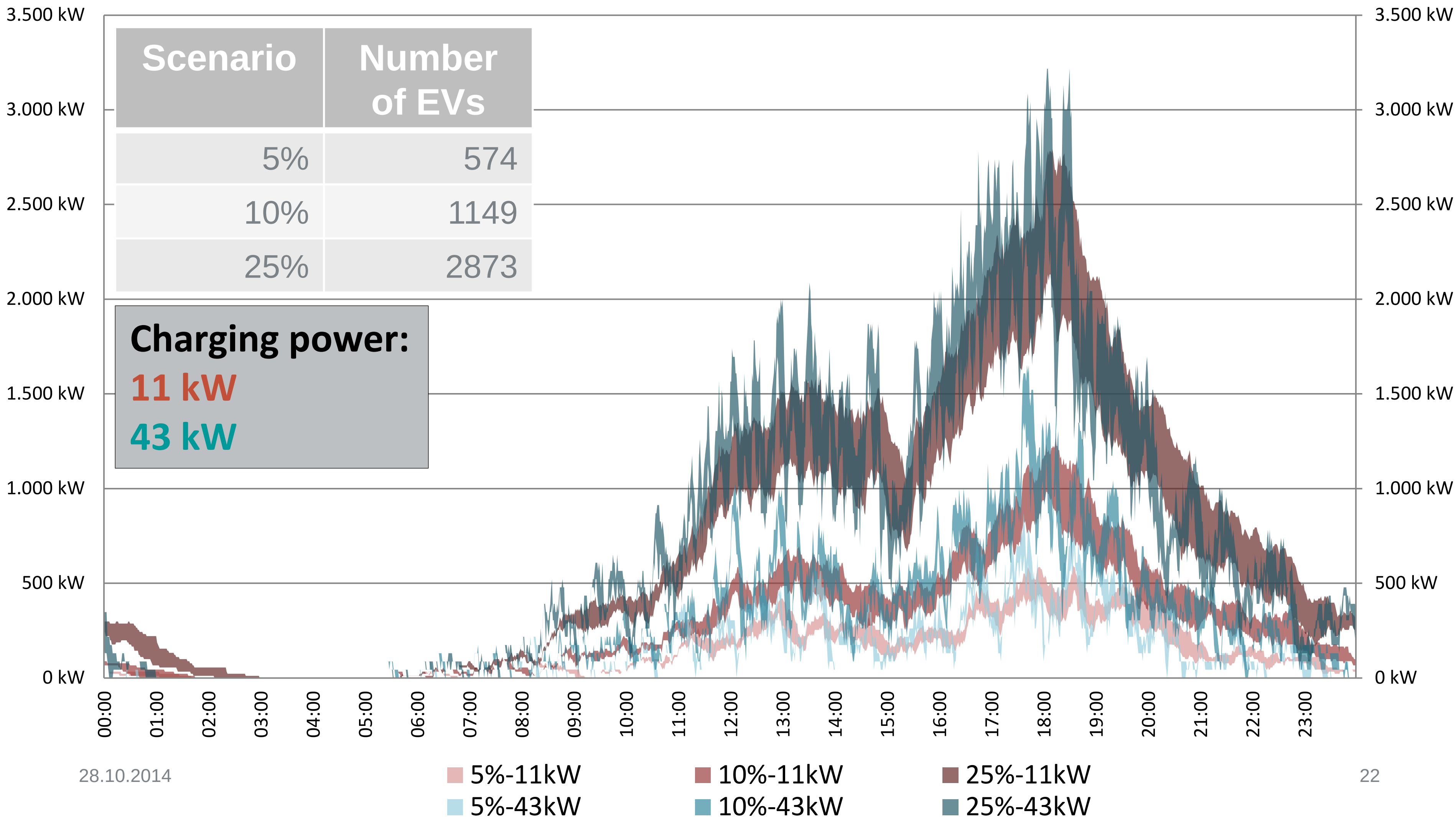
Opportunity Charging – Summary (Summer & Winter)



Scenario	Number of EVs
5%	574
10%	1149
25%	2873

Impact of different maximum charging power (43kW)

Opportunity Charging – Summary (Summer & Winter)



Scenario	Number of EVs
5%	574
10%	1149
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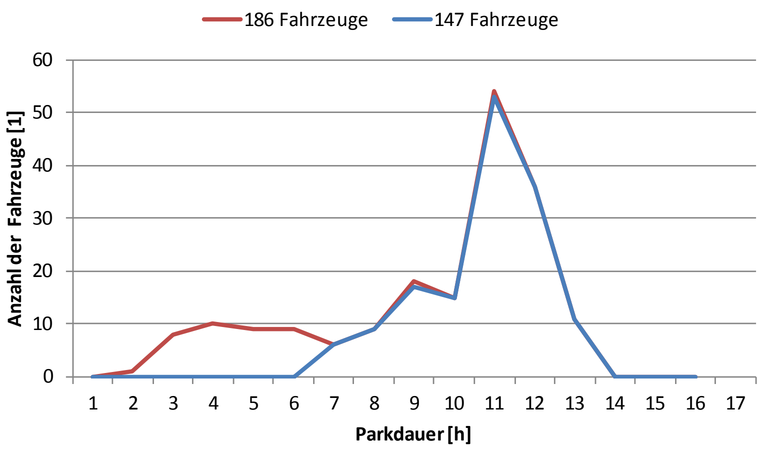
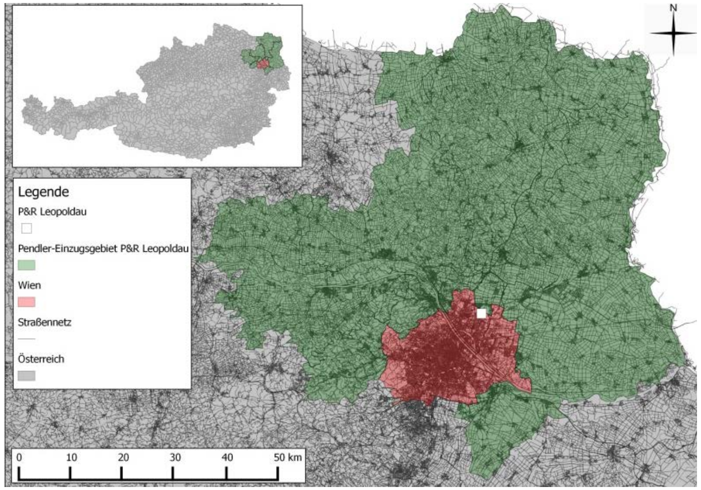
Power demand in a car park (Park & Ride)

- Distribution of parking duration and the zone of attraction



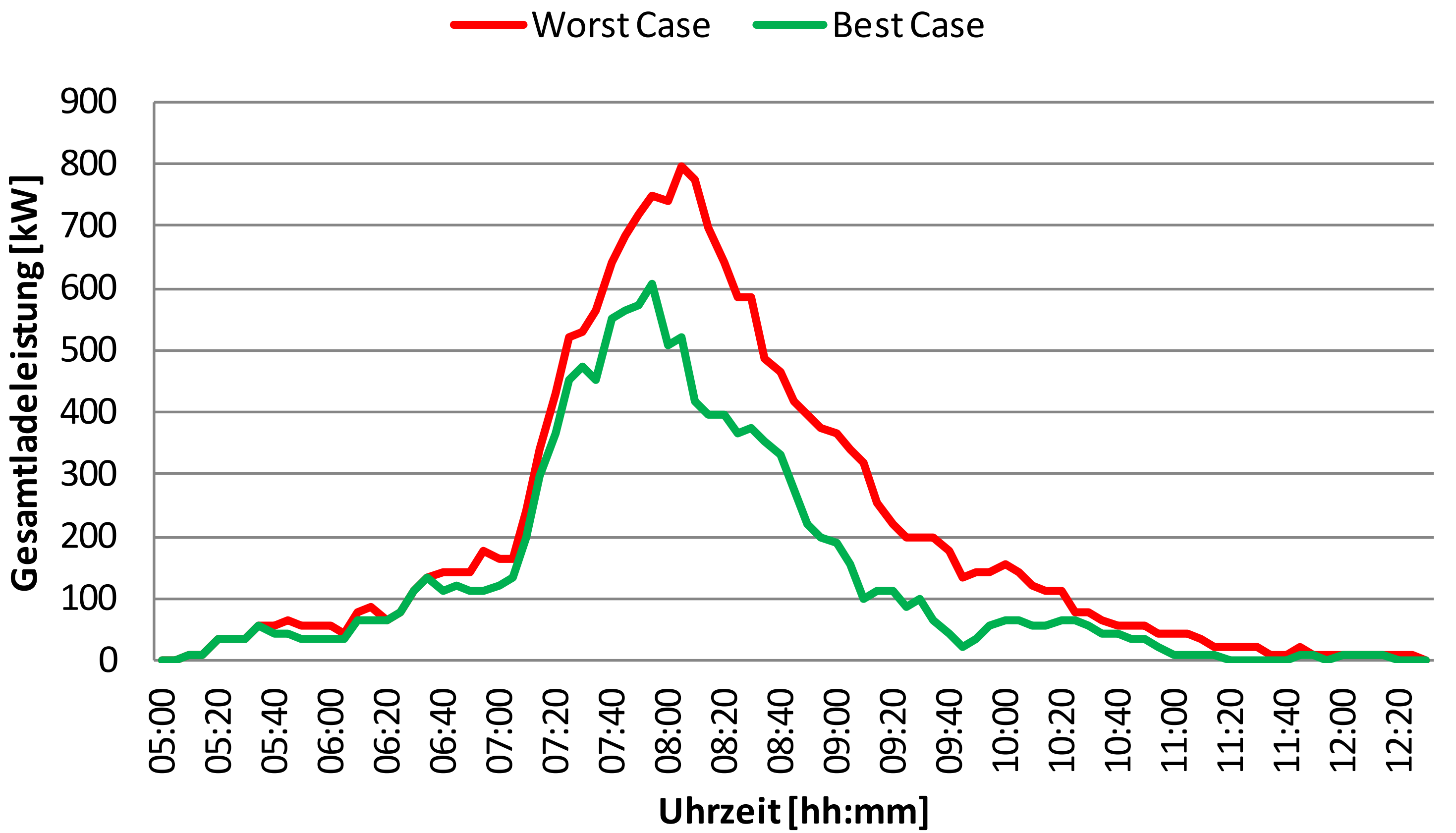
Distribution of parking duration of 147 electric vehicles (t=60min)



Zone of attraction for the car park

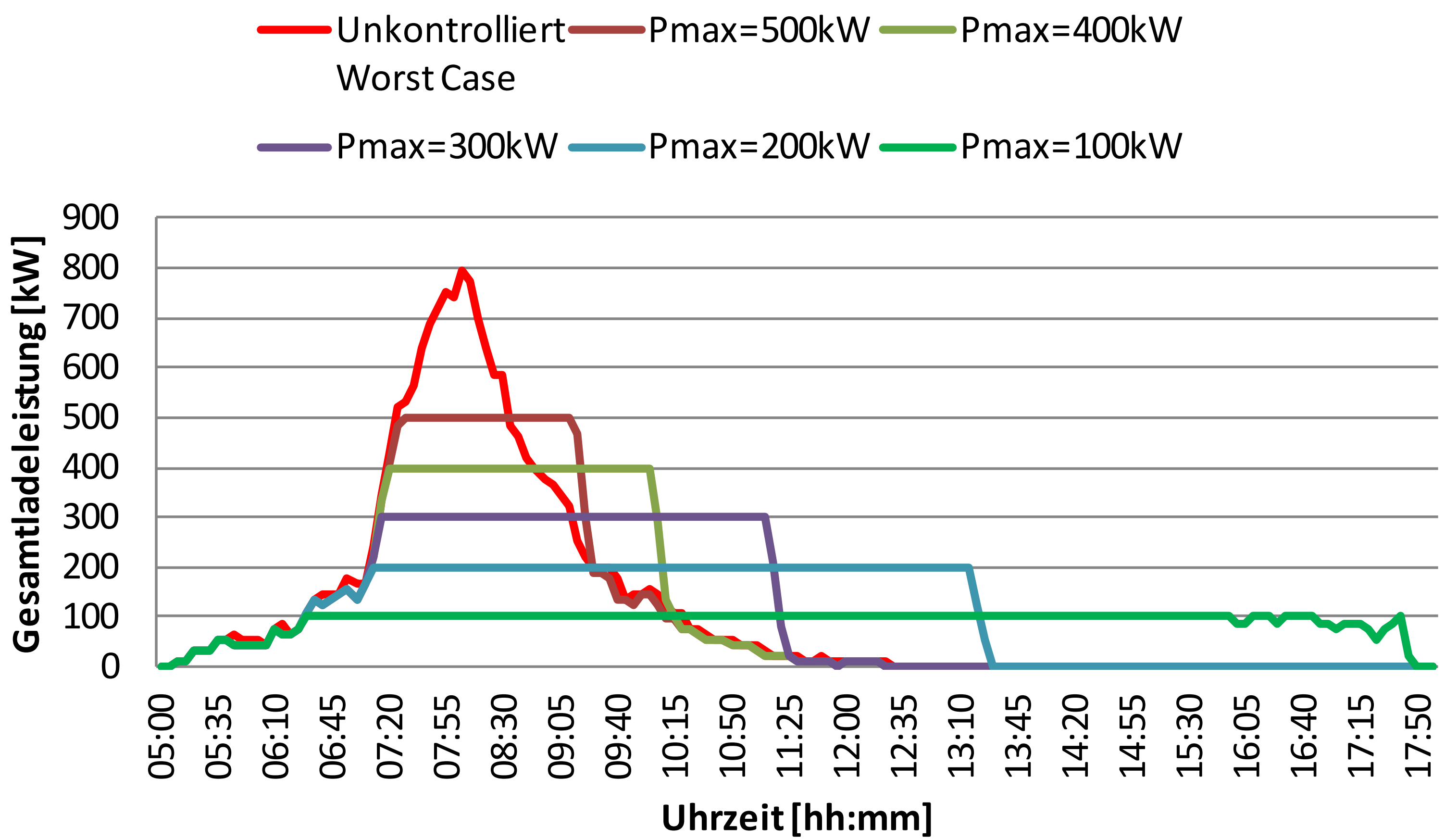
Uncontrolled Charging (2020)

- Charging power for best case (summer) / worst case (winter) (147 Cars)



Controlled Charging Worst Case - Winter (2020)

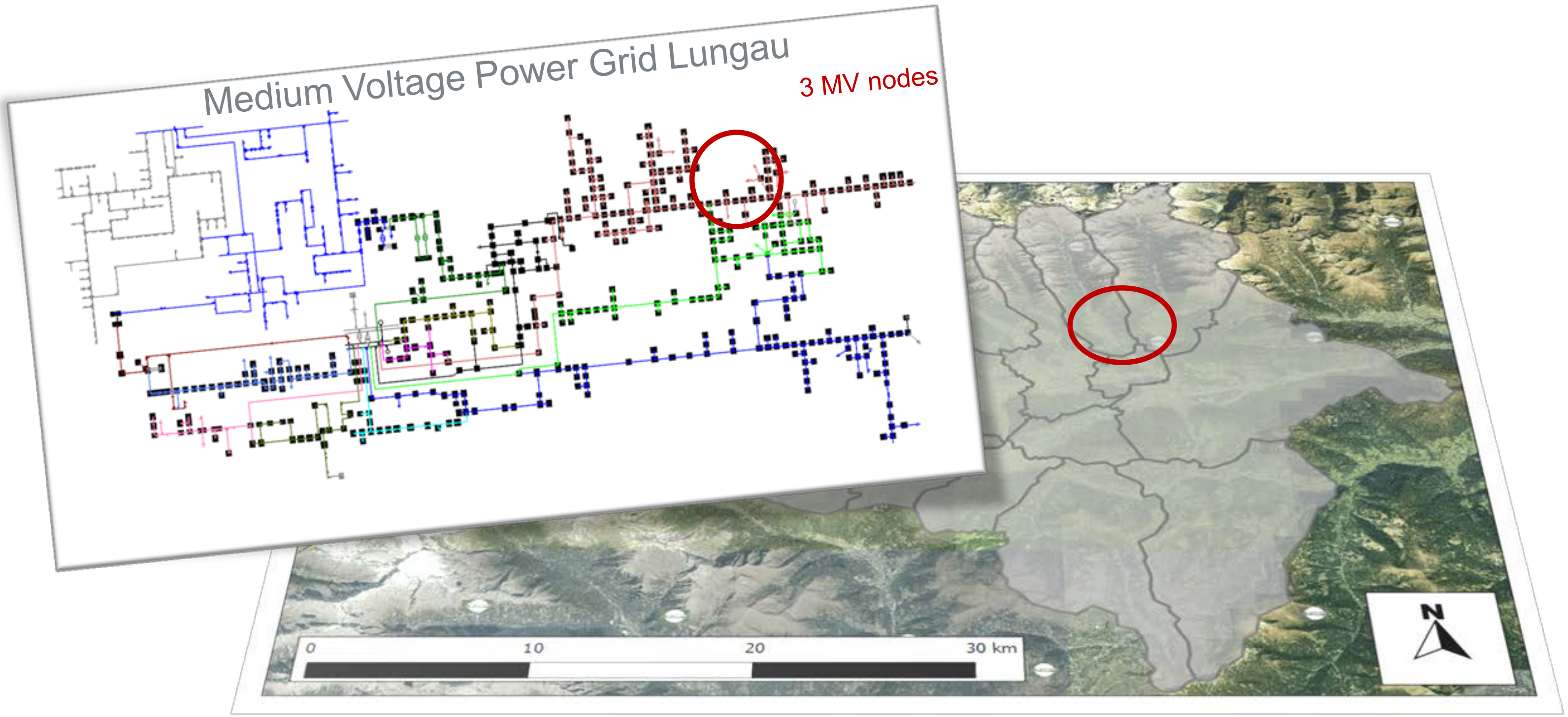
- Charging power for worst case (147 Cars)



Controlled and uncontrolled charging of BEVs (MV)

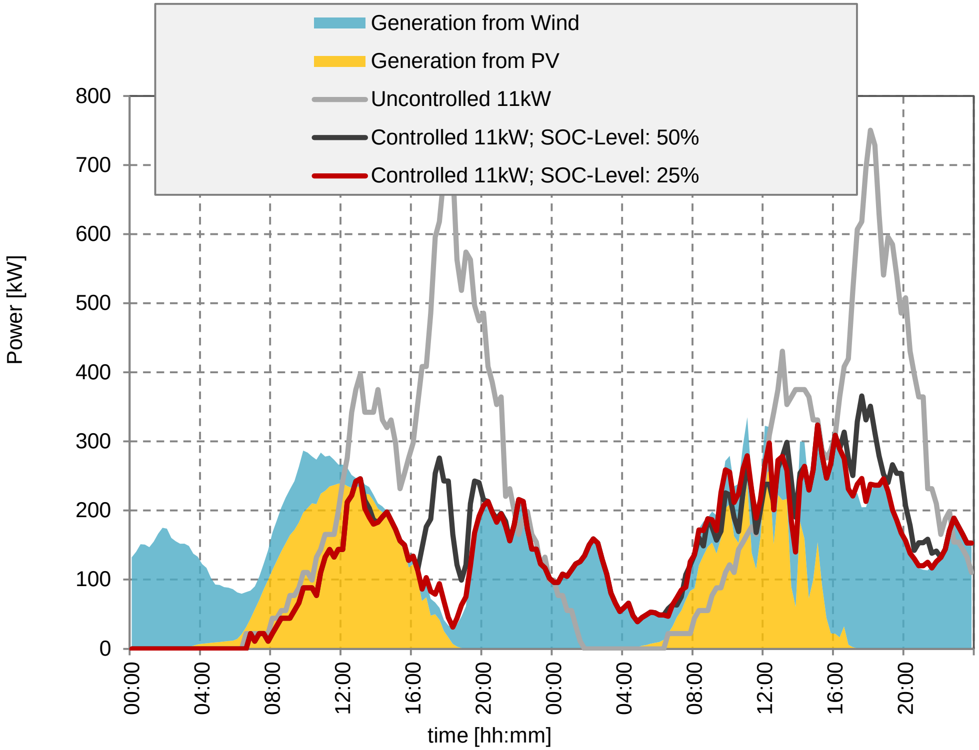
- Local supply - demand match in medium voltage networks

Number of BEVs	Battery capacity	BEV max. charging power	Power limit	PV P_{peak}
306	23 kWh	11 kW	400kW	100kW



Integration of Renewable Energy

- Local supply - demand match in medium voltage networks



Uncontrolled and controlled charging of 306 EVs with 11 kW during two sumer days.
Note: wind is accumulated on top of PV generation

Two days simulation in summer

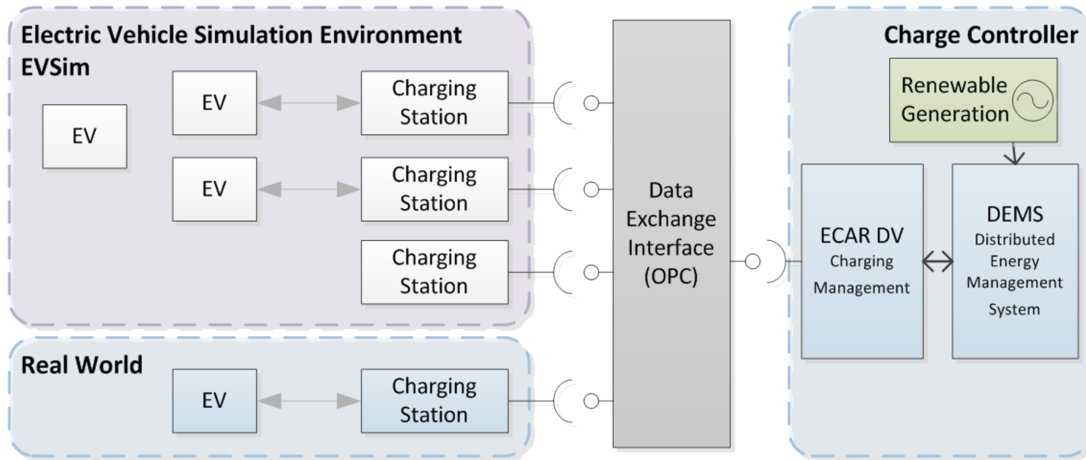
Charging Mode	empty EVs	P-peak [kW]	Charged Energy [kWh]	DER Energy [kWh]	DER Coverage [%]
uncontrolled 11kW	15	751	9964	8079	54%
controlled 11kW/SOC50	55	366	6832	8079	89%
controlled 11kW/SOC25	66	324	6229	8079	99%

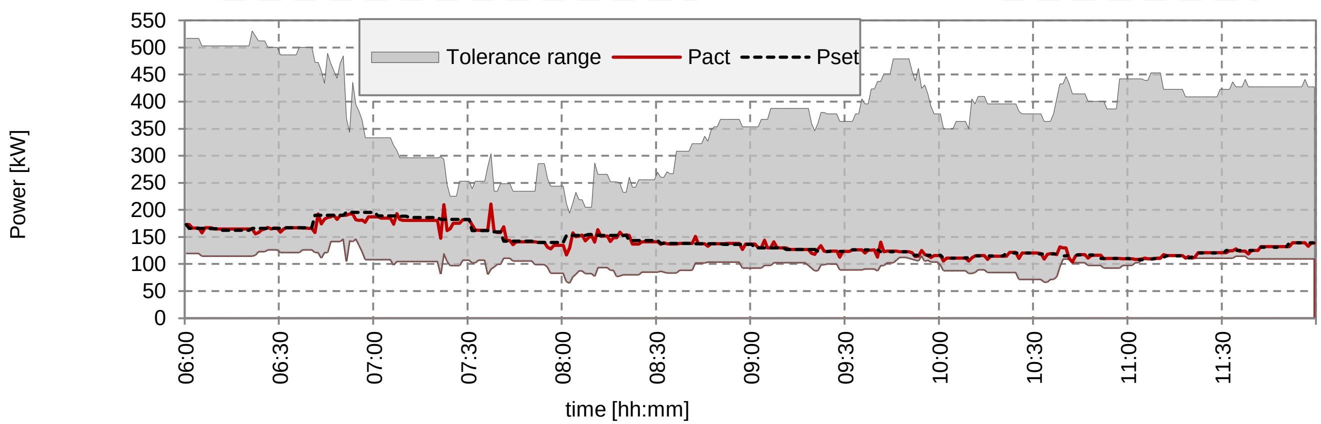
Two days simulation in winter

Charging Mode	empty Evs	P-peak [kW]	Charged Energy [kWh]	DER Energy [kWh]	DER Coverage [%]
uncontrolled 11kW	135	883	12613	3971	26%
controlled 11kW/SOC50	197	552	7267	3971	50%
controlled 11kW/SOC25	218	353	5051	3971	71%

Validation of charging management

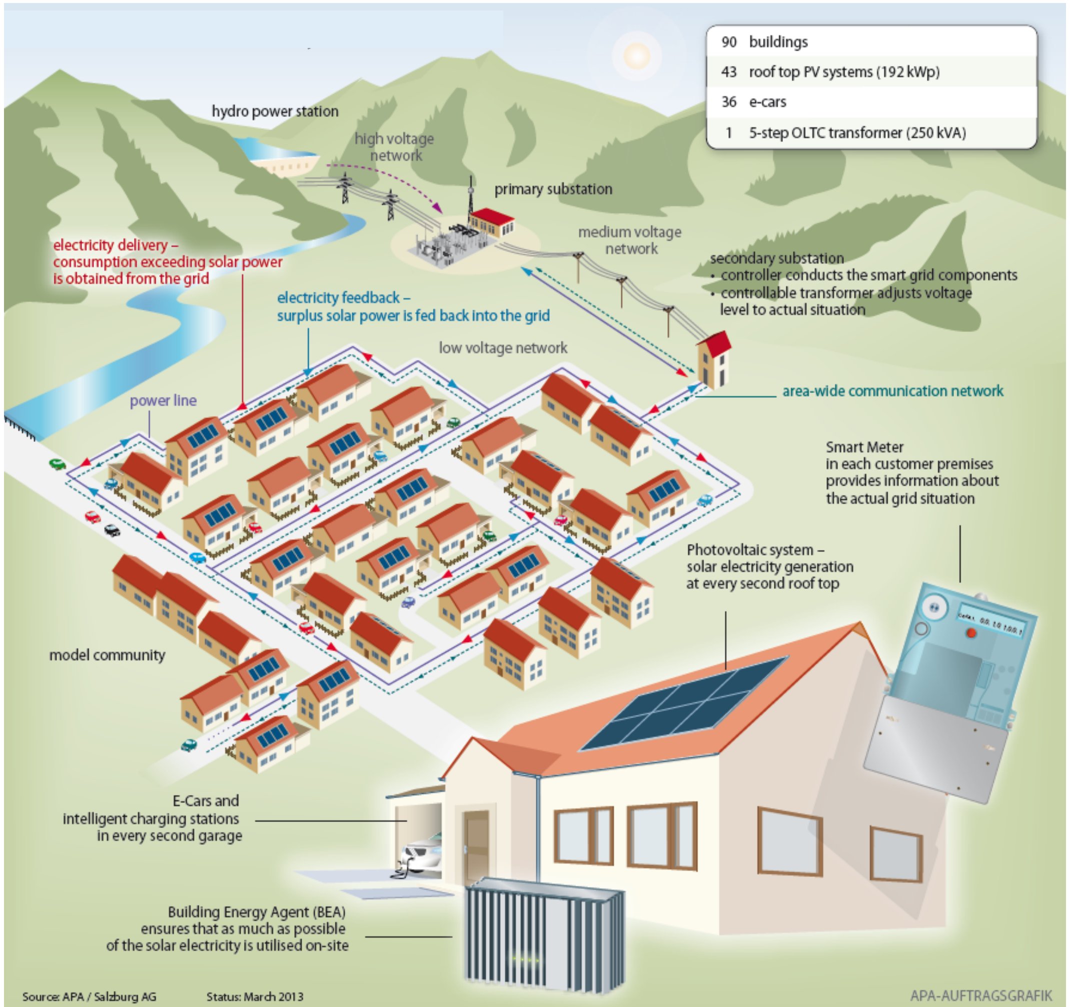
- Real and simulated EVs for charging management validation





Tolerance range, P_{set} and P_{act} during simulation and deviation

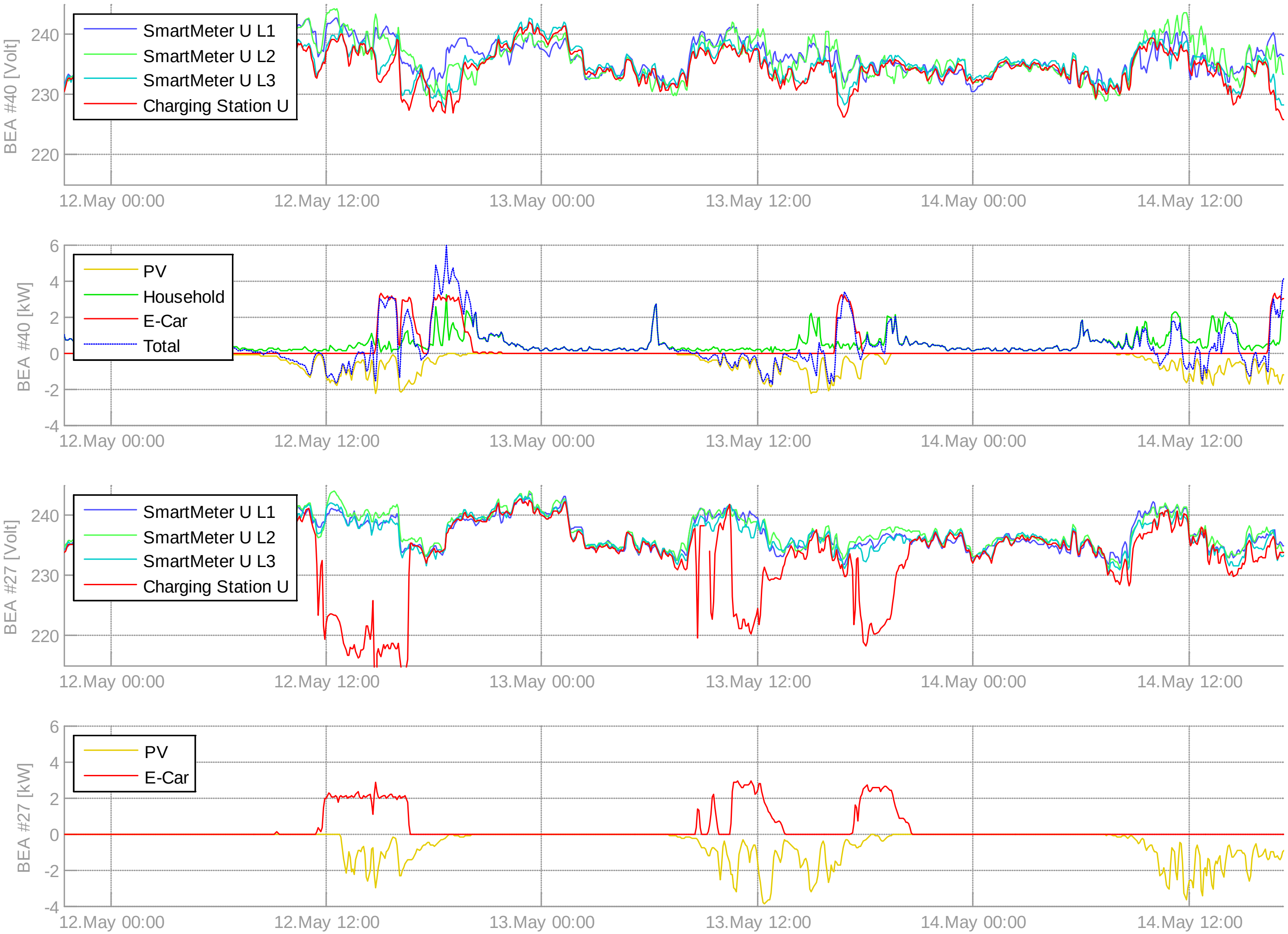
Smart Grids Model Community Köstendorf



In a dedicated demo area supplied by a 250 kVA secondary substation:

- PV system at every second roof top
- Electric vehicle in every second garage
- Field test of an integrated smart grid solution for low voltage grids
- “anticipating the future”
- funded by Austrian Climate and Energy Fund & Province of Salzburg

Controlled e-car charging



source: Roman Schwalbe, AIT

Markus Radauer, 2014

IEA DSM Task 17

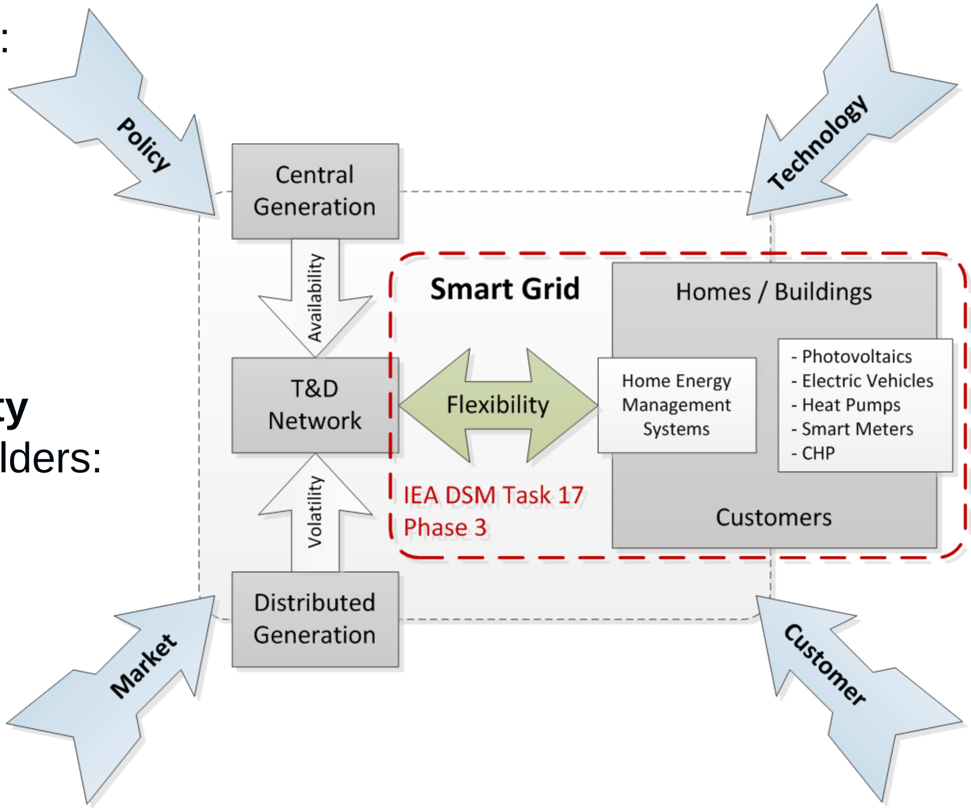
Objectives, Subtasks, Outcomes

Subtask of Phase 3 - Introduction

Systems view on enabling flexibility in the smart grid

- **Different views** on the Smart Grid:
  - Technology
  - Customer
  - Policy
  - Market

- Focus on the **enabling of flexibility** and the impact of it on the stakeholders:
  - What are the requirements?
  - How do we manage it?
  - How will it effect operation?
  - What are the benefits?



Summary

Challenges and Outlook

Summary

Changes and impact on stakeholders operations

- Mayor **differences** between **battery and DR**
- Several studies have identified **DR** as a **cost effective** way to integrate Renewables
- Processes with **thermal** or **electric storage** have high potentials
- **Large** customers, but also **medium** and **small** customers could be targeted
- Charging / **positive** power has more potential
- DR for **balancing forecast uncertainties** of **renewables**
- **Dynamic of load** is a challenge for the system operation.
  Research in understanding and developing tools (e.g. prediction) needed

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Appendix

Additional Information

Subtask of Phase 3 – Subtask 10

Role, and potentials of flexible prosumers (households, SMEs, buildings)

- **Controllability** requirements (generation and consumption)
- **Opportunities**, **challenges** and **barriers** for flexibility services (providers and technologies)
- Energy and power **balancing potentials**
- **Smart technologies** (SM and Customer Energy MS)
  - VPPs
  - EV charging
  - DG-RES integration and storage
  - Integrating heat pumps and thermal storages

Subtask of Phase 3 – Subtask 11

Changes and impact on stakeholders operations

- Methodology development for **assessing/quantifying impact**
- **Grid**, **market** and **customers** (prosumer/consumer) interaction
- Sharing common **benefits/losses**
- **Optimization potential** (eg. DR building audits and customer requirements)
- **Regulatory** and **legislative** requirements
- Comparison **costs** vs. delayed **investments**

Subtask of Phase 3 – Subtask 12

Sharing experiences and finding best/worst practices

- **Collection of data**
  - Workshops

- **Lessons learned** from existing pilots
  - EcoGrid-EU Bornholm, PowerMatchingCity I and II, Linear, Greenlys, Building2Grid, SmartCityGrid: CoOpt, eEnergy, …

- **Country specifics**
  - differences in the implementation
  - applicability

- **Extrapolation** of the results from previously collected projects on applicability

Subtask of Phase 3 – Subtask 13

Conclusions and recommendations

- Based on the **experts' opinion**

- Will provide a **ranking** based on
  - Impacts
  - Costs
  - Future penetration of the technologies

CEMS and Power Management System interfaces

IEC 62746 Technical Report Objective

Use cases and requirements for the interface between the power management system of the electrical grid and customer energy management systems for residential and commercial buildings and industry.

- User stories → use cases → data model → information content & structure
- Examples:
  - The user wants to get the laundry done / EV charged by 8:00pm
  - Grid recognize stability issues
  - CEM feeds own battery pack energy into own network or into the grid
  - Heat pump and Photovoltaic Operation with Real-Time Tariff

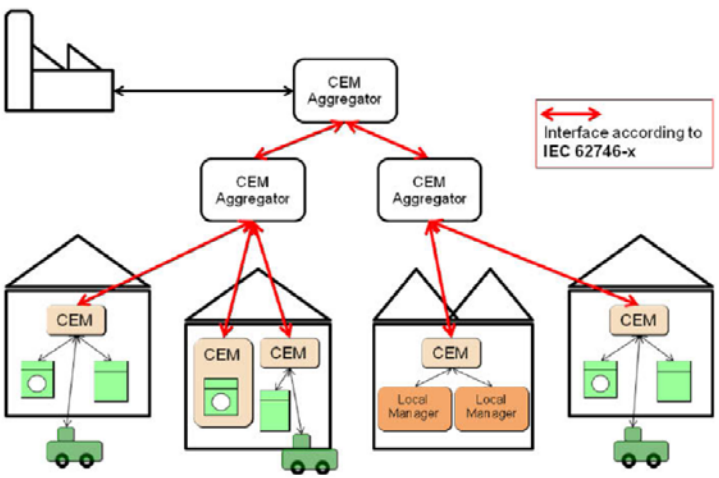

Figure 6: Cascaded CEM architecture