A critical perspective on international demonstration projects, results and their scalability

Workshop on Demand Response

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IRGC, EPFL Lausanne, Sept.2015

Postulations

- **Demand response not wanted**
  - customer participation does not work („toy effect“)

- **Is not economical**
  - Economic potential of DR on household level at Central European market conditions [Prüggerl2013]
    - Household loads: 1€ - 6,5€ / year (2%- 15% shifting)
    - Heatpumps: 4,4€ - 110€ year

- **Real potentials are small**
  - comfort comes for savings

Motivation for Demand Response at Households

Need for flexiblity of the demand

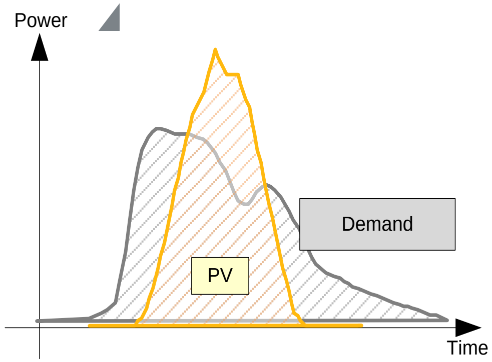
§ Increase of (**local) distributed generation** (e.g..: PV, CHP, Wind)

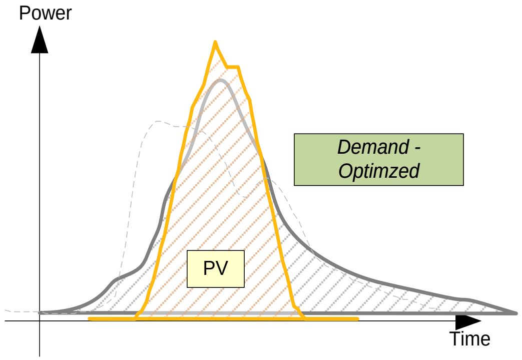
à **PV: „grid-parity“**

à **Impact on network: curtailment**
(Germany: since 2013: 70% Peak curtailment)

à **Higher dynamics** in the power system

à **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) / Heatpumps (“Smart Grid Ready”)
- **Electric vehicles** – electrical storage
  - Controlled charging
- **Public services** – load shifting
  - Water pumps
  - Waste water / sewage

- **Storages** à 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 à Virtual Power Plant

Potentials of DR

Technical and practical potentials in Germany

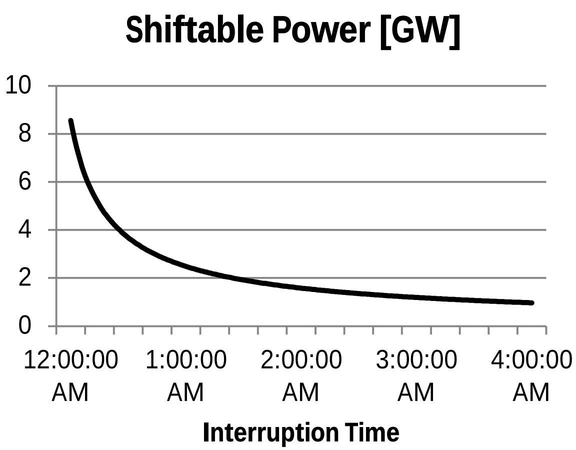
sectors	Techn. shiftable power	Displacable Energy
Household	2010: ca. 2,6 GW 2020: ca. 3,8 GW 2030: ca. 6,0 GW	2010: ca. 8,0 TWh per year 2020: ca. 12,4 TWh per year 2030: ca. 32,3 TWh per year
Tertiary sector	2010: ca. 1,4 GW 2020: ca. 1,7 GW 2030: ca. 1,8 GW	2010: ca. 5,0 TWh per year 2020: ca. 5,6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

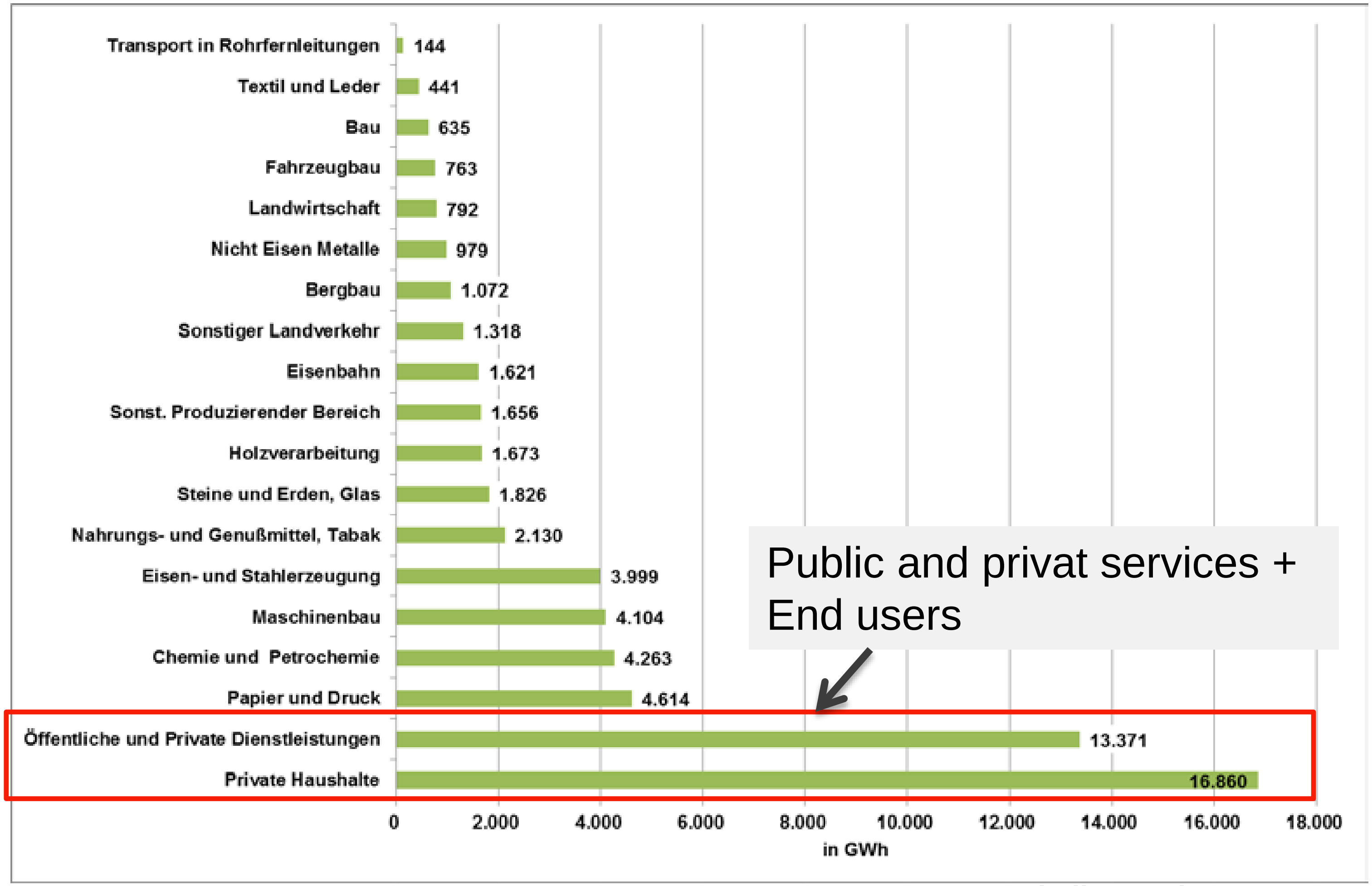
§ 1,5 GW load shifting potential in Germany especially through thermal applications

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



Potentials of DR

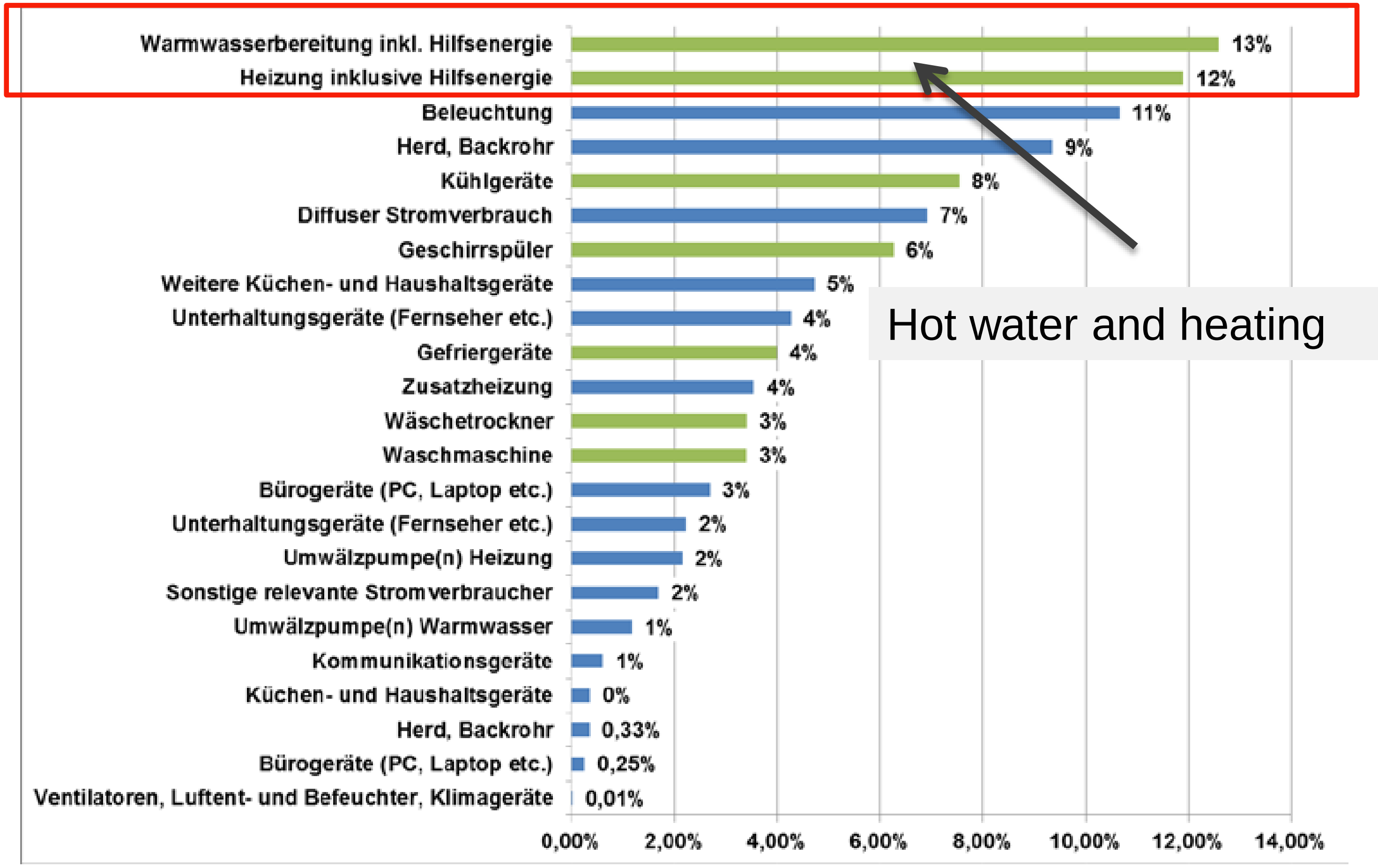
Sectorial electricity end use in Austria (2012)



Source: Statistik Austria, 2012

Potentials of DR

Categories of electricity use in households (2012)

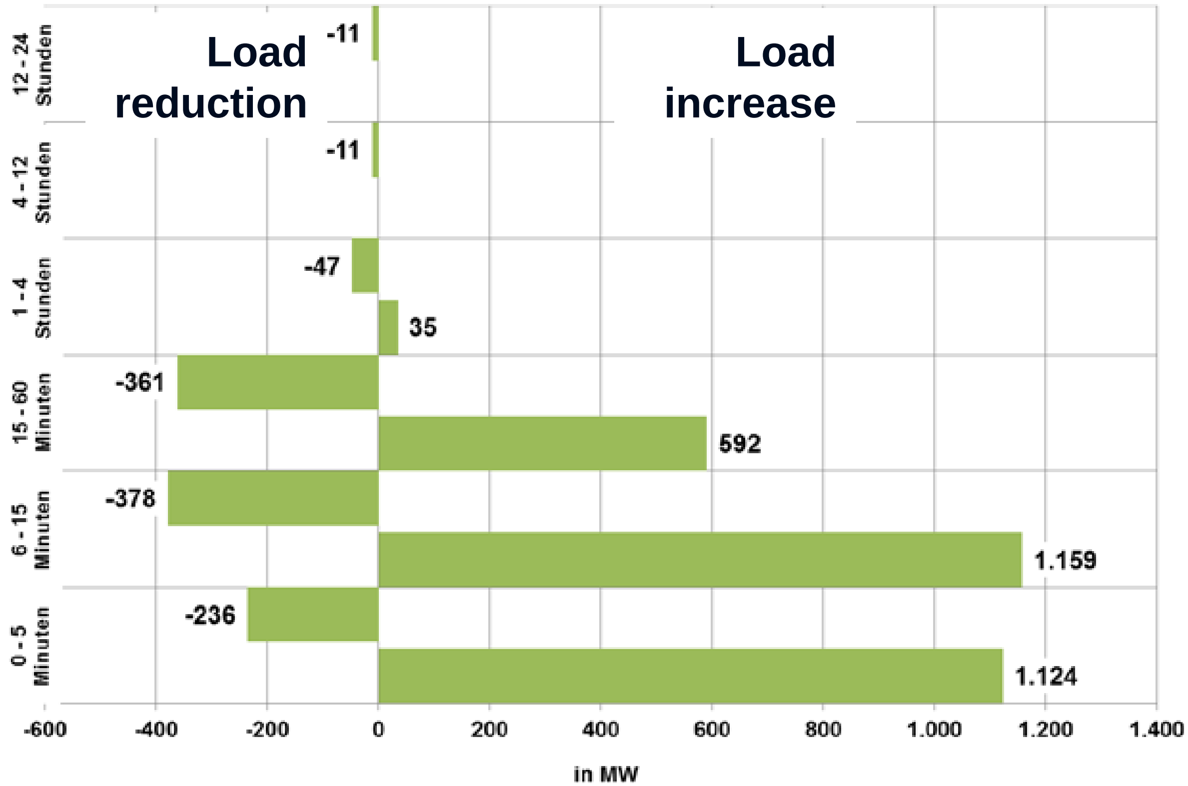


Source: Statistik Austria, 2012

Potentials of DR

Technical potentials in Austria

§ Practical load shift demand at households in Austria

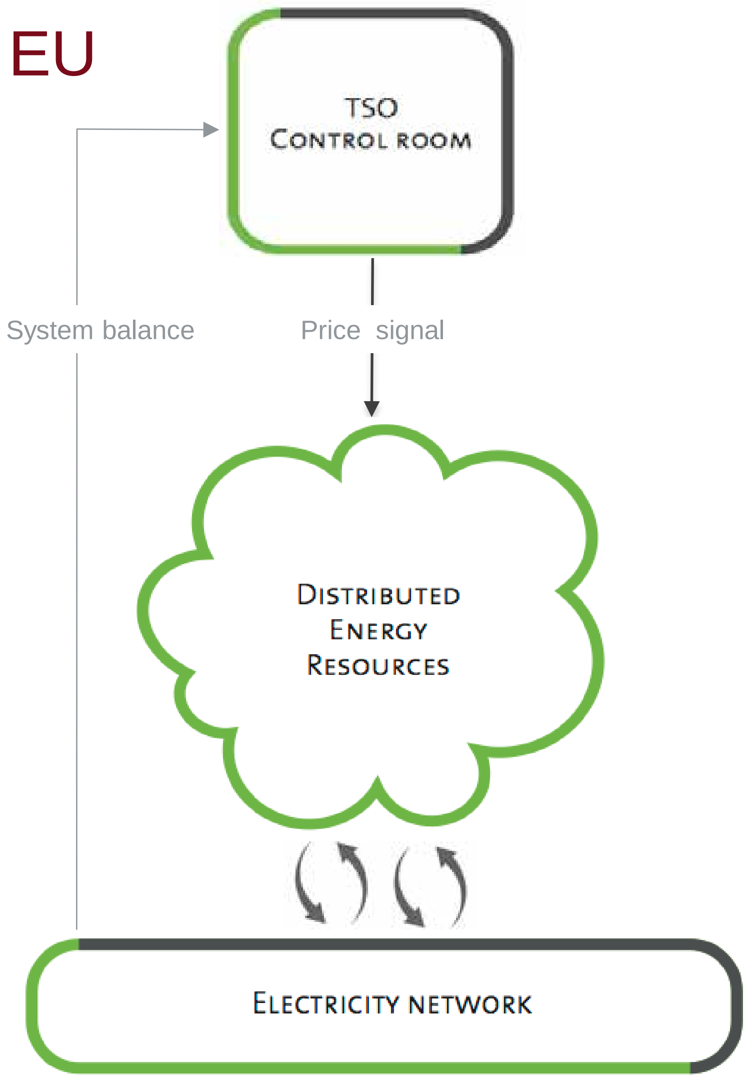


Source: Energieinstitut an der JKU Linz – Project „LoadShift“

Examples from pilots and field tests

Results and Evaluation of DR Potentials

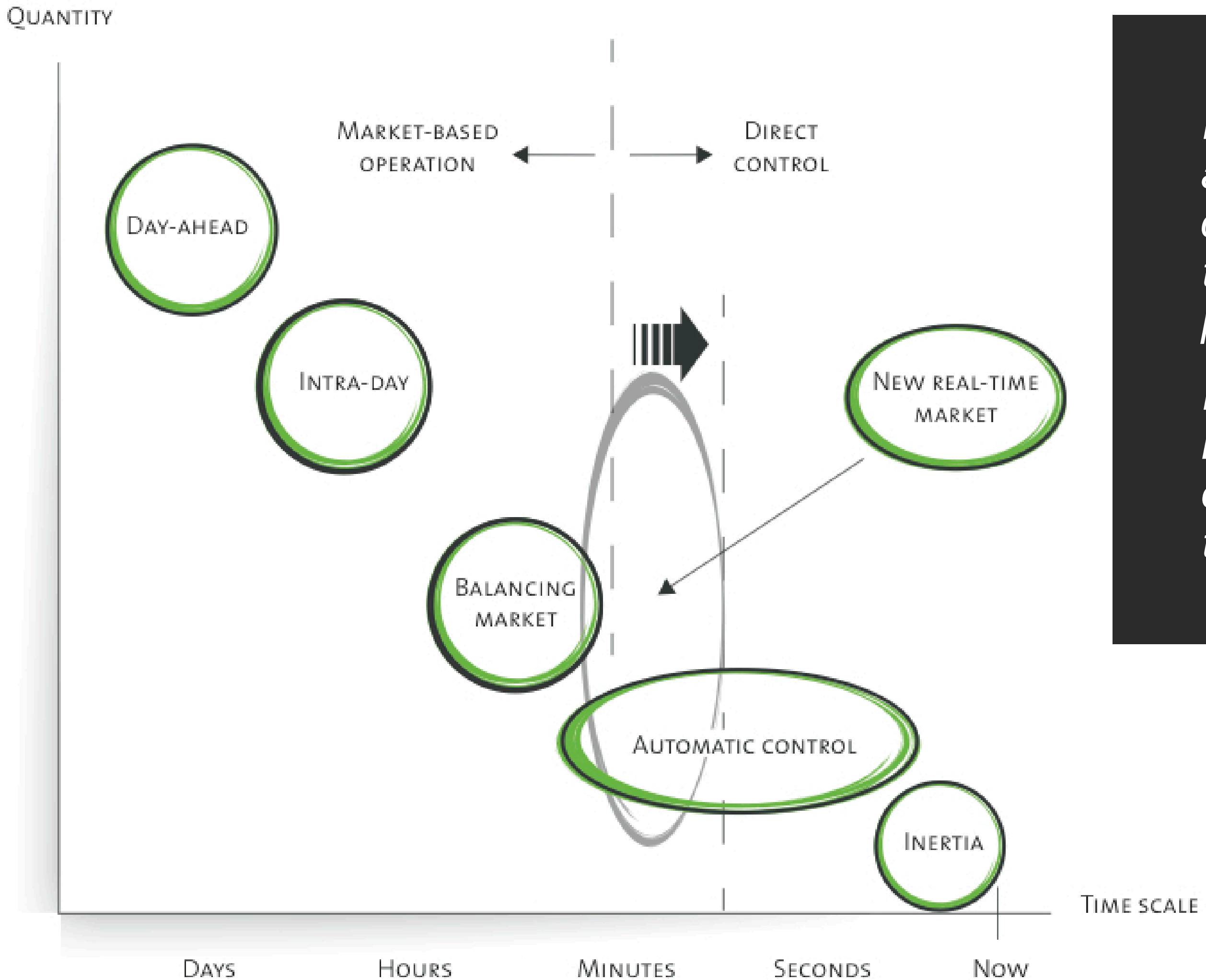
EcoGrid EU



The market concept allows regulation of price signals without direct measurement of the individual DER response

*DER = Distributed Energy Resources

EcoGrid EU



EcoGrid is an example of a real-time market that can be implemented in the context of existing power markets.

EcoGrid supports the need for direct control options on a very short time scale

2000 Participating Customers in the Demonstration

200 households with smart meters

No access to specific information

Manual Control

500 households with smart meters

Receiving simple market price information

Must move their energy consumption on their own

Automatic Control

700 automated households with IBM-Green Wave

Reality equipment and smart meters

All houses have heat pumps or electric heating – responding autonomously to price signals

Aggregated automatic Control

500 automated households with Siemens equipment and smart meters

All houses have heat pumps or electric heating – responding to control signals

Smart Businesses

Up to 100 costumers with smart meters

Including small business and public customers

Connected smart appliances – responding to control signals

Why a new model for evaluation?

- Experimental groups not comparable to the control group due to differences in group composition in terms of
  - Heating systems (type, wood stoves)
  - Usage (Holiday houses)

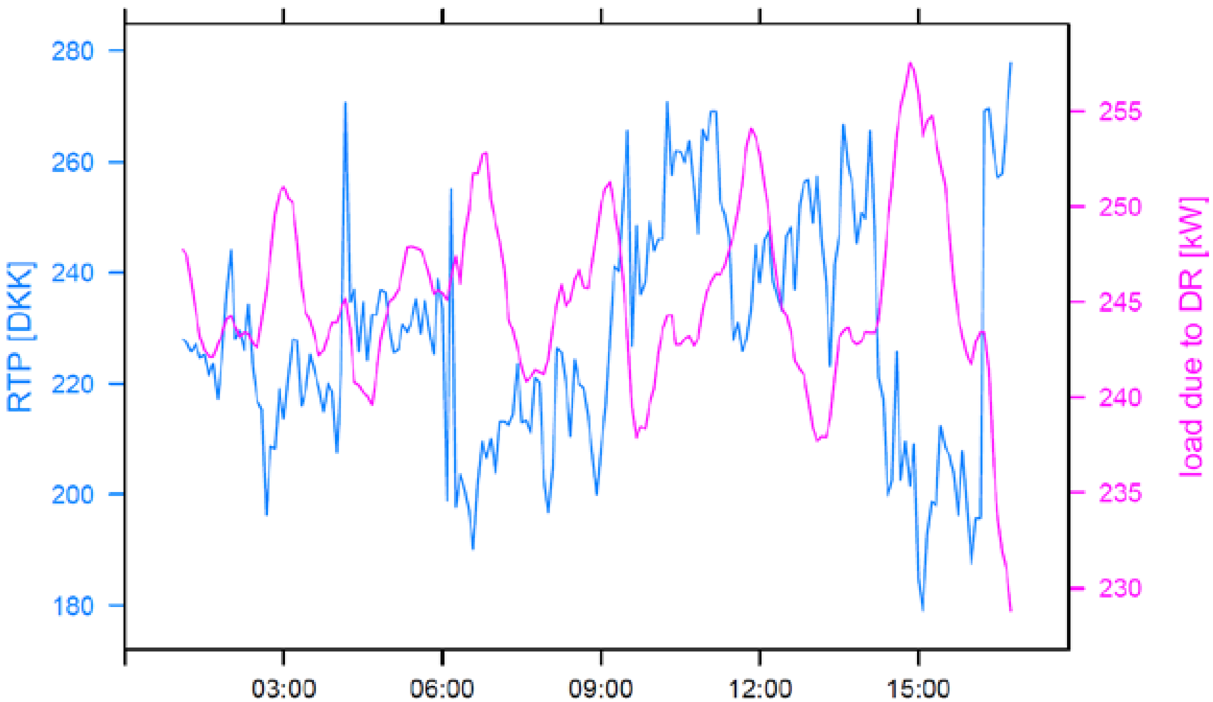
- Market model is mostly nonlinear

  - Models systems response, but not statistically treatable

- Therefore a purely linear model was used

Sample reaction

- Although linear, not always the same reaction to the same price due to influence from the past



Manual Customers

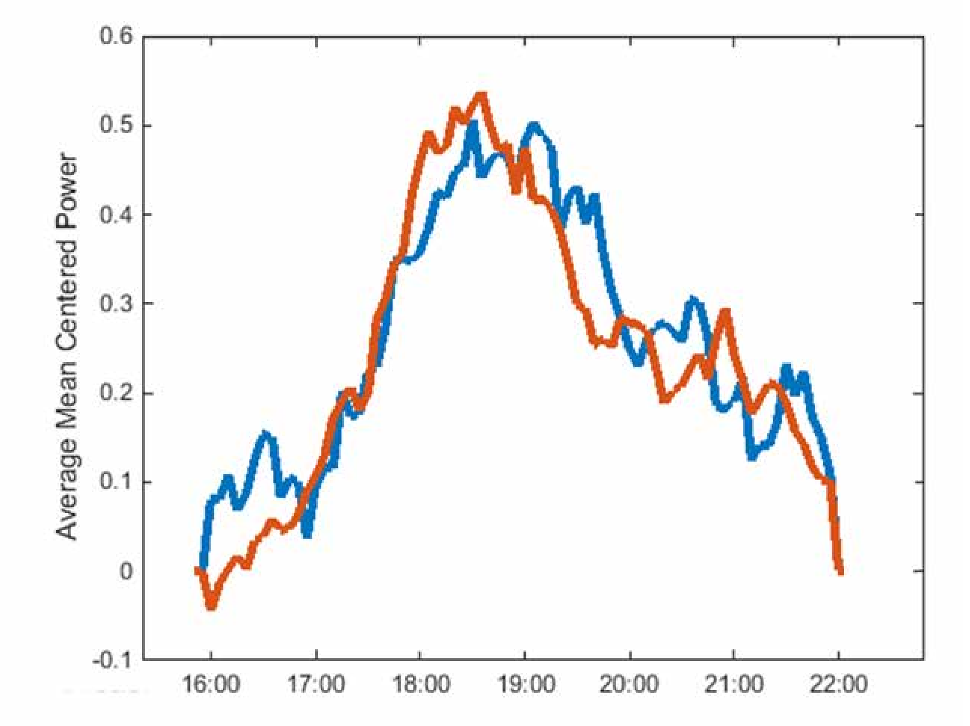
- Tested in detail with very extreme control signals

- Results for (for high prices)

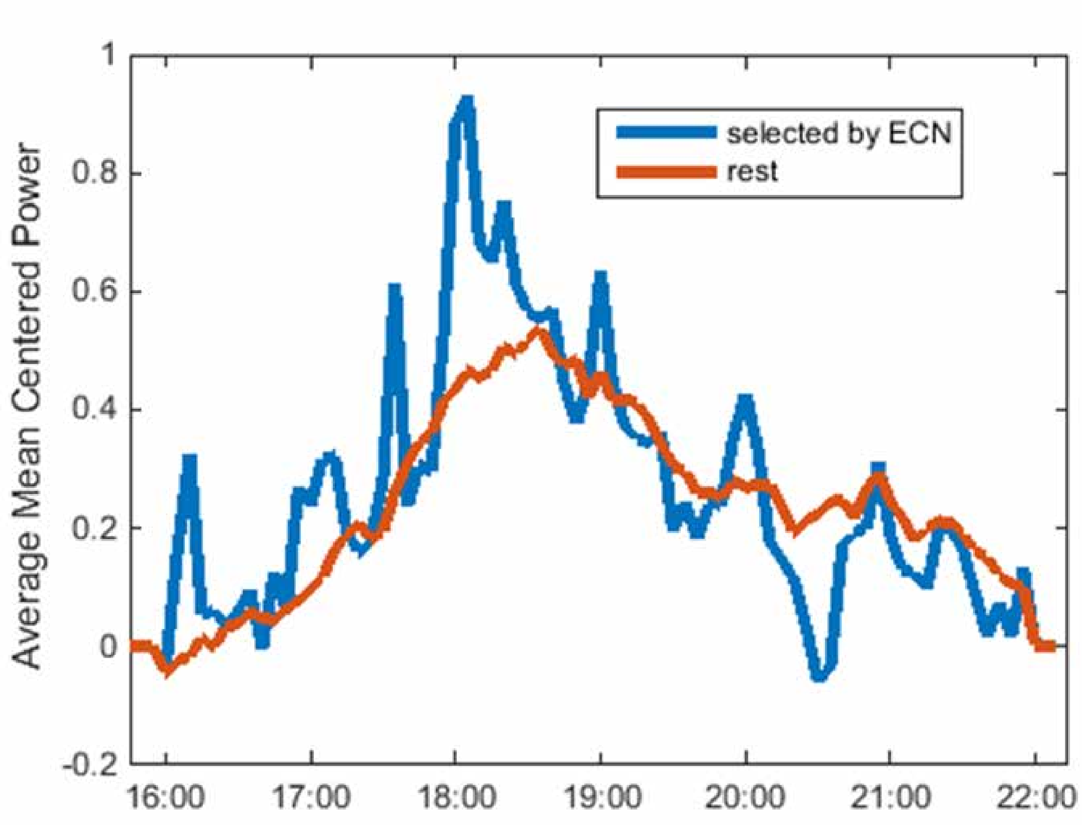
    - Reference group used for qualitative behavior

    - manual group (red)

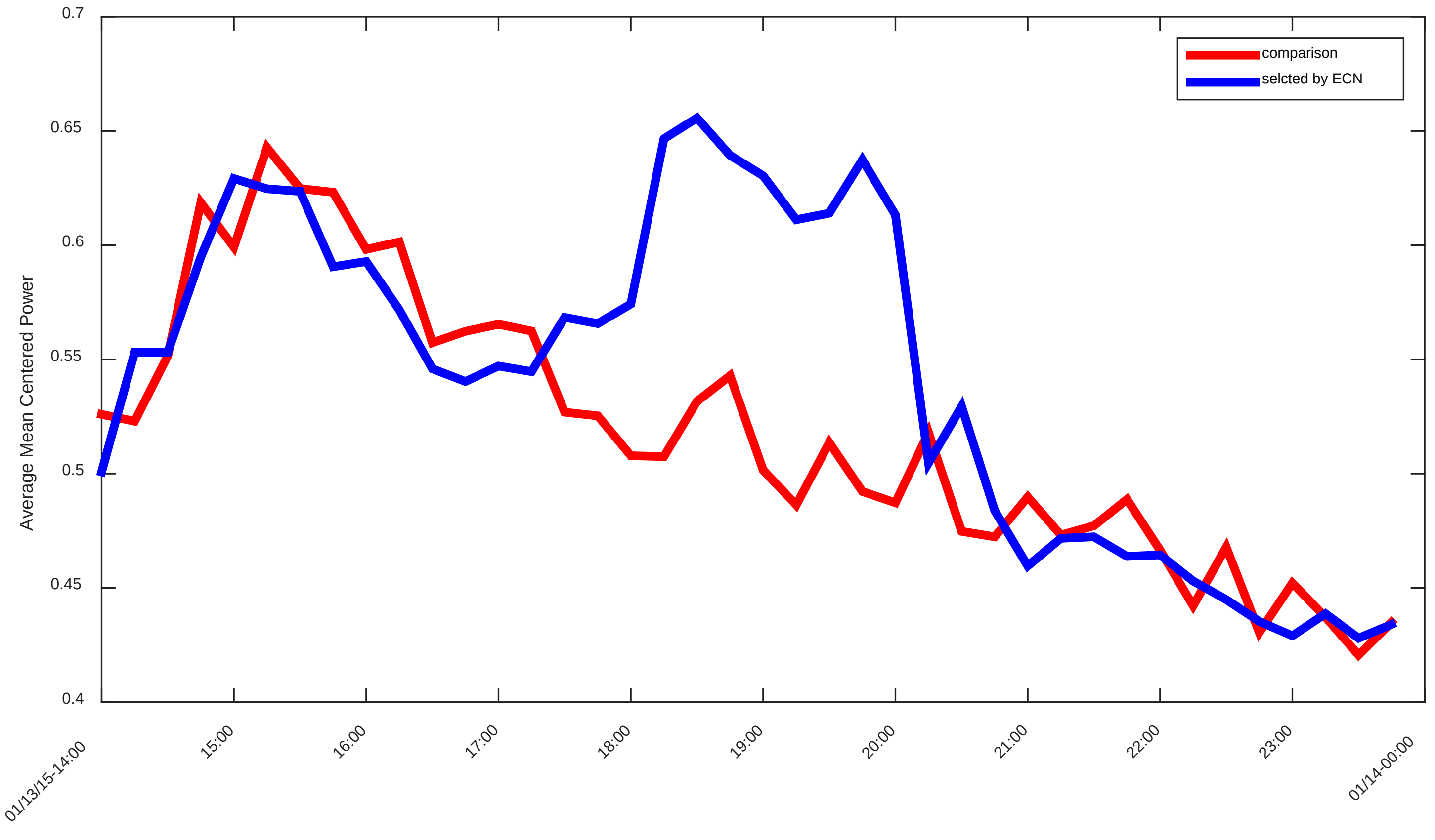
  and reference group (blue)



Very high prices – customers claiming to use the FBS



Very low price – customers who claimed to use the FBS



Hourly Response

	Increasing RTP [kW]			Decreasing RTP [kW]		
	Best	Average	Worst	Best	Average	Worst
Reference	0,0306	0,0017	0,0000	-0,0323	-0,0017	0,0000
Manual	0,0166	0,0013	0,0000	-0,0170	-0,0013	0,0000
Siemens	0,3177	0,0147	0,0000	-0,2101	-0,0147	0,0000
All households connected by IBM	0,1413	0,0089	0,0000	-0,1329	-0,0089	0,0000

No comparison feasible because of

- Group composition
- Degree of automation (simply blocking heat sources vs. home automation)

Demand response potential in EcoGrid project

§ Normalized to group size (by average load) [%]

- Groups	- Increasing RTP [%]		- Decreasing RTP [%]		- Increasing DA [%]		- Decreasing DA [%]	
-	- Best	- Average	- Best	- Average	- Best	- Average	- Best	- Average
Semi-automated heat pumps (1A)	-20,5%	-1,5%	20,5%	1,5%	-10,9%	-0,5%	12,9%	0,5%
Semi-automated electric heating (1B)	-12,1%	-0,7%	9,4%	0,7%	-4,8%	-0,4%	5,1%	0,4%
Semi-automated heating with aggregation (1C)	-6,1%	-0,3%	6,4%	0,3%	-5,3%	-0,6%	5,2%	0,5%
Fully automated electric heating (2)	-41,7%	-1,9%	27,6%	1,9%	-23,4%	-1,6%	23,1%	1,6%
Manual	-2,6%	-0,2%	2,7%	0,2%	-12,5%	-0,5%	10,5%	0,5%

Replicability and Scalabilty

- household characteristics
- customer demography
- acceptance of automation
  - increase of comfort and savings
  - overrule
  - information / support
  - needs to keep it simple as possible

- Need of ICT infrastructure (e.g. AMI, big data handling)

Project SGMS-HiT– Smart Grids Model Region Salzburg

Buildings as interative participants in the Smart Grids

klima+energie fonds · 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**
  à **Buffering** with thermal storages

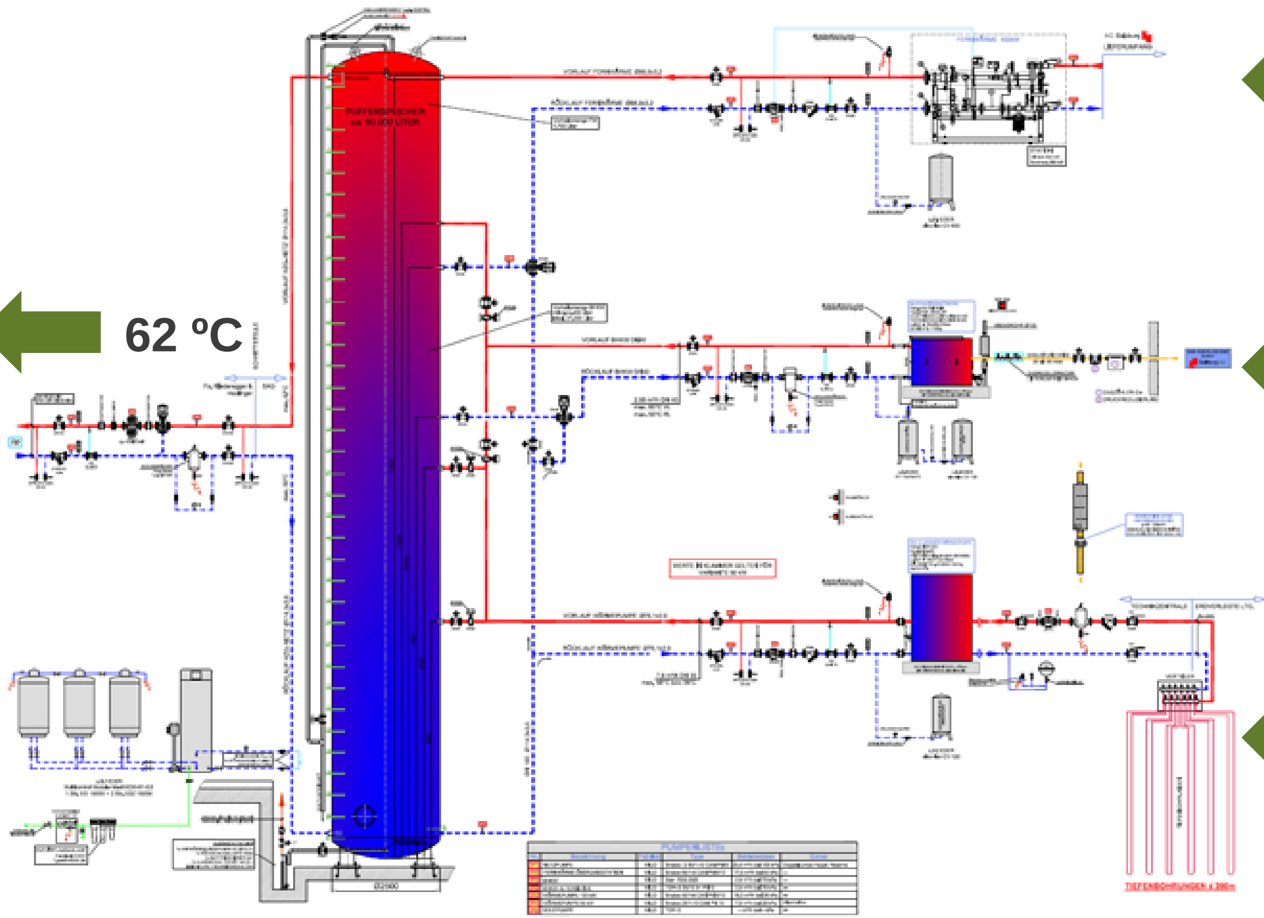
- Use **energy** which is most **efficient** for the grid
  - PV - Heatpump
  - Biogas (CHP)
  - Grid
  - District heating

  à **grid friendly building**

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

SGMS – HiT

Three heat sources feeding into one storage tank



62 ºC

District heating

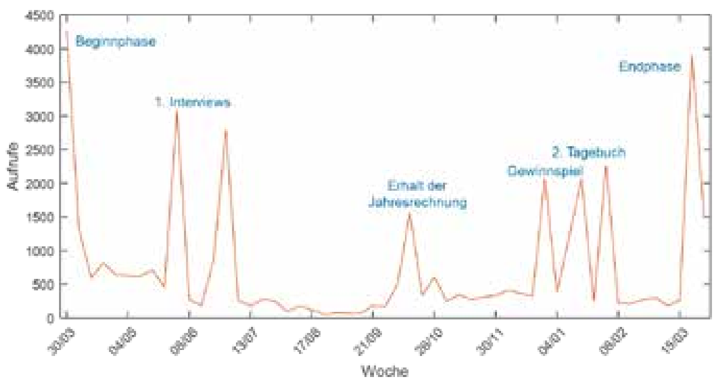
Combined heat and power plant
(68 kW therm,
30 kW elec)

Heat pump
(45 kW therm)

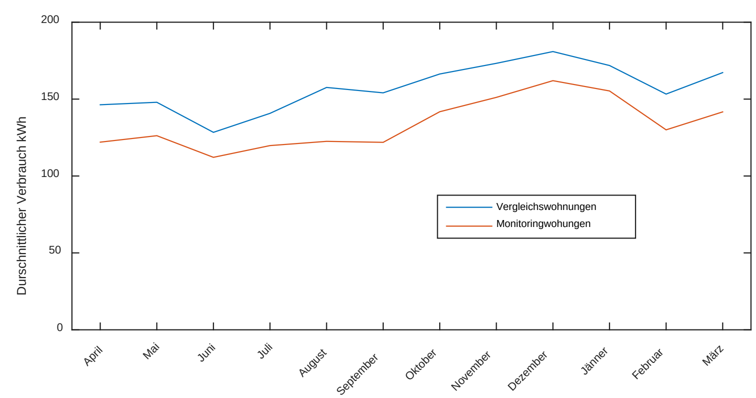
90m³ Hot water storage tank

SGMS – HiT – Consumer Evaluation

- Usage of *Smart Center*

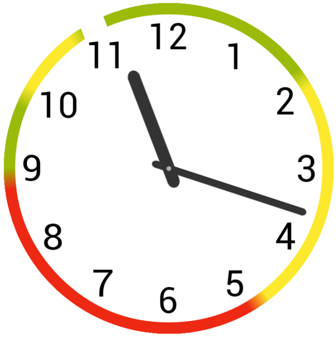


- Energy Consumption
  - EcoButton
  - Dish Washer shiftable
  - Cooking not shiftable
  - Comfort for consumption



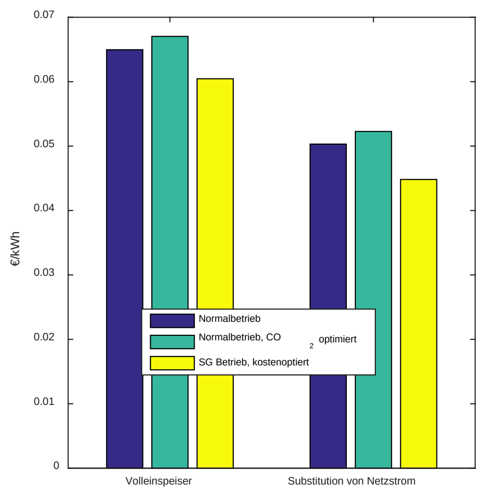
SGMS – HiT - Building Energy Management System

§ Results of load shifting:



Heat source	Red	Yellow	Green
CHP	+17 %	-11 %	-6 %
HP	-12 %	+9 %	+3 %

§ Cost savings:



Postulations

- **Demand Response ~~not~~ wanted**
  - Increase the *direct use* of generated energy (PV use, EV charging)
  - Keep it simple, no over engineering
  - Potentials in areas of *low system reliability* (little energy better than no)

- **Is ~~not~~ economical**
  - Building energy management system (MPC) save up to 30%
  - Additional objectives with „grid friendly“ constraints

- **Real potentials are NOT small**
  - Start with the *„low hanging fruits“*
  - Big loads with technology which is in place (ripple control, smart meters)
  - No comfort loss, even increase

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