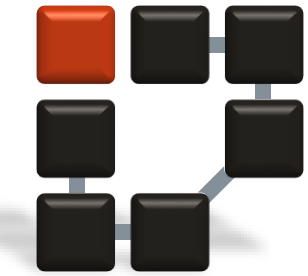
SWARM

Increasing Households' Internal PV Consumption and Offering FCR Power with Distributed Batteries

Energieinformatik 2015, Karlsruhe

David Steber, Peter Bazan, Reinhard German



Computer Science 7
Computer Networks and
Communication Systems

FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG

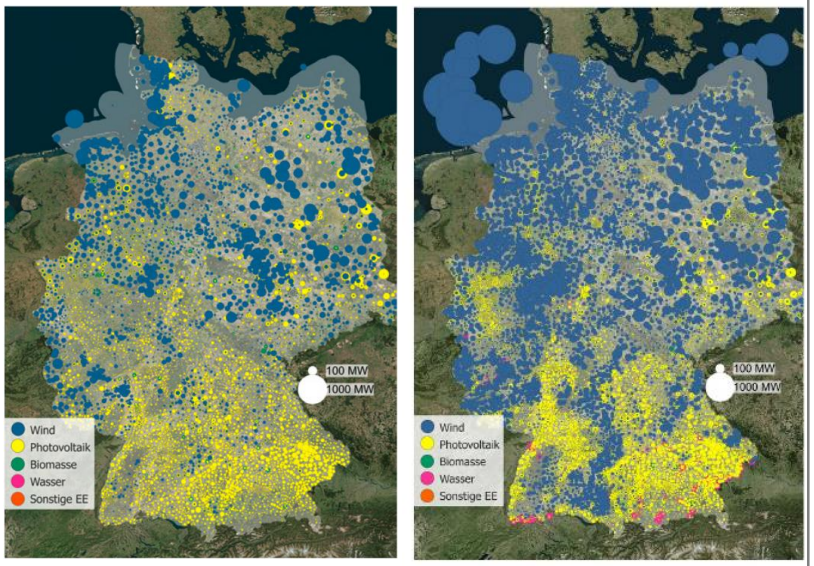
Outline

- Motivation
- Overview SWARM Research Project
- i7AnyEnergy Simulation Toolbox
- SWARM Simulation Model
- Results
- Conclusion & Outlook

Motivation

German GDP scenario framework

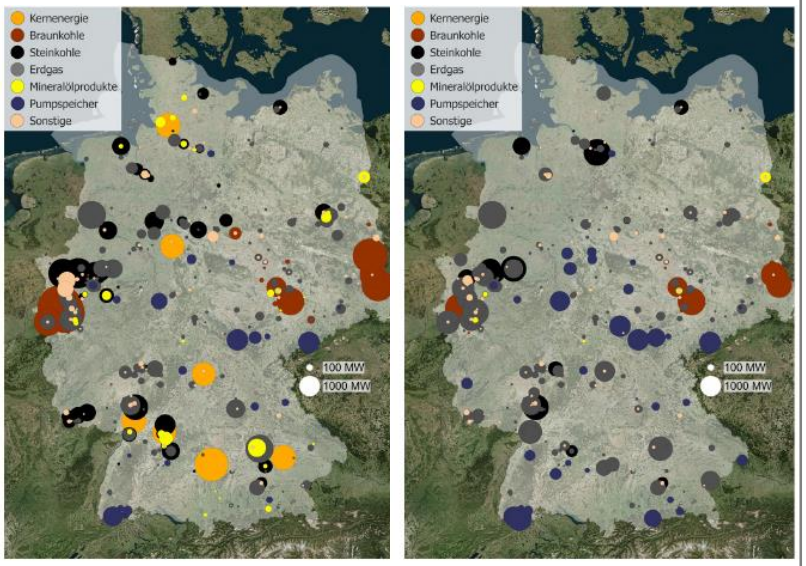
RES 2013 → RES 2035



81,1 GW → 181 GW

German GDP scenario framework

CPP 2013 → CPP 2035



101 GW → 77,6 GW

- Conventional power plants will no longer be capable of contributing to ancillary services as today[1]

➢ **demand for sustainable & alternative solutions**

[1] dena Ancillary Services Study 2030

Storage With Amply Redundant Megawatt **SWARM Research Project**

- Cooperation between Caterva GmbH, Munich and N-ERGIE AG, Nürnberg

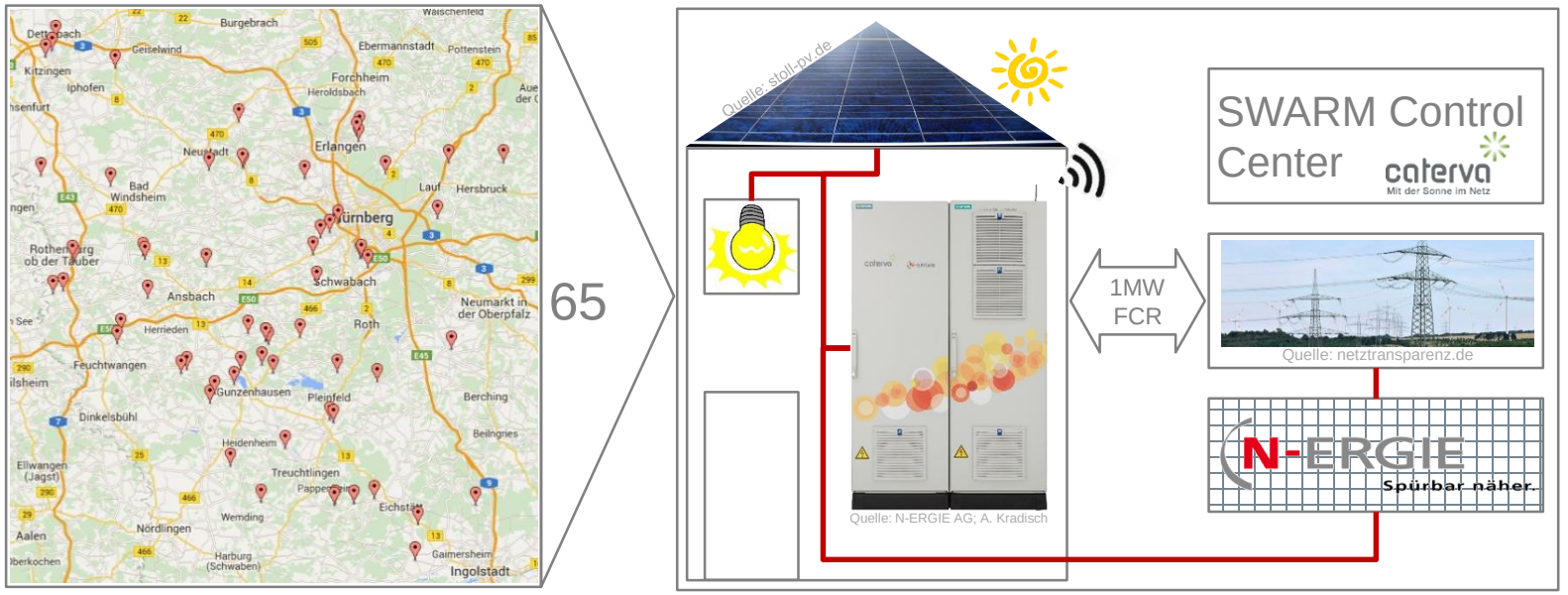
caterva Mit der Sonne im Netz

N-ERGIE Spürbar näher.

funded by Bayerische Staatsregierung

- Research Topics
  - Household's benefit of installing a battery energy storage system (BESS)
  - Changes in local distribution grid
  - Comparison of conventional and SWARM's frequency containment reserve (FCR)
  - User behavior and motivation

SWARM Research Project

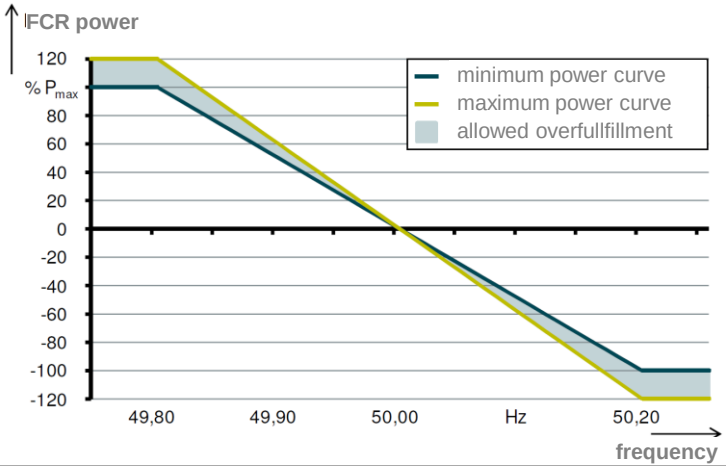


- Caterva BESS
  - P_n = 20 kW, η > 90 %, net capacity CAP_{ESS} = 18 kWh
- Virtual mass storage *SWARM* prequalified for FCR market in summer 2015

Current FCR Regulations

- Transmission Code
- Key issue papers published by TSOs
  - FCR power provision's degrees of freedom (04/14)
  - Capacity requirements for batteries providing FCR power (09/15)

Optional overfulfillment



Capacity requirements

- 30-minute criteria

$$SOC_{ub}^{SWARM} = \frac{E_{usable} - 0,5h \cdot P_{FCR}}{E_{usable}}$$

$$SOC_{lb}^{SWARM} = \frac{0,5h \cdot P_{FCR}}{E_{usable}}$$

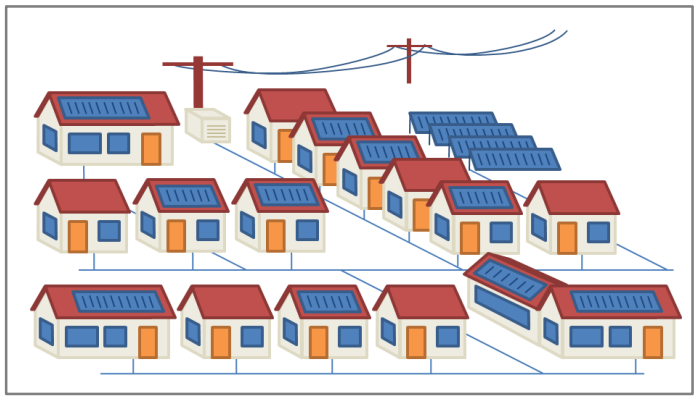
$$\frac{E_{usable}\,[MWh]}{P_{FCR}\,[MW]} > 1$$

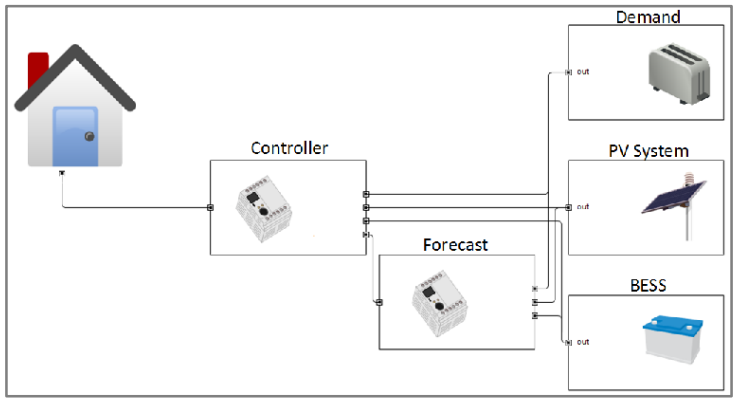
regelleistung.net

i7AnyEnergy Simulation Toolbox

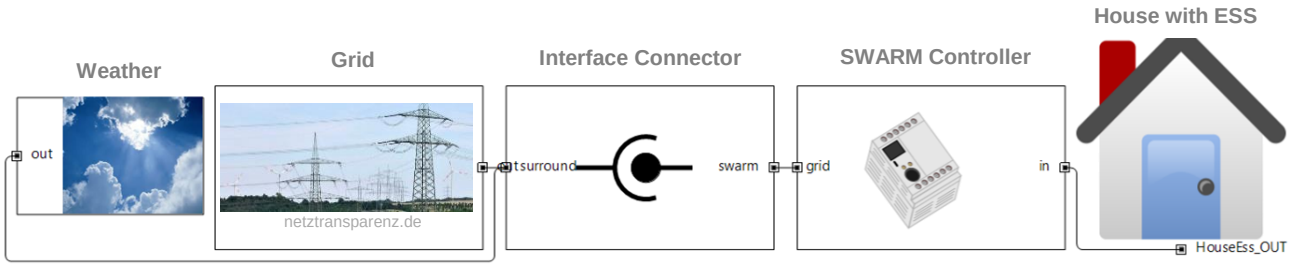
- Component based, flexible hybrid simulation framework
  - Continuous simulation of flows (e.g., energy, material, money)
  - Discrete event simulation of (e.g., control decisions)
  - Hierarchical interface and filter concept for exchange of parameters and control messages within the model

- Fast construction of micro grid models



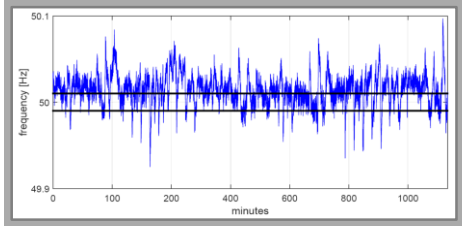


SWARM Simulation Model



Exogenous conditions

- Weather + clouds
- Economic parameters
- Power frequency



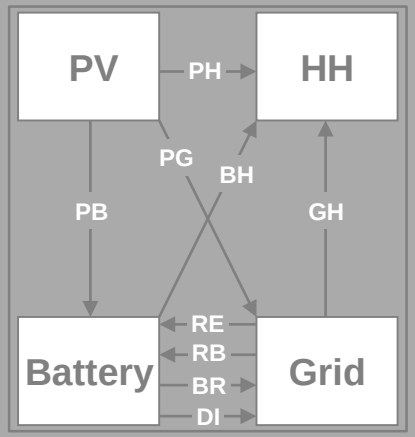
SWARM Control Center

- Calculation of FCR power each BESS has to deliver
- Calculation of re- & discharge power

➢ Different scheduling strategies

House with BESS

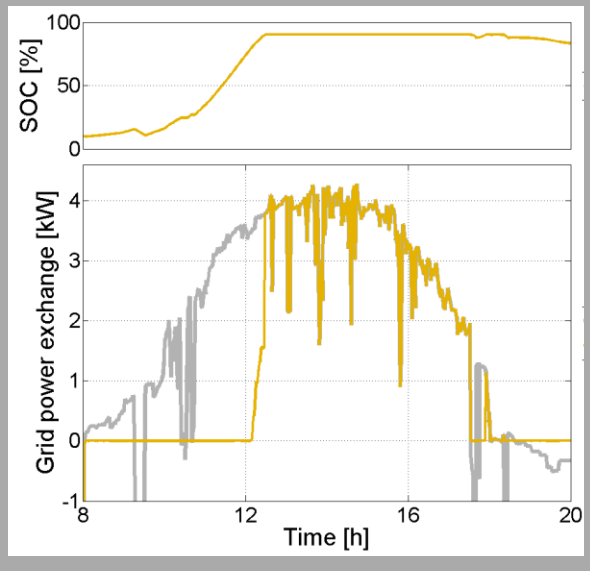
- power flow contr.
- Balancing



House Control
SWARM Simulation Model

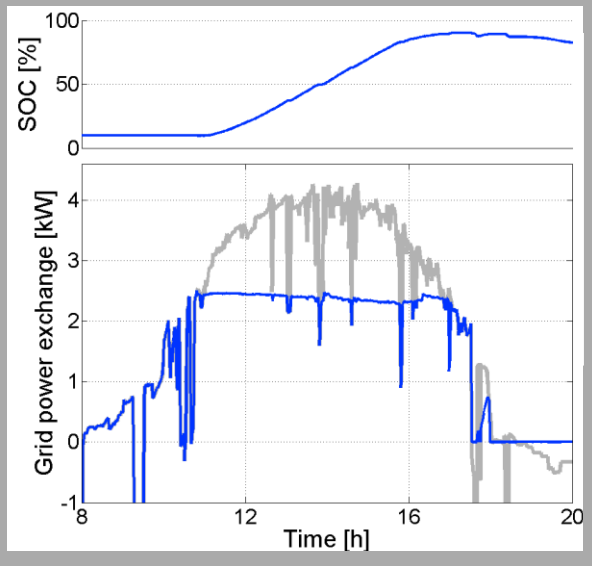
greedy charging

- Charge BESS every time, when PV power and free storage is available
- BESS can run full very quick



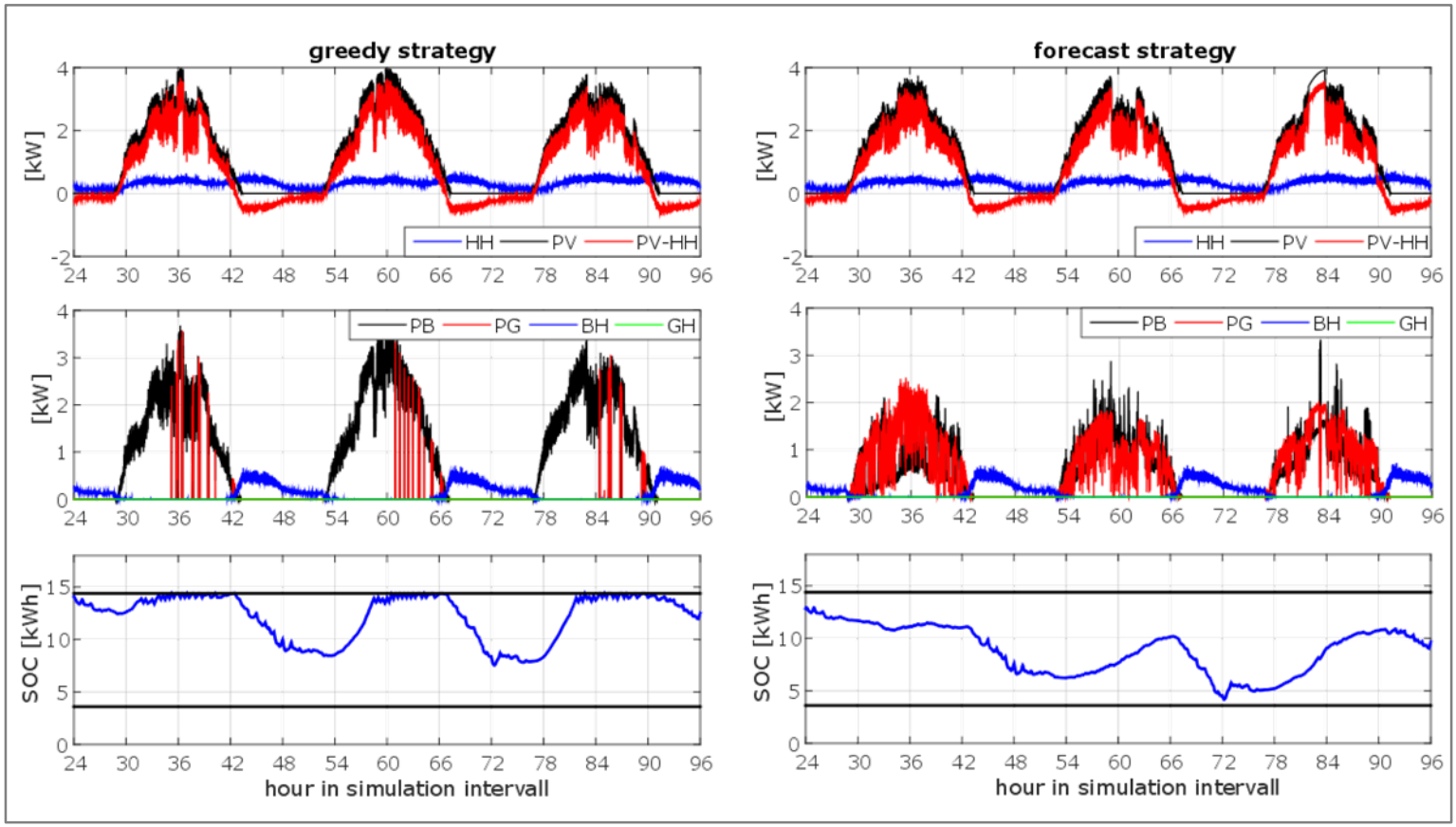
forecast based charging

- Smooth BESS charging
- Avoid high power gradients
- Store only part of PV power, that fills BESS



Moshoevel et al. "Analysis of the maximal possible grid relief from PV-peak-power impacts by using storage systems for increased self-consumption," Applied Energy, Vol. 137, No. 1, p. 567–575, 2015

House Control Strategies
Simulation Results



- Greedy: high power gradients of grid in-feed
- Forecast: smoother BESS charging

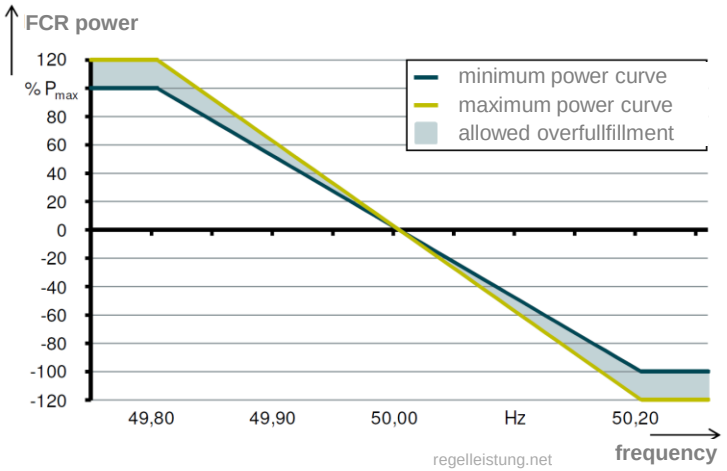
Household's profitability
Simulation Results

Strategy	greedy		forecast based	
	w/o BESS	*w/ BESS*	*w/o BESS*	*w/ BESS*
own consumption	29,90 %	58,70 %	29,92 %	58,75 %
self-sufficency	49,49 %	97,17 %	49,50 %	97,20%
Financial result	-183,82 € p.a.	262,79 € p.a.	-184,17 € p.a.	262,68 € p.a.
internal rate of return	7,79 %		7,80 %	

- Household's benefit of installing BESS confirmed
- High self-sufficiency rates result from ensuring an average SWARM SOC of 50 %
  - market as seasonal storage
- No significant difference of applying strategies

Conclusion & Outlook

- Simulation model of a real installed battery mass storage for FCR power provision
- Possibility to evaluate different control strategies
- Different control strategies do not effect the household‘s benefit of installing a BESS
- Influence of exogenous requirements
- ToDo‘s
  - Extensive comparison with real user data and fitting of methods
  - Implementation of further SWARM/house control strategies
  - Use of FCR provision’s degrees of freedom
  - …



Thanks for your attention!

Questions?

David Steber
Research Assistant

Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU)
Computer Science 7 – Computer Networks and Communication Systems
Martensstr. 3 | 91058 Erlangen, Germany
Tel: +49 (0) 9131 85-27907 | Fax: +49 (0) 9131 85-27409
Mail: david.steber@fau.de