ELEKTRISCHE UND THERMISCHE ENERGIESPEICHER IM SMART GRID

Dr. Bernhard Wille-Haussmann

Fraunhofer Institut für Solare
Energie Systeme ISE

TELI-Expertengespräch
München, 20th Juni 2013

www.ise.fraunhofer.de

Fraunhofer ISE

AGENDA

- Motivation
  - Was ist ein Smart Grid?
  - Stromerzeugung und Strompreis
  - Erneuerbare Energien Szenarien
- Entwicklung der Residualen Last
- Speicher im Smart Grid
  - Elektrisch thermisch gekoppelte Systeme:
    Kraft-Wärme-Kopplung und Wärmepumpen
  - Netzgekoppelte PV-Batterie-Systeme
- Zusammenfassung

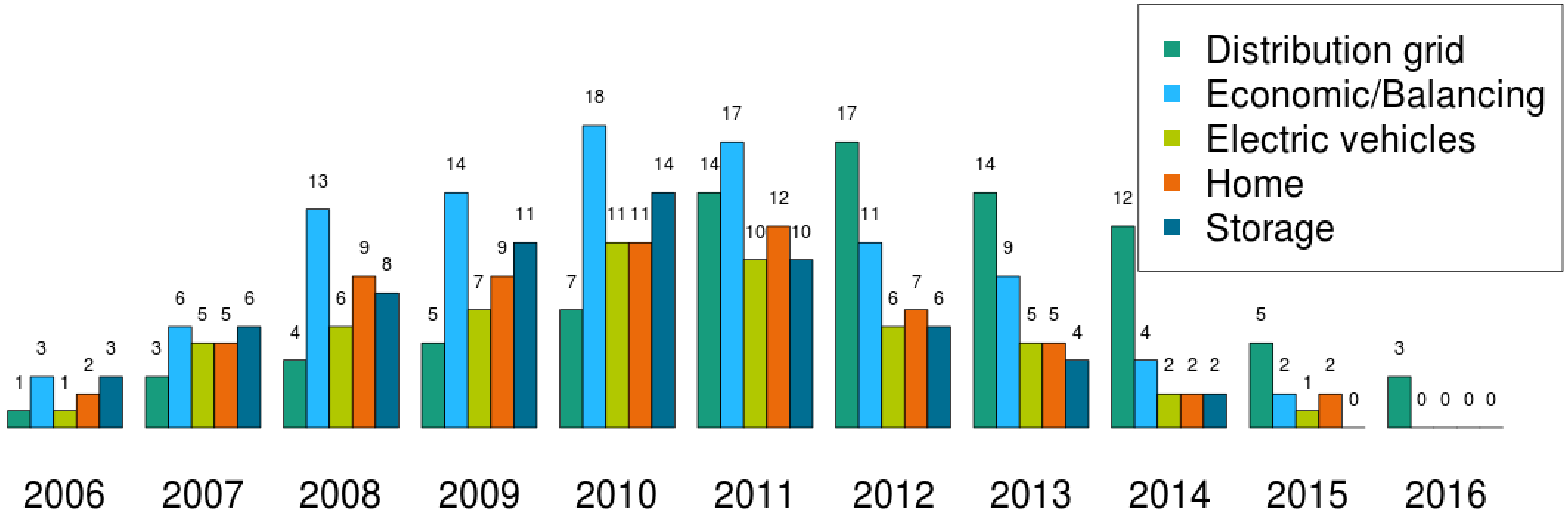
Motivation
What is a Smart Grid?

Smart Grid keyword search (June 2013):

- Google.com: 96.800.000 hits
- Google Scholar: 413.000 hits
- SciVerse/ScienceDirect: 16119 hits
- IEEE Xplore: 7914 hits

Categorize

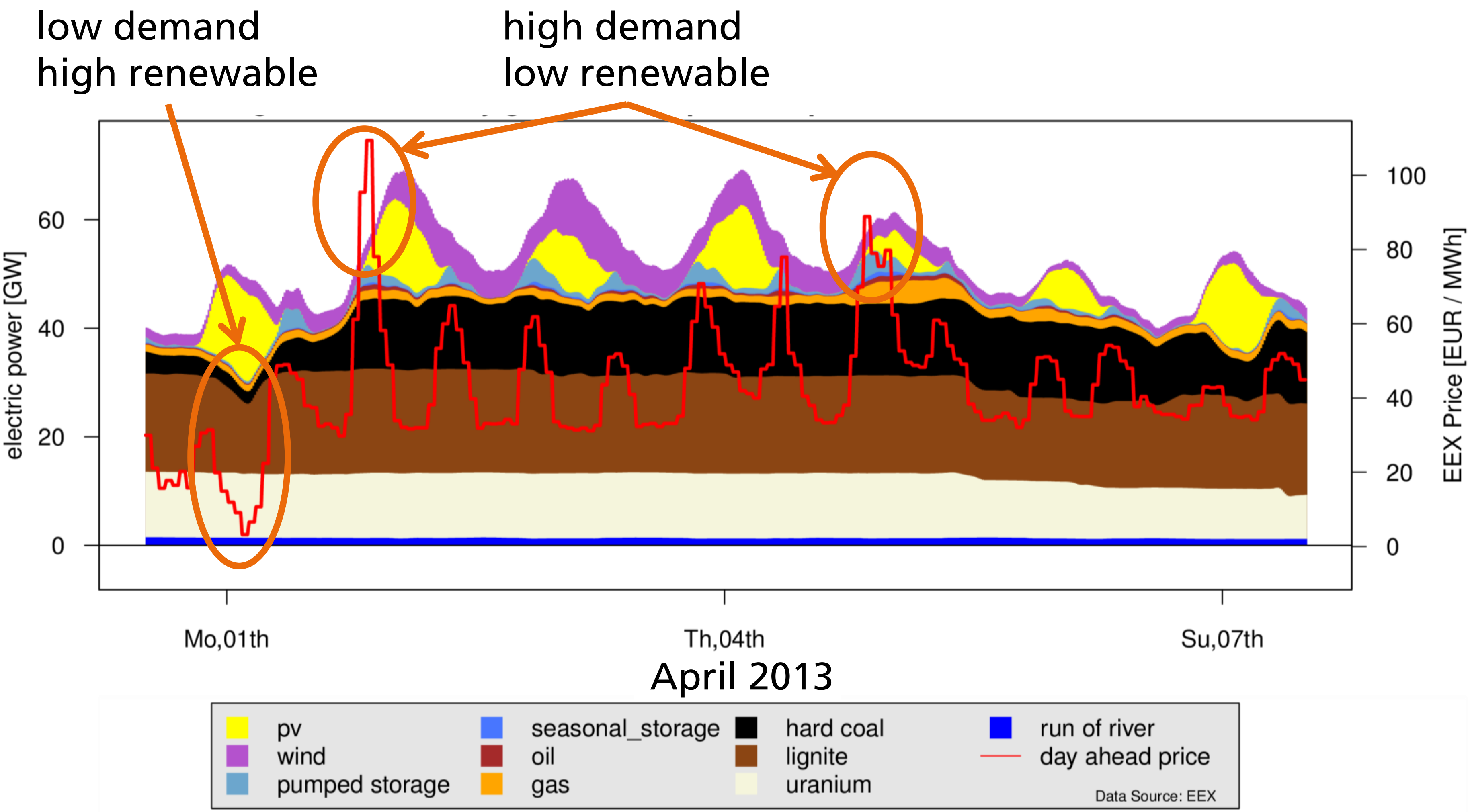
75 Smart Gird projects



Fraunhofer ISE

German Electricity Generation & Prices

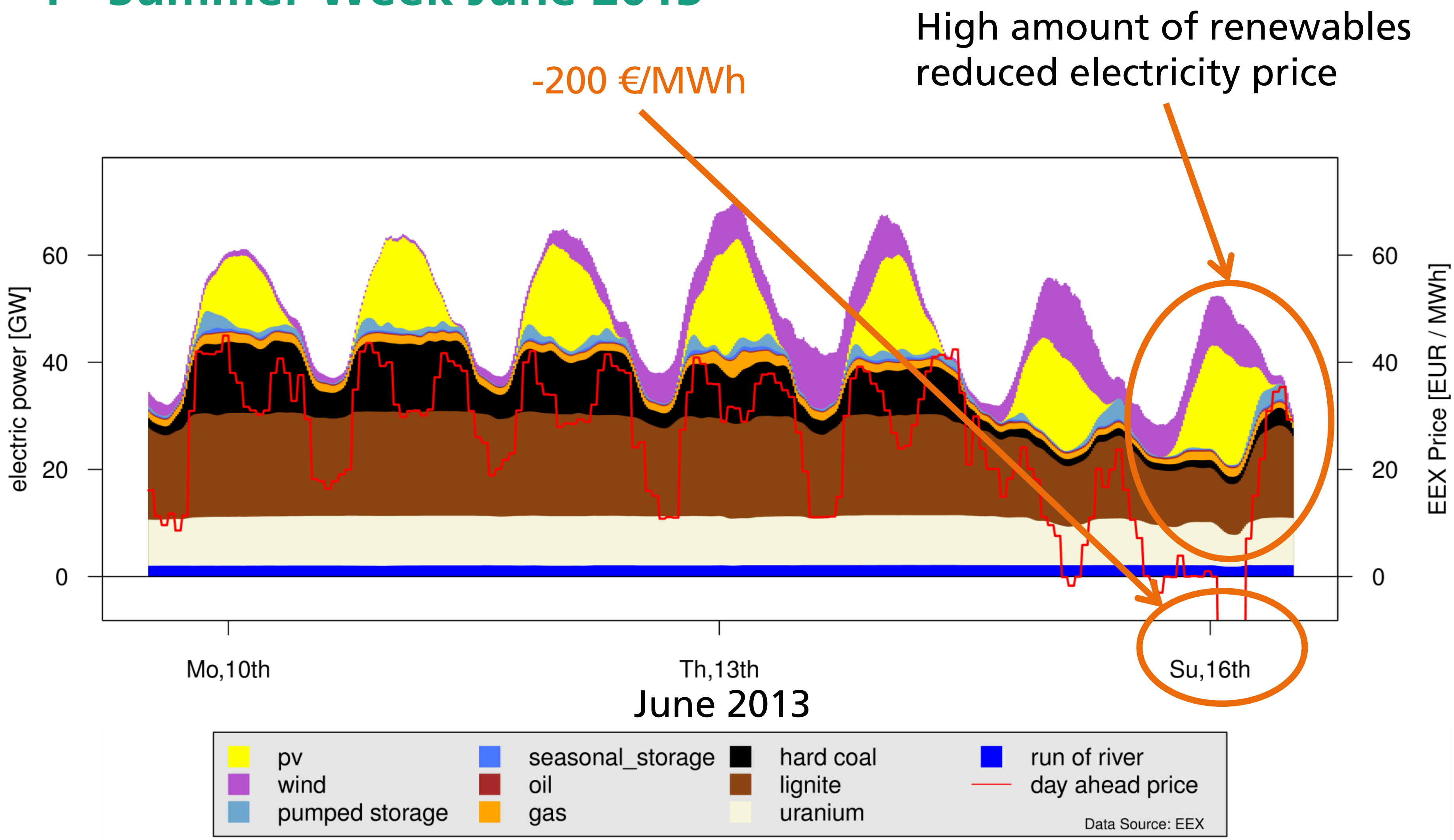
Eastern Week 2013



Fraunhofer ISE

German Electricity Generation & Prices

1st Summer Week June 2013

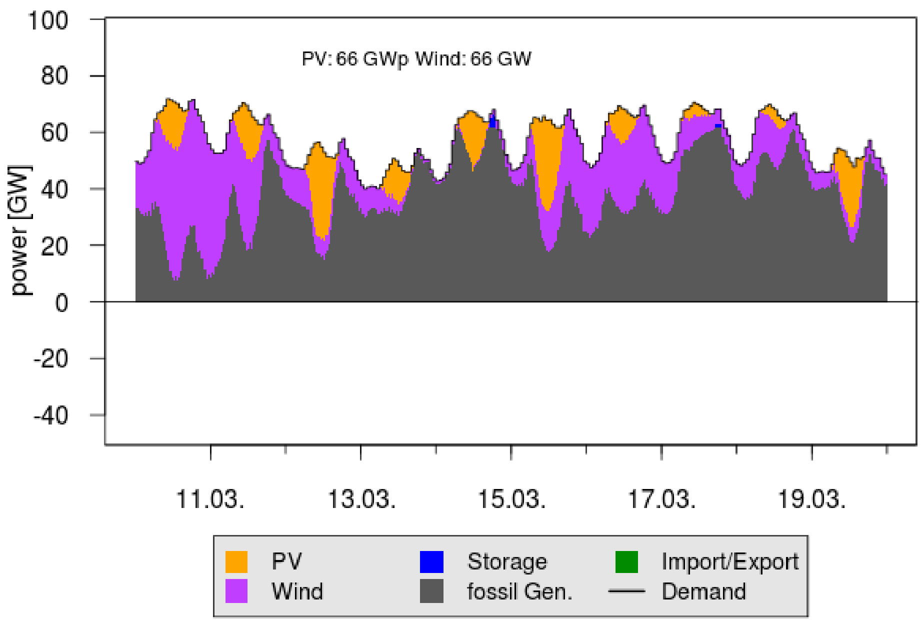


Fraunhofer ISE

Different Energy Scenarios

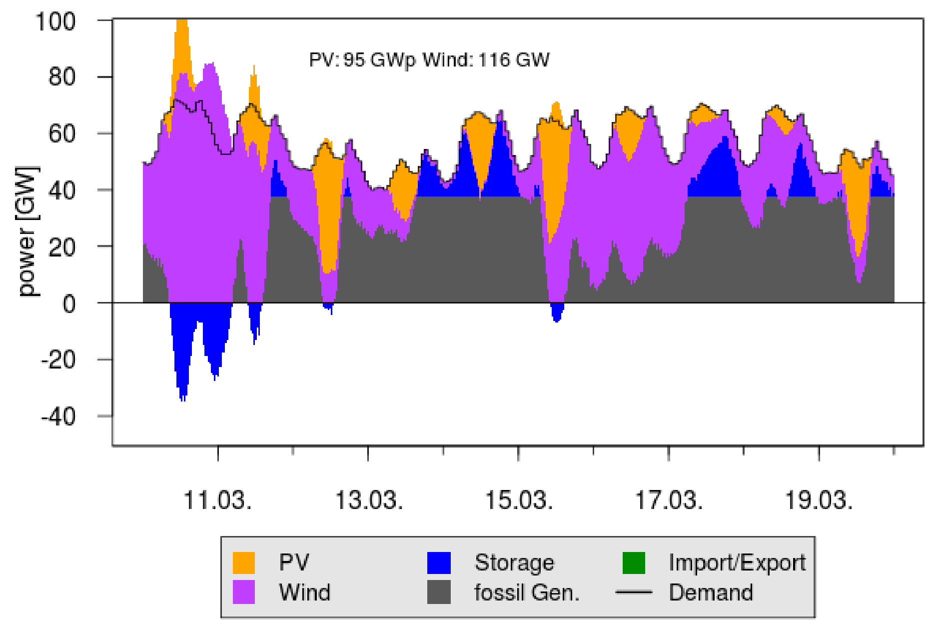
Scenario 2030

Leitstudie 2010 Szenario B



Scenario 2050

Leitstudie 2010 Szenario B

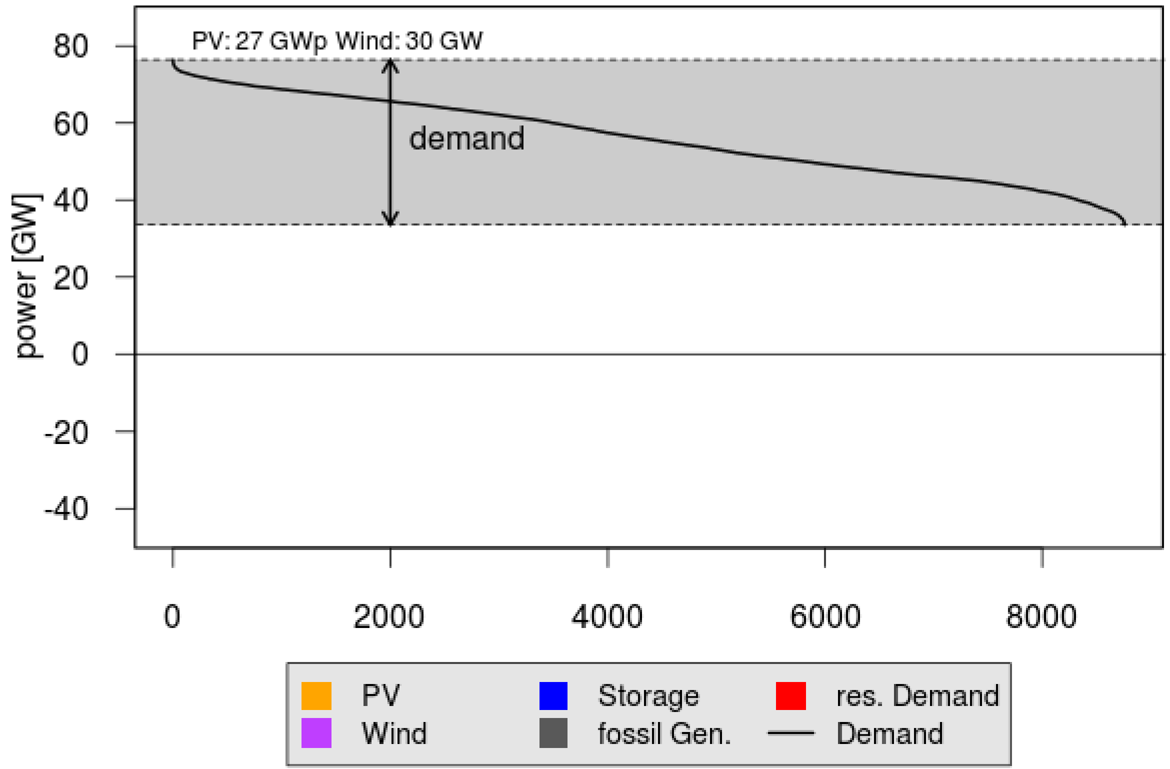


- Renewables will supply a significant part
- High gradients for conventional generation

Fraunhofer ISE

Renewable Scenario – status quo
demand

- German electricity demand ranges from 40 GW to 80 GW



Duration curve

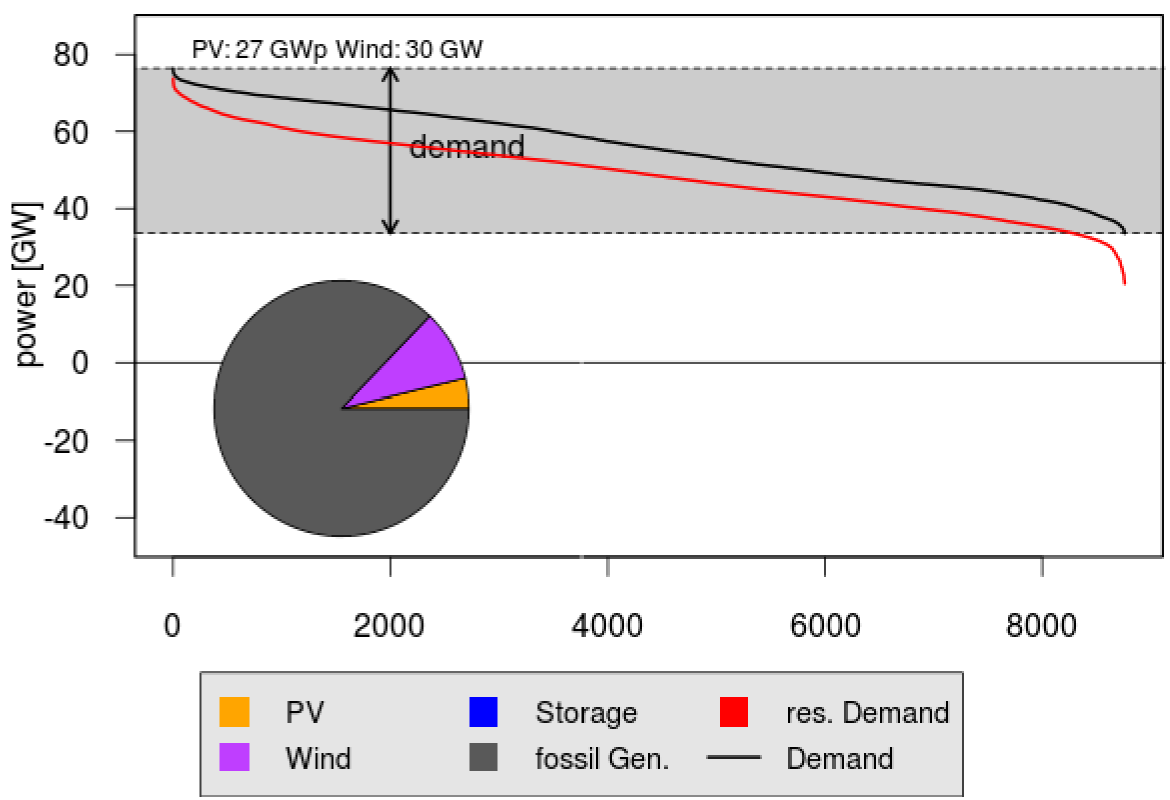
Values of demand are ordered by their size and plotted.

Renewable Scenario – status quo
residual demand

- German electricity demand ranges from 40 GW to 80 GW
- Residual load:

$$P_{res} = P_{load} - P_{PV} - P_{wind}$$

- 15% of the demand is covered by PV and Wind



Fraunhofer ISE

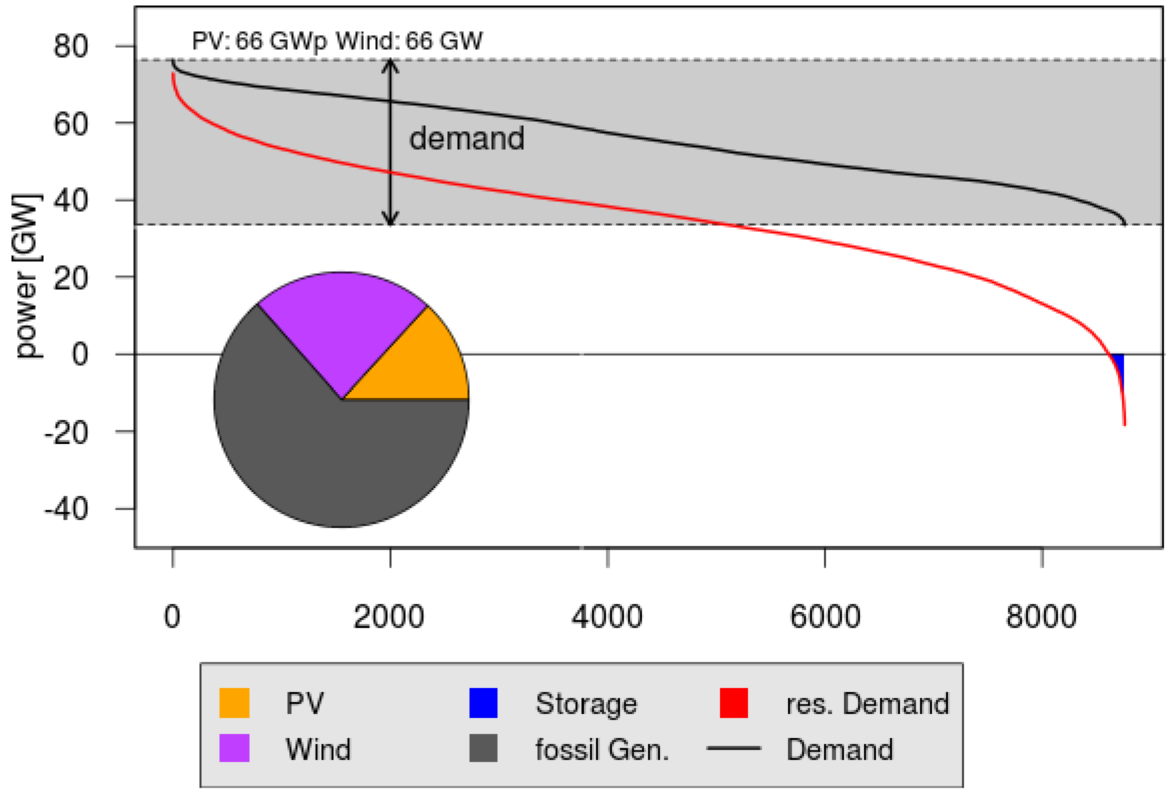
Renewable Scenario 2030
residual demand

- German electricity demand ranges from 40 GW to 80 GW
- Residual demand:

$$P_{res} = P_{load} - P_{PV} - P_{wind}$$

- 40% of the demand is covered by PV and Wind
- Residual load becomes negative

Szenario 2030: Leitstudie 2010 Szenario B



Fraunhofer ISE

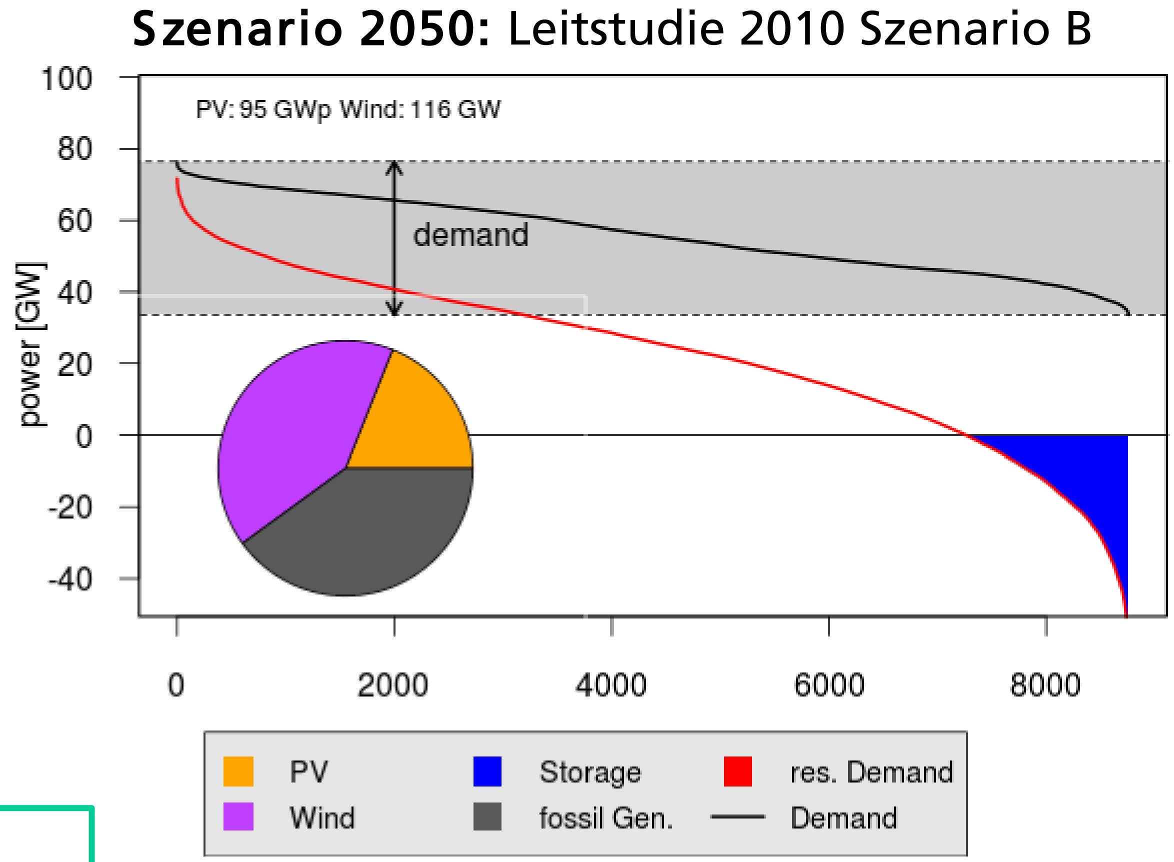
Renewable Scenario 2050
residual demand

- German electricity demand ranges from 40 GW to 80 GW
- Residual demand:

$$P_{res} = P_{load} - P_{PV} - P_{wind}$$

- 60% of the demand is covered by PV and Wind
- Residual load becomes negative

► Need of storages balance residual demand



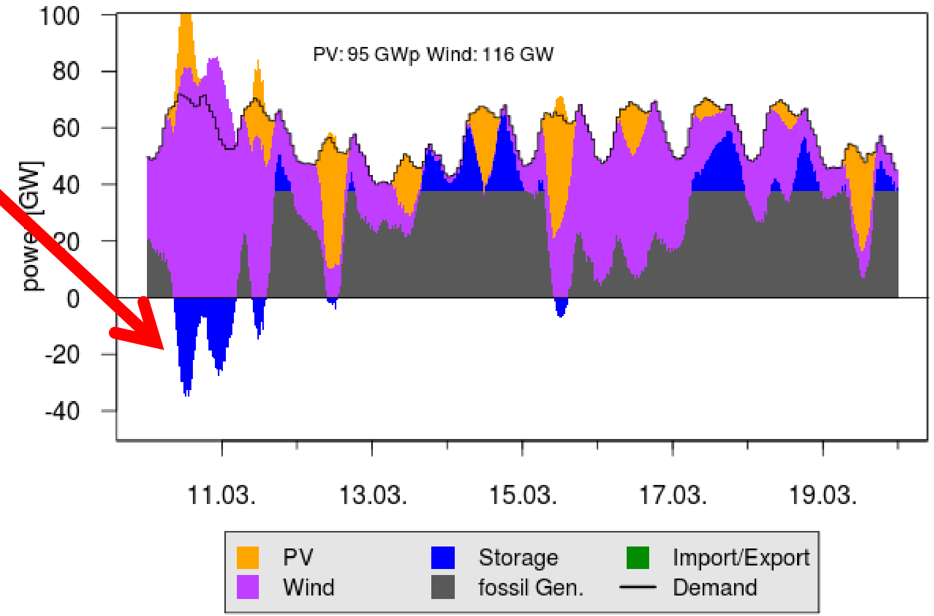
Fraunhofer ISE

Storages in the Smart Grid
Impression of the storage size

400 GWh ≠ 40 GWh
(pumped hydro in GER)

Szenario 2050

Leitstudie 2010 Szenario B

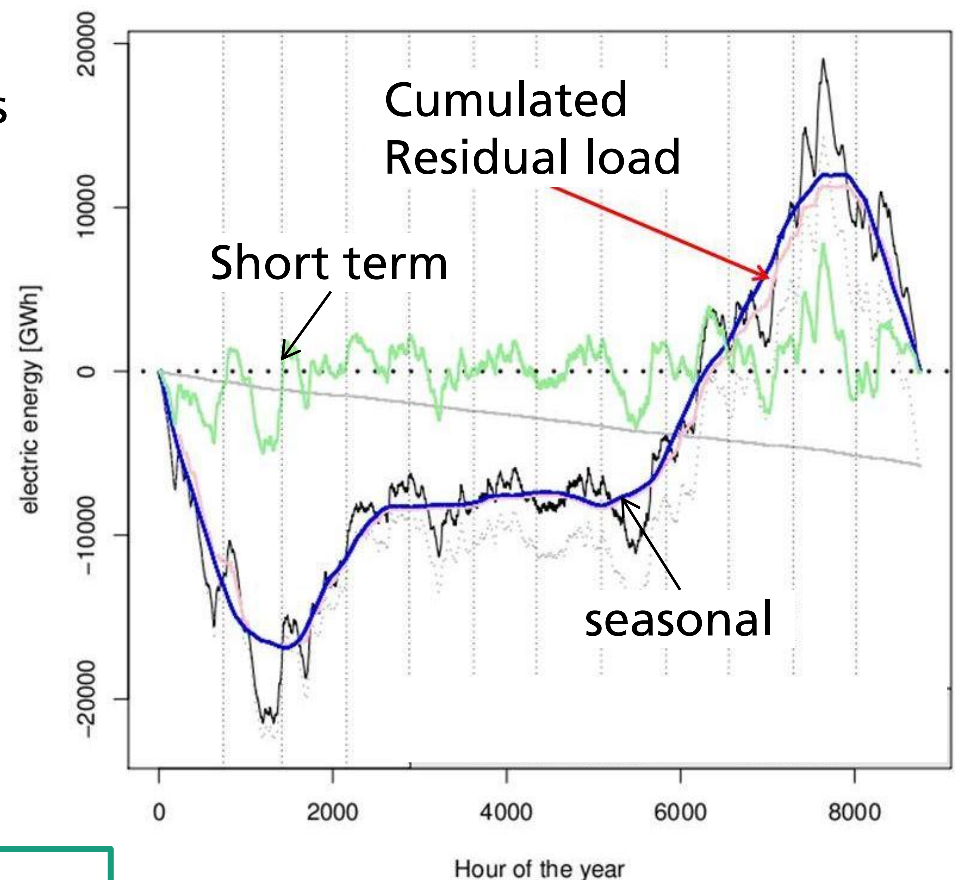


Pump Storage e.g. Goldisthal: ~1GW; ~8.8 GWh

Fraunhofer ISE

Storages in the Smart Grid
What kind of storage do we need?

- Cumulates Residual load minus fossil generation
  1. Negative due to wind
  2. Constant
  3. Positive less regenerative generation
- Components of residual load
  - Seasonal component
  - Short time component



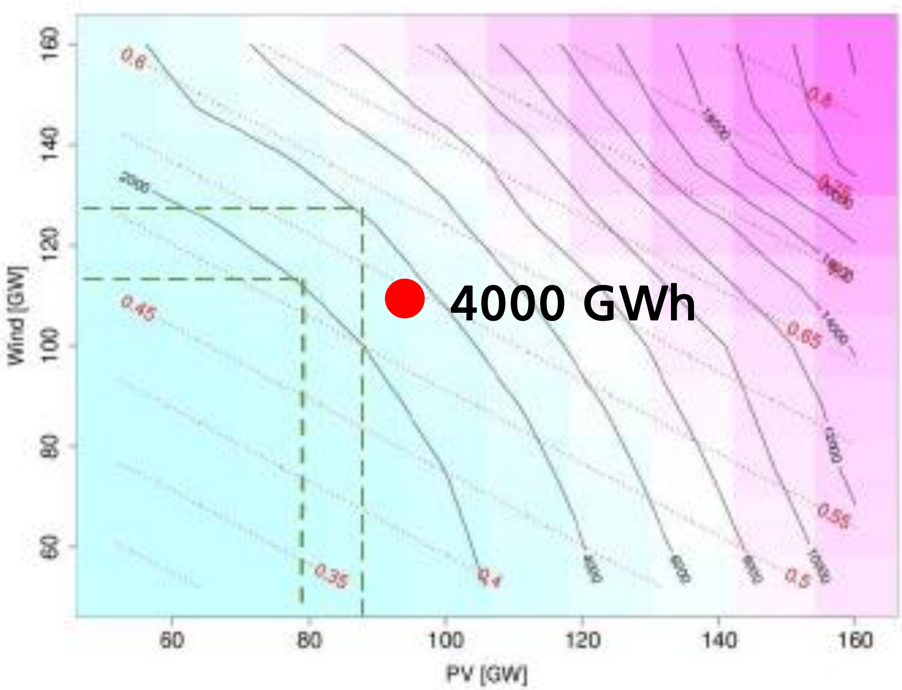
Dimensioning of storages

Fraunhofer ISE

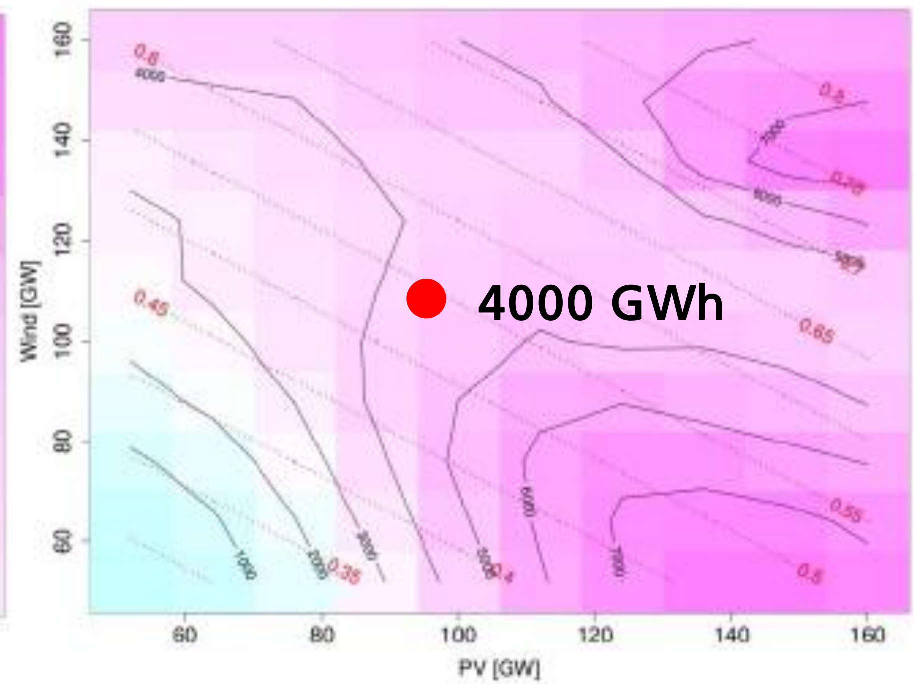
Storages in the Smart Grid

Required storage capacity

Seasonal effect



Short term effect



Szenario 2050

PV: 95 GW

Wind: 116 GW

≈ 100 times the German capacity of pumped storage

Fraunhofer ISE

Storages in the Smart Grid

There are many options to store electric energy

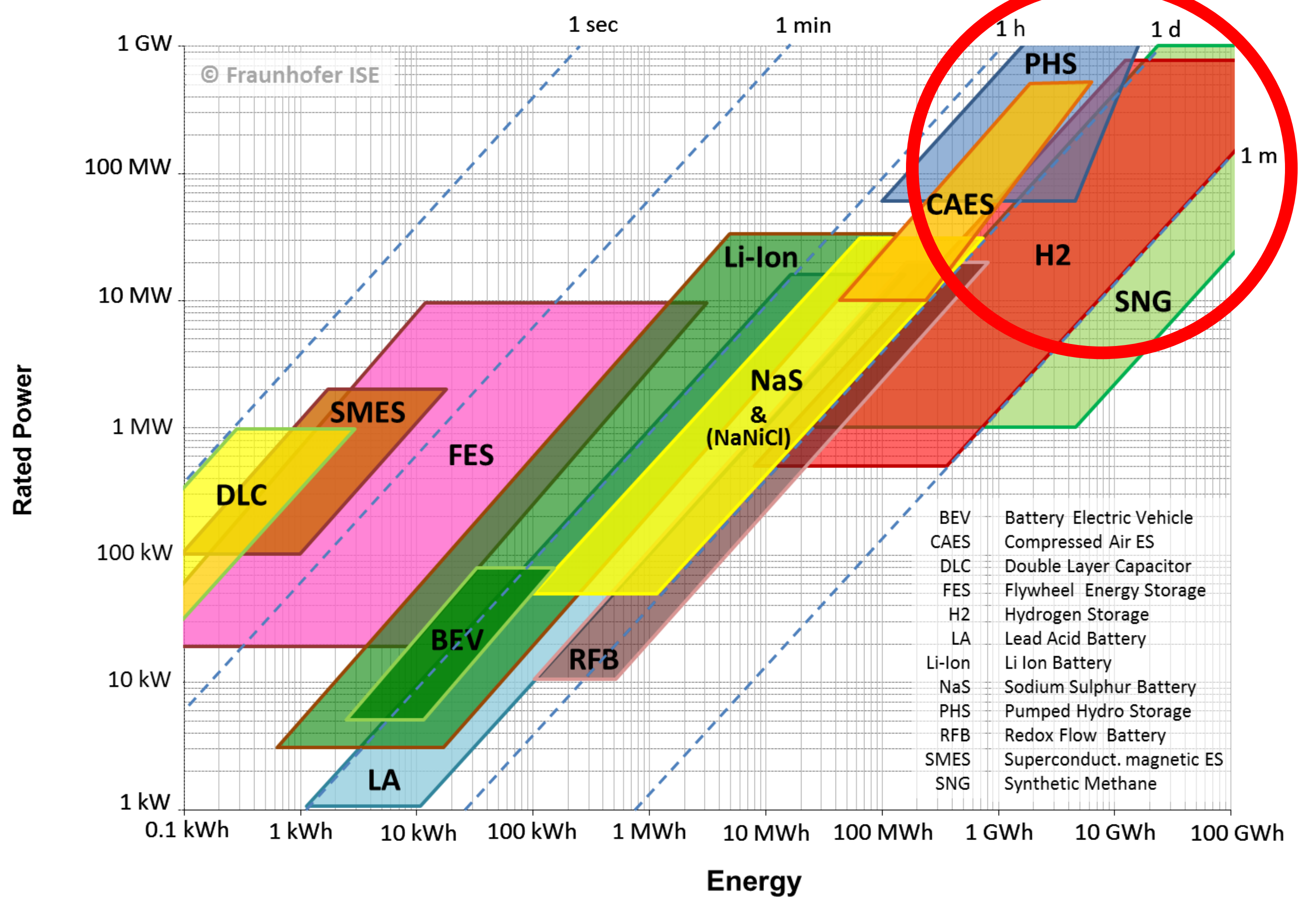
Limited resources, topographic requirements

Applications:

- Mobile
- Stationary

Storage principle:

- Electrochemical
- Chemical
- Mechanical
- Electromagnetic



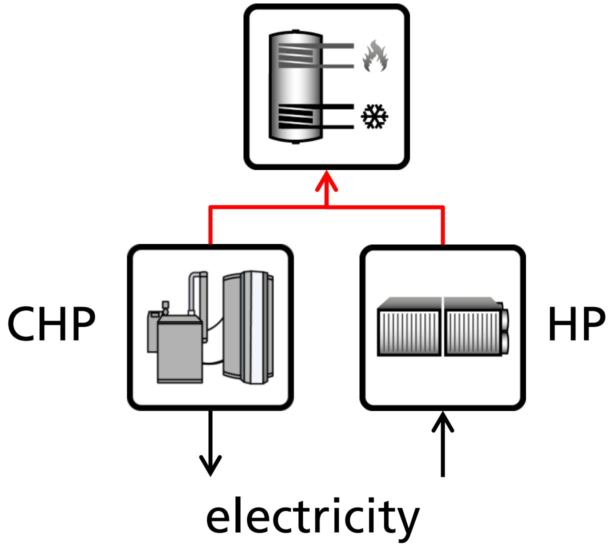
Not all technologies are commercially available as shown

Fraunhofer ISE

Storages in the Smart Grid
not only electricity storage!

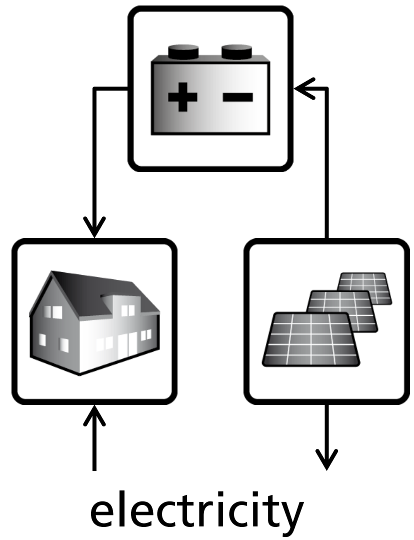
Electric Thermal Systems

- Thermal storages offer the possibility to decouple thermal and electric processes



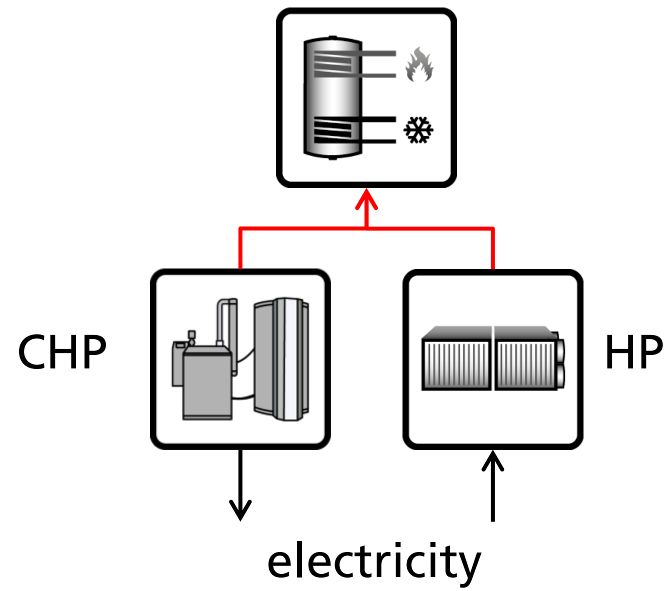
PV-Battery Systems

- Local self consumption of electricity from PV
- Grid oriented operation



Electric-thermal systems in 2030
Assumptions

- installed power in 2030
  - Heat pumps : 16 GW (electric)
  - Cogeneration: 15 GW (electric)
- Storage capacity
  3 h operation of CHP or HP
- Decreasing of heat demand
- Thermal demand profiles
  based on VDI 4655



Operation based on residual load

Target: balance residual load

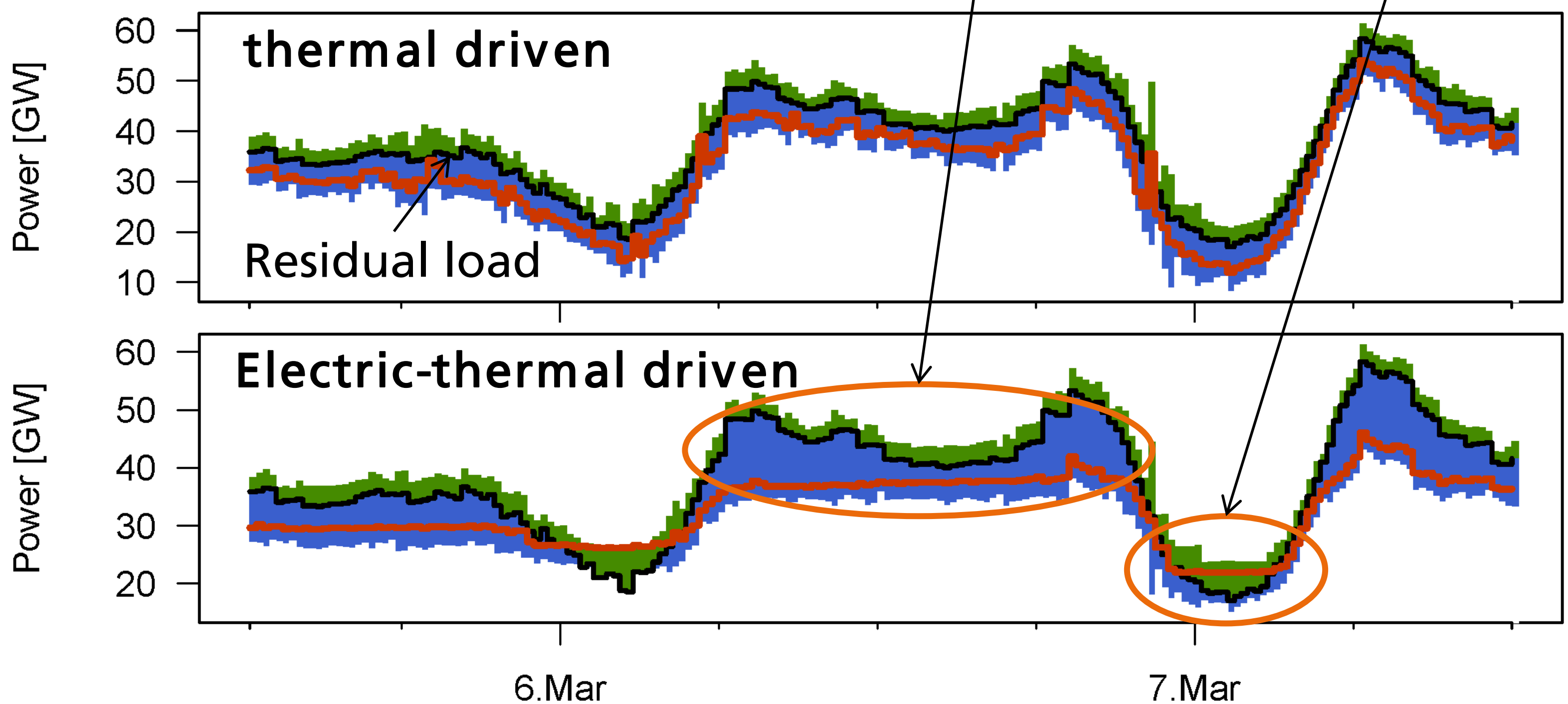
Smart Grid operation of cogeneration and heat pump

- Cogeneration
- Heat pump
- thermal storage

Smart Grid control

Reduce load peaks by CHP

Fill load valleys by HP



Fraunhofer ISE

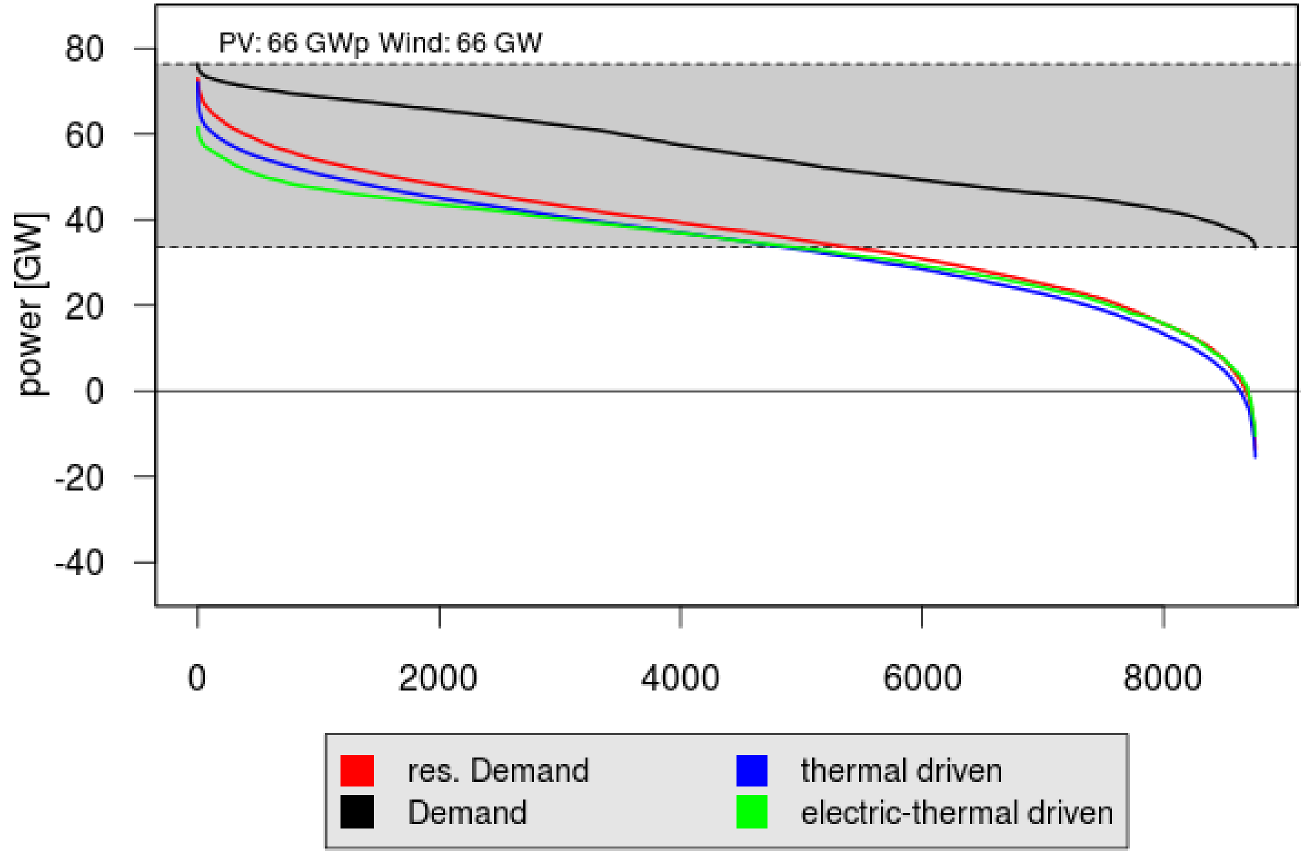
Smart Grid operation of cogeneration and heat pump
duration curve

Thermal

- Constant reduction of duration curve

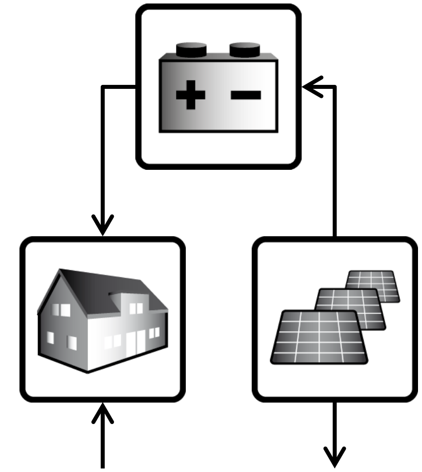
Electric-thermal

- High demands are reduced
- Reduction of feed-in peak

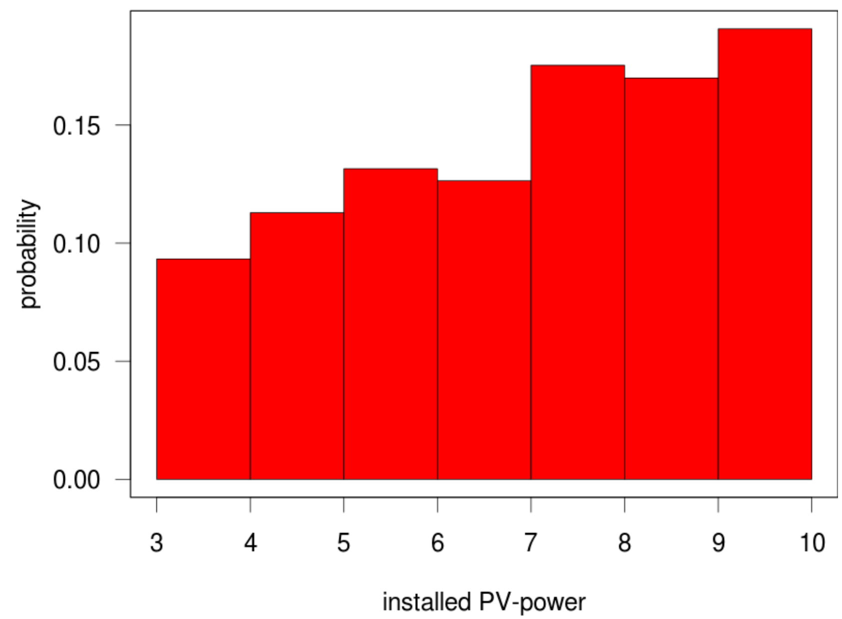


Fraunhofer ISE

PV-Battery Systems in Smart Grid
Assumptions Scenario 2030



- System design:
  - PV form 3 kWp to 10 kWp
  - Capacity: 0.8 installed power
  - Battery Power: 0.5 C



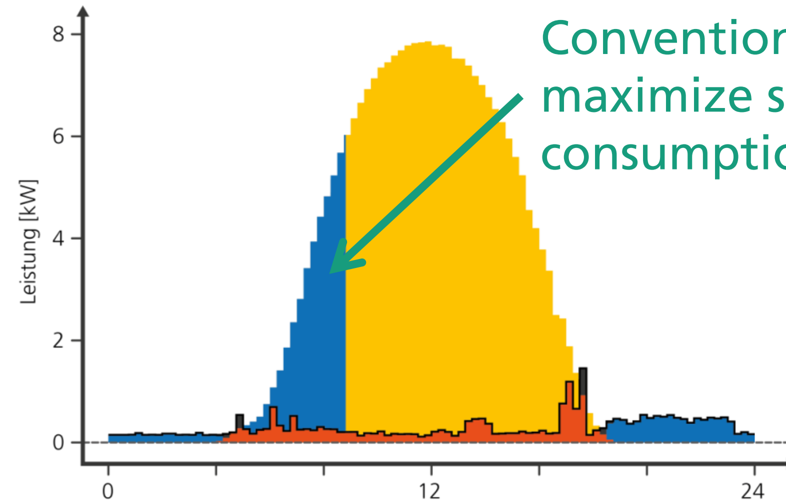
- Scenario 2030
  - 1 Million PV-Battery systems
  - Distribution like installations 2011
  - 7.4 GWp of PV with
  - 5.5 GWh usable battery capacity

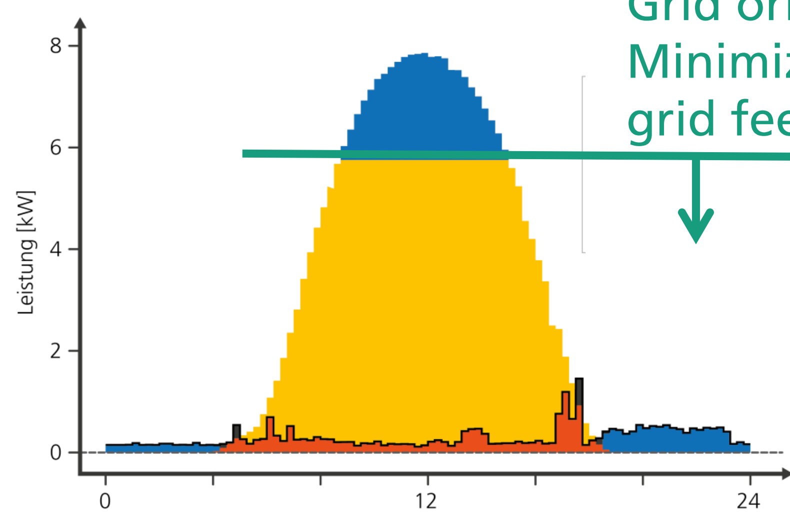
Speicherstudie 2013
http://www.ise.fraunhofer.de/de/veroeffentlichungen/studien-und-positionspapiere/speicherstudie-2013

Fraunhofer ISE

PV-Battery Systems in Smart Grid
operation strategy

- Just maximizing self consumption does not have significant grid effects.
- Maximum feed-in peak of 60..70% installed PV-power is possible without shutdown of PV.
- Minimizing local grid effects
- Optimization over 1 year
- Maximize self consumption
- Effects on the residual load

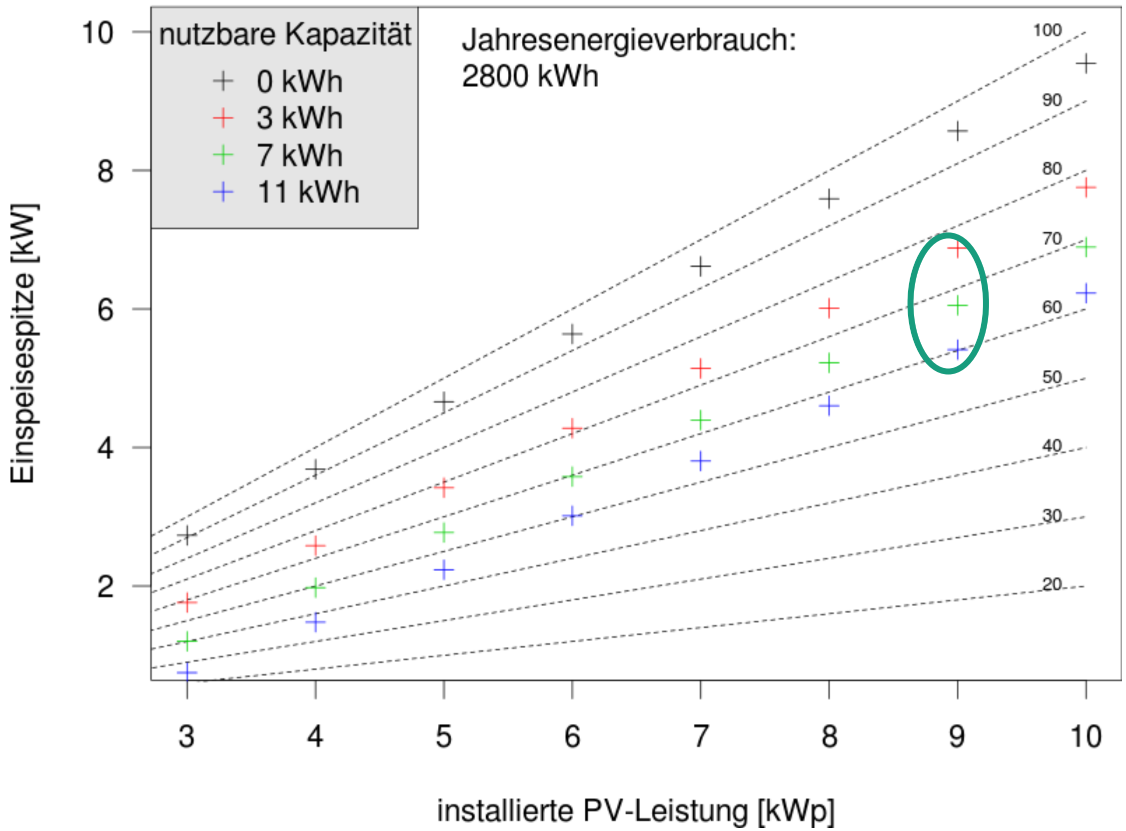




Speicherstudie 2013
http://www.ise.fraunhofer.de/de/veroeffentlichungen/studien-und-positionspapiere/speicherstudie-2013

Fraunhofer ISE

Welche Verringerung der Netzspitze ist möglich?
ohne PV-Abregelung, Netzeinspeisung aus Batterie

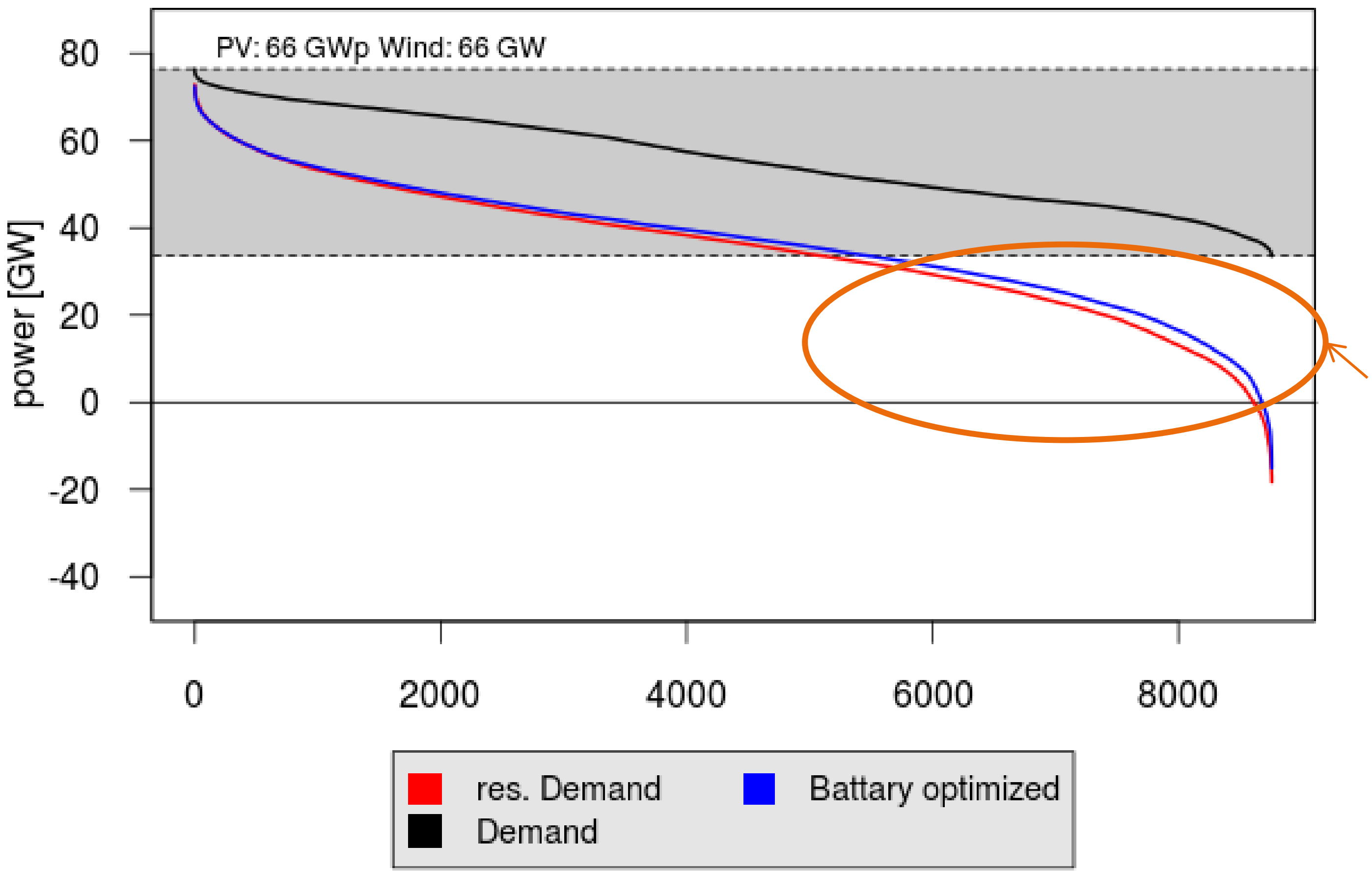


- Netzeinspeisung aus der Batterie ermöglicht eine wesentliche Reduktion der max. Einspeisespitze bei größeren Speichersystemen!

Speicherstudie 2013
http://www.ise.fraunhofer.de/de/veroeffentlichungen/studien-und-positionspapiere/speicherstudie-2013

Fraunhofer ISE

PV-Battery Systems in the Smart Grid
duration curve



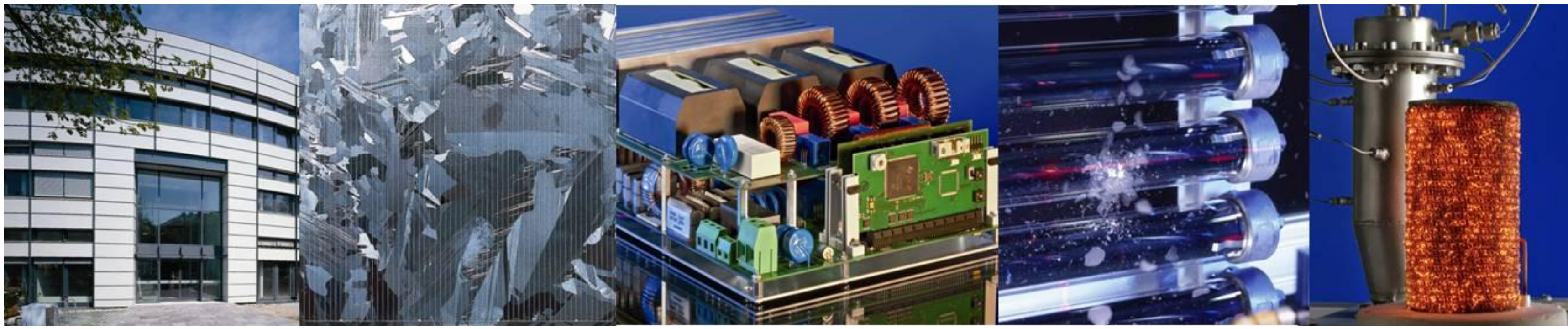
- Shifting of duration curve
- Reduction of feed-in peak

Fraunhofer ISE

Zusammenfassung

- PV und andere erneuerbare Energieträger haben einen signifikanten Einfluss auf unser Energiesystem.
- Es ist höchste Zeit entsprechende Speicher im Netz zu allokieren.
- Kraft-Wärme-Kopplung und Wärmepumpen Verbindung mit thermischen Speichern reduzieren Spitzen in der residualen Last.
- Ein netzorientierter Betrieb von dezentralen Batterien vermeidet hohe negative residuale Lasten.
- Lokale Speicher können, netzorientierter Betrieb vorausgesetzt, auch das lokale Netz entlasten und Netzausbau verzögern.

Thank-you for your attention!



Fraunhofer Institute for Solar Energy Systems ISE

Dr.-Ing. Bernhard Wille-Haussmann

www.ise.fraunhofer.de

bernhard.wille-haussmann@ise.fraunhofer.de

Fraunhofer ISE