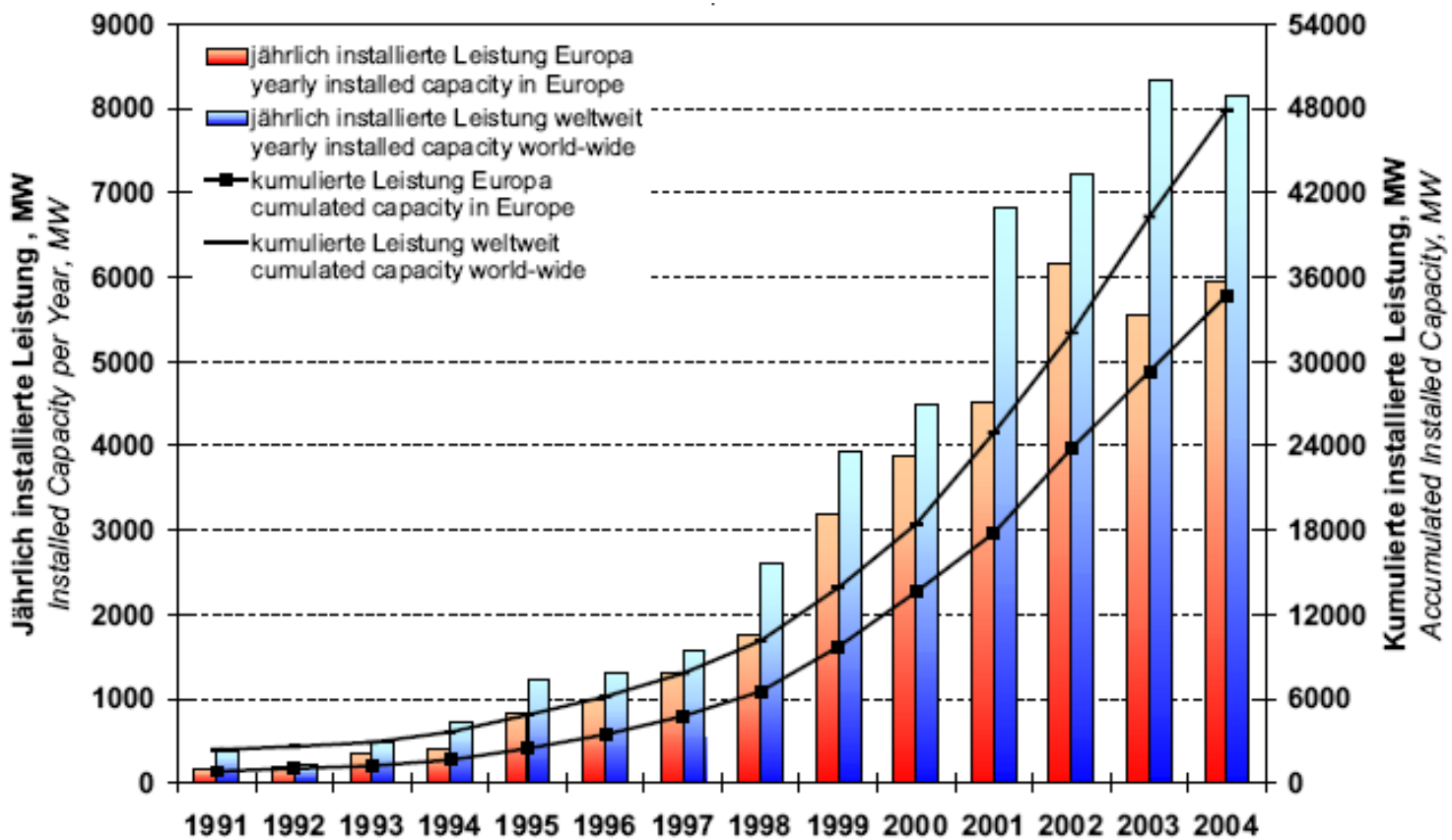
Large-Scale Integration of Renewable Energies in Supply Structures by Demand Side Management

- From supply response to demand response

Renewable Energies world wide

Wind Energy: installed nominal power

Annual increase: 27%

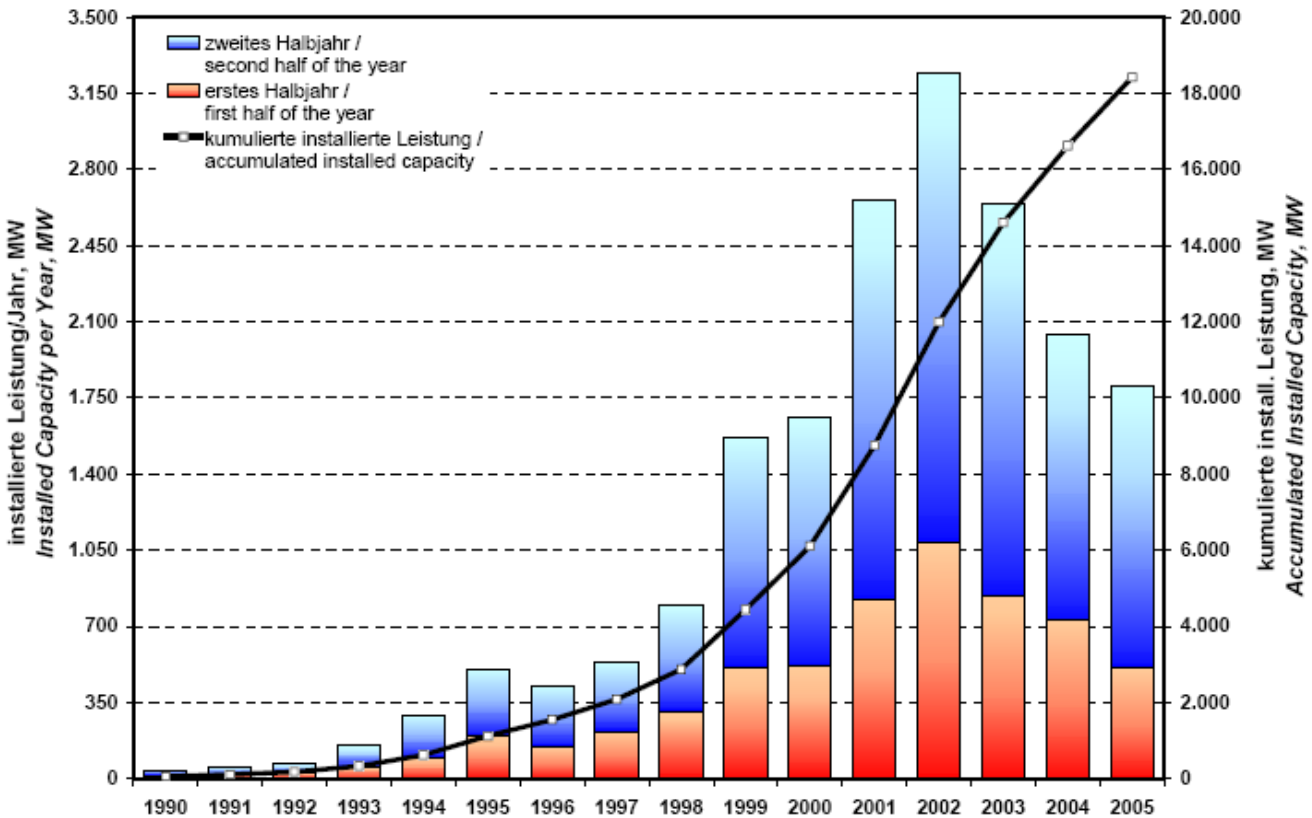


Source: DEWI

Renewable Energies world wide

Wind Energy in Germany: installed nominal power

Annual increase: 25-45 %



Quelle: DEWI

Resistance against Renewable Energies

How much fluctuating renewable energies are possible to integrate into electricity supplies?

- **Balance power**
- **Transport restrictions**
- **Control power (primary and secondary control)**

„dena“-study

Title:

Energiewirtschaftliche Planung für die Netzintegration von Windenergie in Deutschland an Land und Offshore bis zum Jahr 2020

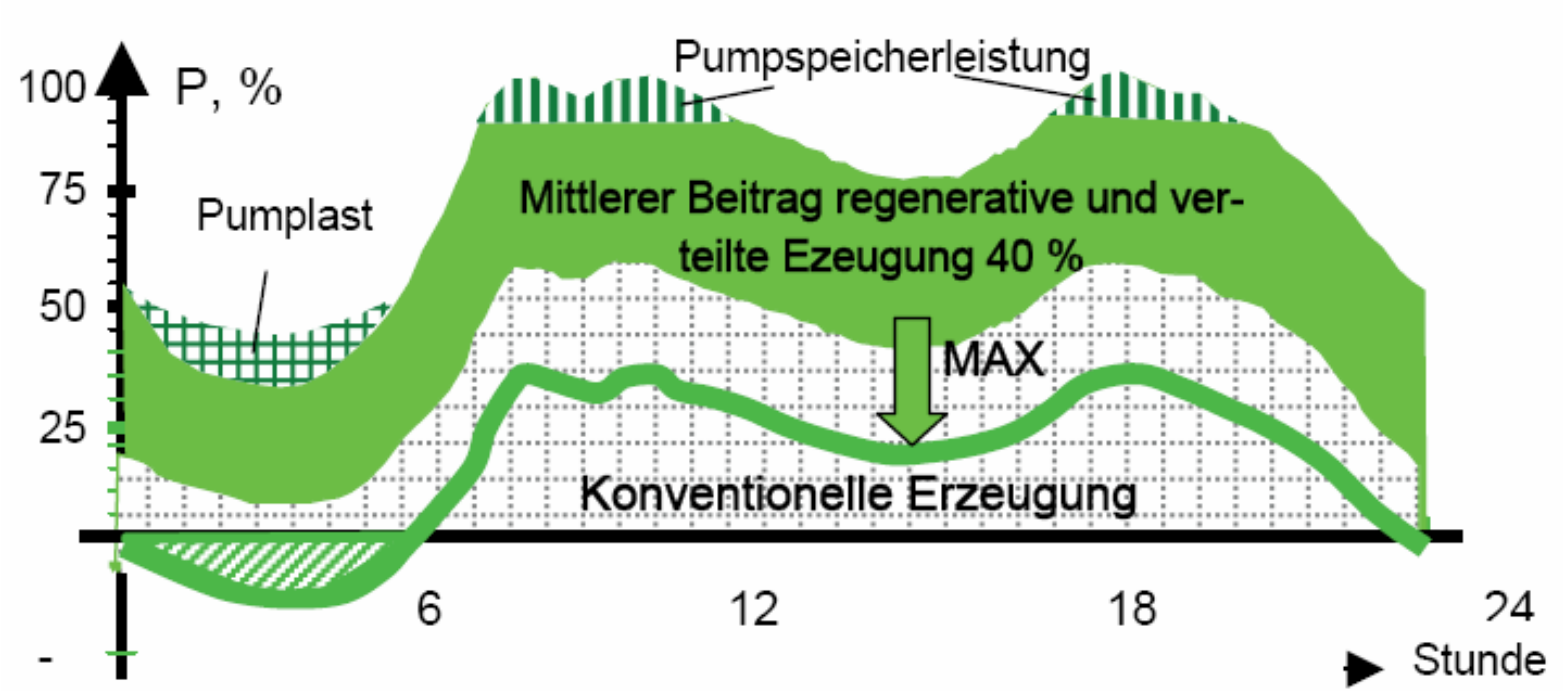
- **Wind Energy Integration until 2015: 35,9 GW**
- **Integration is possible**
- **but only with immense costs for grid extension: 1,1 Billion Euro**

- **in terms of energy industry that is not much and transmission grid operators are willing to invest in 850 km new transmission lines**
- **that would increase electricity costs for 0,025 €ct/kWh**
- **the barrier are more long planning and permission procedures**

„dena“-study

- **a planned scenario for 2020 with 48,1 GW was not followed**
- **it was considered as not to be integrable – independent from grid extension**
- **with traditional methods of network control grid stability could not anymore be guaranteed!**

Control Power



Maximum integrable share of renewable energies: 20-25 %

Source: Buchholz, Siemens

Transition to flexible electricity usage

- There are two possibilities to achieve a balance between generation and consumption
  - Response by adopting generation
  - Response by adopting consumption

84. Minute

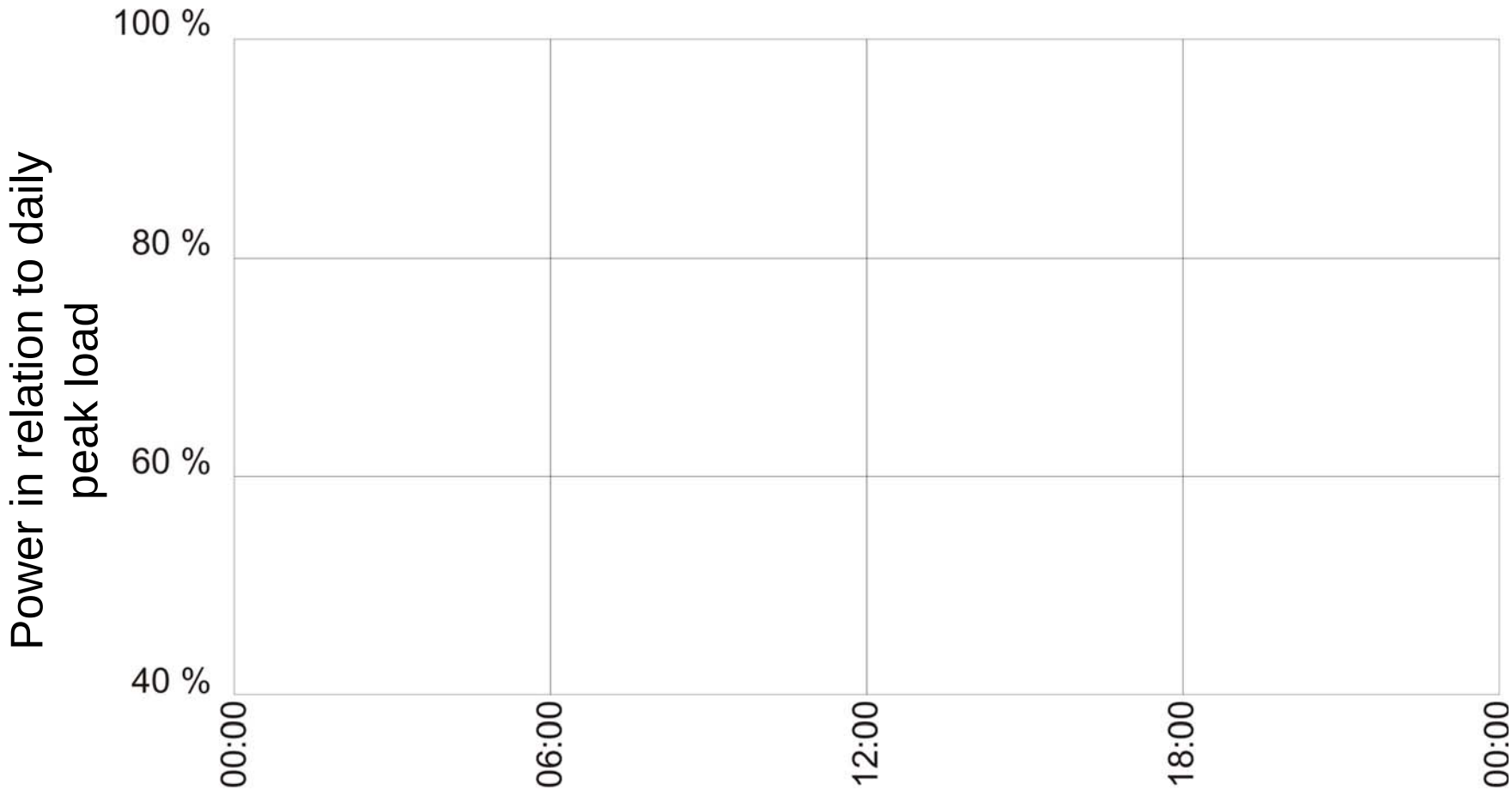
- for sure, TV is not meant here.
- Lighting is not suitable for that purpose, too.
- … but many other things in the household
- … without any changes to the user habits.

Transition to flexible electricity usage

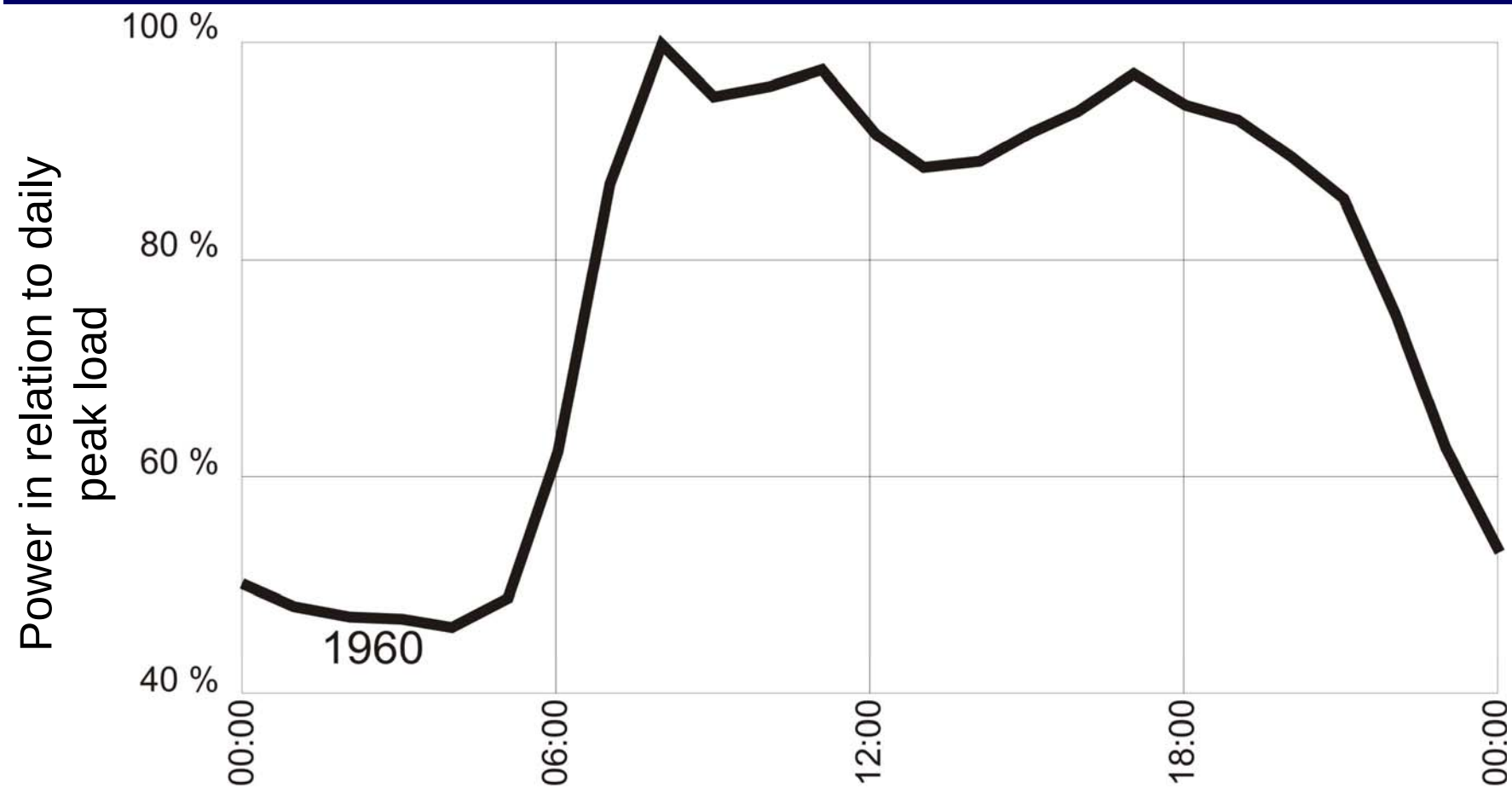
- Demand Response is not a new idea!

- In Germany almost half of electricity production is done in coal power plants and almost a third is done in nuclear power plants
- Most of them are base load power stations

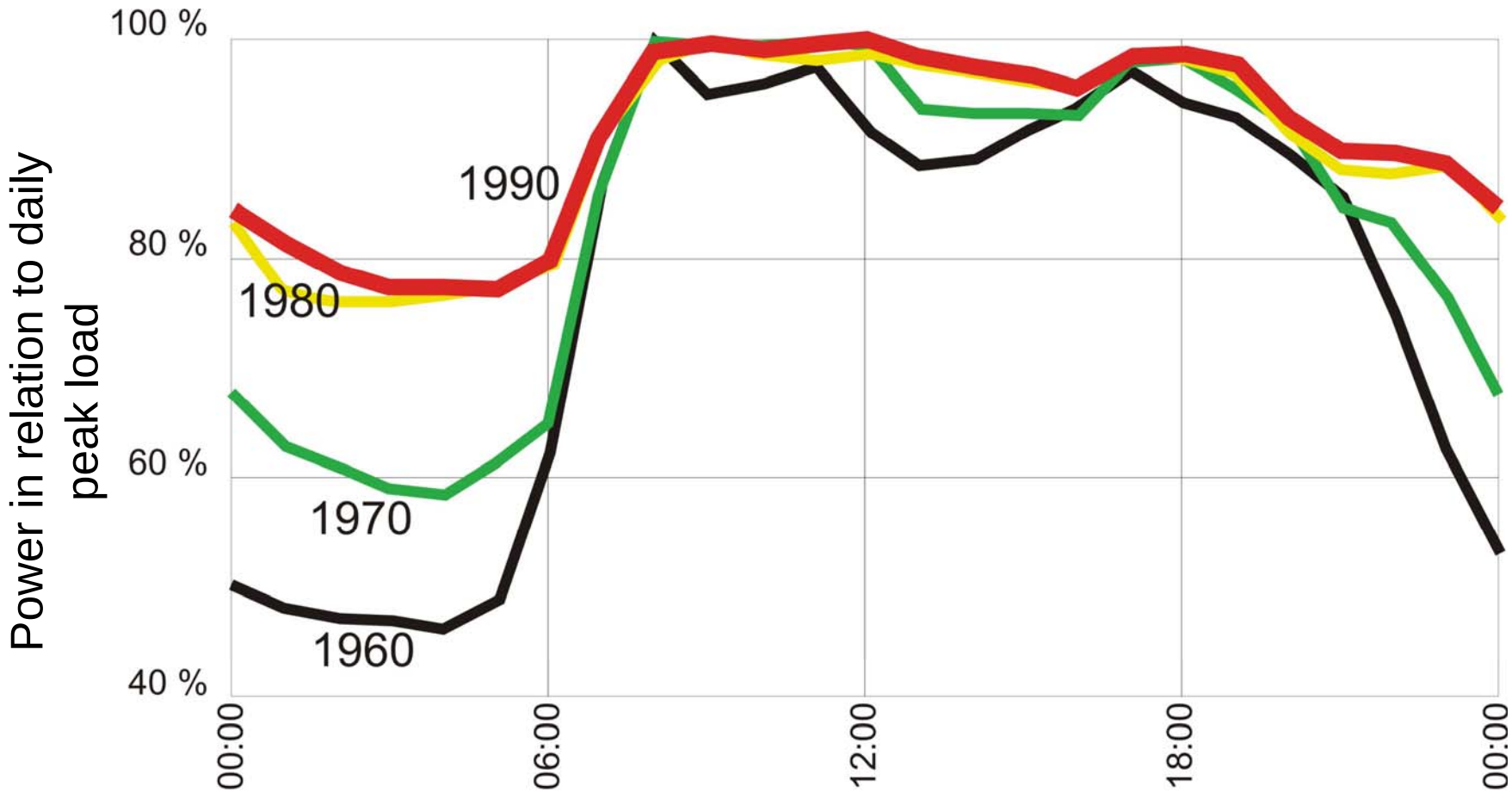
Transition to flexible electricity usage



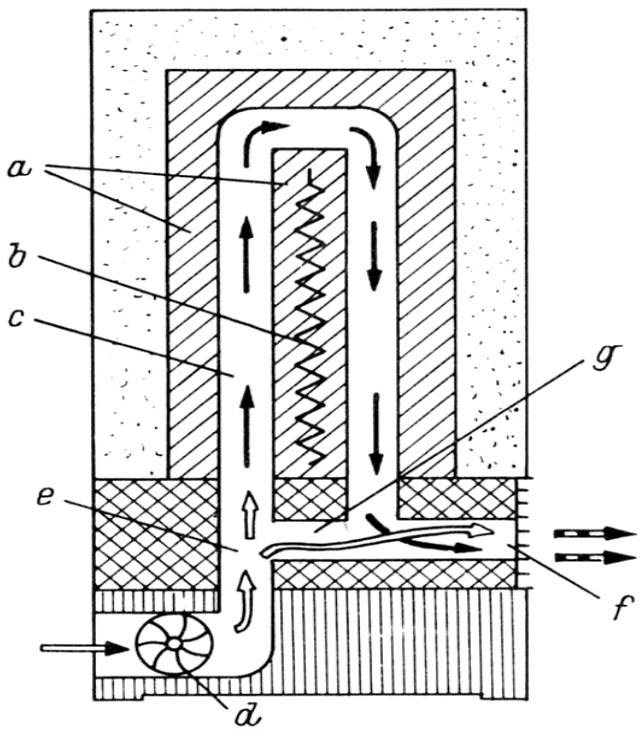
Transition to flexible electricity usage



Transition to flexible electricity usage



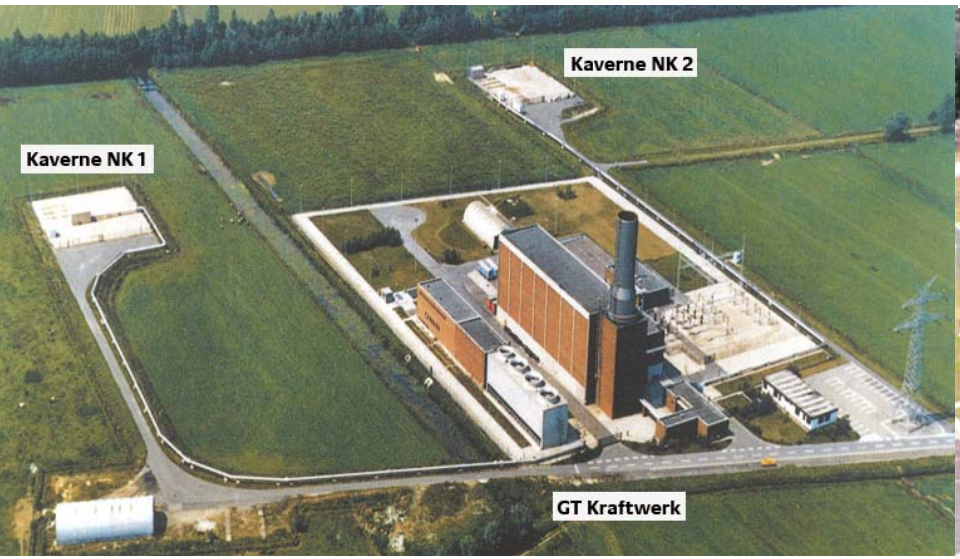
Night Storage Heating



Night Storage Heating

- Conversion from electricity into heat is done with an efficiency of 100%
- Storage heating has a self discharge – like batteries – but the lost heat is used for room heating
- When the self discharge is less than the heat demand a storage heating system is an energy storage with an efficiency of (almost) 100%

Compressed Air Energy Storage (CAES)



Elsfleth-Huntorf, Deutschland

290 MW / 2 h
8 h Compressor operation
Storage Volume: 300.000 m³

McIntosh, Alabama, USA

110 MW / 26 h
Storage Volume: 538.000 m³

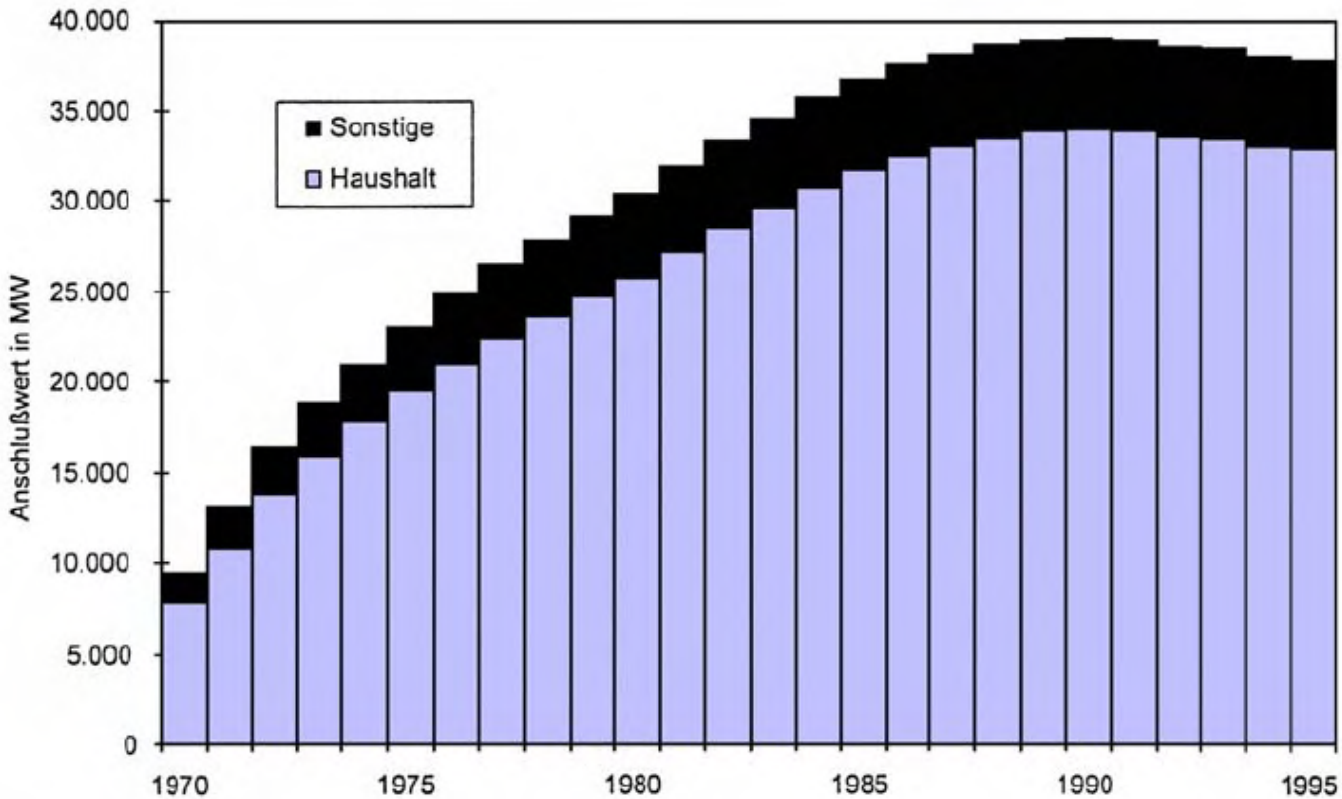
Efficiency < 50%

~~Night~~ Storage Heating

- Energy is not stored before electricity generation
- It is not stored as electricity
- It is stored in form of the end energy and has not to be reconverted into electricity again

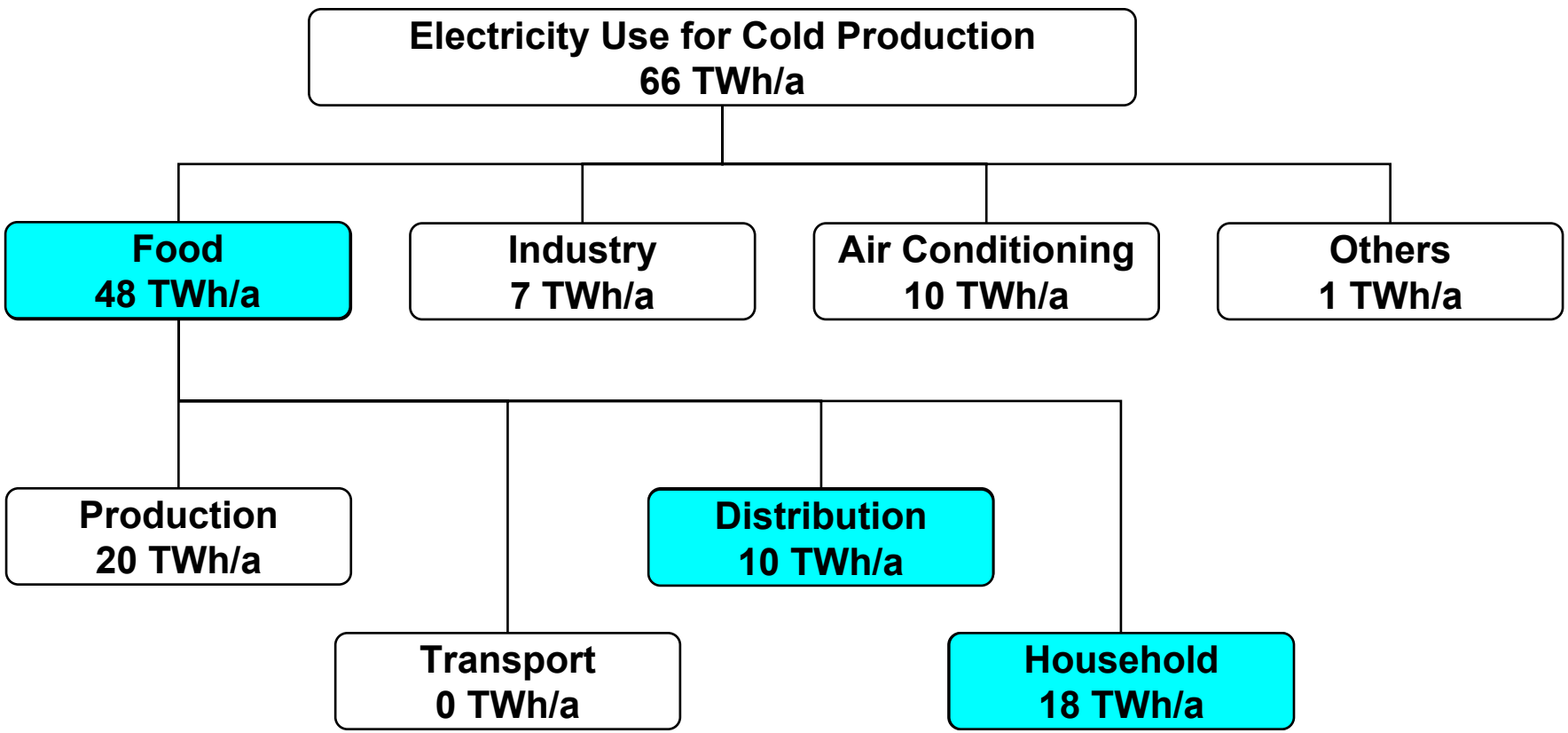
- When Germany has got rid of nuclear power and electricity from coal production will decrease these storage heating systems are ideally suited to balance fluctuating renewable energies
- There is no reason that they keep their bad reputation

~~Night~~ Storage Heating



- In Germany every year about 27 TWh of electricity are shifted to times when electricity is available
  (with pumped hydro it is less than 5 TWh)

Cold Storage



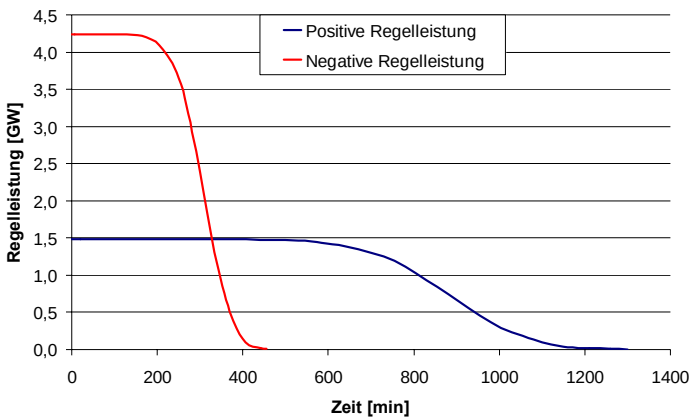
Cold Storage

Freezers

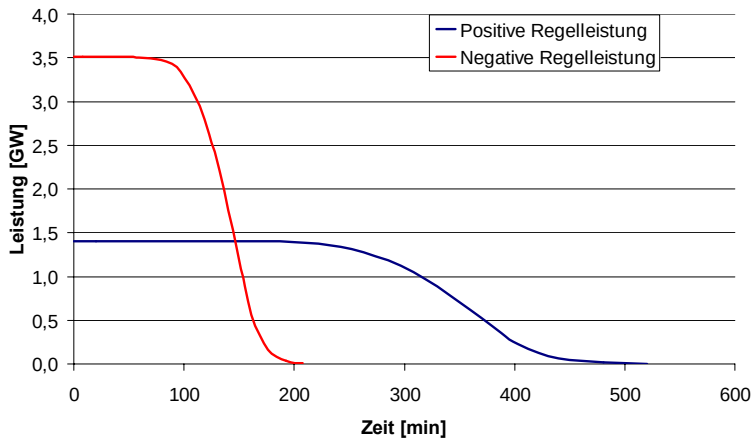
Refrigerators

Cooling shelves, cooling boxes

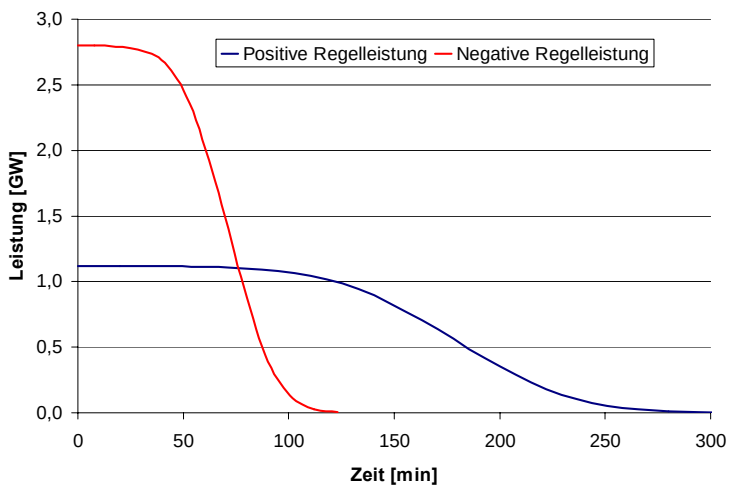
Cold Storage



Household refrigerators



Household freezers



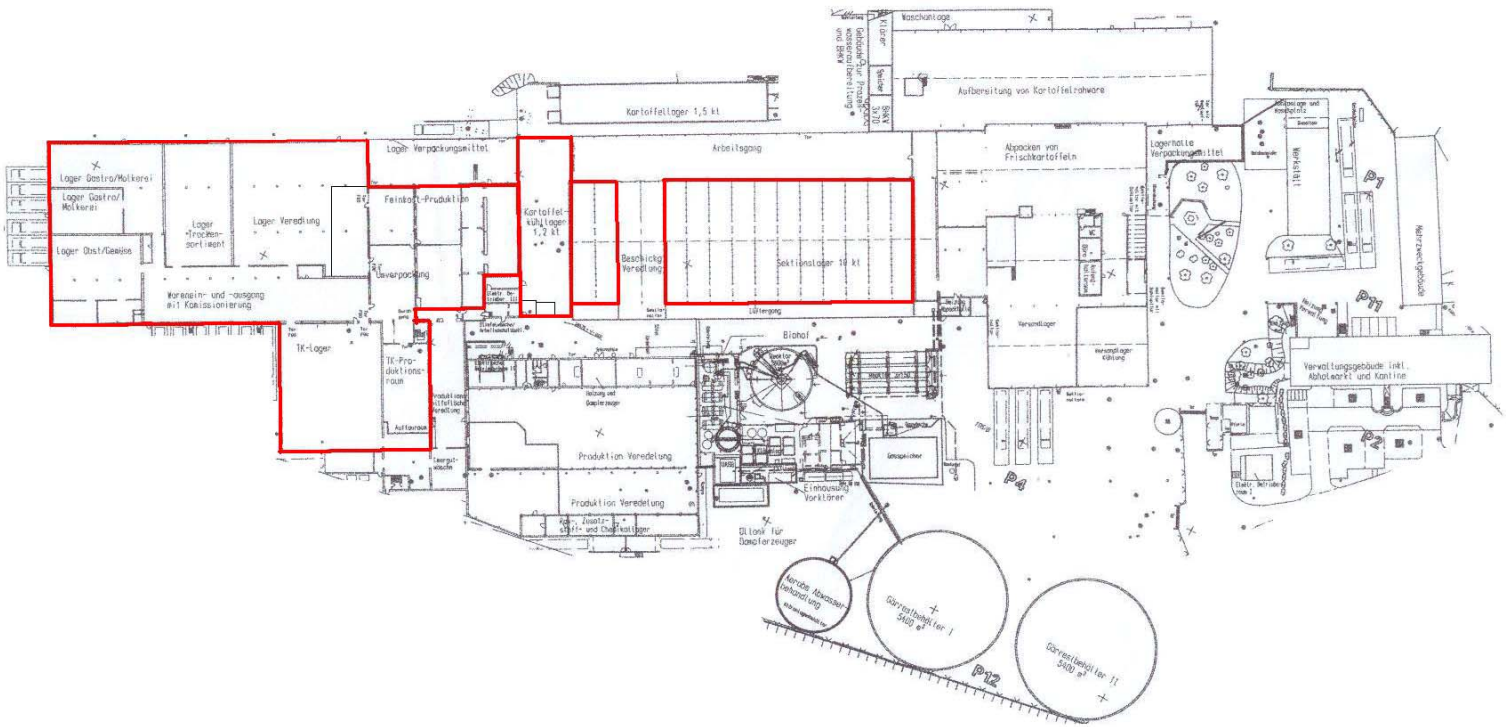
Cold storage in supermarkets

Cold Storage

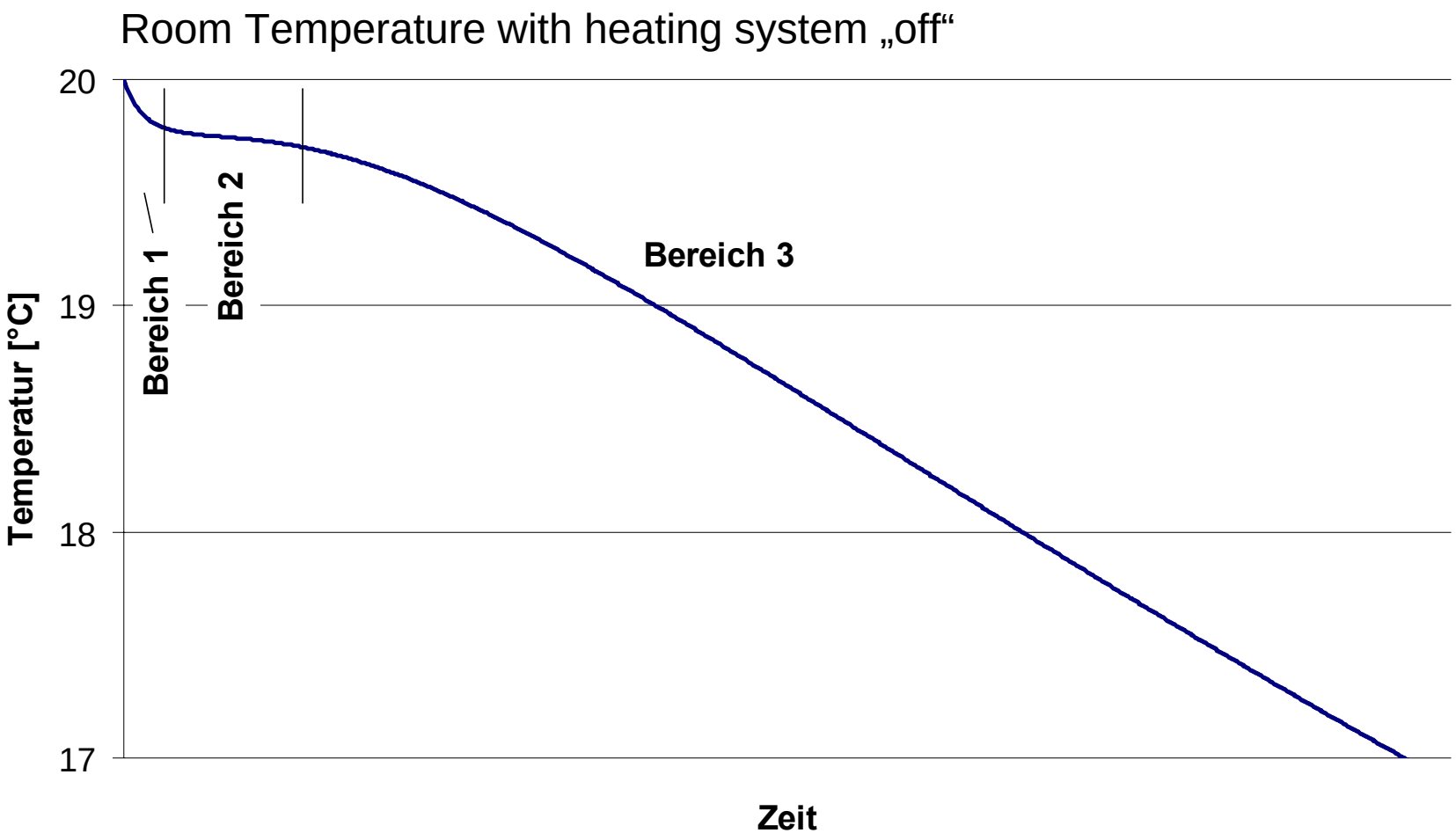
Friweika, Saxony

Cold Storage

Cooling departments and Cooling Houses



Heat capacity of buildings



Heat capacity of buildings

- Oil
- Gas
- Distance heating
- … but electricity?

Heat capacity of buildings

- Oil
- Gas
- Distance heating
- … but electricity?

Annual Energy consumption in Germany: 15 TWh (3,5%)

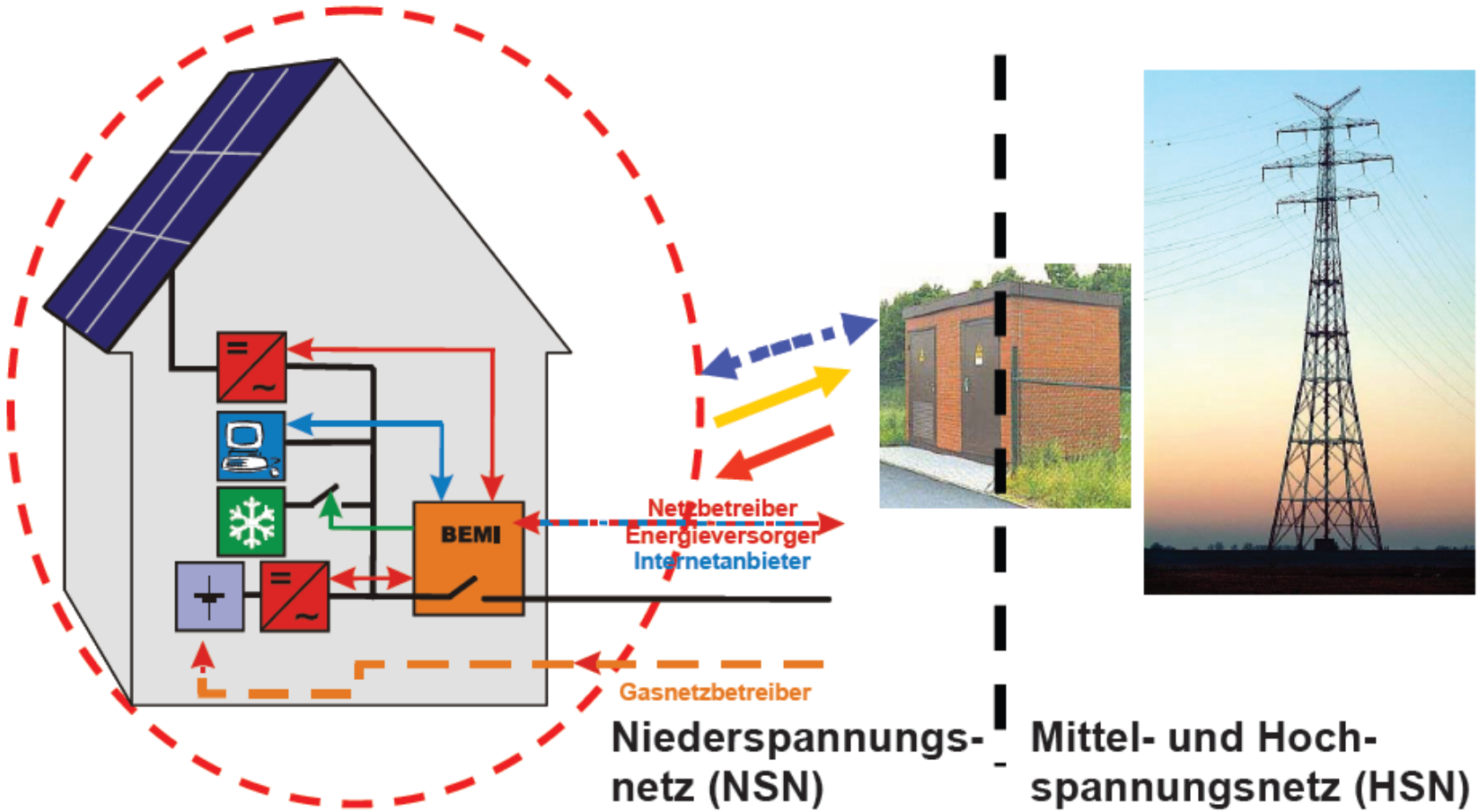
How to integrate refrigerators and circulation pumps etc. into energy management?

- So-called intelligent metering

<u>Example Italy</u>

- ENEL, IBM
- 30 Million intelligent electricity counters
- Motivation:
  cost reduction in meter reading,
  introduction of tariffs with power limitation
  (e.g. air conditioning units)
  Disconnection of costumers who do not pay
- Communication via PLC, GSM and ISDN

How to integrate refrigerators and circulation pumps etc. into energy management?



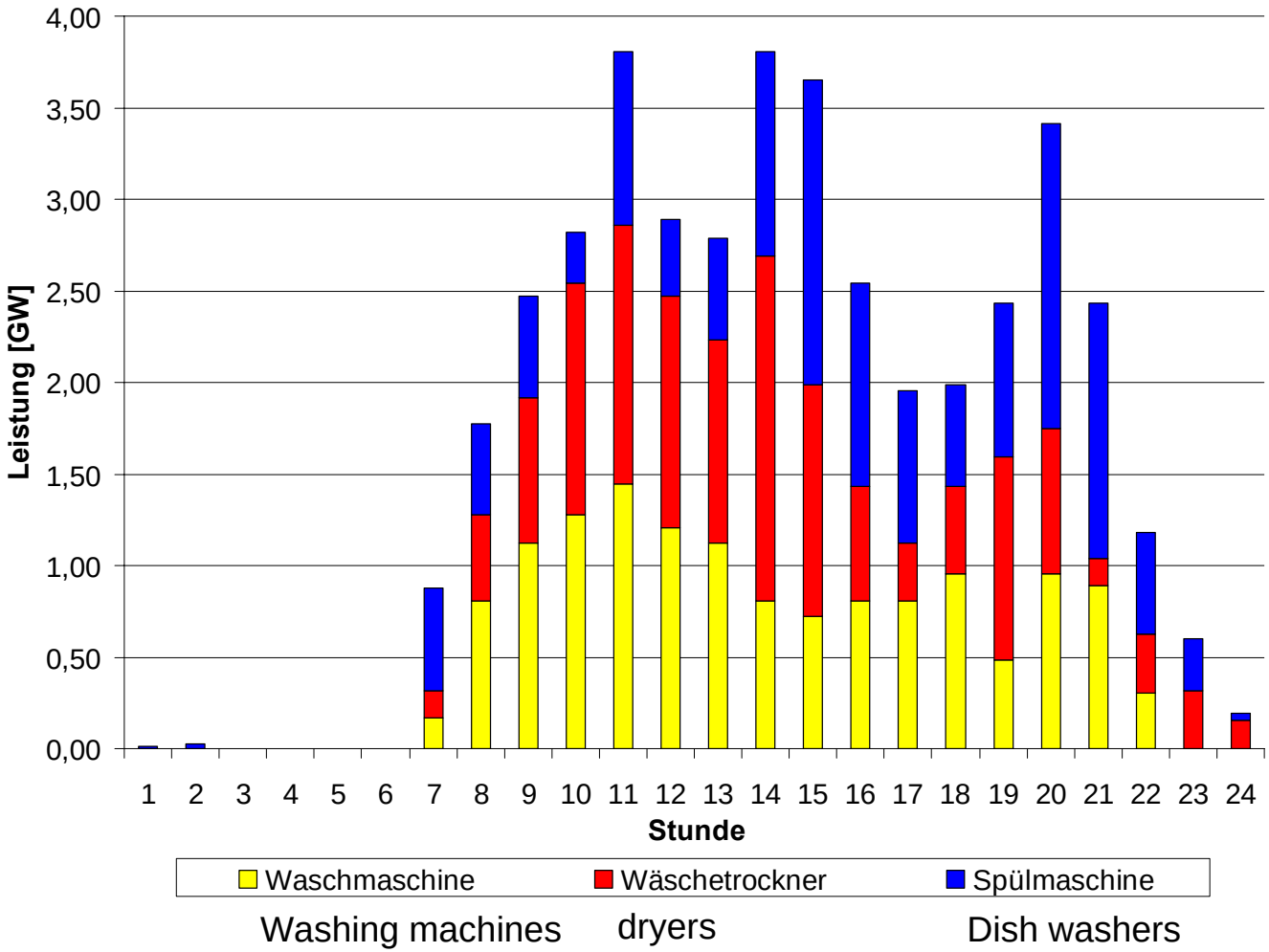
… other examples of end use energy storage

- Ventilation systems

  The storage is air with a high oxygen content, it is discharged when e.g. we humans have used the oxygen and have produced CO_2
- CHP systems with heat storage
- Heat pump systems with heat storage
- Adopted use of washing machines, dish washers and dryers

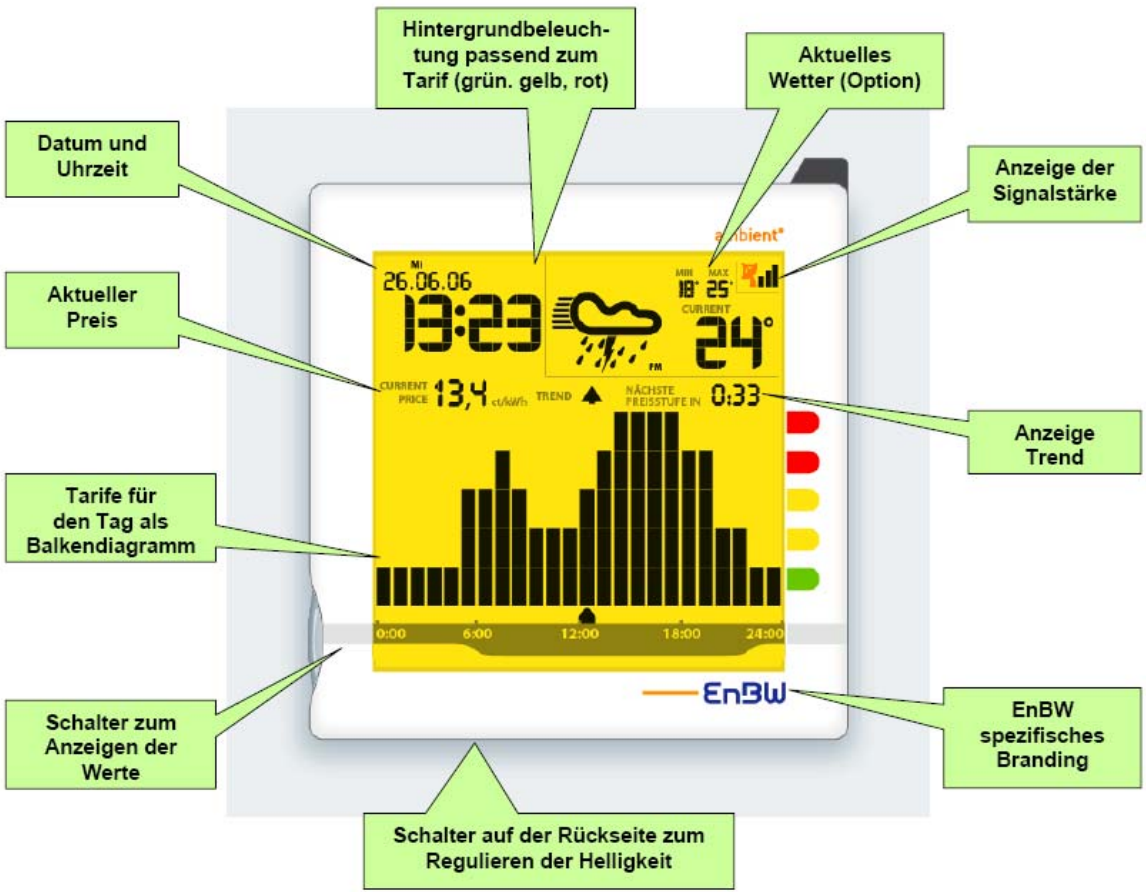
  (that is not storage! And the only possibility where the user really takes account of the energy management)

Transition to flexible electricity usage
Change of user behavior



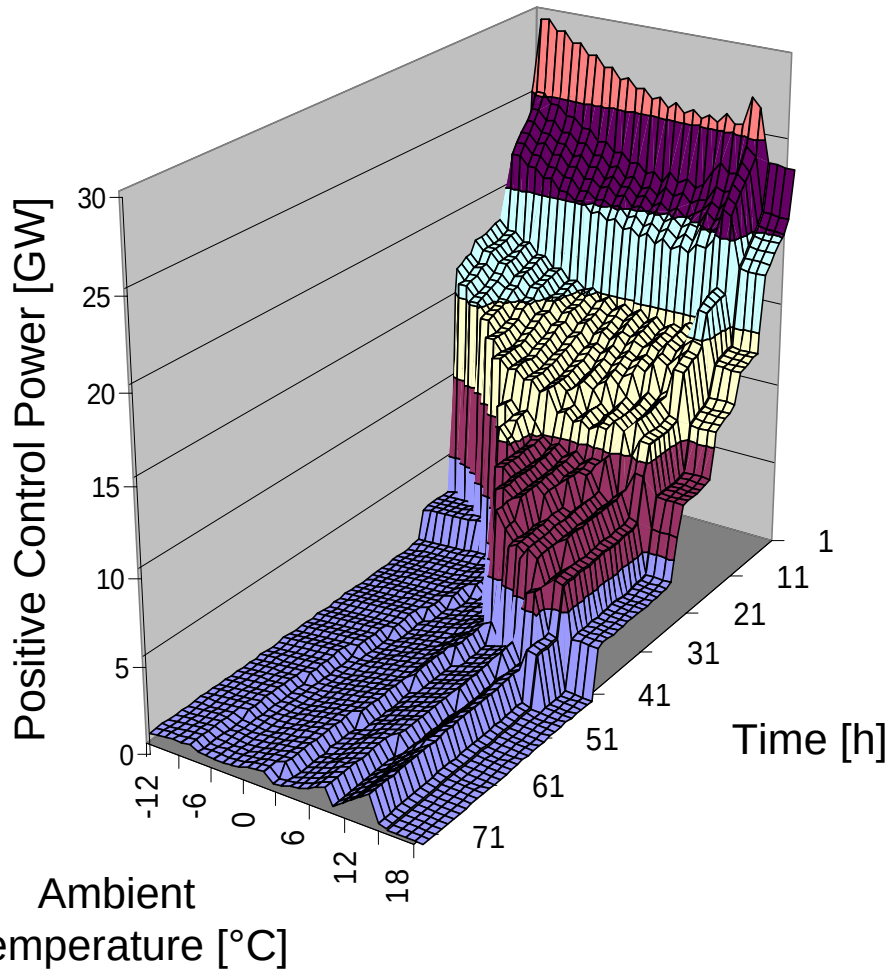
Annual electricity consumption of dish washer, dryer and washing machine: 15,2 TWh.

Energy Price Displays



Source: EnBW

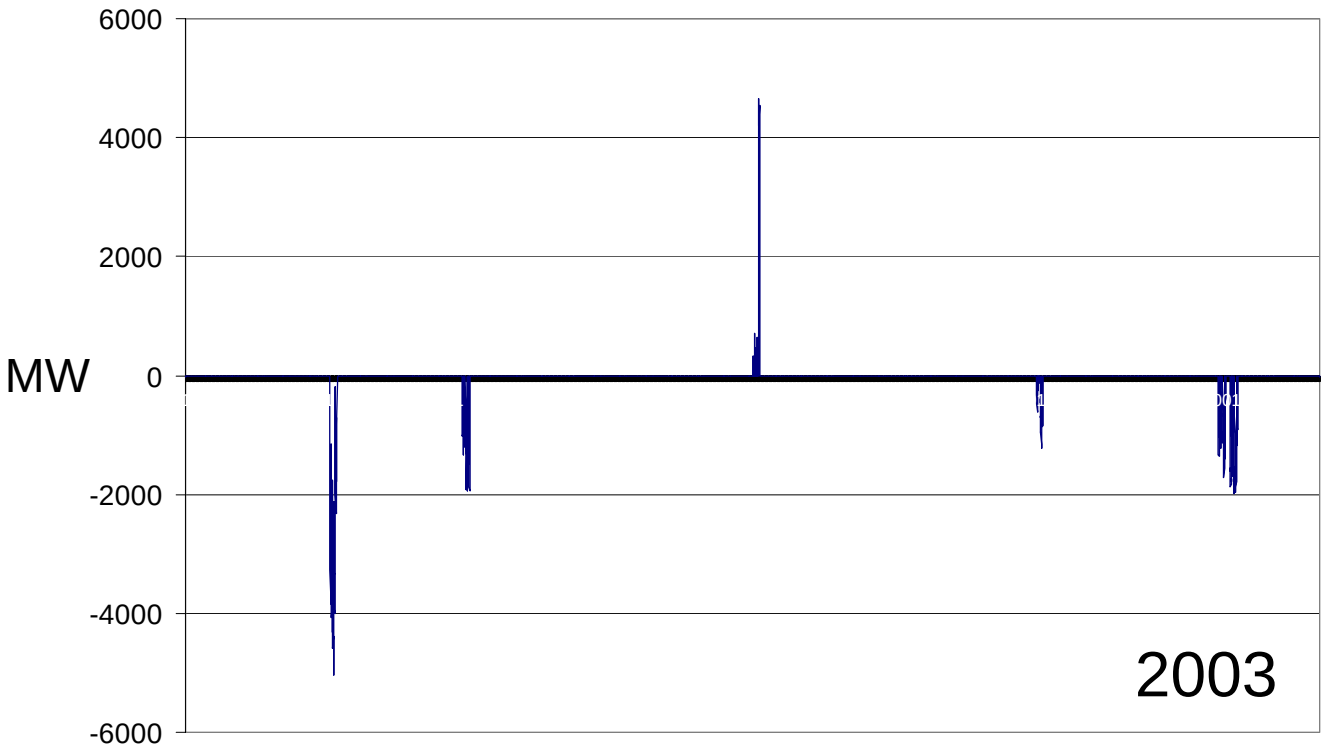
Summary



Positive control power of all non-electrical storage devices discussed

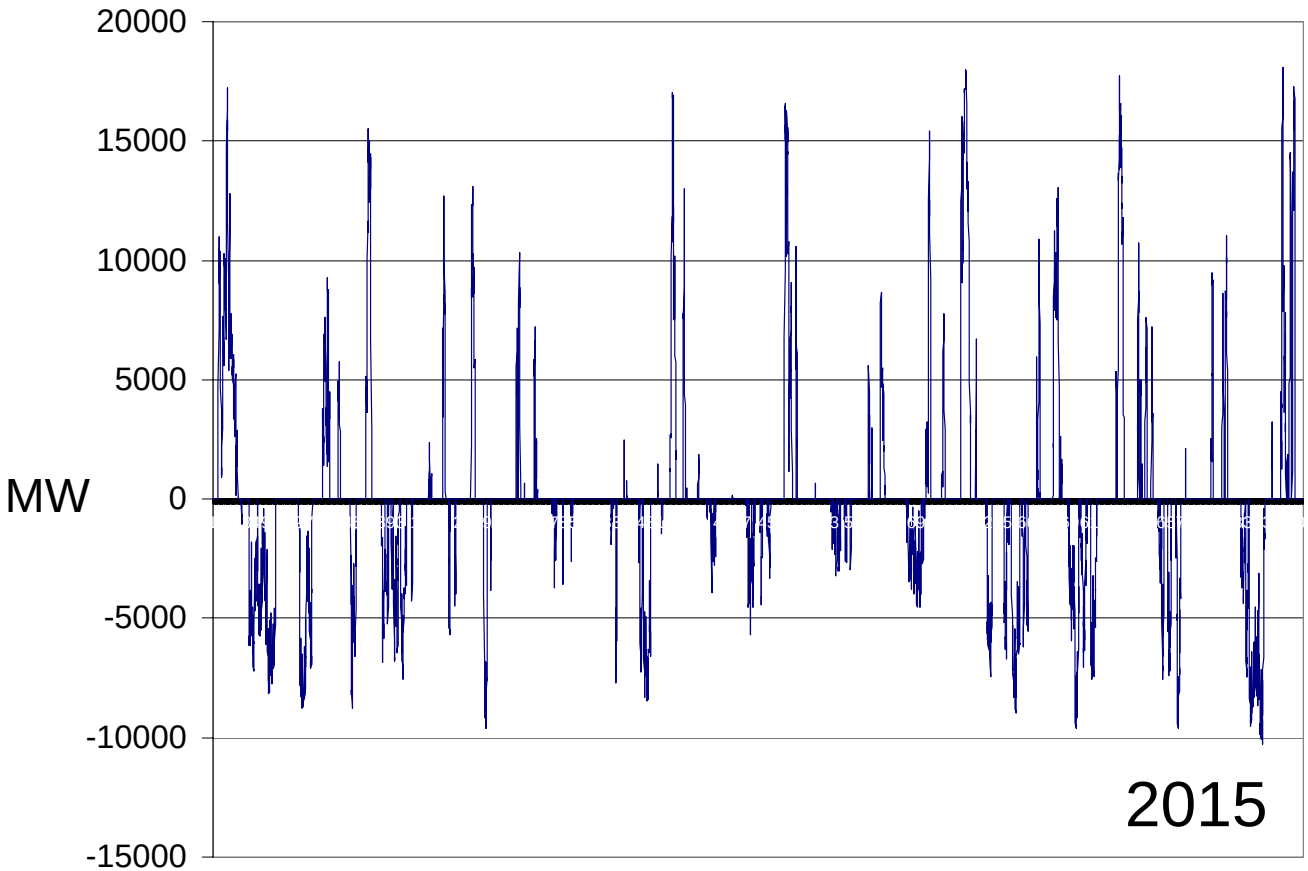
400 GWh of end use energy storage capacity all the year

Summary, Worst Case scenario (mixture of base load and wind only)



1. Long time balance of fluctuating energy sources

Summary, Worst Case scenario (mixture of base load and wind only)

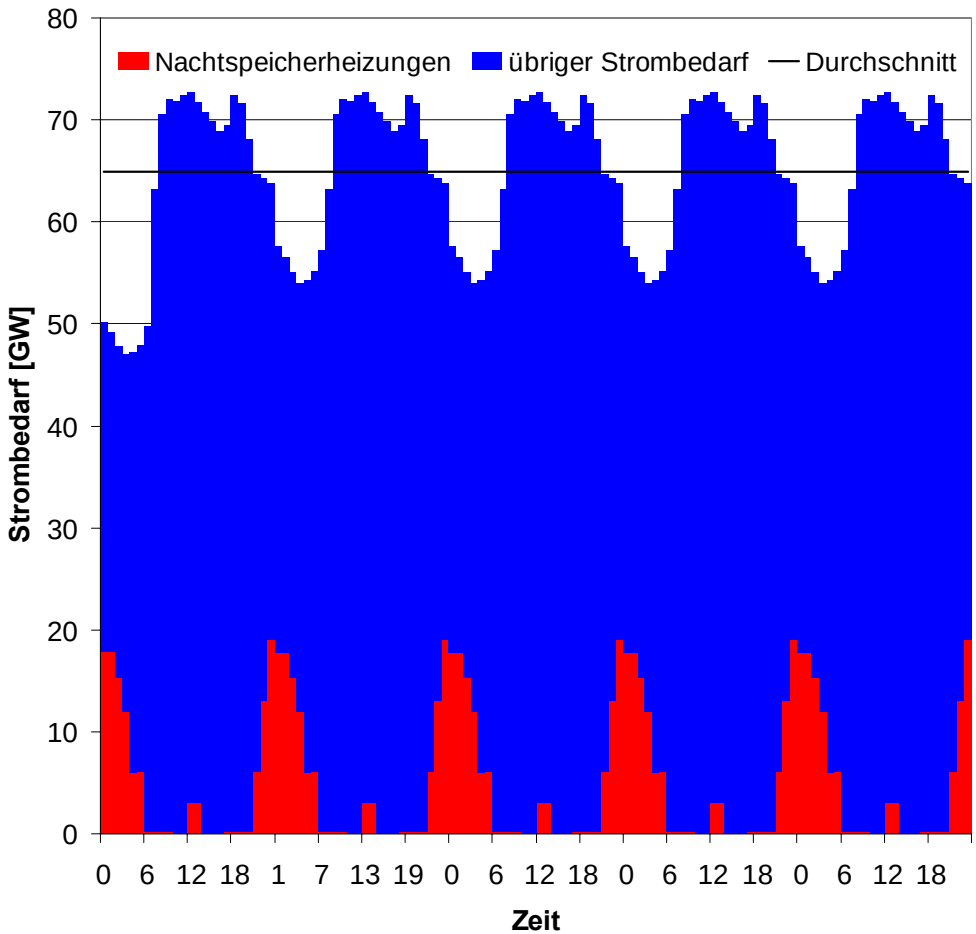


1. Long time balance of fluctuating energy sources

- requirement of diversification (wind, solar, biomass, hydro, etc.
- requirement of other storages than end energy storage

Conclusions

2. Reduction of annual peak power demand



- at 13 hours per day the electrical load is above avarage
- 78,7 GWh would have to be shifted
- this is possible without new installations of thermal storage devices

→ Saving of conventional power station capacity

Conclusions

3. Control Power

- at any season at least 23 GW control power in the time range of primary and secondary control is available
- in all UCTE area only 3 GW are required

Conclusions

There is no theoretical upper limit for the integration of renewable energies in electrical grids

Bytes are cheaper than iron!