

# The trend of renewable energies and smart grids in Europe and Germany

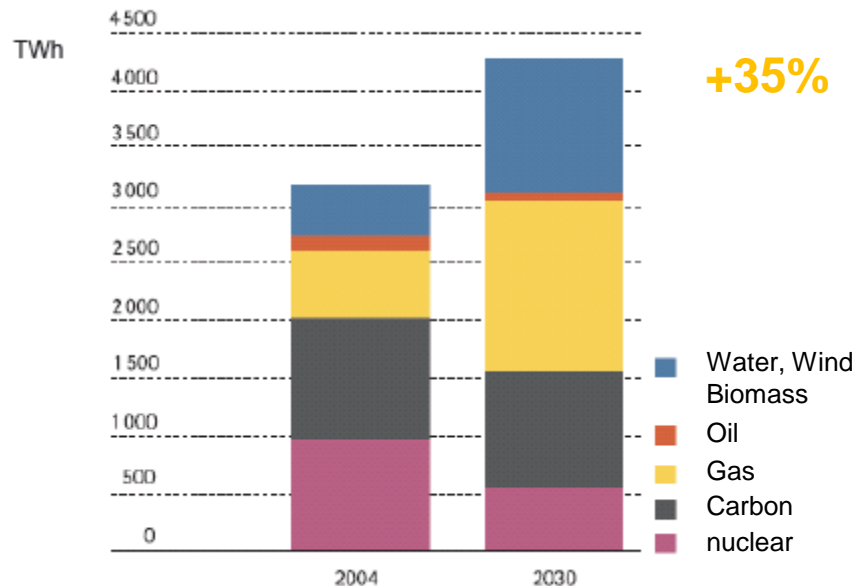


TECHNISCHE  
UNIVERSITÄT  
DARMSTADT



# The European Situation

## Expected power generation in EU-25 in 2030



Source: E.ON/Ruhrgas/IEA/Eurostat, DENA

Renewable Energies

nuclear

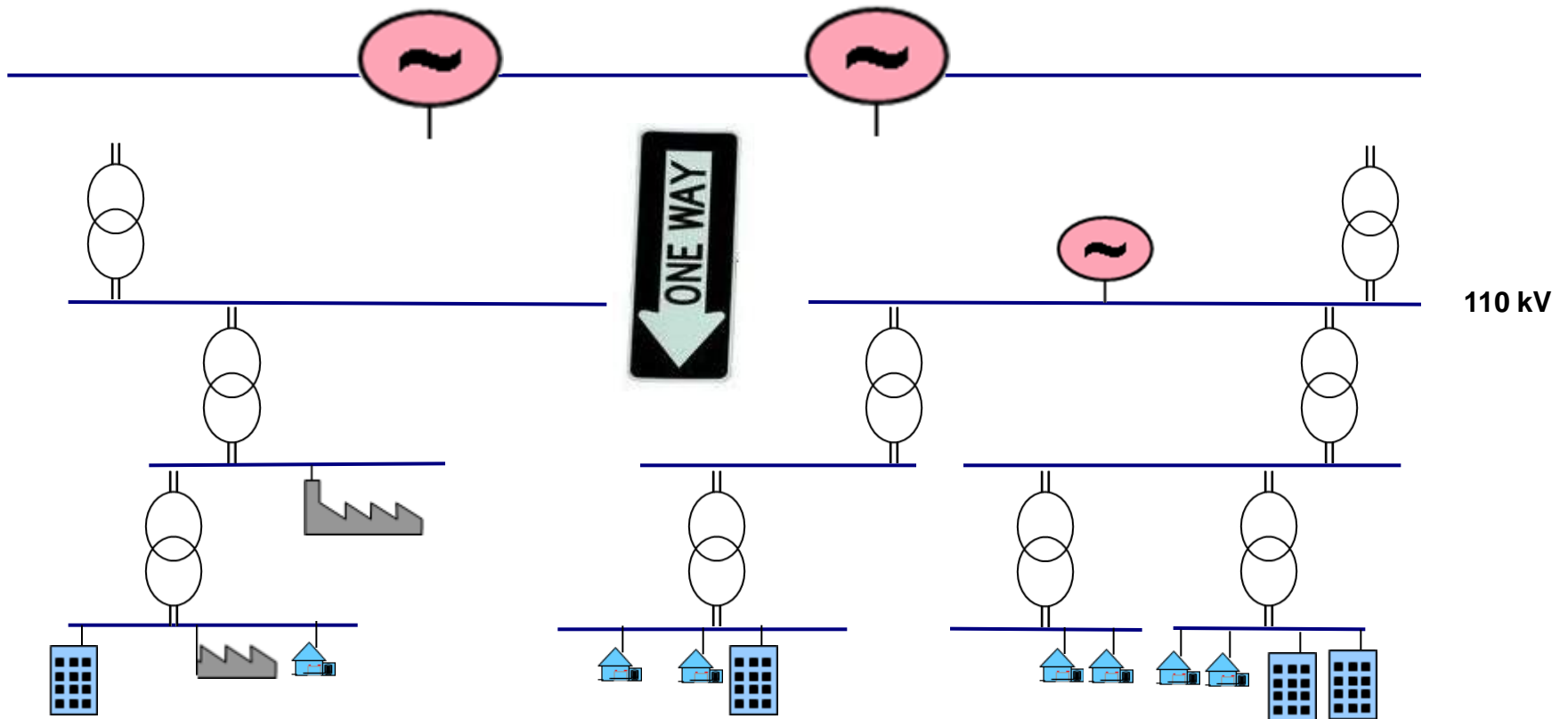
Volatile structures



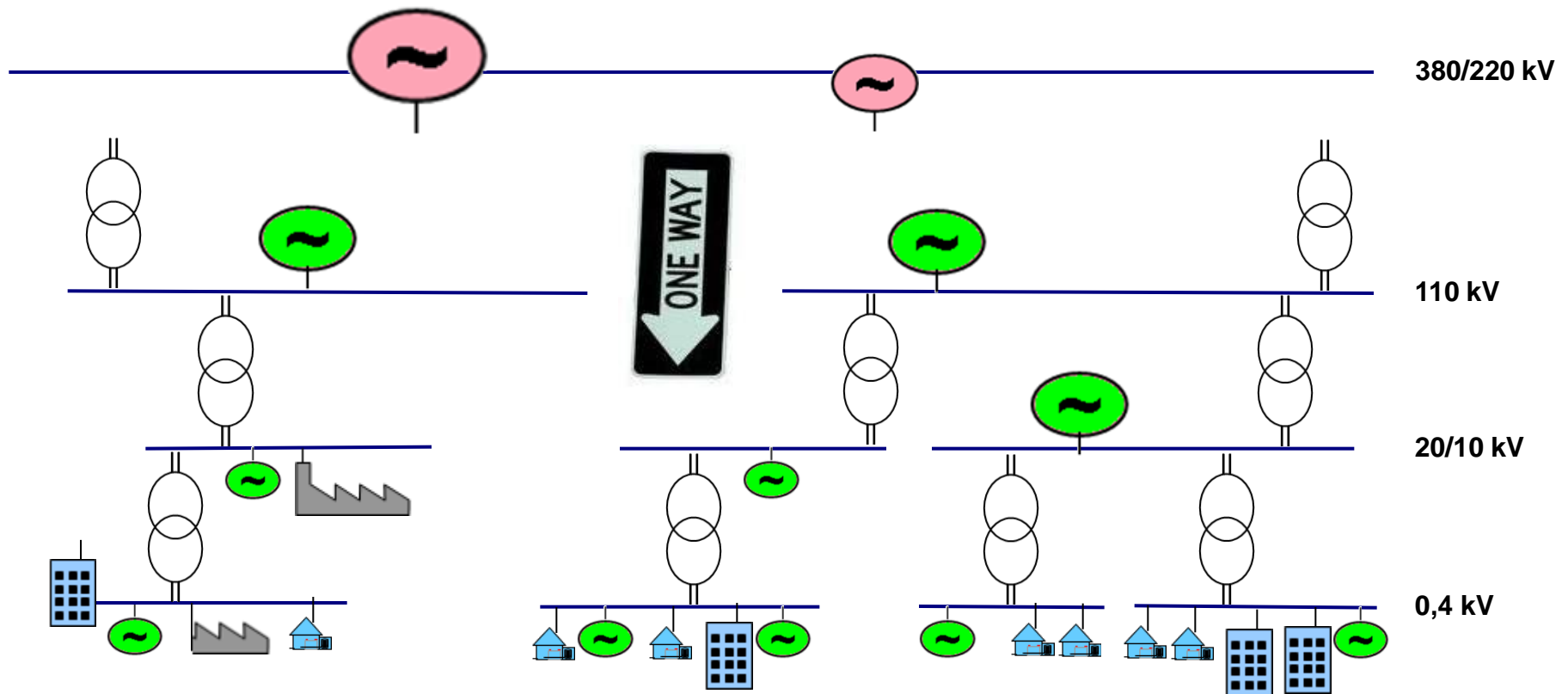
→ **The energy generation  
structure is changing**



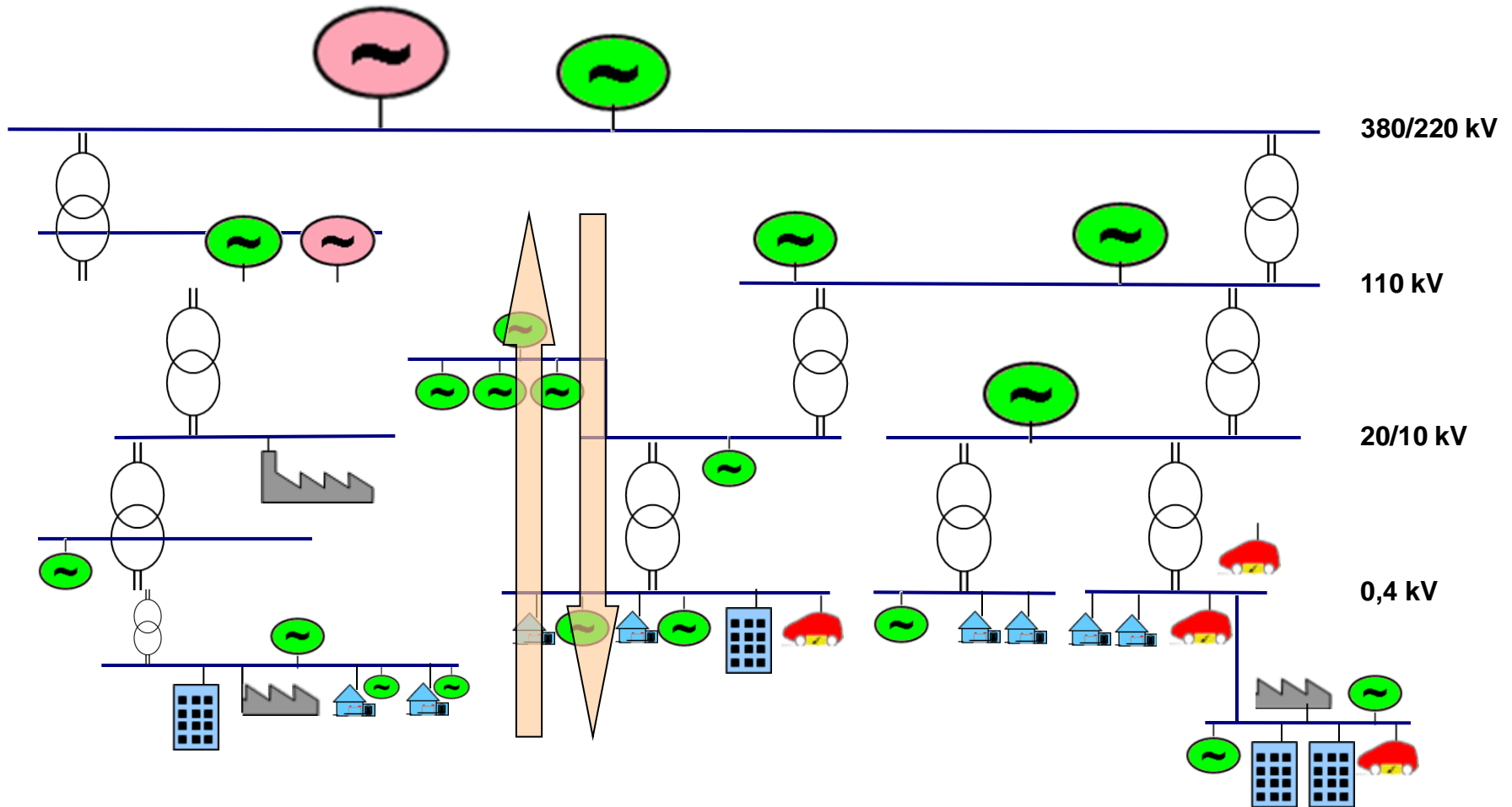
# The conventional grid



# Tendencies in the grid



# Two way system



# What are the reasons for a changing energy generation structure?

- Expansion of renewable energies to reduce CO<sub>2</sub> emissions
- Compatibility to the environment
- Political decisions and boundary conditions
  - Nuclear power phaseout (Germany)
  - Feed-In tariffs for renewable energy lead to a fast expansion of renewable energies (Spain and Germany)



# What are the reasons for a changing energy generation structure?

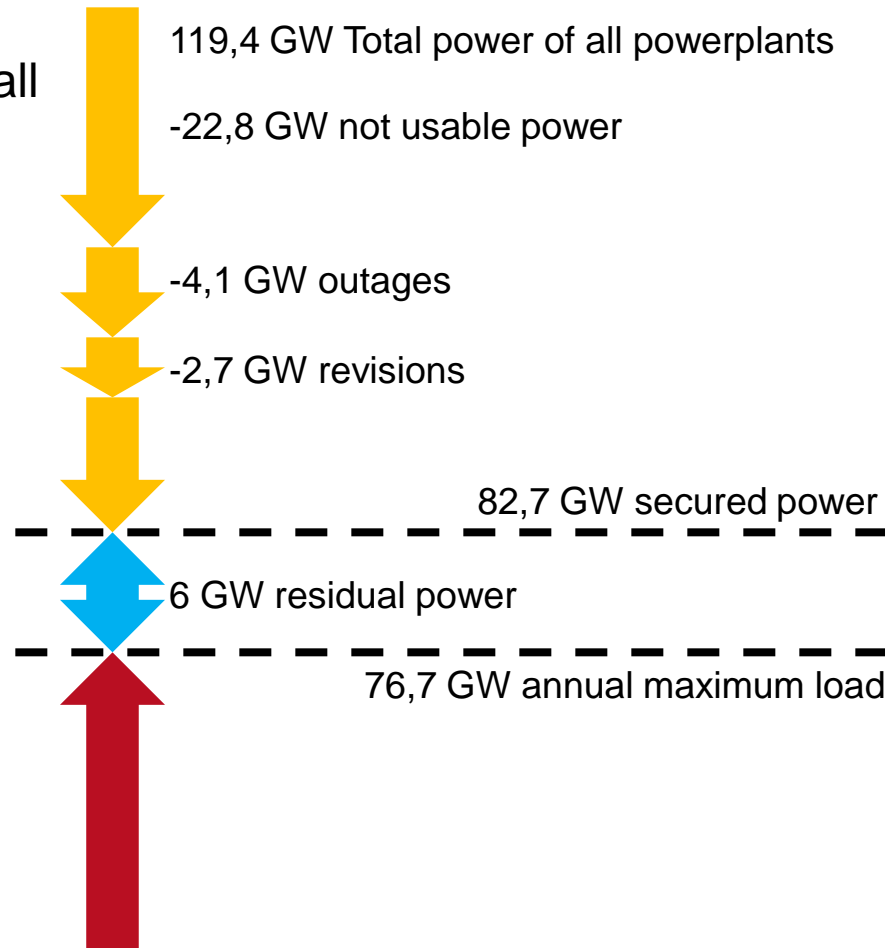
- Energy efficiency aims of the German government from 1990 until 2020:
  - About 40% reduction of CO<sub>2</sub> emissions
  - About 25% increasing of renewable energies
  - About 14% increasing of renewable energies in the heat sector
  - About 25% increasing of the cogeneration of heat and power

**→ What are the consequences?**



# The secured power today

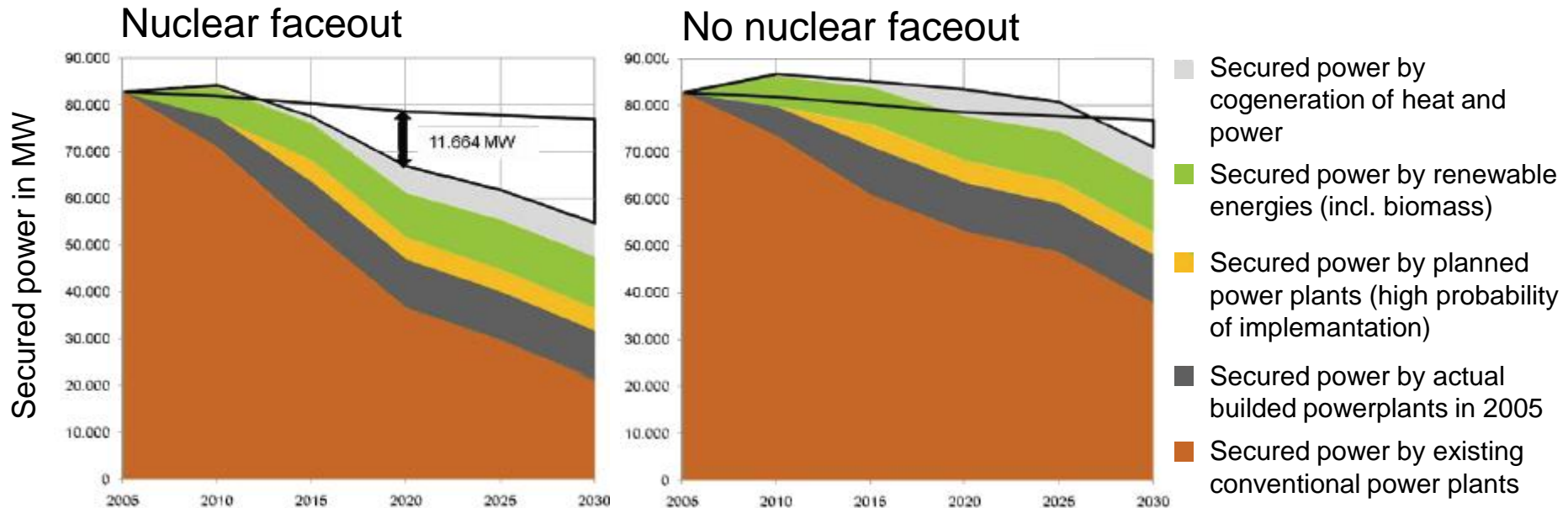
The secured power from all power plants and renewable energies in Germany in 2005



Source: dena



# The secured power in Germany until 2030



- Nuclear faceout: In 2020 a lack of nearly 12GW occurs.
- No nuclear faceout: After 2025 a lack occurs.

➔ **The secured power does not cover the maximum annual load**

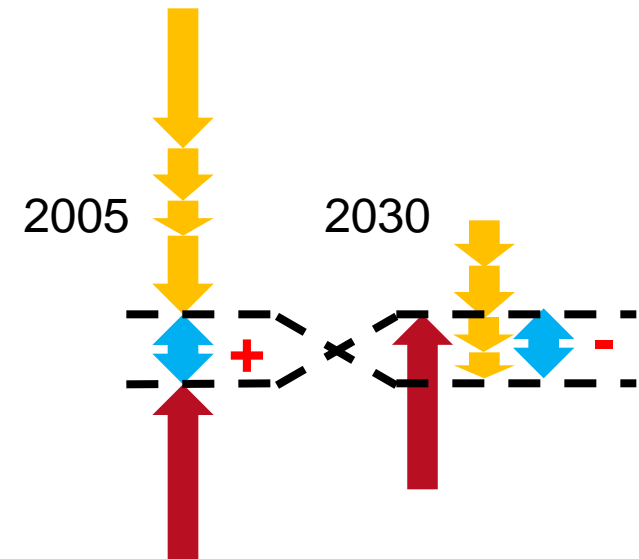
Source: dena



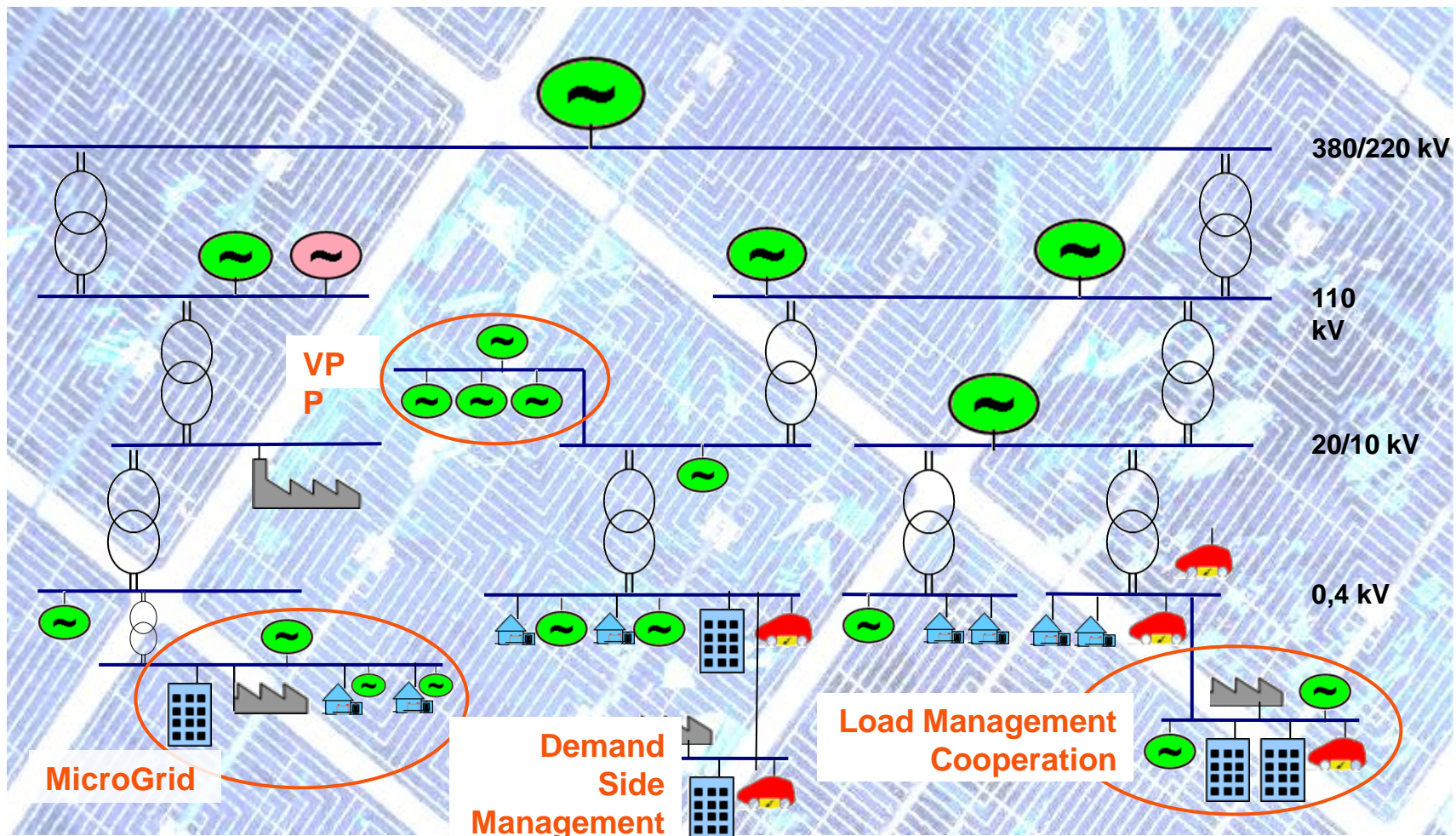
# What needs to be done?

- New strategies for managing volatile energy structures need to be found
- The total lack of secured power resulting from a new energy generation structure needs to be balanced.
- Energy efficiency strategies are necessary to work against an increasing demand of energy and thus also against an increase of the annual maximum load.

→ smart grids can be an opportunity



# Smart grids: Linking energy generation and consumption by ICT



# E-Energy: The german program of smart grids

- A four year term initiative by the German Federal Ministry of Economics and the German Ministry of Environment.
- Founded with over €140 million Eur



Bundesministerium  
für Wirtschaft  
und Technologie



Bundesministerium  
für Umwelt, Naturschutz  
und Reaktorsicherheit

- ➔ E-Energy develops an Information and Communication Technology based energy system
- ➔ E-Energy develops the intelligent integration of electric vehicles (E-Mobility) into the energy system



# The German Chancellor Angela Merkel about E-Energy



TECHNISCHE  
UNIVERSITÄT  
DARMSTADT



*"E-Energy shall bring intelligent IT-support to energy production and consumption – from the generator in the power station way down to the customer."*

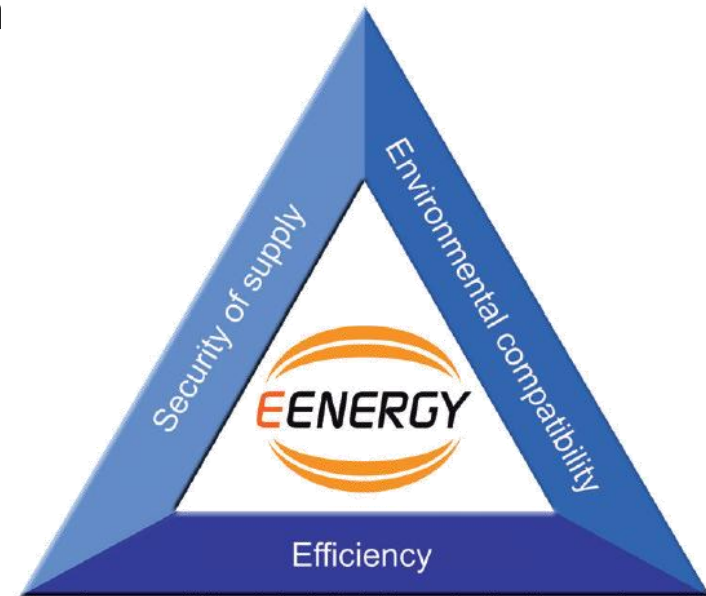
*Dr. Angela Merkel, Chancellor, at IT summit in Darmstadt, November 2008*

**Make it work today!**



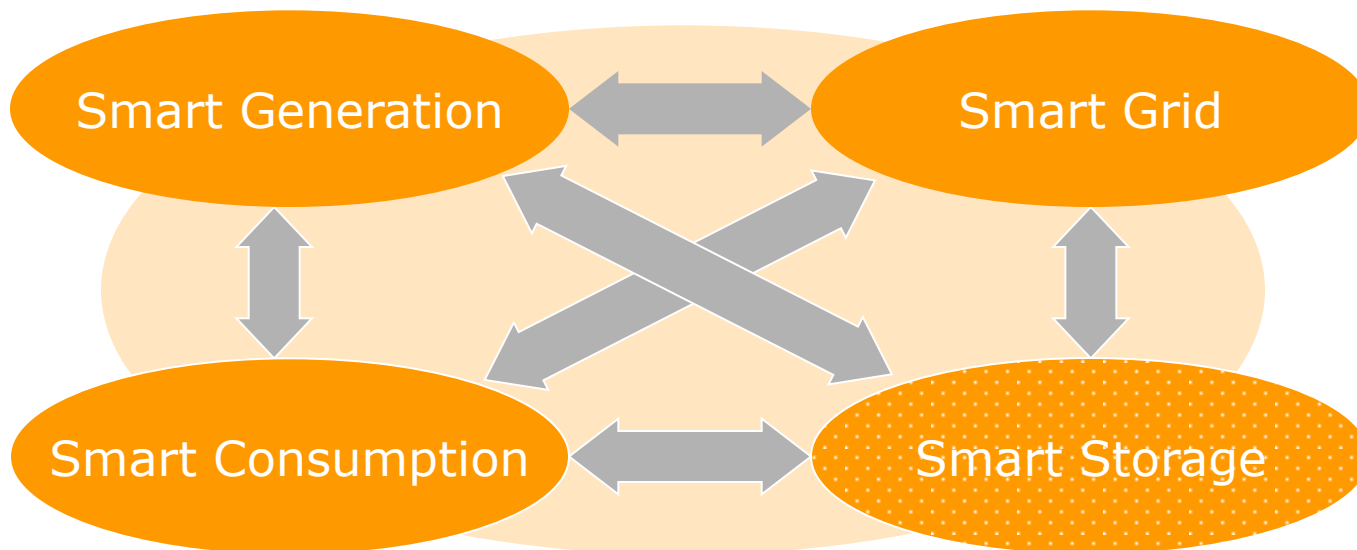
# E-Energy Goals

- Security of supply, efficiency and climate protection with digital networking of the power providing system
- Optimisation of the energy supply system using modern information and communication technologies (ICT)
- New interdisciplinary jobs in the fields of renewables and communication
- New market for hightech solutions
- Progress in liberalisation and decentralization of the energy market



# E-Energy makes grids smarter

- E-Energy makes the grid smarter by linking all components of smart power systems to information and communication technologies



# A new paradigm

---

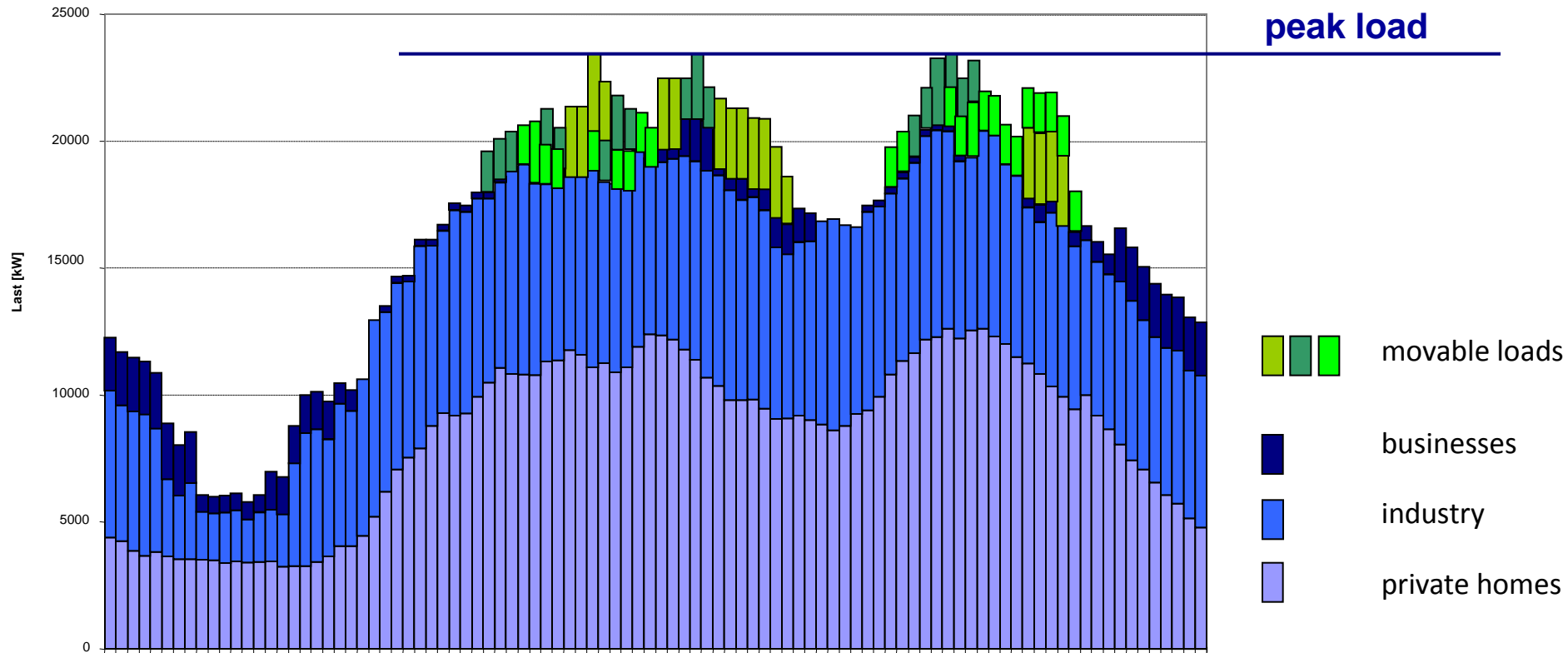
**consumer oriented generation**

**plus**

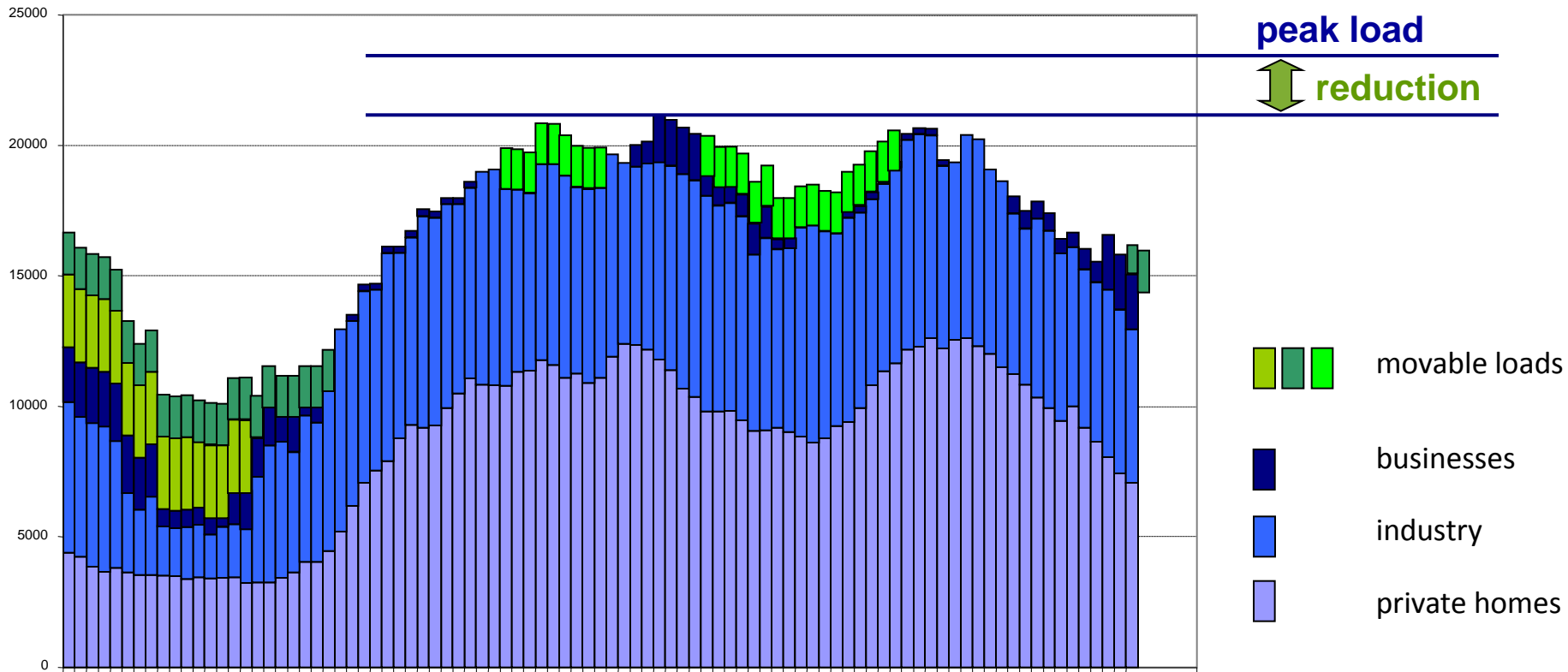
**generation oriented consumption**



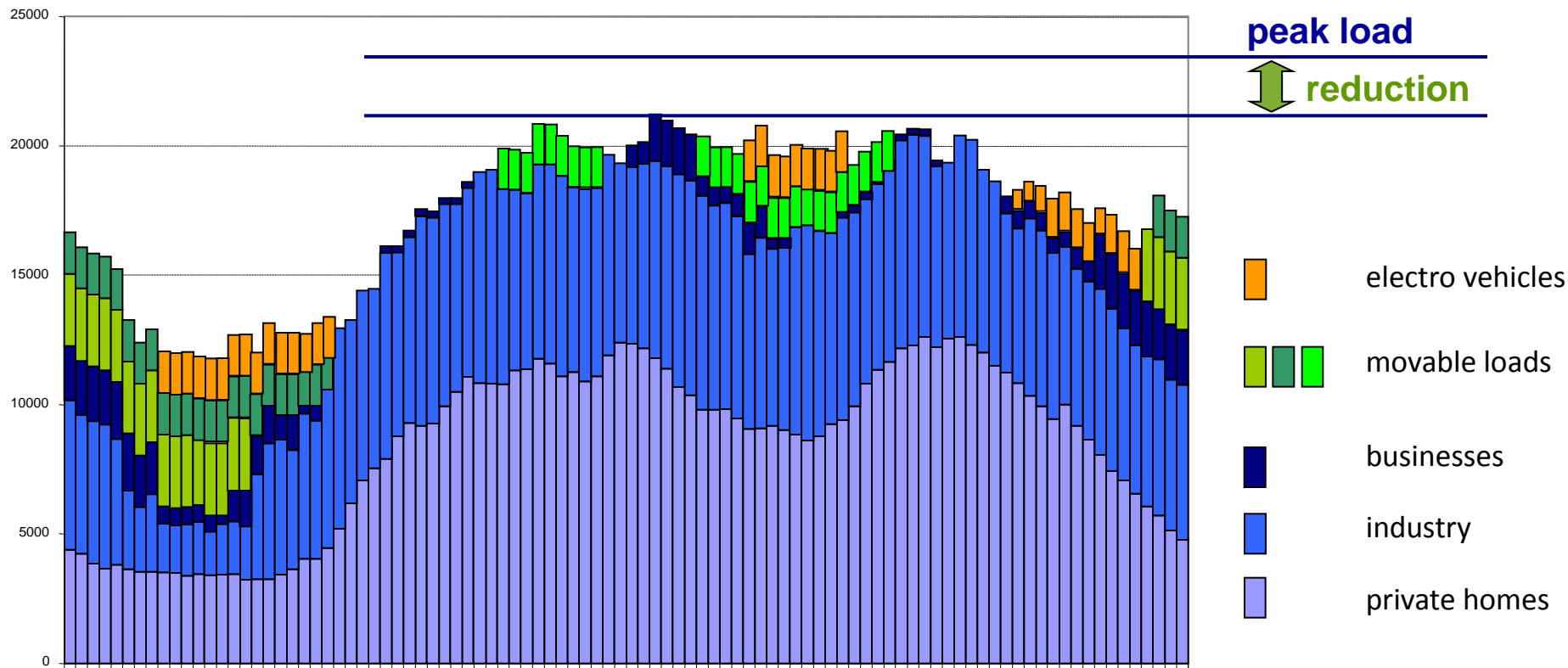
# Movable loads



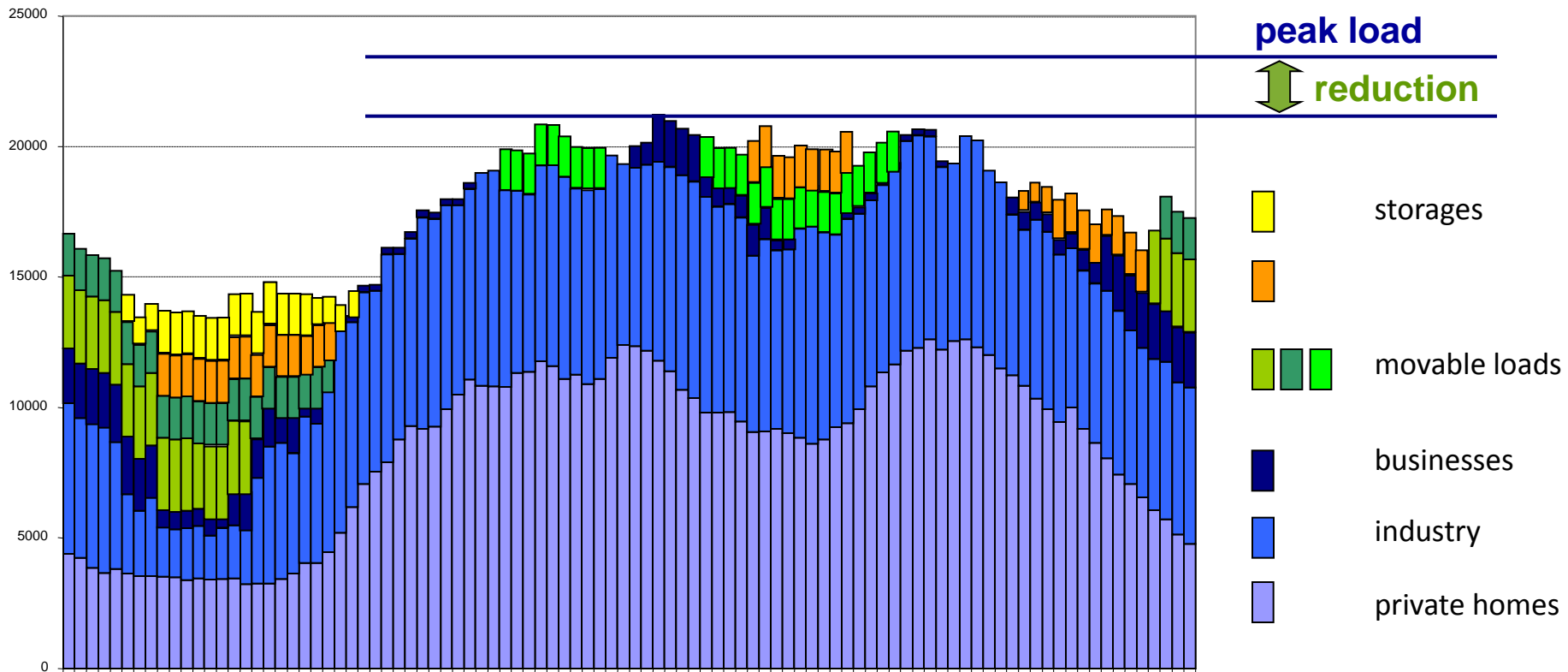
# Moved loads into off-peak times



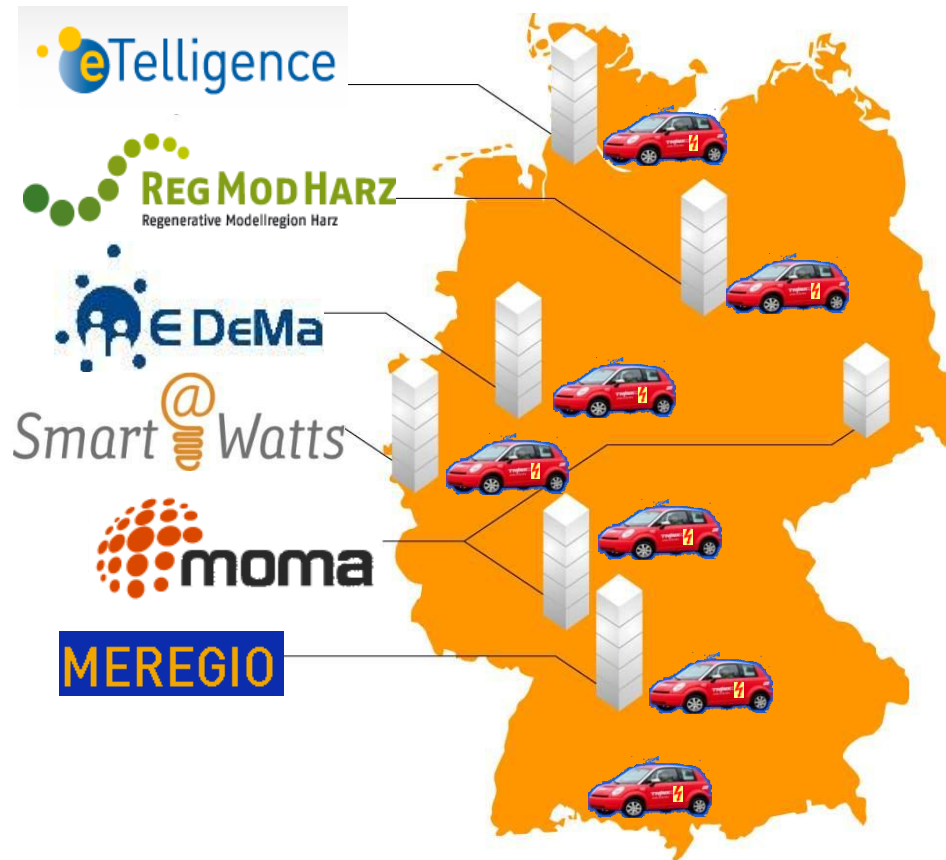
# Charging of electrical vehicles



# Integration of storages



# E-Energy Projects



# E-Energy project: MEREGIO

- Specifics:
  - Energy efficiency in the integrated house
- Instruments:
  - Smart meters
  - Price incentives at the outlet
  - Minimum emission certificates
  - Central platform to control and run the system
- Main partner: EnBW Energie Baden-Württemberg AG
  - Other partners: IBM, ABB, SAP, Systemplan, University of Karlsruhe



# E-Energy project: moma



TECHNISCHE  
UNIVERSITÄT  
DARMSTADT

- Specifics:
  - New business models and tariff incentives
- Instruments:
  - „Energy Butler“, control devices connected via powerline carrier
  - CORE platform as a basis for the electronic market place
- Main partner: MVV Energie AG
  - Other partners: IBM, Power PLUS Communications, Papendorf Software Engineering, DREWAG, University Duisburg-Essen



# E-Energy project: RegModHarz



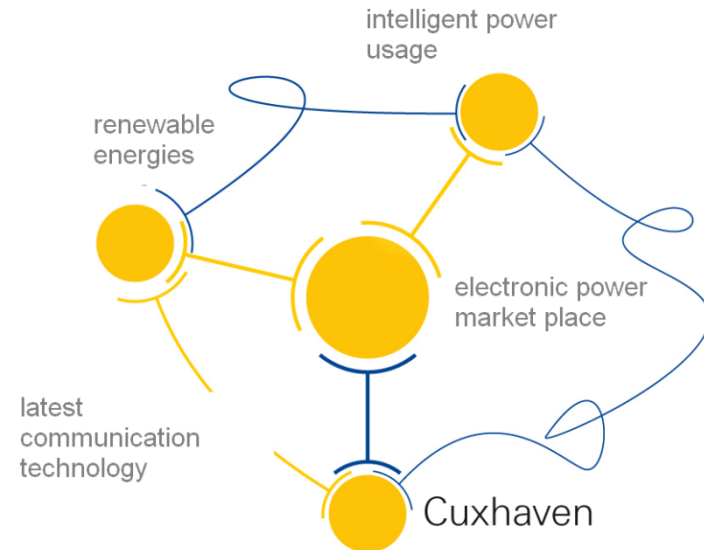
TECHNISCHE  
UNIVERSITÄT  
DARMSTADT

- Specifics:
  - Multitude of renewable energy plants and a storage power station
- Instruments:
  - Control system guarantees grid stability
  - Bidirectional Energy Management Interface (BEMI)
  - Forecast-system for wind energy
  - New business model: bundling regional distributed power generating units
- Main partner: RegenerativKraftwerk Harz GmbH & Co
  - Other partners: Siemens, E.ON, in.power, ]



# E-Energy project: eTelligence

- Specifics:
  - High percentage of renewable energies, cold stores and indoor swimming pools as energy storage
- Instruments:
  - Regional power portal
  - Plug&play networking of appliances
  - Online visualisation
  - Using regulation capacities of big consumers
- Main partner: EWE AG
  - Other partners: OFFIS, energy & meteosys, Fraunhoferverbund Energie

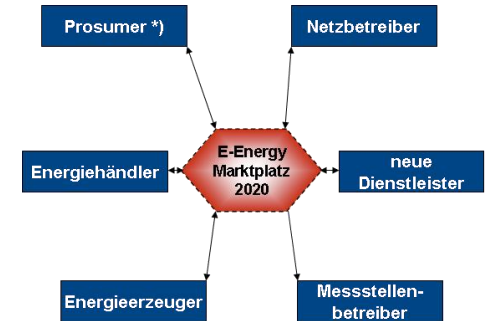


eTelligence



# E-Energy project: EDeMa

- Specifics:
  - Cooperation of big supplier and municipal utility; intelligent household appliances
- Instruments:
  - Smart ICT gateways
  - Incentive systems
  - ICT for grid management of decentralized power distribution networks
- Main partner: RWE Energy AG
  - Other partners: Siemens, Prosyst Software, Miele, ef.ruhr, Stadtwerke Krefeld

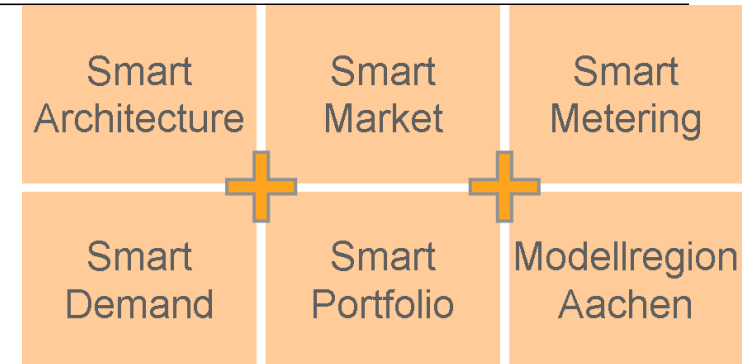


# E-Energy project: Smart Watts



TECHNISCHE  
UNIVERSITÄT  
DARMSTADT

- Specifics:
  - Pricing signals at outlets, self regulation of the grid
- Instruments:
  - Central data base, smartmeters and communication network
  - Forecast systems and optimization algorithms
  - Electronic device to upgrade household appliances and power supplies
- Main partner: Utilicount
  - Other partners: Stadtwerke Aachen, FIR at RWTH Aachen, PSI Büsing & Buchwald, Kellendonk Elektronik



Smart @ Watts



# Solar Decathlon 2009

- Competition in which 20 teams of college and university students designed, built and operated the most attractive, effective and energy-efficient solar powered houses
- The competition took place in October 2009 on the National Mall in Washington D.C.
- TU Darmstadt took part with 24 students and built the solar house "surPLUShome"

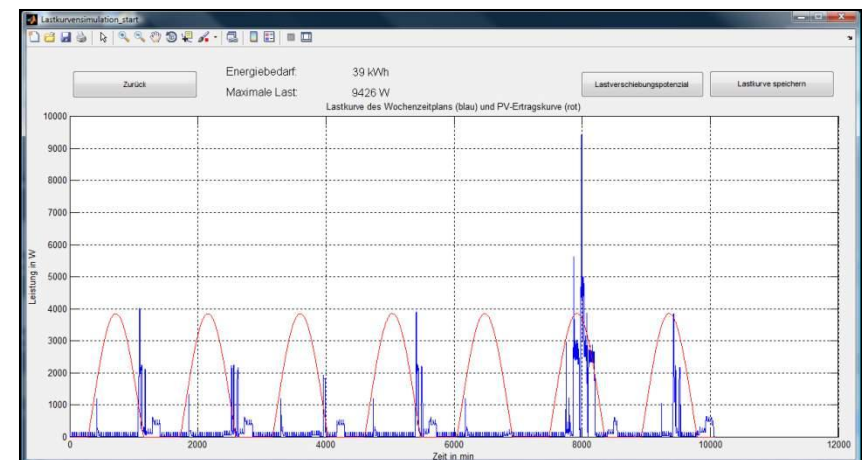
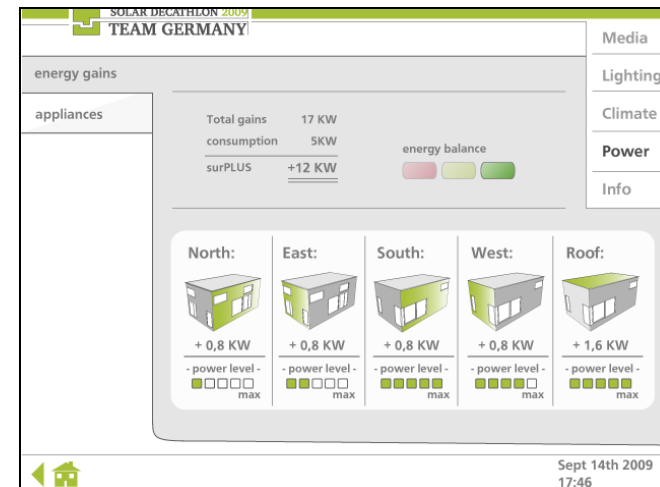


# Building control system and load shifting capability of surPLUShome



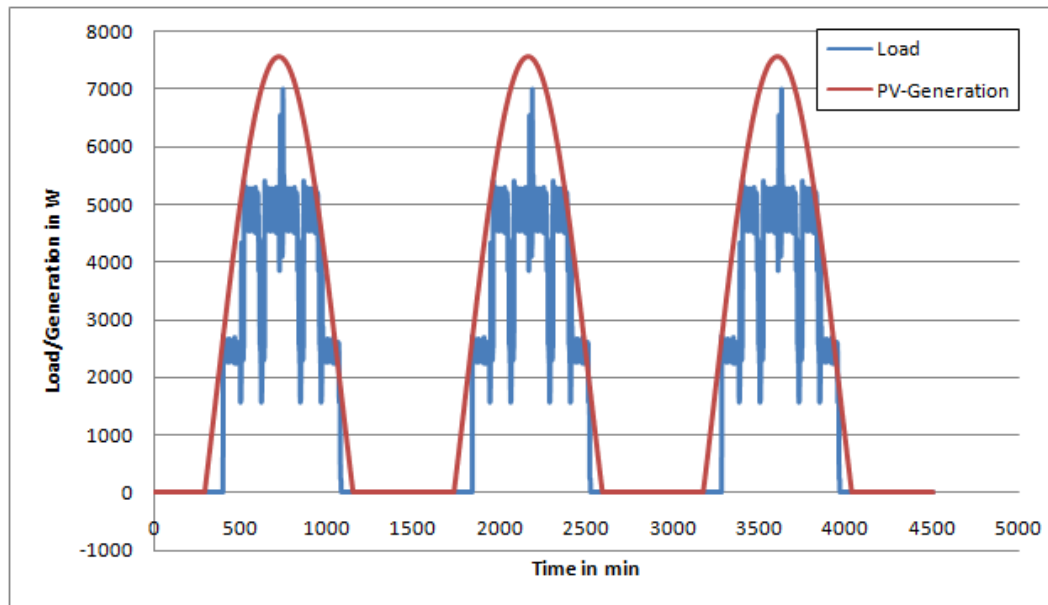
TECHNISCHE  
UNIVERSITÄT  
DARMSTADT

- All electric loads and a power measurement system are connected to a control processor
- Time shifting of specific loads can be either...
  - ...manually activated or...
  - ...taken care of by a forecast-model and a shifting algorithm



# Load Shifting Algorithm

- Since not every load can be shifted, an algorithm has to work with shiftable loads like the appliances (washer, dryer etc.)
- The loads are shifted by solving a nonlinear optimization problem using either the load and generation forecast or real-time measurements



**Example:** Load shifting a set of 30 dryers towards an ideal pv-generation curve

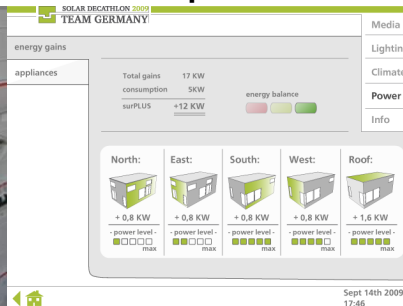


# Features of the Building Control System



TECHNISCHE  
UNIVERSITÄT  
DARMSTADT

- surPLUShome can adapt an electricity tariff curve or its own PV generation curve by an intelligent building and appliances control (**Demand Side Management**)
- surPLUS home uses an intelligent Smart Meter system for giving its inhabitant a feedback about the actual energetic condition.
- An energy signal light supports manual load shifting
  - **red:** actual power consumption < actual PV power generation
  - **yellow:** actual power consumption  $\approx$  actual PV power generation
  - **green:** actual power consumption > actual PV power generation



# An example house for E-Energy



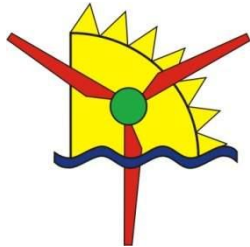
- surPLUShome complies all three E-Energy grades of Load Shifting (***Demand Side Management***) :
  - 1. Measurement only:** Smart electric meters collect information about the electrical power consumption and production and send it to the energy supplier every 15 minutes. This information is used to improve forecasts of the needed power in a grid.
  - 2. Measurement and rate adaptation:** The data and forecasts gained of grade 1 are used to build a variable electricity tariff. Consumers are informed about their energetic state and can adopt their loads manually to save money.
  - 3. Controller based load shifting:** A variable electricity tariff or the power production of a PV array is used as an input signal for a controller that can adopt the loads automatically.



# surPLUShome: Conclusion

- surPLUShome is the overall winner of Solar Decathlon 2009 because of its innovative Building control and features
  - surPLUShome is full compatible to E-Energy
  - surPLUShome can control its demand
  - surPLUShome delivers realtime informations about its actual energetic condition by an intelligent smart metering System
  - surPLUShome shows, that it is possible to establish smart grid compatible building controls with the technology of today





## Prof. Dr.-Ing Thomas Hartkopf

Head of Institute of Renewable Energies

[Thomas.Hartkopf@re.tu-darmstadt.de](mailto:Thomas.Hartkopf@re.tu-darmstadt.de)

## Dipl.-Ing. Lutz Steiner

[Isteiner@re.tu-darmstadt.de](mailto:Isteiner@re.tu-darmstadt.de)

[www.re.e-technik.tu-darmstadt.de](http://www.re.e-technik.tu-darmstadt.de)

[www.e-energy.de](http://www.e-energy.de)

[www.solardecathlon2009.de](http://www.solardecathlon2009.de)

