# The transformation of distribution grids in the context of the European Energy Transformation

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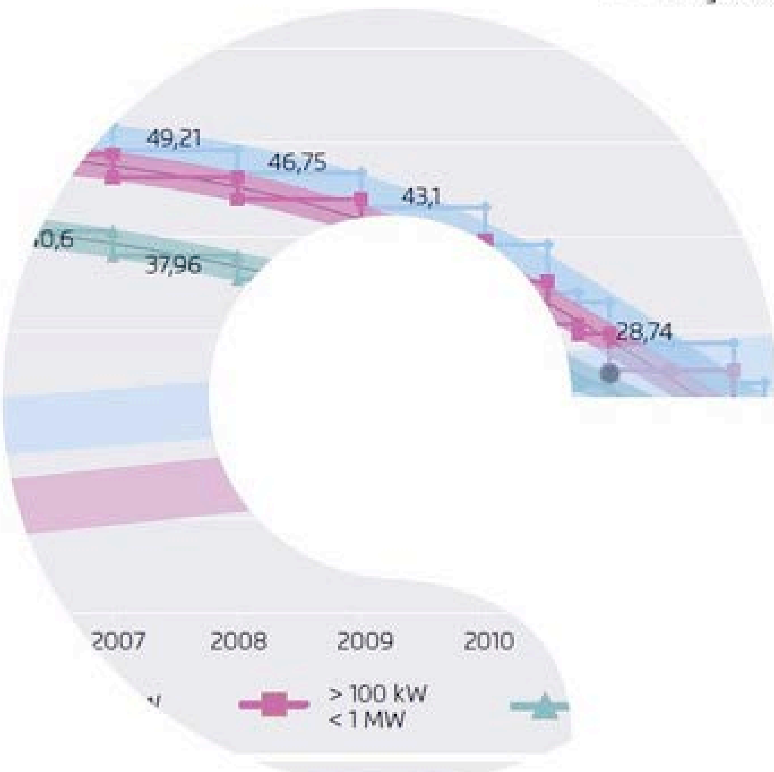
# Stromverteilnetze für die Energiewende

Empfehlungen des Stakeholder-Dialogs
Verteilnetze für die Bundespolitik - Schlussbericht

**IMPULSE**

Agora
Energiewende




# Stromverteilnetze für die Energiewende

## IMPRESSUM

**SCHLUSSBERICHT**

Empfehlungen des Stakeholder-Dialogs
Verteilnetze für die Bundespolitik

**ERSTELLT IM AUFTRAG VON**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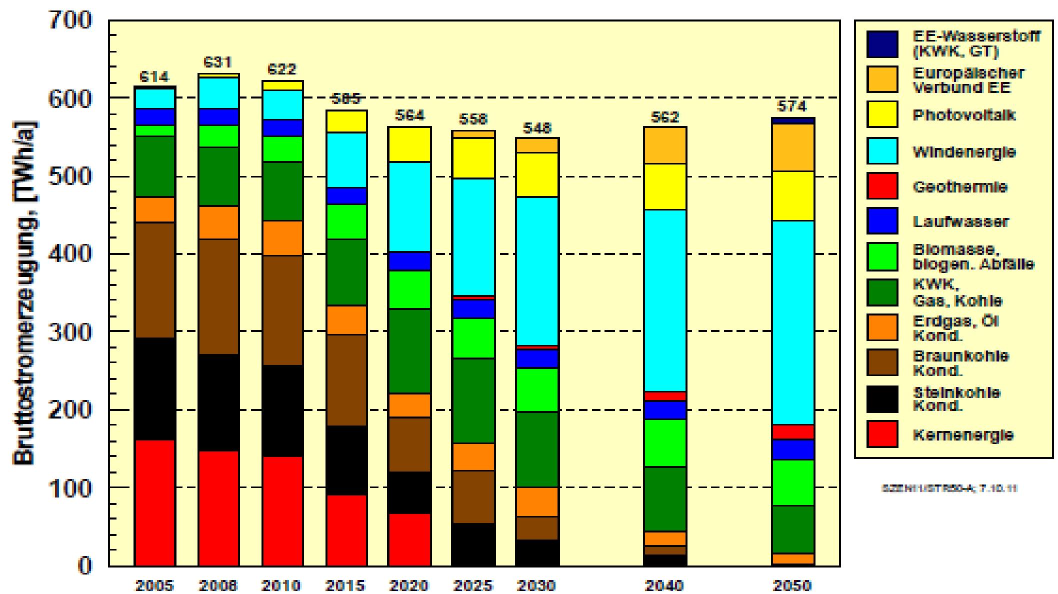
# Driver 1:
# Politics wants renewable energies

- Binding EU target for 2020: 20% of all energy from renewable sources
  → renewable share in power production must be higher
  Targets for 2030: 45% Renewables ??
- Denmark: - 2020: 50% wind power
  - 2035: power and heat completely renewable
- Germany: - Reduce CO2 emissions by 80-95% until 2050

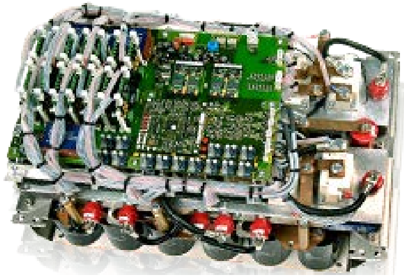
Lead scenario 2011: structure of gross power production



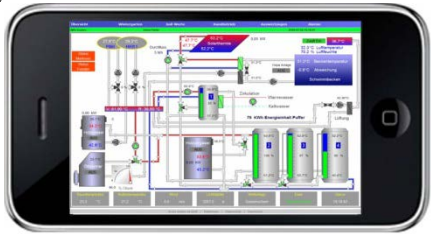
# Driver 2: Breakthrough of ICT and semiconductor technologies

- PV: electricity production from solar radiation with semiconductors
  - No moving parts
  - No fuel, no operational costs
  - Mass production of standardised elements
  - High scalability, distributed application possible

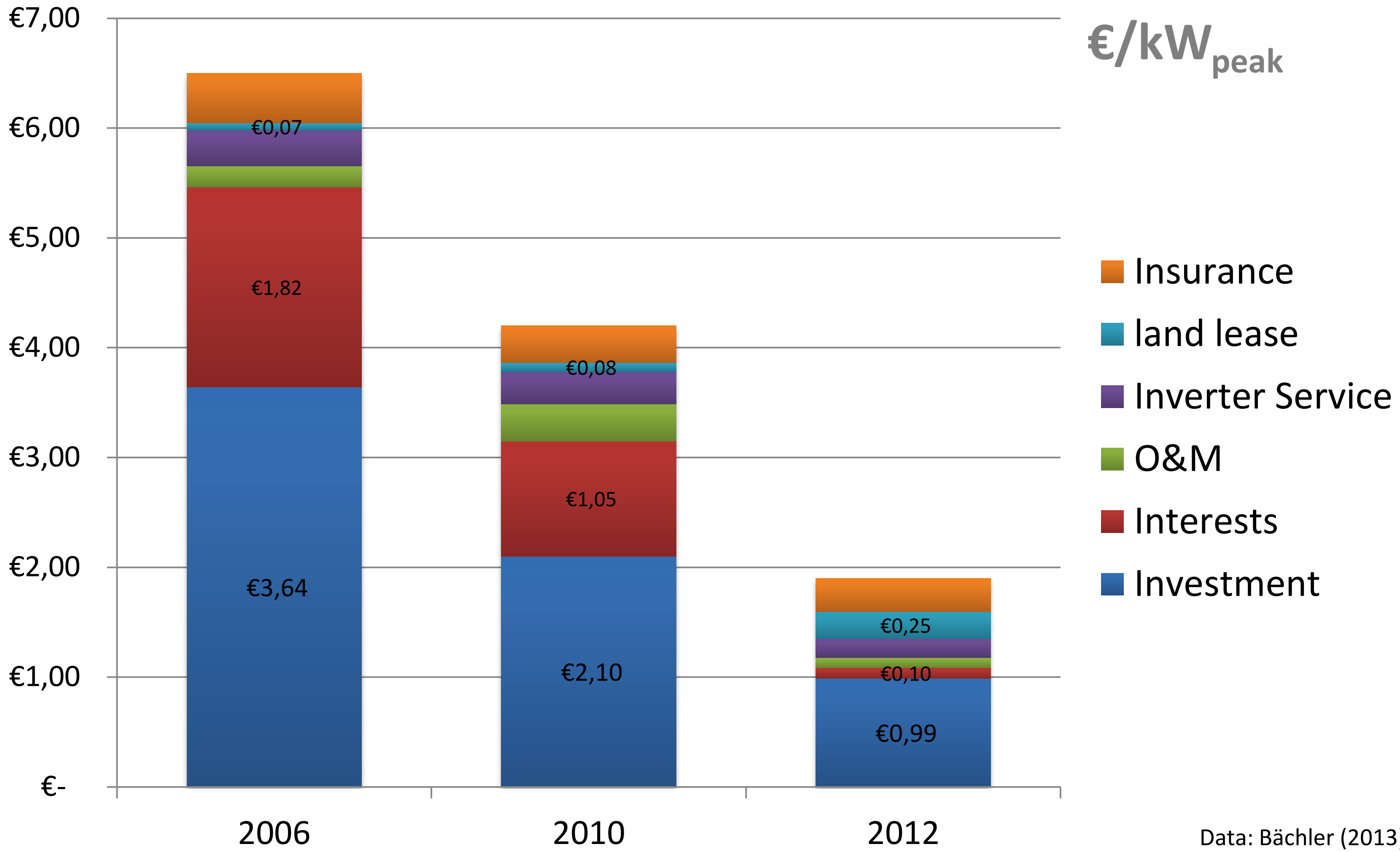
- Semiconductor power electronics
  - Highly efficient converters, transformers
  - Remote control of electrical parameters
  - New options for DC applications and systems



- ICT
  - Complex control options with cheap distributed intelligence
  - Multi-level systems
  - Flexible configuration, involvement of a variety of actors
- Breakthrough of storage technologies ???



# Cost of Ownership over 20 years in Germany




Data: Bächler (2013), PV-magazine

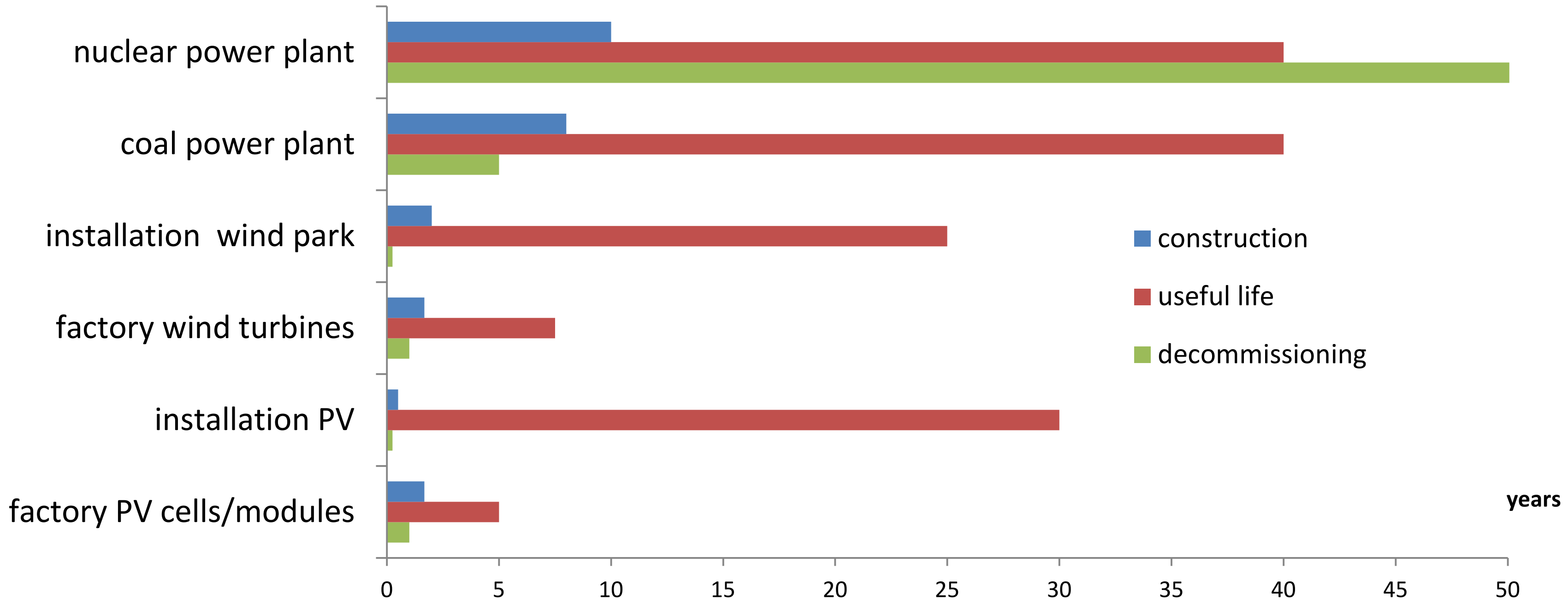
# Unfamiliar to business and government: 5 to 10 times shorter innovation cycles

→ More rapid build-up of capacities (e.g. Dec. 2011 in Germany: 3,5 GW PV)

→ More rapid decrease of costs

→ More rapid transformation of the electricity sector

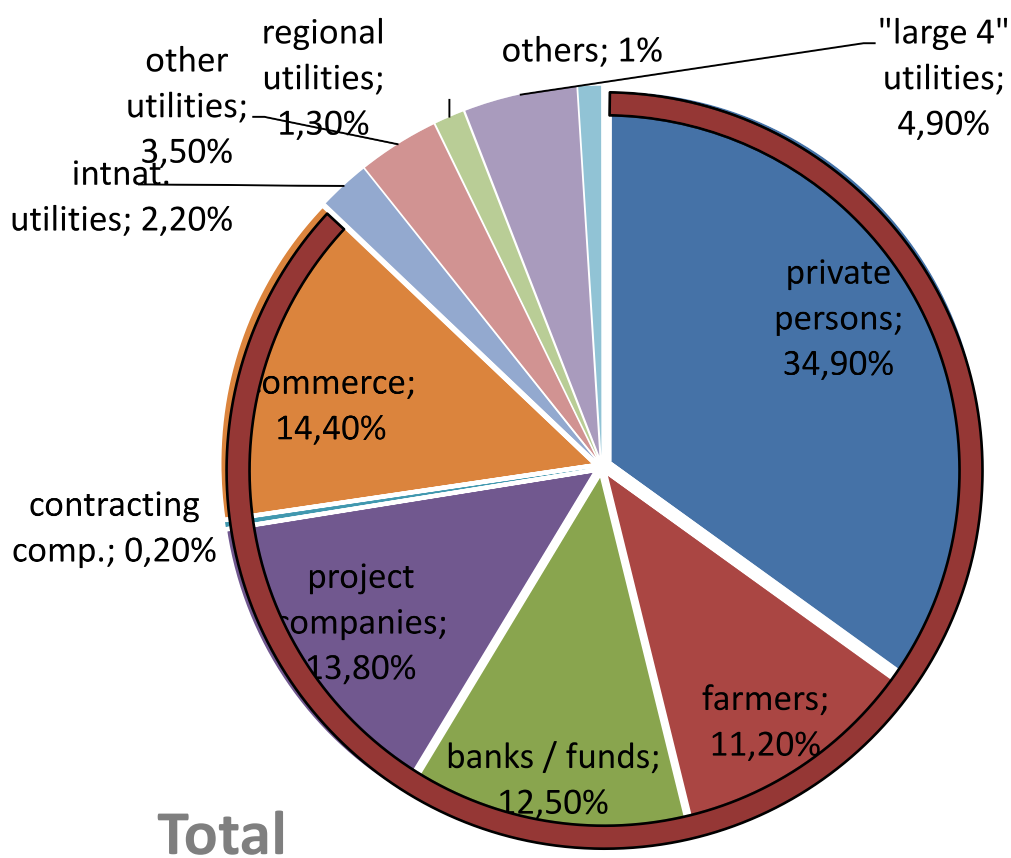
**Dramatic acceleration compared to traditional energy technologies**



# Driver 3:
# New actors in the game

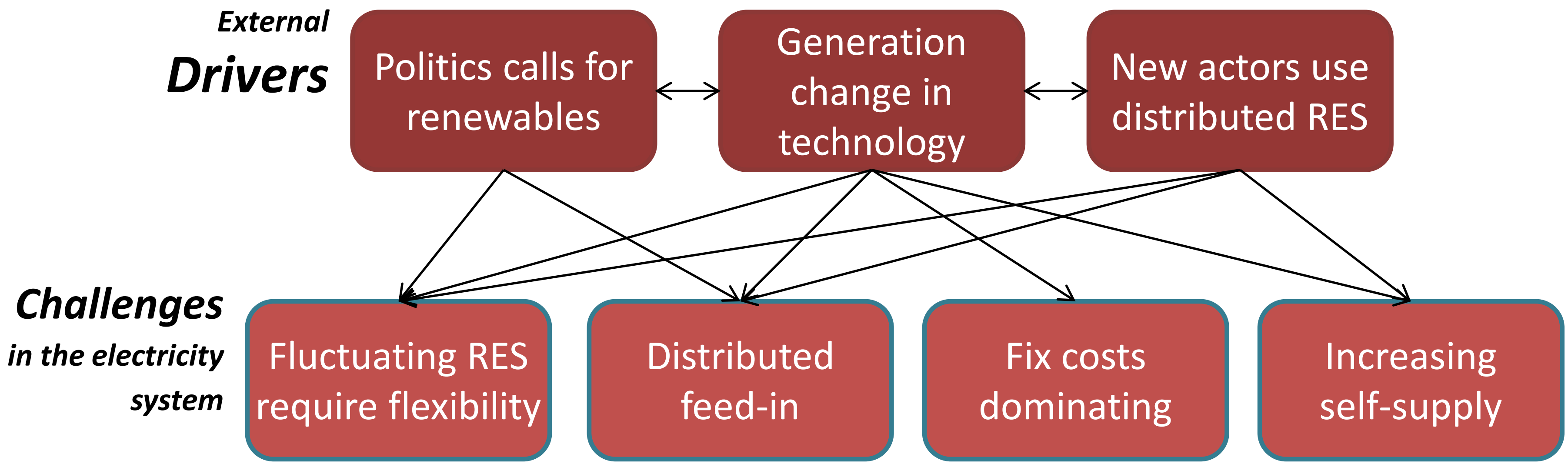
- Classical utilities have only a small share in renewable electricity generation
- Over 1 million solar power installations in Germany
- Local and regional initiatives and cooperatives
- **New actors have other decision criteria and profit expectations**
- Revival of municipal utilities with new business models
- IT and communication industries

## Ownership of renewable power generation in Germany 2012




**Total 72,9 GW**

# Drivers for change → Challenges in the the electricity system



# Germany: 28,5% renewable electricity in Q1-2, 2014

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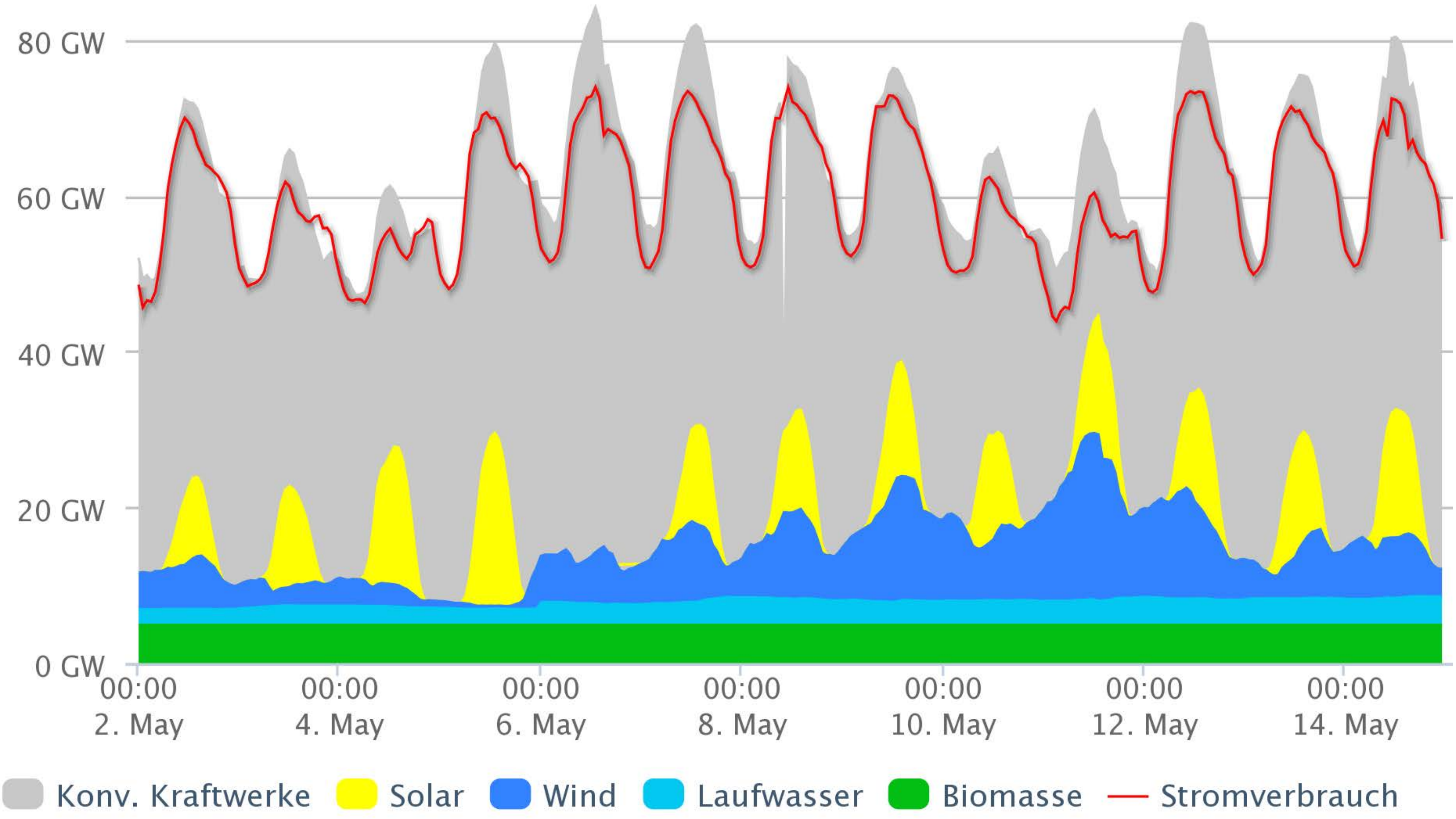
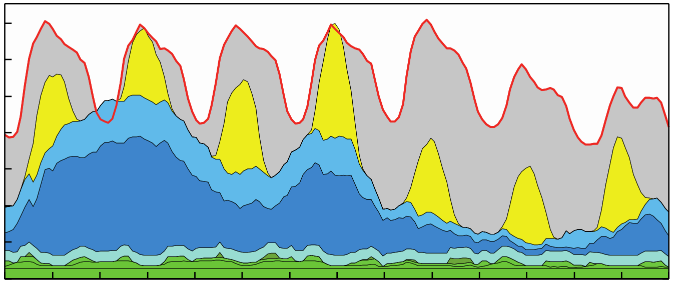
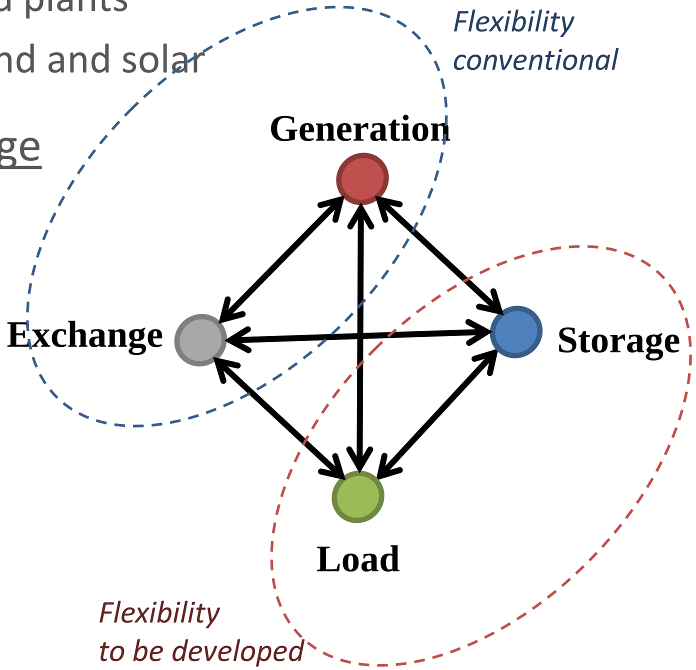


# Challenge 1: Fluctuating generation
# Four basic options for more flexibility



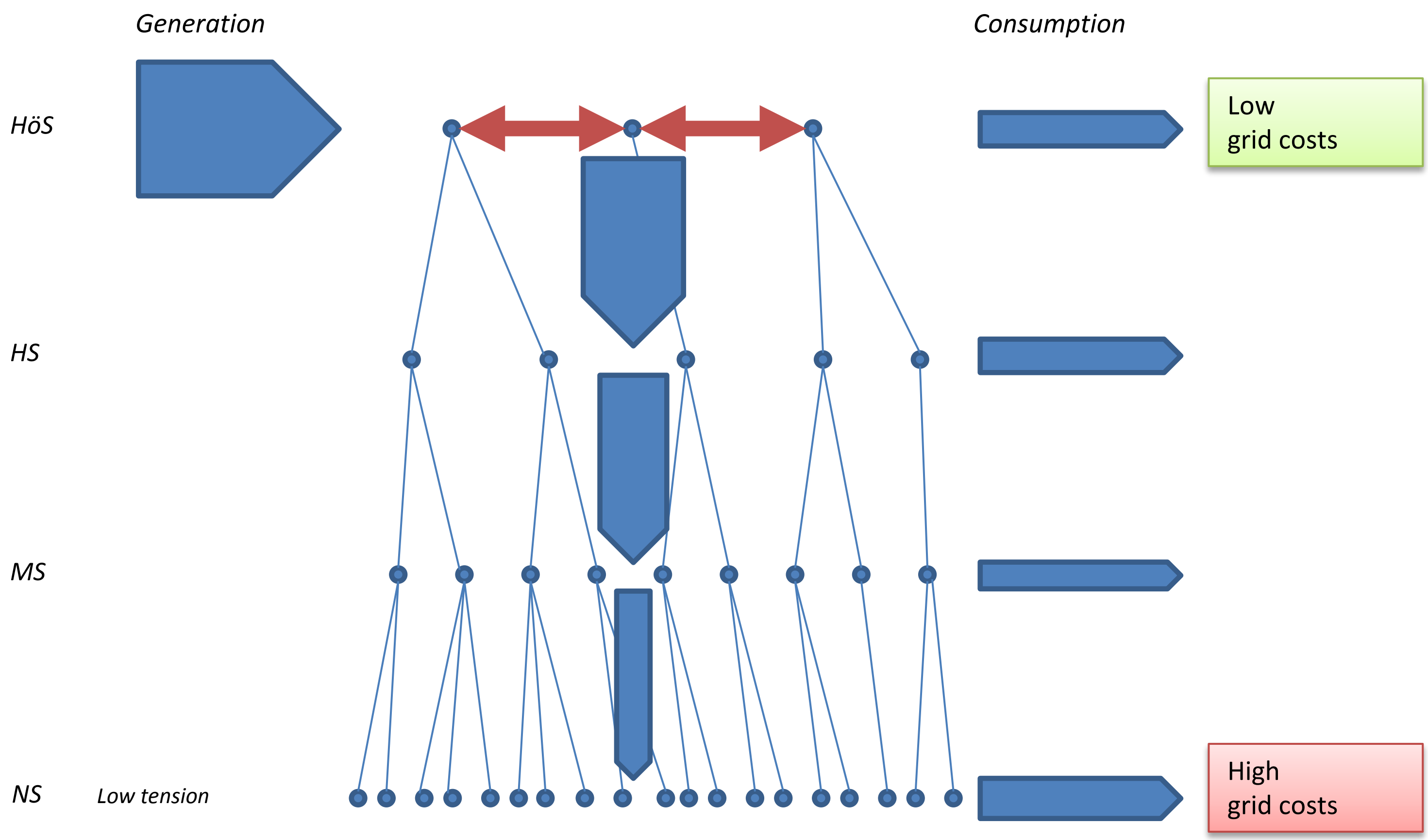
1. Flexible generation
   - flexible fuel-based plants
   - curtailment of wind and solar
2. Increased exchange
   - grid expansion
   - on all levels




3. Power storage
   - requires cheaper storage
   - in proximity of generation or consumption
4. Demand side management
   - requires incentives and learning
   - Lowest system level

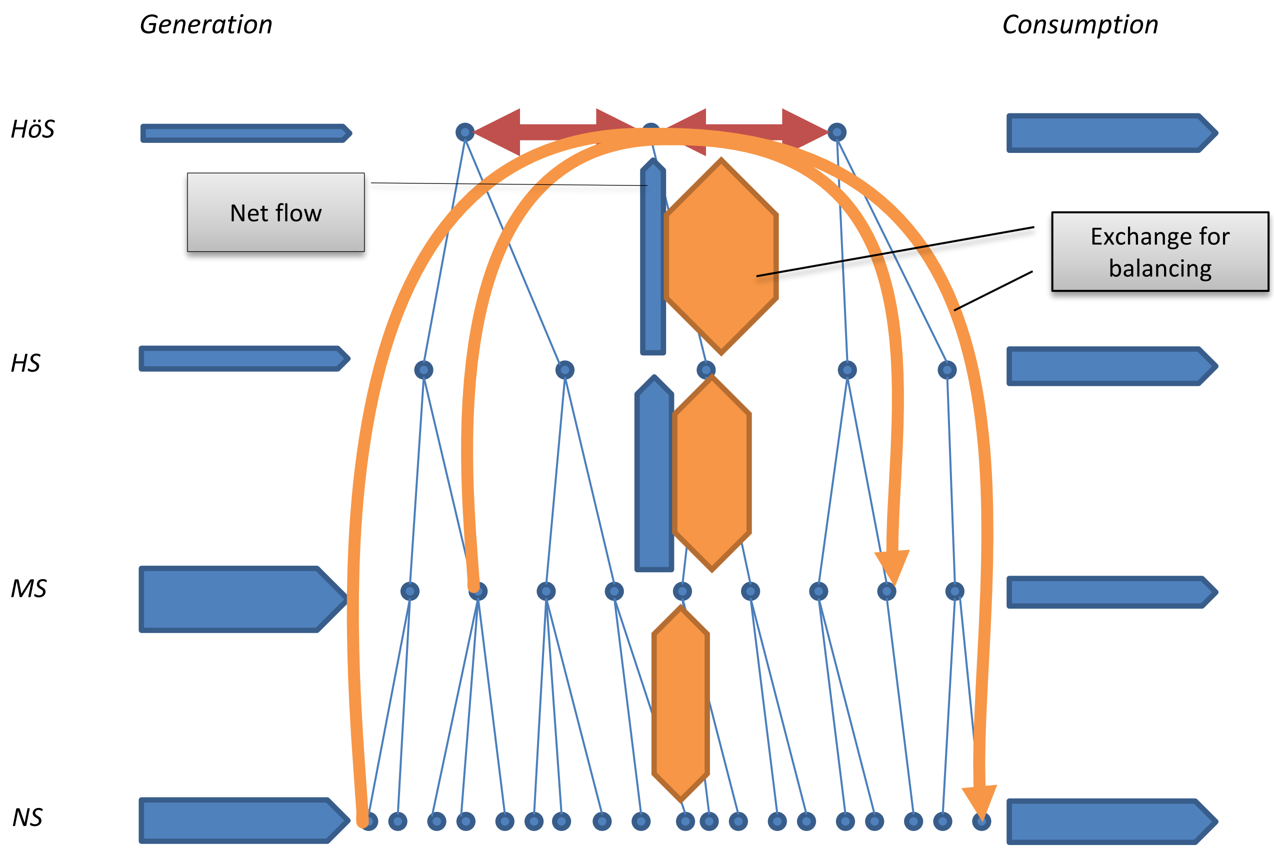
# Challenge 2 – distributed generation

## From centralised to distributed generation: the old system




**Central generation, central balancing**

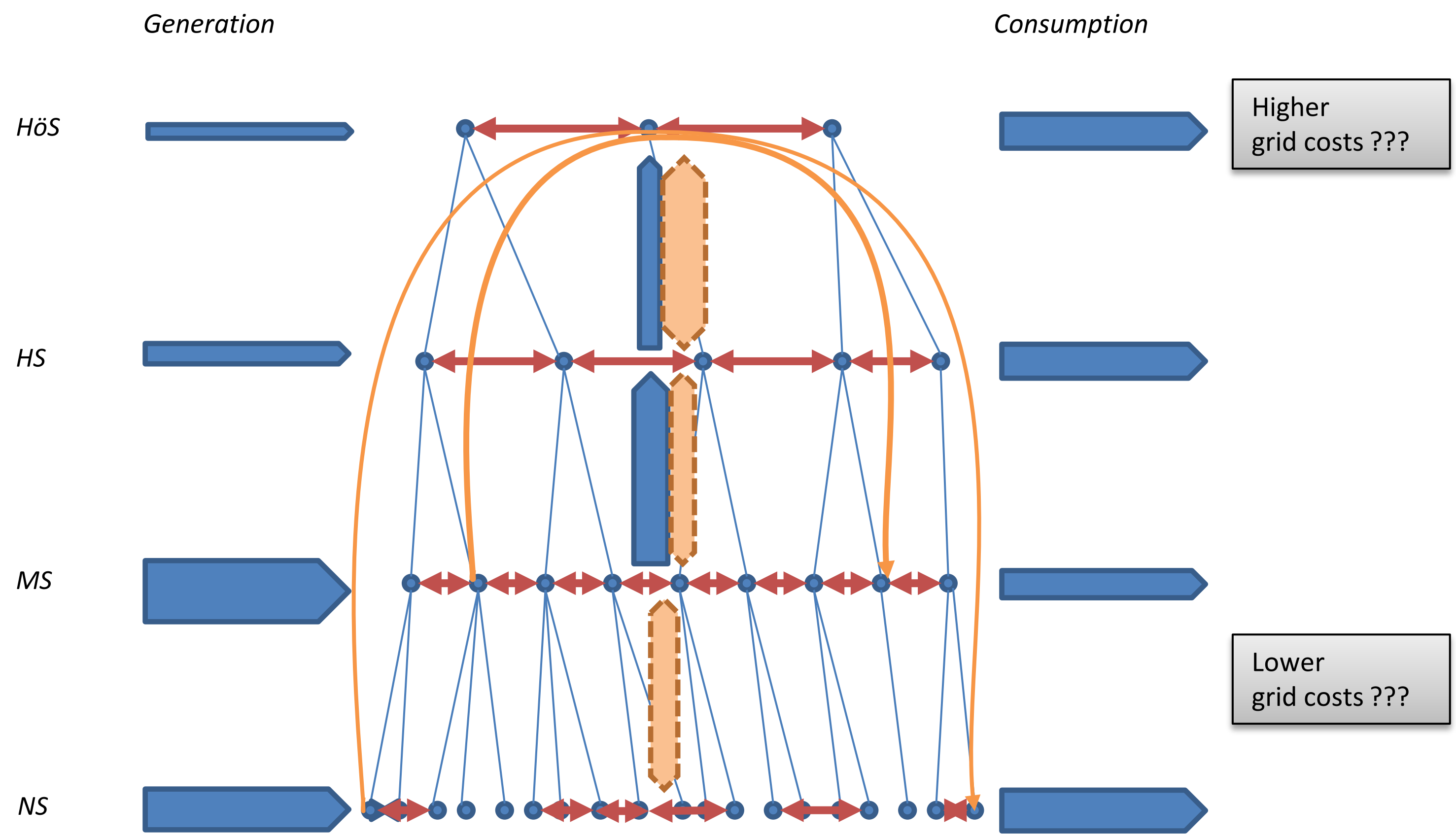
# From centralised to distributed generation: new generation pattern – old logic?




## Distributed generation, centralised balancing

- Partially reversed flows
- Reduced net flows
- Balancing requires strong exchange between levels

# From centralised to distributed generation: active distribution grids



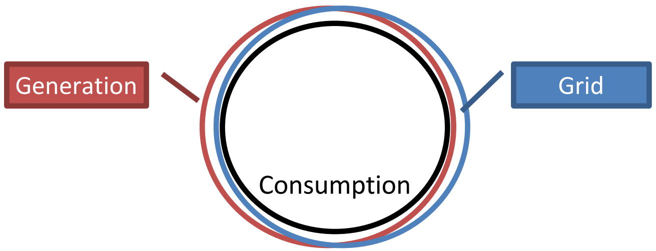

## Distributed generation, balancing on all levels

- Active balancing on lower levels can significantly reduce the need for exchange
- This, however, requires new frame conditions

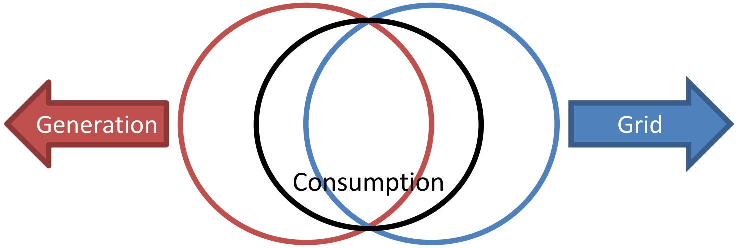
# Liberalisation & Unbundling: Problematic disregard for spatial patterns

- Newly created markets entirely based on characteristics of traditional technologies
  - Large scale, highly centralised power generation
  - Considerable variable costs (fuel)
  - System governance on the top level, dumb distribution
- Intrinsic consideration of spatial aspects by the old monopolies was abolished
  - Growing role of non-spatial markets
  - More and more non-spatial balancing groups
  - Separate decision making for grid development and generation investmemts
  - → Increasing divergence of grid pattern & generation pattern → more grids needed
- New technologies exacerbate this tendency → COPPER-PLATE APPROACH GETS INCREASINGLY UNSUSTAINABLE

Coherent Planning by Monopolies




Liberalisation: different Criteria



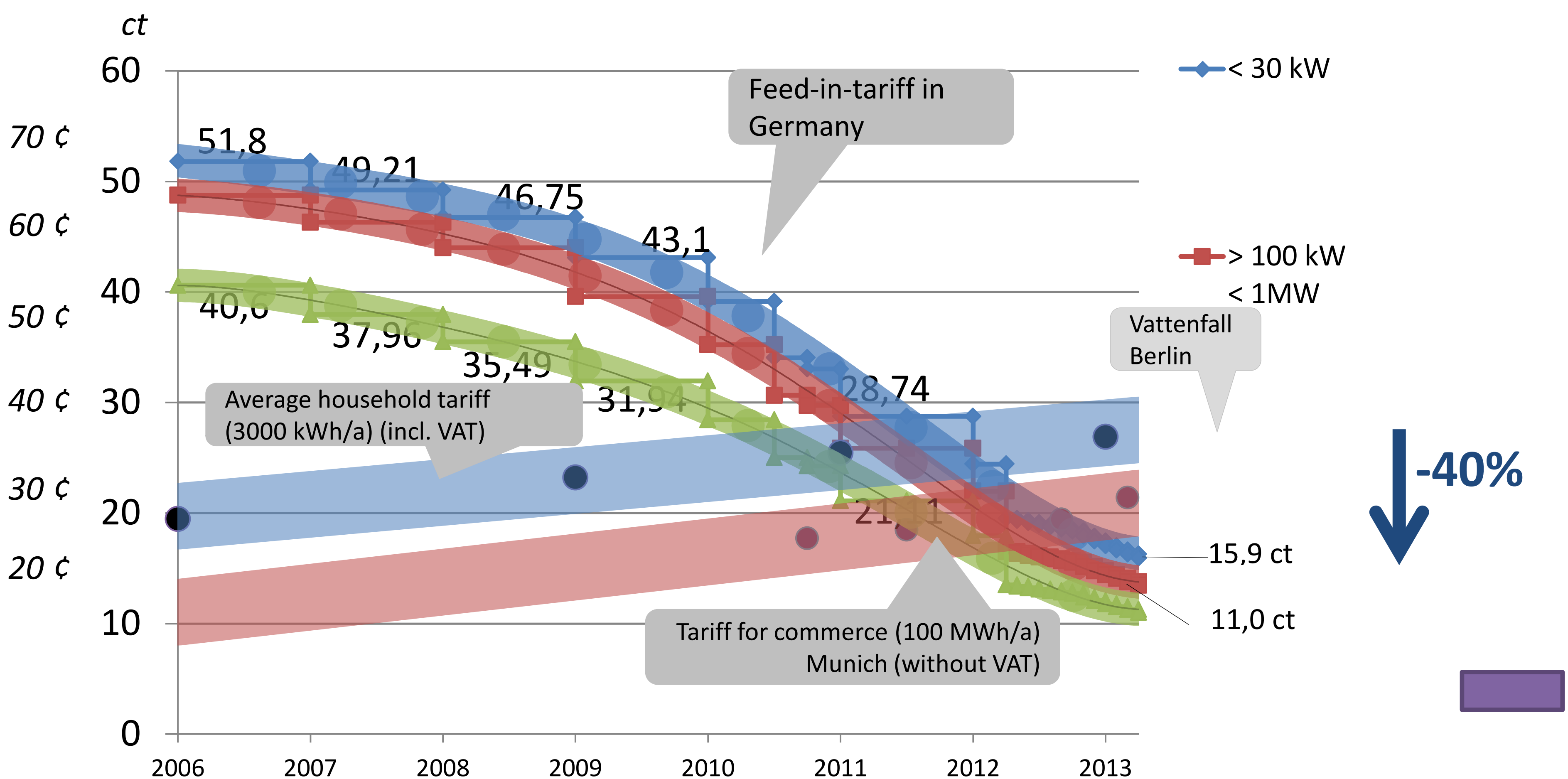

- **Technicians call for cellular structures and tendentially to go back to integrated area monopolies**
- **Economists insist on competition, but tendentially are stuck with old centralistic market structure**

**→ New Approaches are necessary**

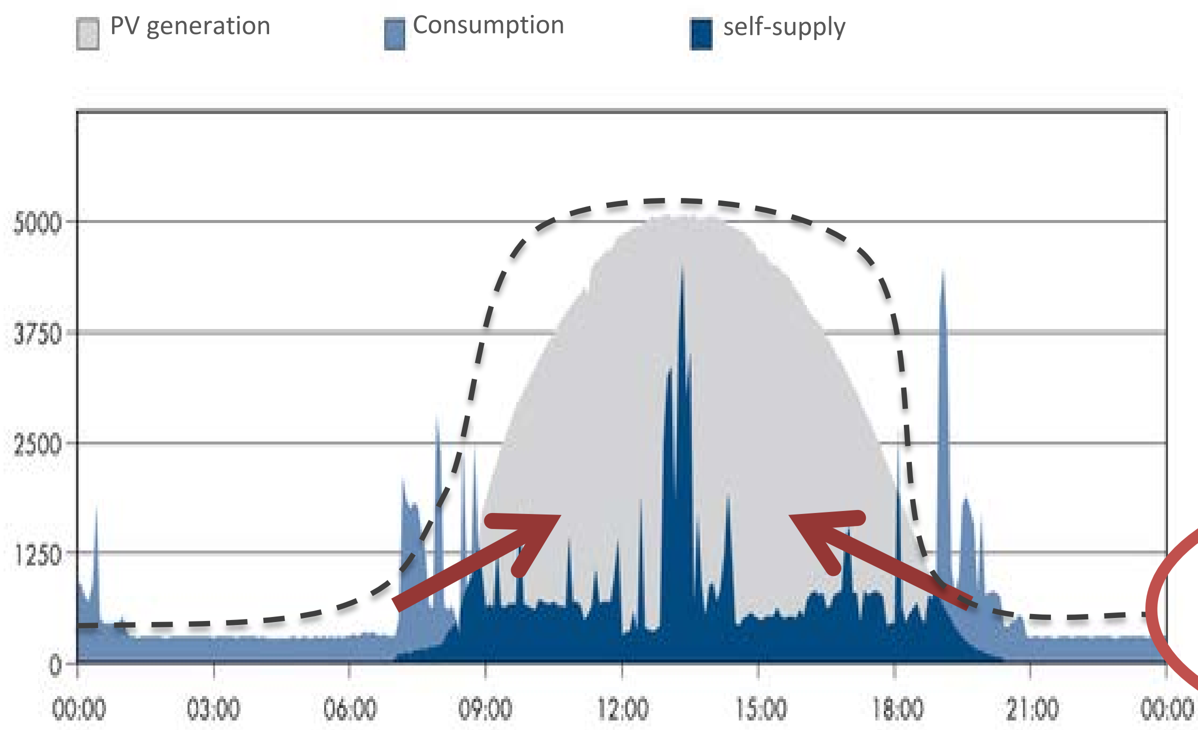
# Challenge 3: Renewables have nearly no variable costs

- Present energy only markets have been designed for electricity generation with fuels and high variable costs
- Growing share of renewables drives spot market prices down → generation cannot cover costs through these markets
- Electricity supply becomes all infrastructure: long-term investments in grids & generation
  - Public infrastructure (similar to water supply?)
  - Private long-term consumer goods (similar to houses?)

# Challenge 4 – Self-Supply
# Power from the roof cheaper than from the grid



# Self supply boosts interest in energy management




## Shifting loads into sunshine hours

- Storing electricity
- Shifting loads
- Coupling with heat and mobility markets
- **Flexibility of user system increases massively**

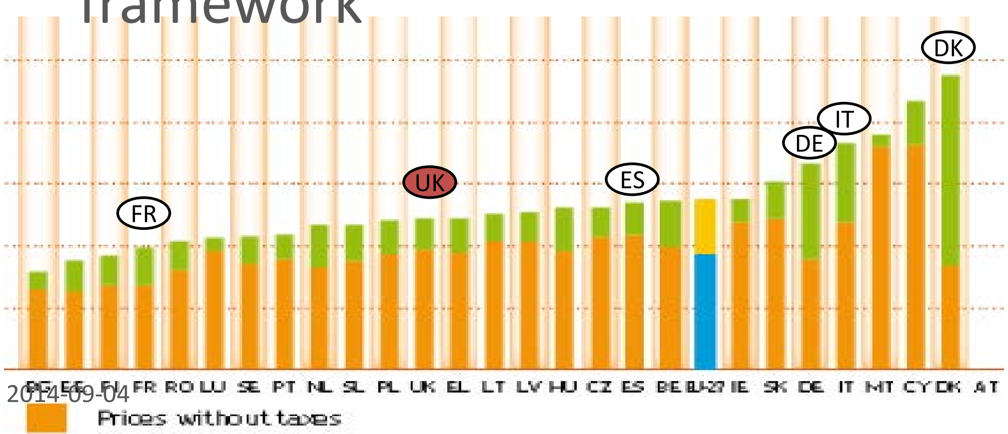
**Private household** cloudless summer day, 4 persons, PV system 5 $kW_p$
Without additional measures self-supply only ca. 30%

Should be used for increasing flexibility of the whole system

**Commerce**: Consumption mainly during sunshine hours

# Boom of self-supply to be expected: industry, small business, residential

- Inquiry on captive power generation in German industry:
  - 13% of have it, mostly conventional
  - additional 16% are planning, mostly RES
- Cost advantage interesting in growing number of countries
- Also self-supply with CHP increases
- Uncertainty about future regulatory framework

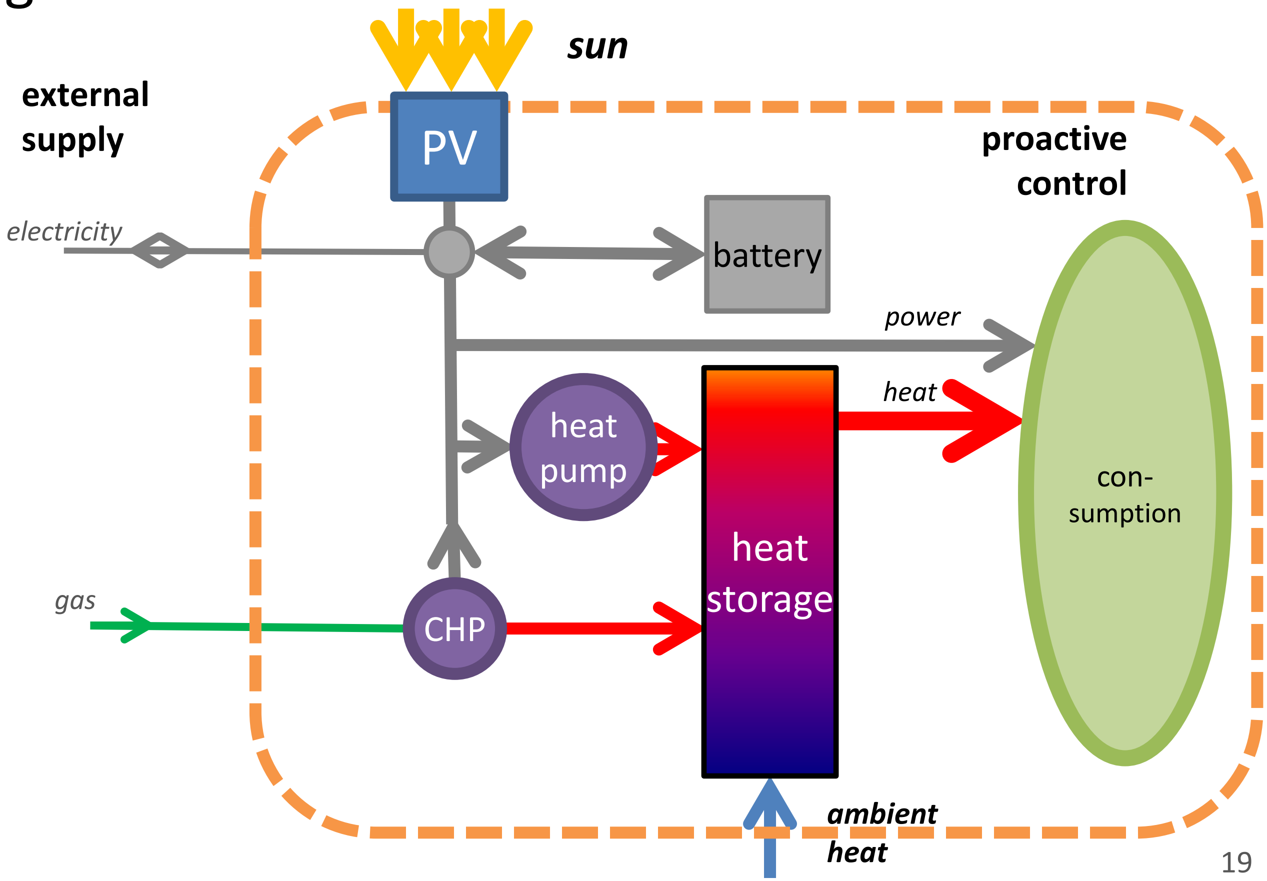



Belgium: Audi factory:
3,5 MW rooftop PV plant for self-supply

Germany: ALDI Süd:
> 100 food retail stores with PV :
own consumption 90%, self-supply 50%

# Integrated heat and power supply: cheap heat storage increases flexibility

- Particularly interesting for large office and residential buildings
- Regulatory obstacles can be overcome
- District heating



# High potential for self-supply threatens financiability of the system

Estimating the self-supply potential in Germany:

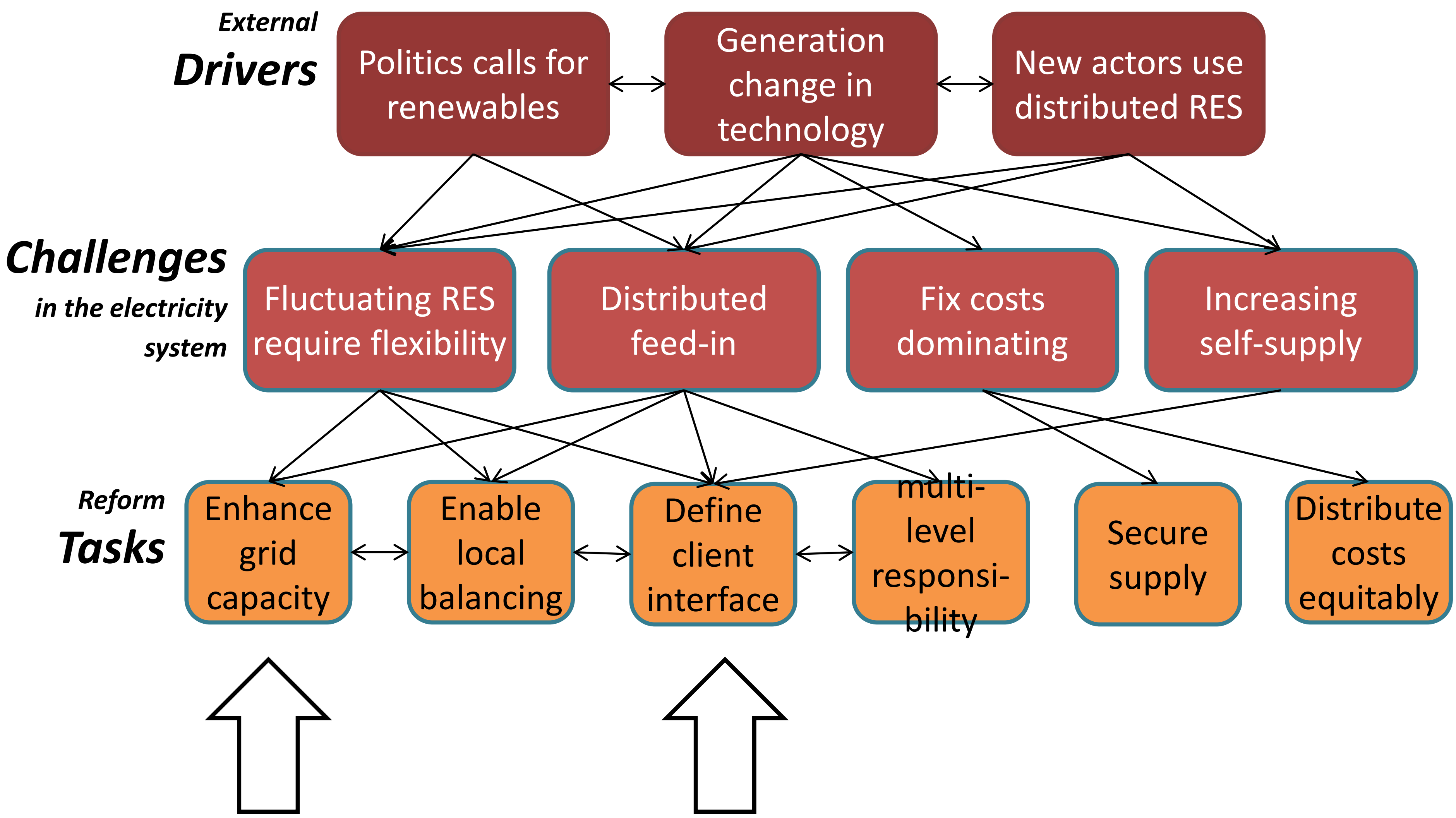
| | | |
|---|---|---|
| Roof areas „well suited“ for PV | 20% | of electricity consumption |
| PV on nearby surfaces | 10% | of electricity consumption |
| CHP | 10% | of electricity consumption |

50% of electricity consumption is directly used by industry and does not flow through distribution grids

→ **Electricity sales flowing through distribution grids could drop considerably**

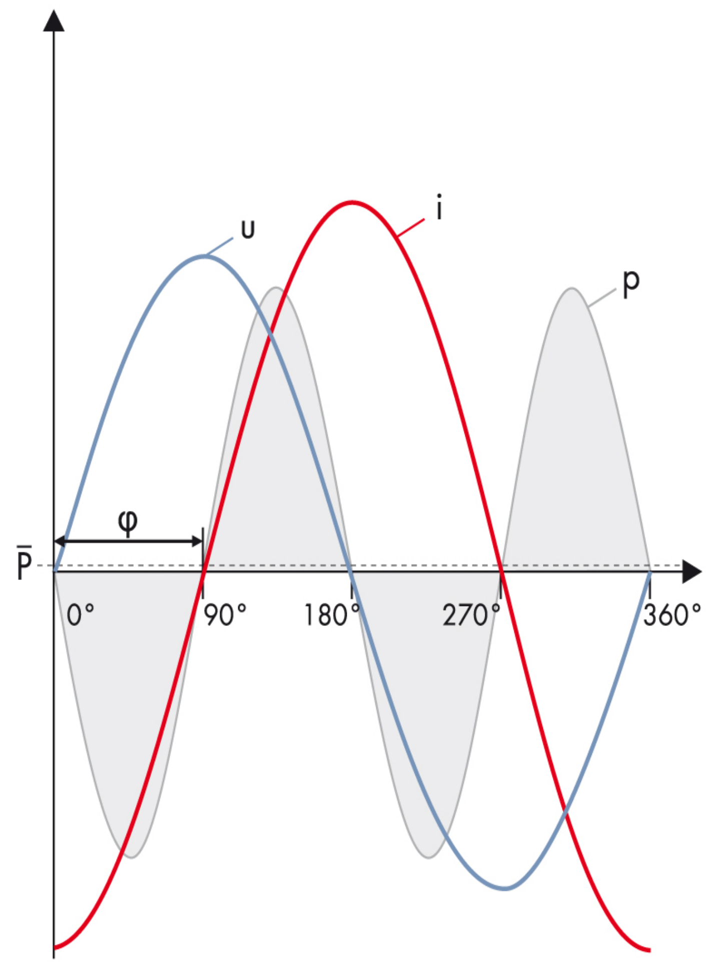
→ **New tariff structures are needed**

# Drivers → Challenges → Tasks



# Task 1: Intelligent grid capacity management in distribution grids

- In a series of regions in Germany reverse flows are already frequent
- Reverse flow in distribution grids can cause capacity problems
- **Adding conventional hardware to remove bottlenecks can be costly**
- **Over 80% of these costs can be saved by intelligent grid capacity management**
- Most capacity problems are caused by voltage problems as voltage patterns change. Two strategies can be combined to avoid them:
  - Controlling reactive power in the distribution grid
  - Installing controllable local network substations where this is not sufficient
- Peak shaving can be the next step, grid pricing
- Approaches differ strongly concerning the required information exchange



# Task 2:
# Enable local balancing

- Delimitation ancillary services / volume market
- Local selling models
- Structuring of the balancing groups
- Grid fees
- Local markets

# Task 3: Interface public system / client: external control or autonomy of the consumer?

## Direct control by utility/DSO

- Calculable reaction
- Immediate response
- Short-term control concept

⇩

- High data volume exchange
- High requirements for technical interface (smart meters)
- Data security issues
- Local optimisation more difficult

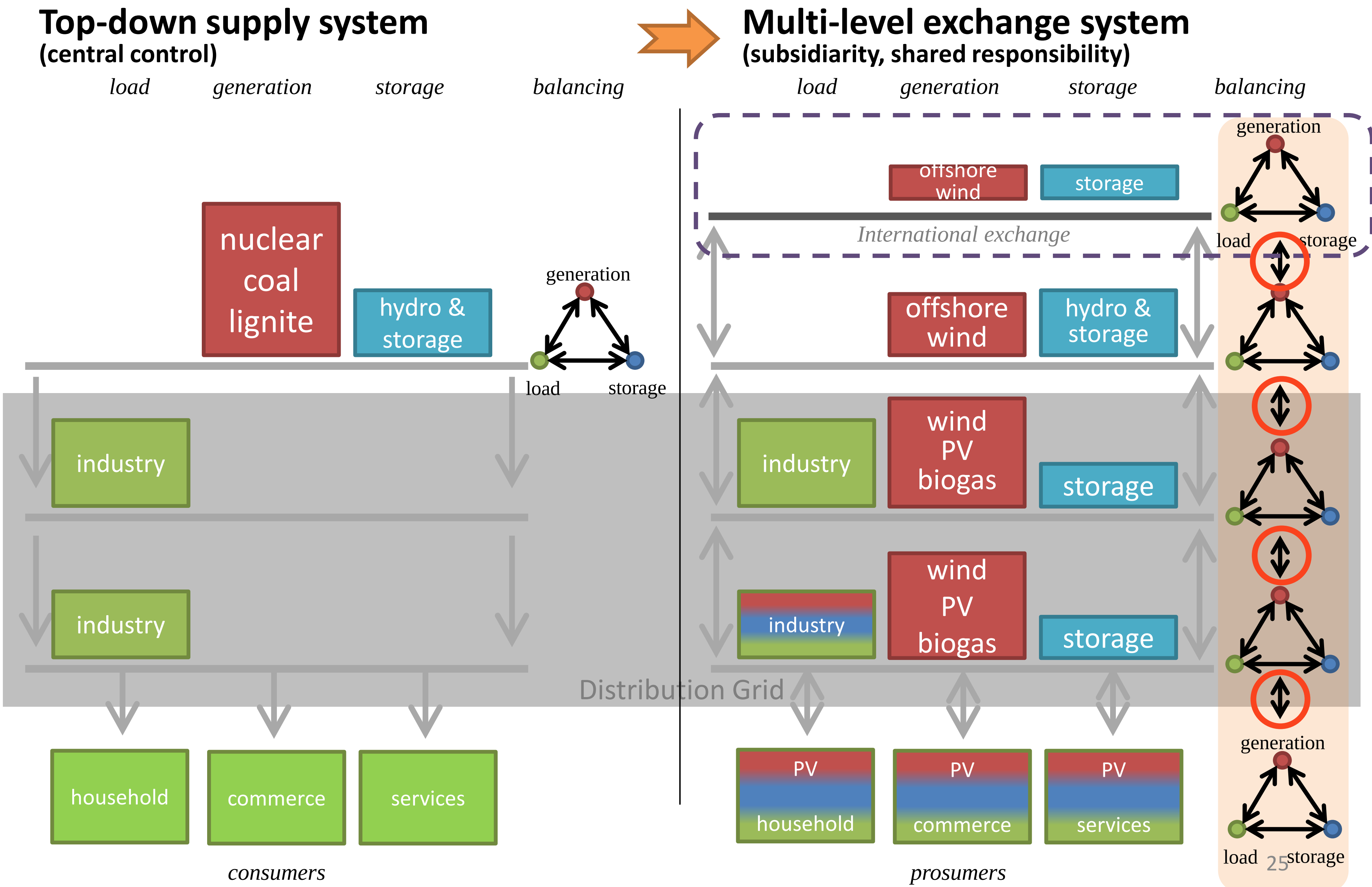
## Control over price signal

- Price signal from supplier
- Manual or programmed reaction
- Contracts / learning of bulk effects

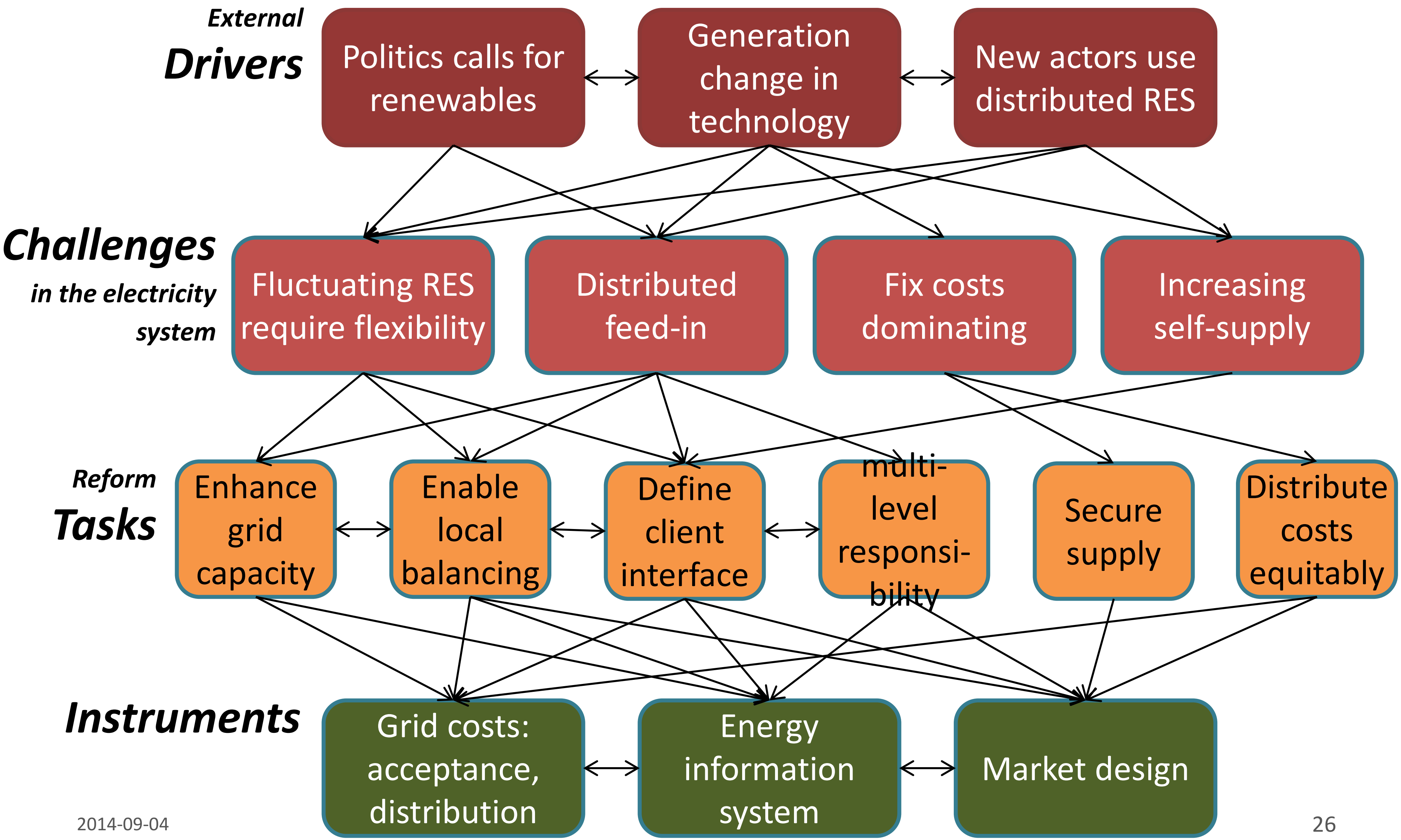
⇩

- Low requirements for data exchange: only price signals and cumulated consumption / supply
- Market design needs to deliver time and location dependent price signals, stronger dependency on kW
- Combines with decentralised grid stabilisation concepts

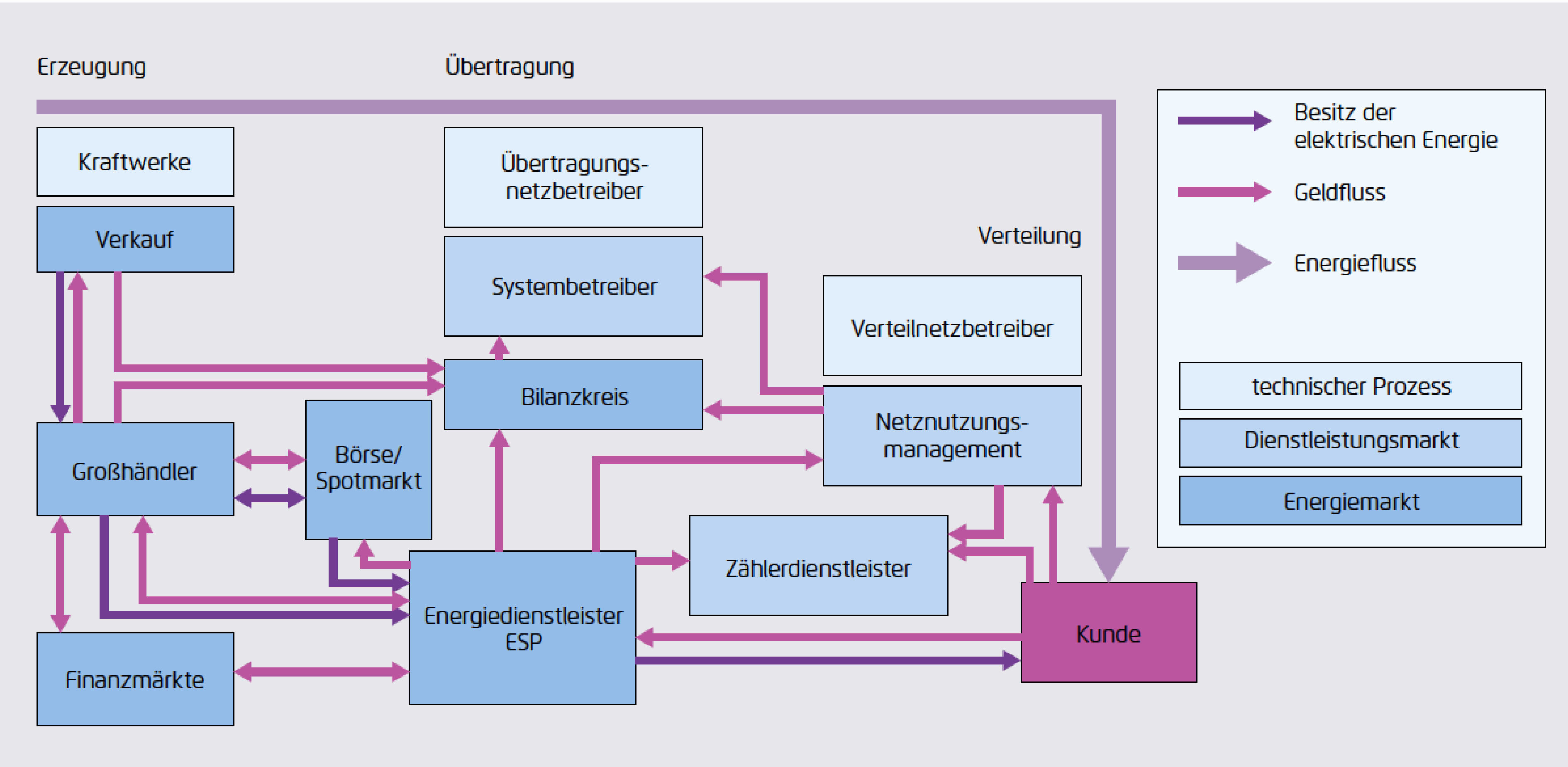
# Task 4: Multi-level responsibility



# Drivers → Challenges → Tasks → Instruments



# Strong interests in a complex system: Lack of Transparency, Conflicts, Resistance to change



# Outlook

- Turbulent change of the electricity system
- Increasing costs of the public system
- Increasingly interesting private solutions
- Strong efforts needed for adapting the system to new challenges,  maintaining a reliable, affordable, public system
- Who pays the bill for the transformation?
- Public debate more and more confused
- Transparency !

# Thank you

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