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How renewables will change electricity markets

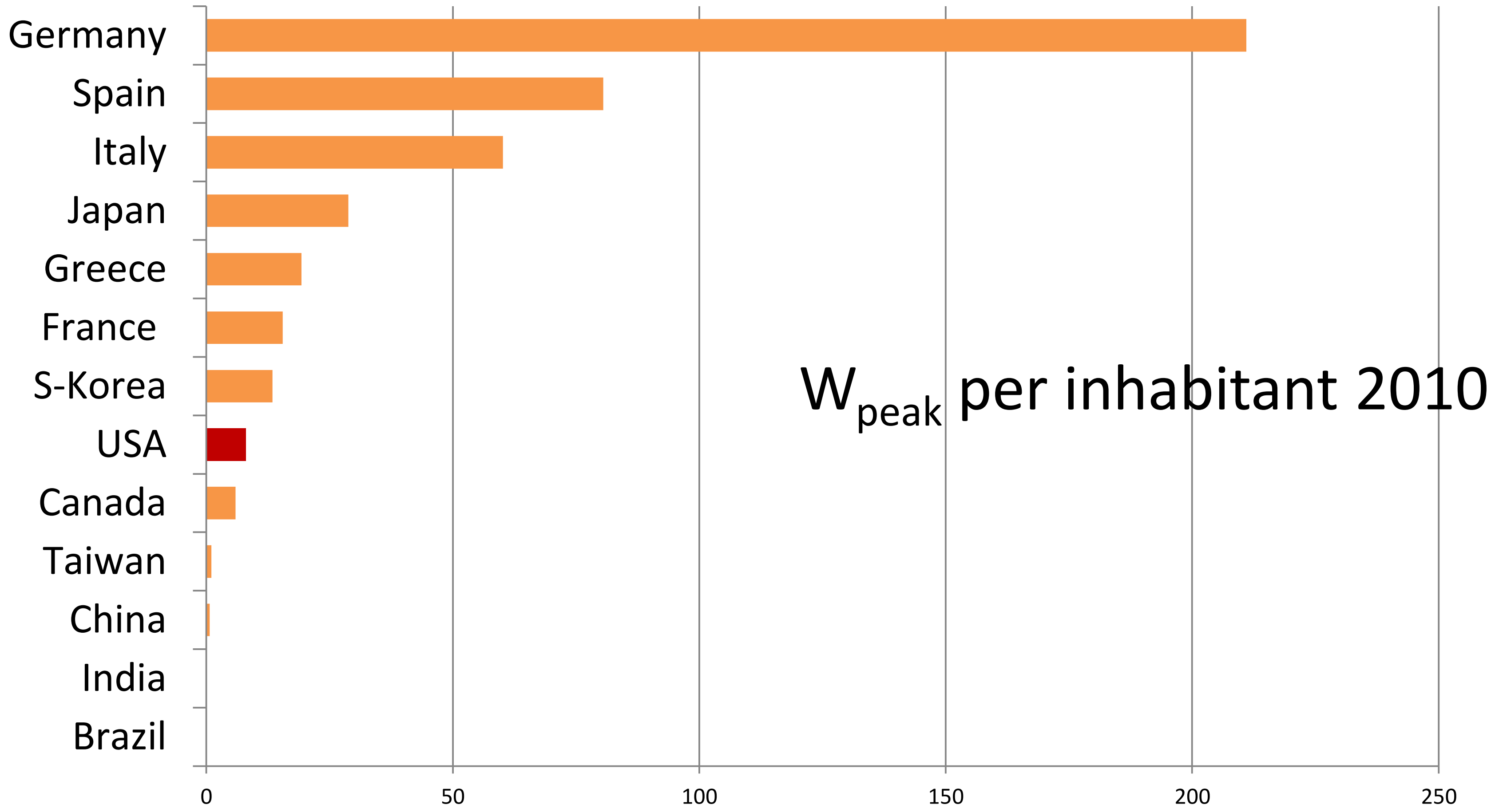
IEA PVPS Workshop @ EUPVSEC 2012

“Assigning a fair price to photovoltaic electricity “

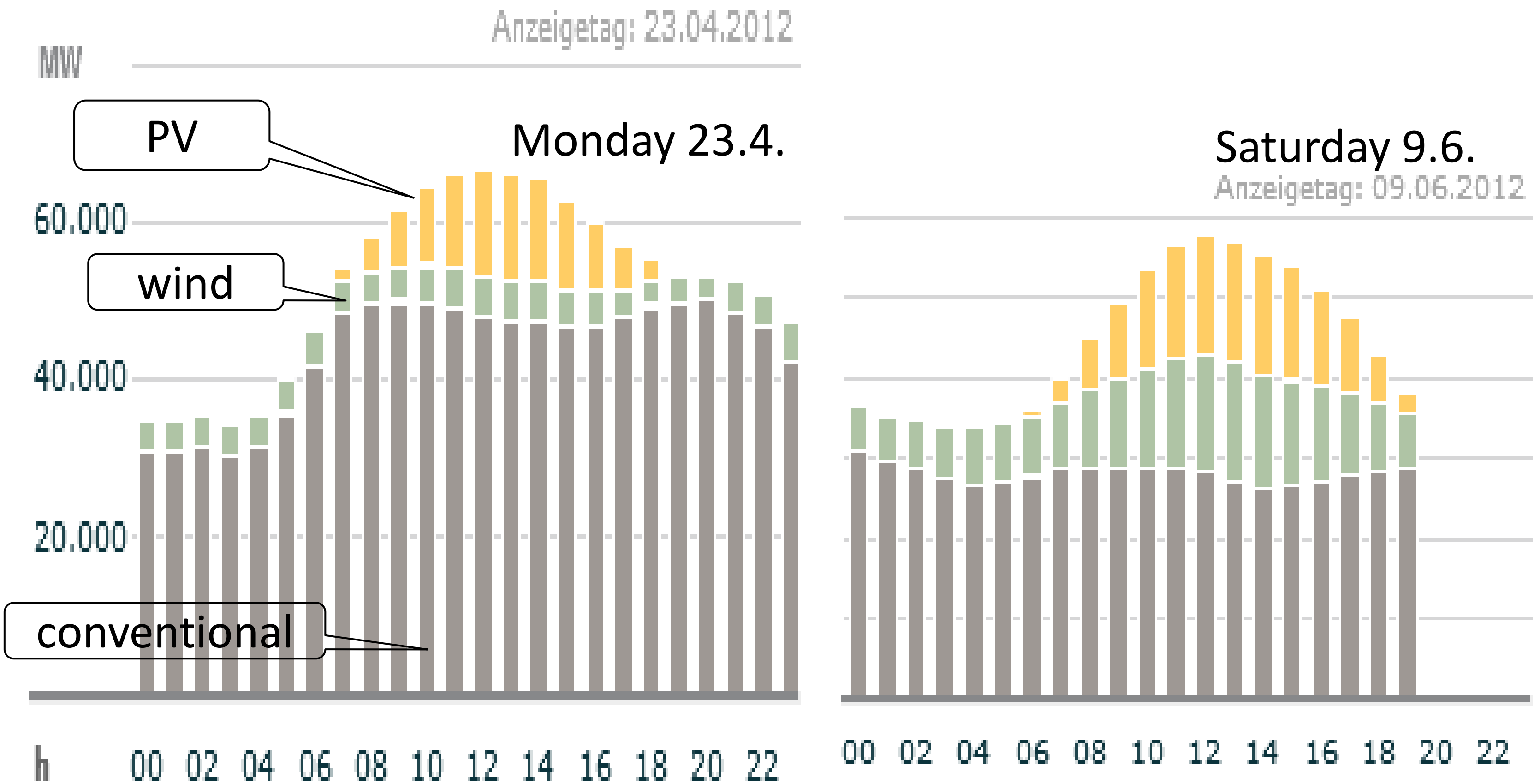
Frankfurt, Thursday, September 27, 2012

AN UNPRECEDENTED CHALLENGE FOR THE ELECTRICITY SYSTEM

Germany first country to experience major effects of PV in the grid



PV covers consumption peak → declining prices at the power exchange



→ Billions lost for conventional power producers

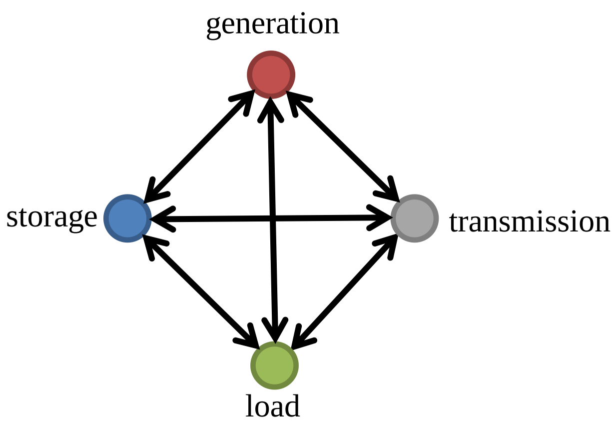
The three key challenges of solar and wind power

1. <u>Fluctuating power generation</u>:
   Power generation directly depends on changing natural input
   - ➢ Forecasting production is a challenge
   - ➢ Flexible compensation needed
2. <u>No marginal costs</u>:
   Wind and solar power need no fuel
   - ➢ Dispatch priority
3. <u>Distributed generation:</u>
   Photovoltaics and onshore wind: essentially distributed
   - ➢ “Distribution” grid changes role
   - ➢ Captive power generation: Prosumers emerge as new actors

The system gets much more complex: more flexibility – four options

Generation, load, storage and exchange must be balanced at each point in time – all four can be managed:

1. Flexible backup generation
   - traditional approach, limited when needing fossil fuel
   - old technologies not flexible enough
   - new technologies: gas turbines, distributed CHP, fuel cells
   - today: natural gas, tomorrow: renewable fuel – SNG
2. Increased transmission
   - compensates local fluctuations over distance
   - requires additional transmission capacities
   - cannot compensate daily and seasonal cycles
3. Storage of electricity
   - intuitively the easy solution, but costly
   - different technologies for different time horizons, scales
4. Adapting demand
   - up to large extents cheaper than other solutions
   - nearly untapped: regulatory barriers, new opportunities with ICT



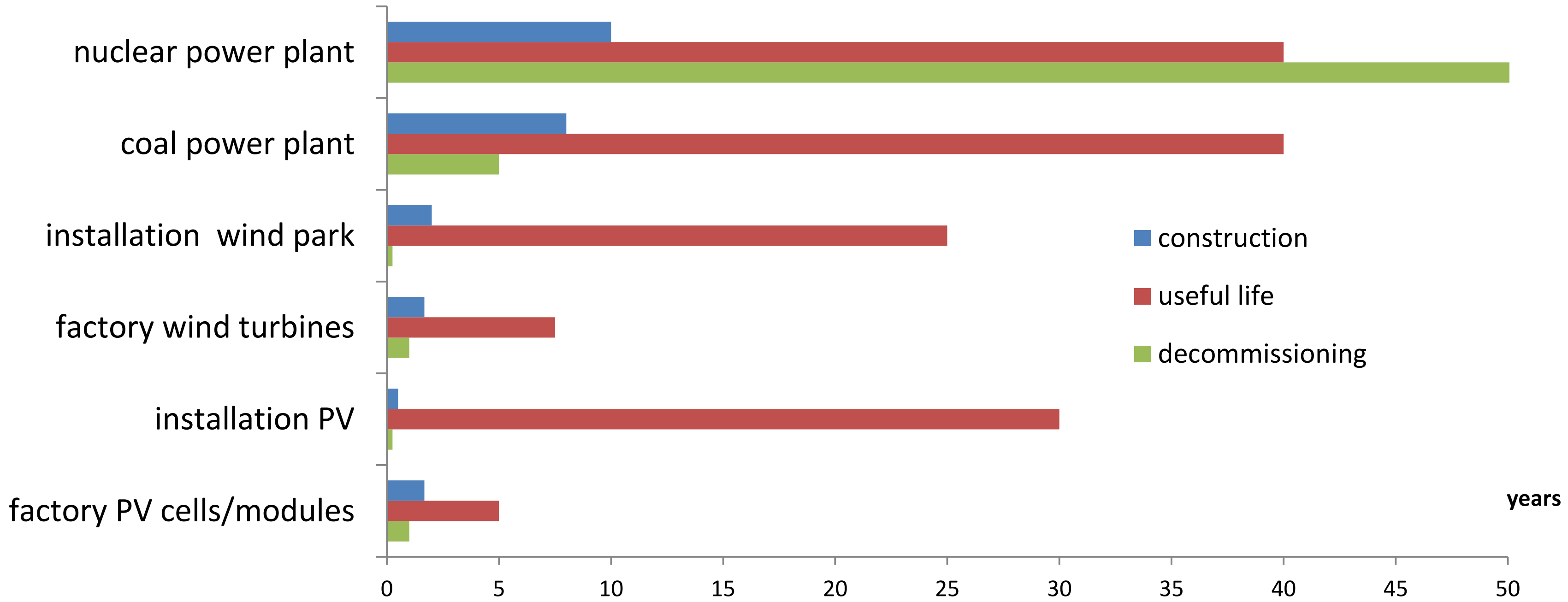
Business and government grappling with 5 to 10 times shorter innovation cycles

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

→ More rapid decrease of costs

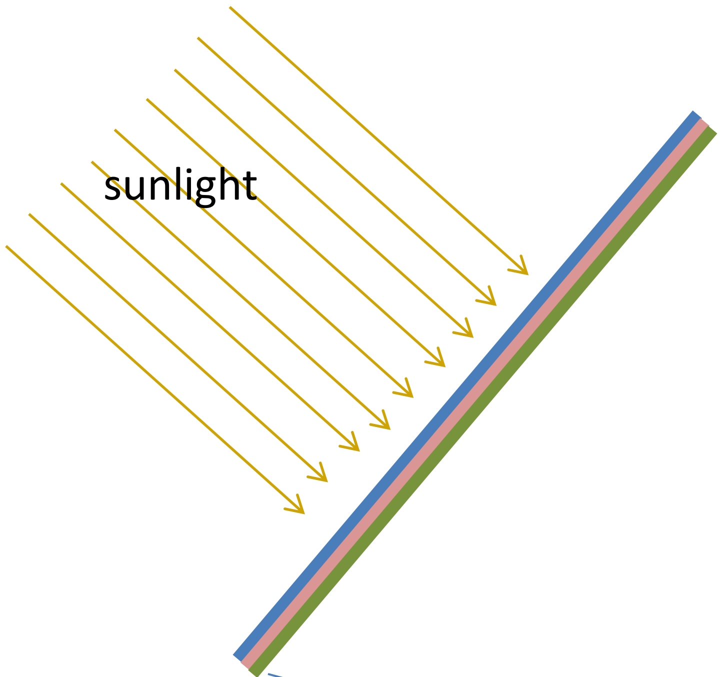
→ More rapid transformation of the electricity sector

Dramatic acceleration compared to traditional energy technologies



PHOTOVOLTAICS – A DISRUPTIVE TECHNOLOGY

PV is a Semiconductor technology: Direct transformation of sunlight into electricity

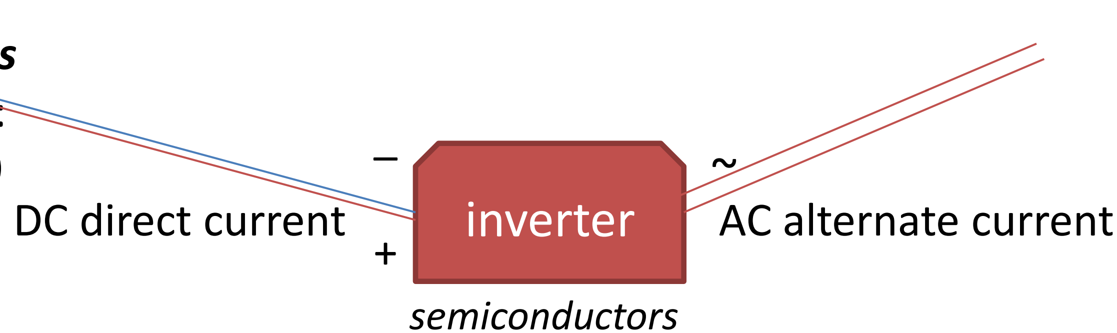


- **no moving parts**
- **no maintenance**
- **no fuel**
- **high cost reduction potential**

several layers of semiconductors

variety of different technologies:

- crystalline silicon c-Si (ingot-wafer)
- thin-film technologies
- organic …
- ….



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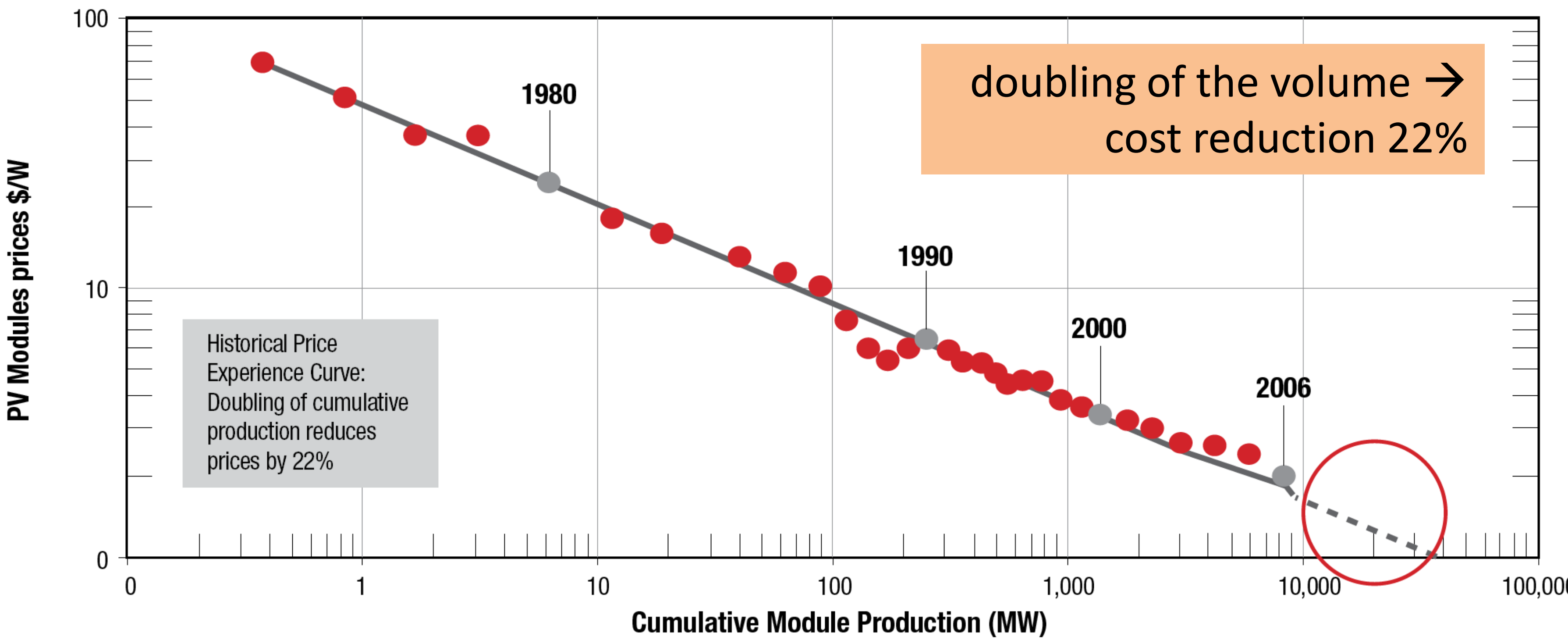
PV is an extremely scalable technology: mass production of standardised cells

Rapidly decreasing Costs: The historical learning curve of PV

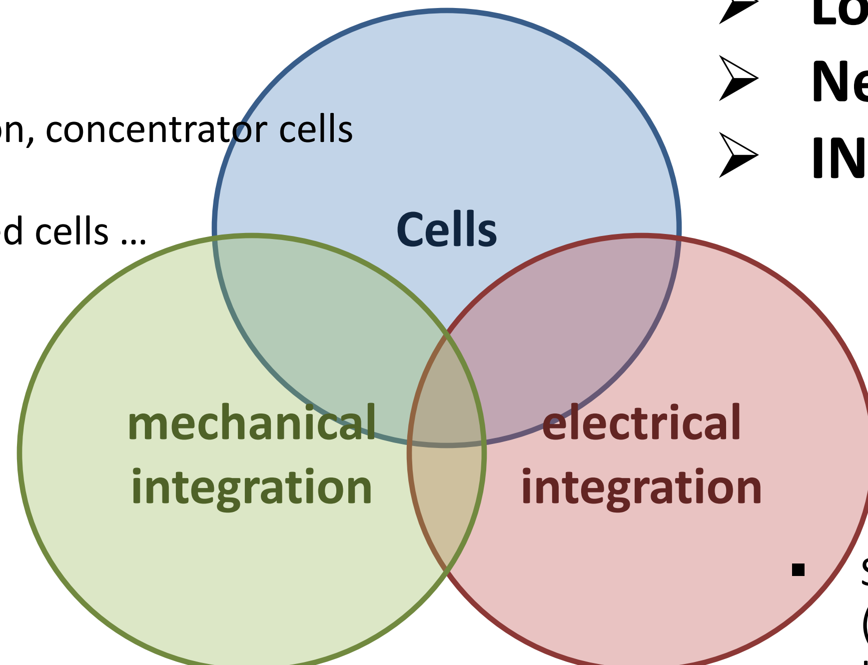


Sources: EU Joint Research Centre - EIA - National Renewable Energy Laboratory - A.T. Kearney analysis.

Innovations in PV development: large variety guarantees further cost reductions

- Silicon, improvement c-Si cells
- Thin film:
  - Si,
  - CIGS,
  - CdS, …
- Multi-junction, concentrator cells
- Organic cells
- Dye sensitised cells …

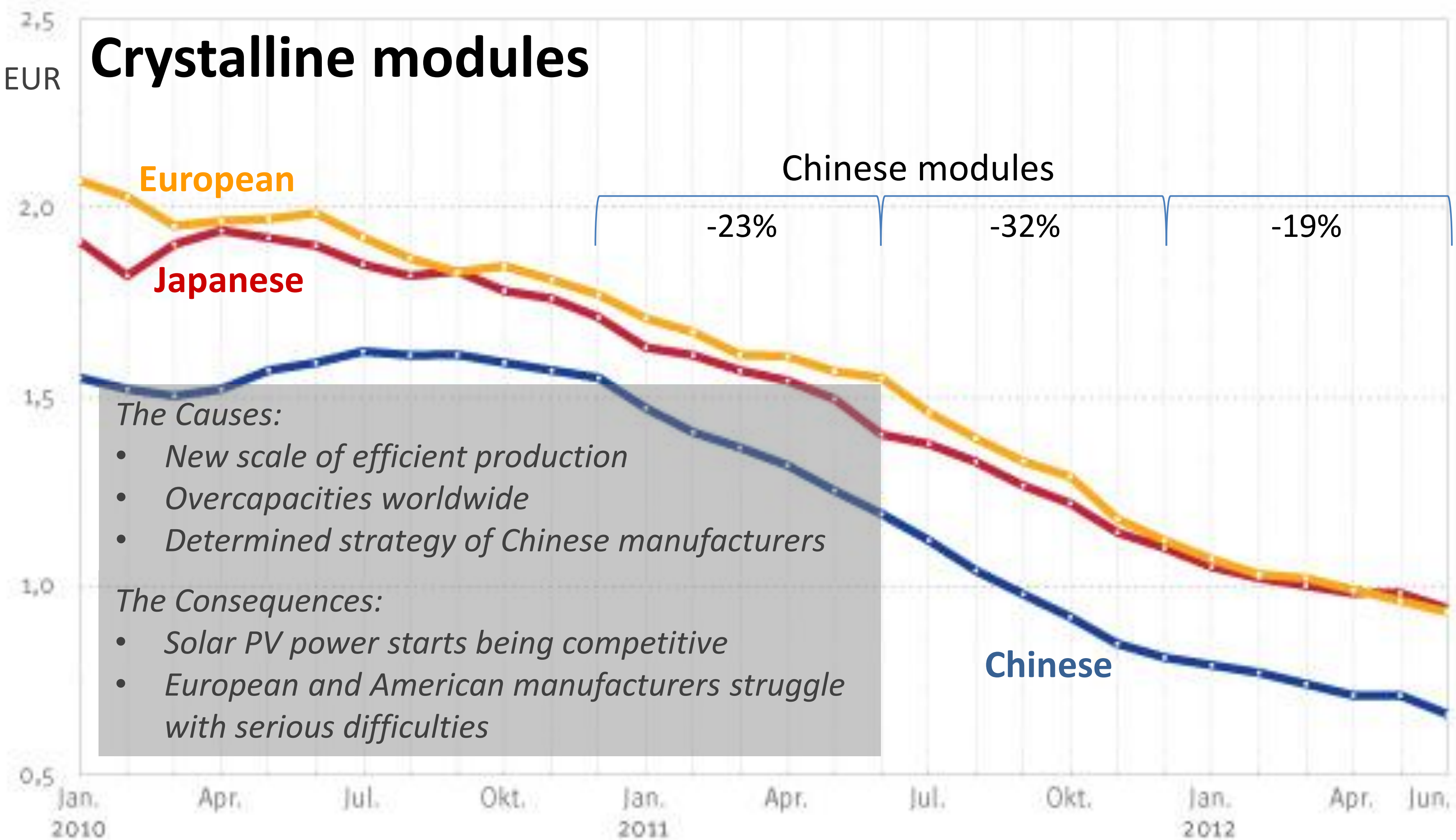
- ➢ **Higher efficiency**
- ➢ **Lower production costs**
- ➢ **New application fields**
- ➢ **INTEGRATION**



- Carrying materials, module design
- Concentrators, tracker systems
- BIPV: integration in buildings, construction elements
- in appliances, in vehicles
- Free space, traffic areas, roofing

- Storage technologies (stationary, mobile, off-grid, grid)
- Intelligent inverters
- System design
- Hybrid systems, mini-grids
- Grid concepts, grid steering
- Regulation, markets

Heavy PV module price drop since 2010: - 45% in 12 months



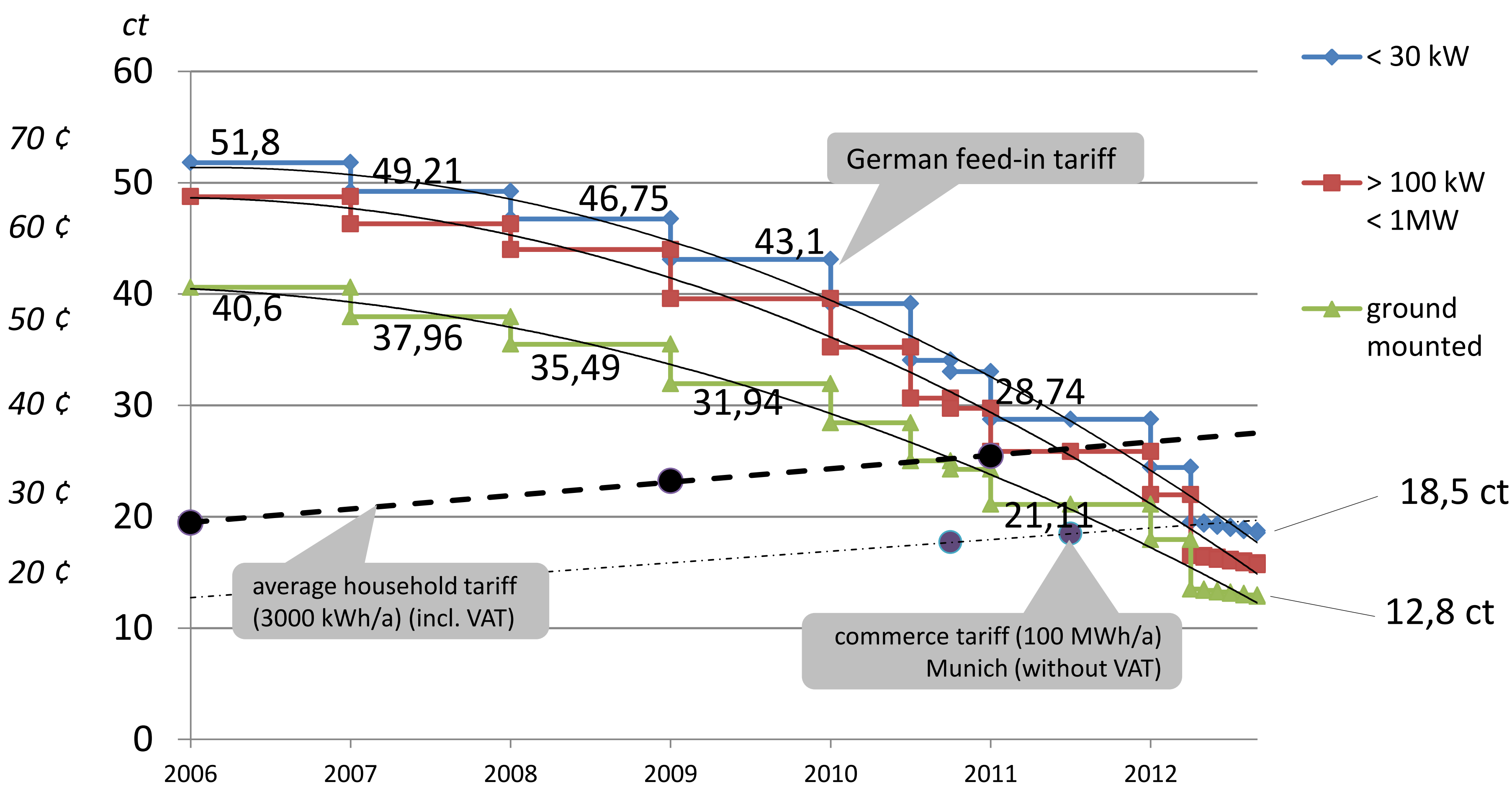
The Causes:

- *New scale of efficient production*
- *Overcapacities worldwide*
- *Determined strategy of Chinese manufacturers*

The Consequences:

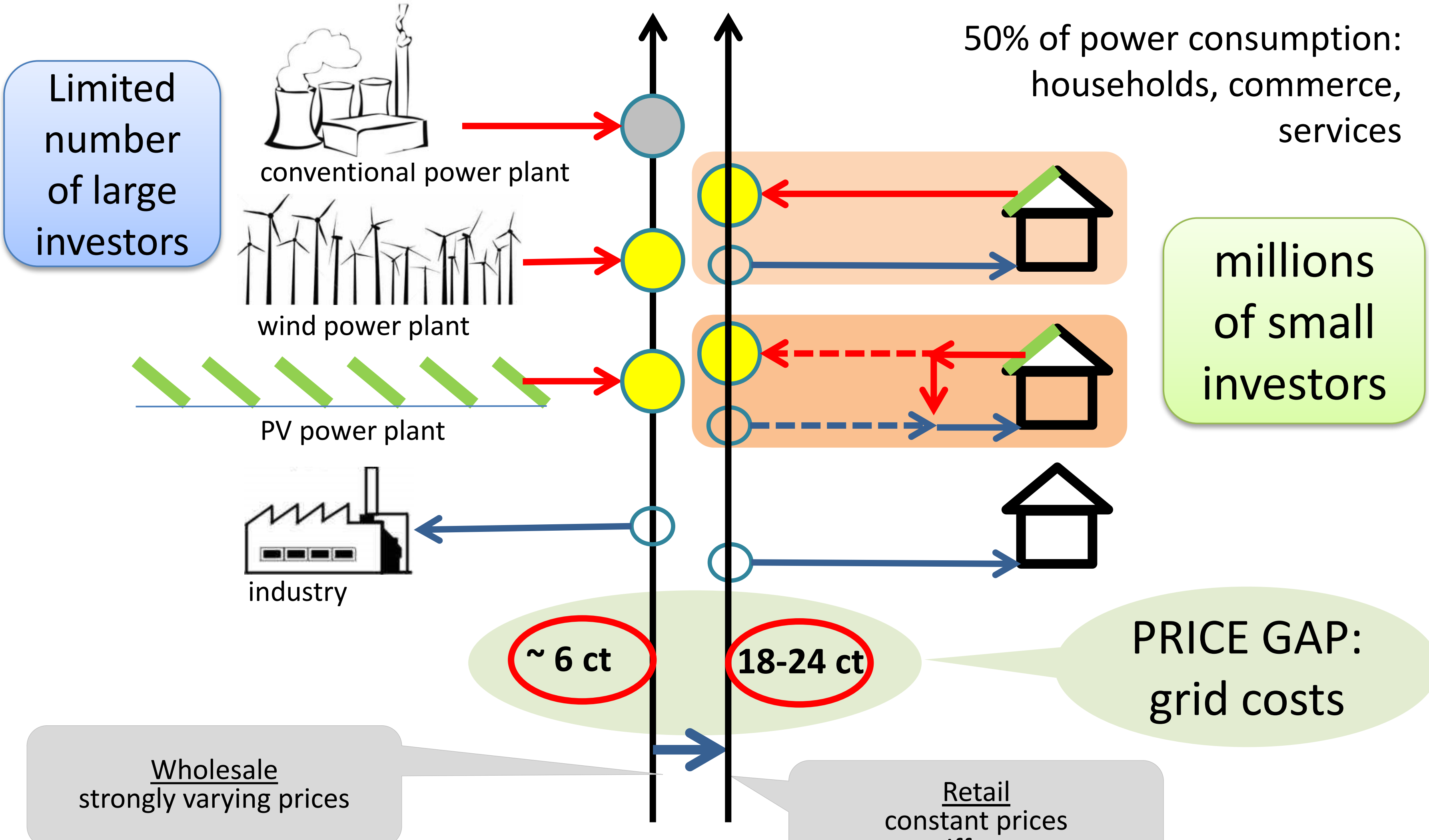
- *Solar PV power starts being competitive*
- *European and American manufacturers struggle with serious difficulties*

Rapidly decreasing German feed-in-tariffs: grid parity residential & commercial since 2012

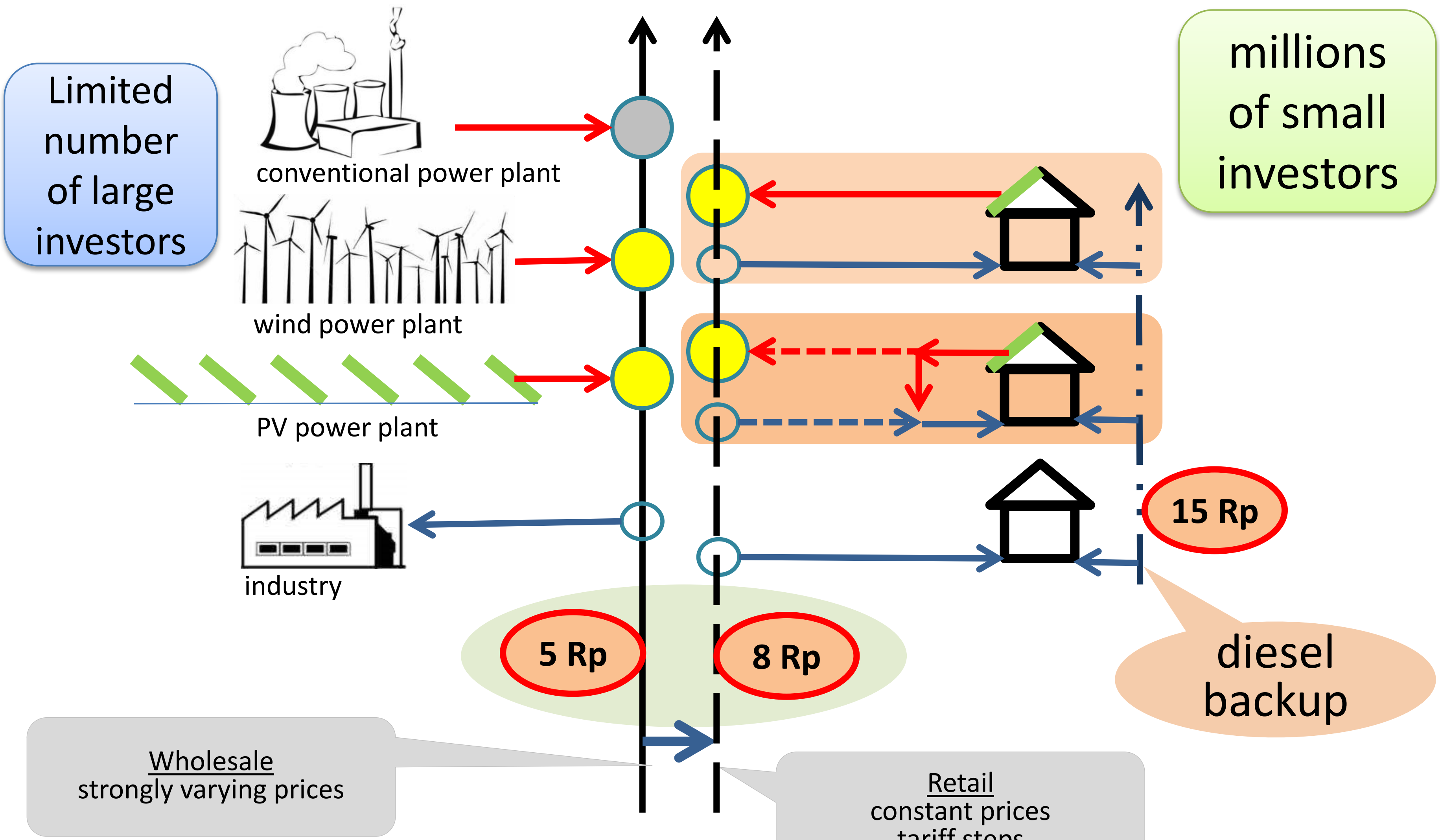


CAPTIVE POWER GENERATION CHANGES THE GAME

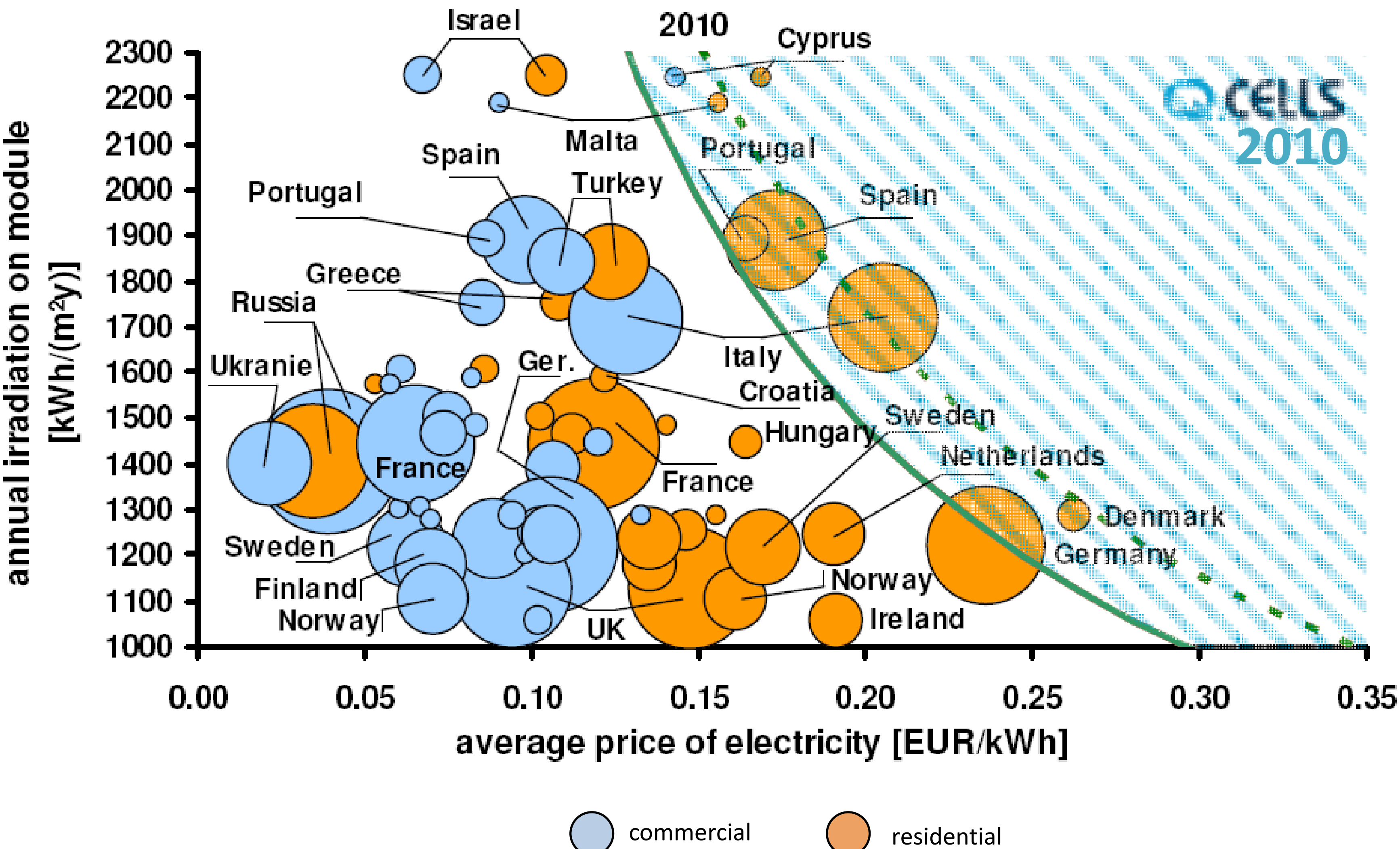
Photovoltaics is a modular technology: competing on the retail side



<u>India</u>: Photovoltaics in weak grids competing against diesel backup

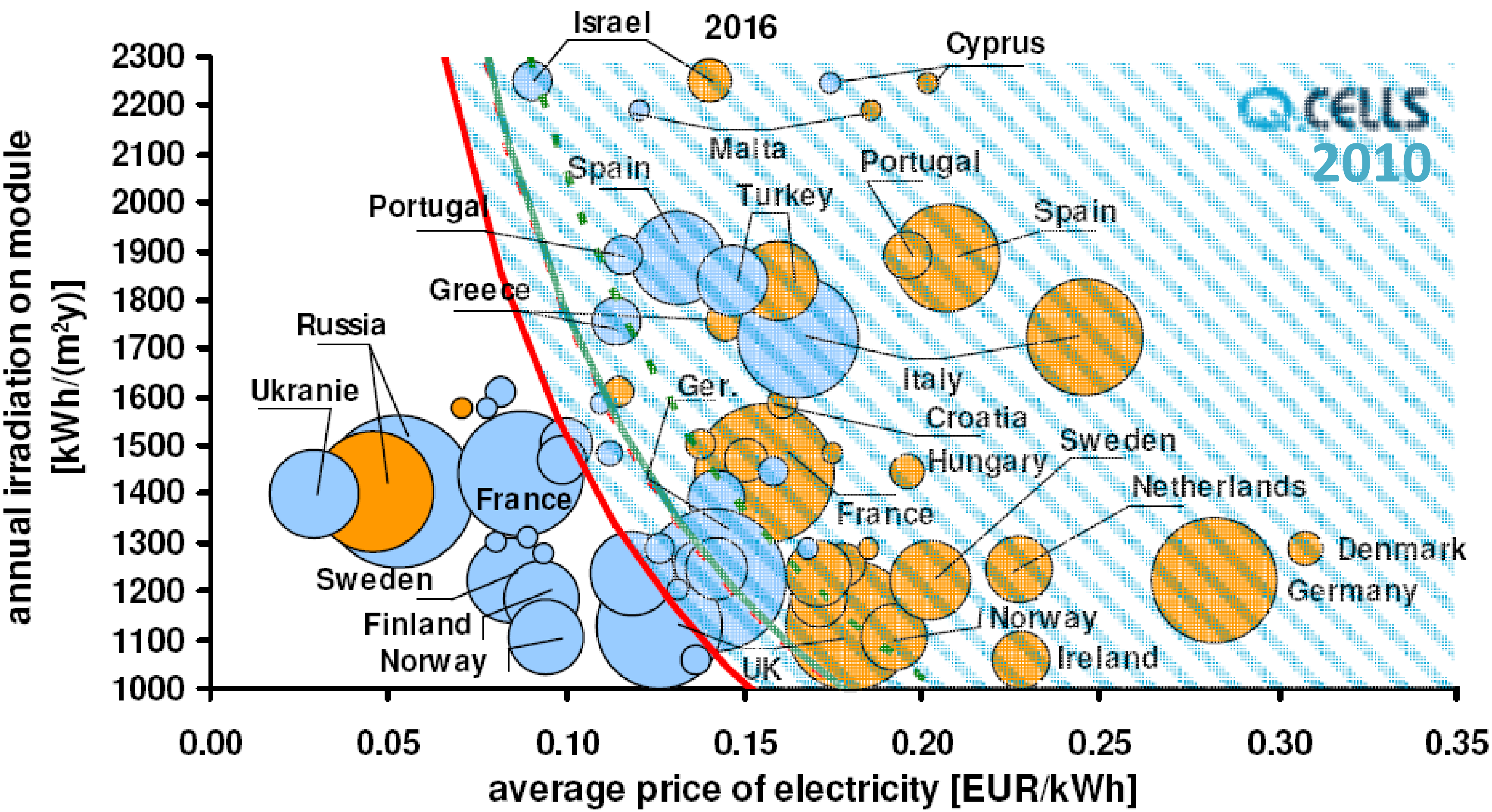


Grid parity in Europe 2010



Grid parity in Europe 2016

(forecast in 2010, might be reached already in 2013)



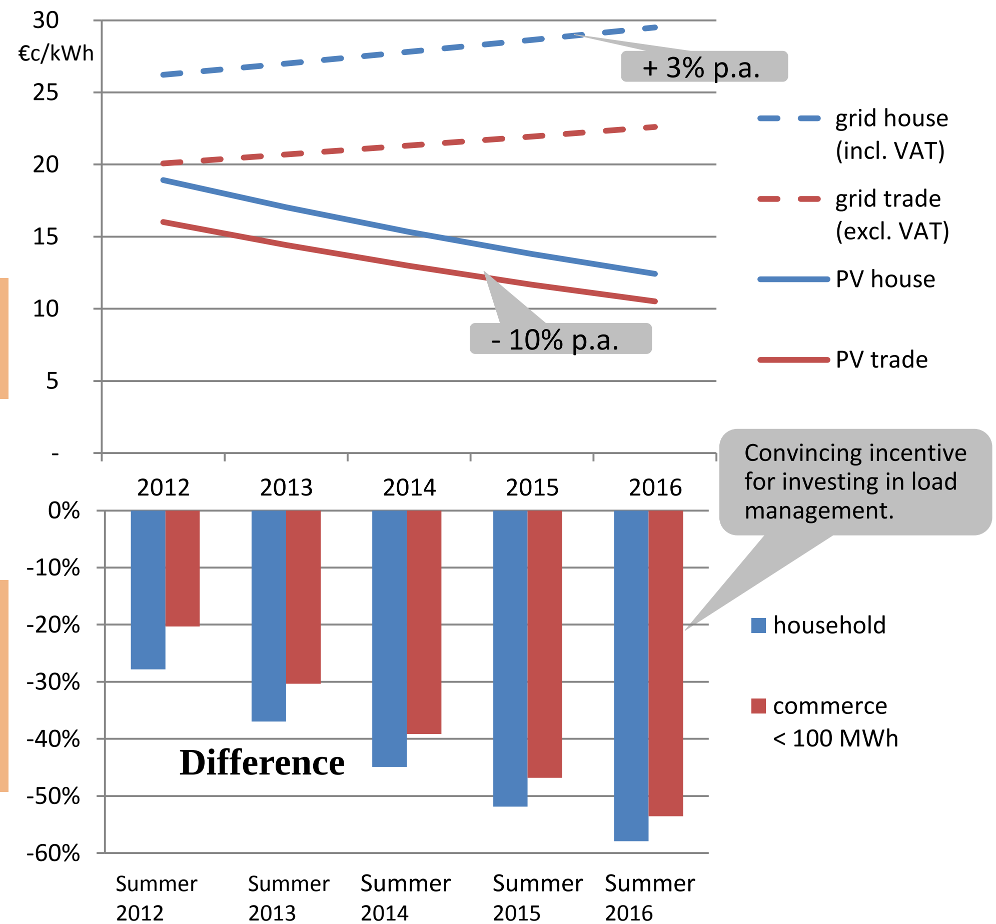
Attractiveness for own power production: Germany - Scenario for the next four years

- In the last six years the average PV system price declined by 65% (3Q06-3Q12, <100kWp, Germany) corresponding to *-16% p.a*.

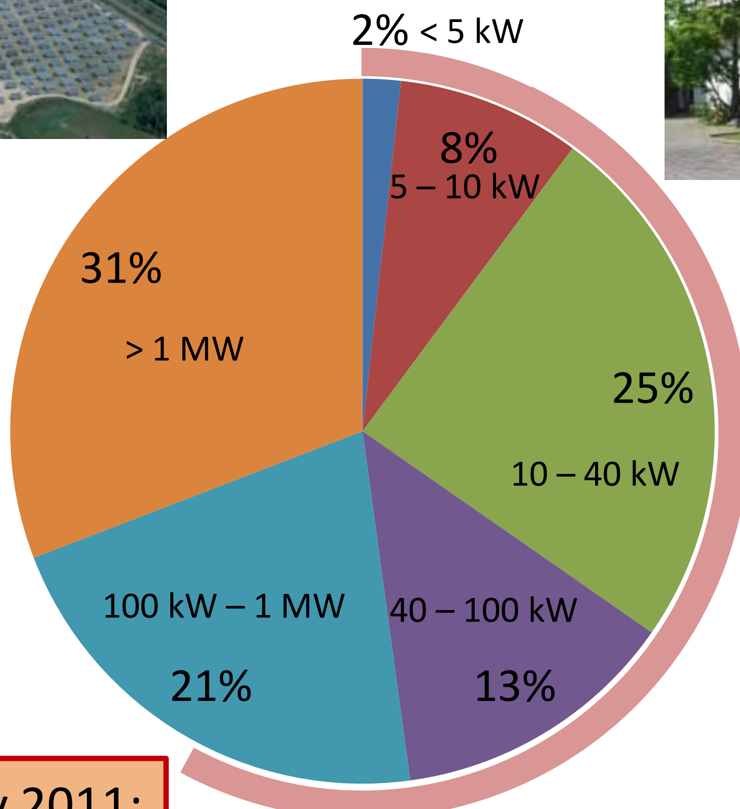
- Scenario assumptions
  - System price development: *-10% p.a*.
  - Power from the grid: + 3% p.a.
  - FIT July 2012 in Germany represents present PV power costs

➢ In four years PV power from the roof may cost 50% less than power from the grid

Evolution of the difference between grid tariffs and own PV power costs



Germany: The lions share of the installed capacity is on roofs



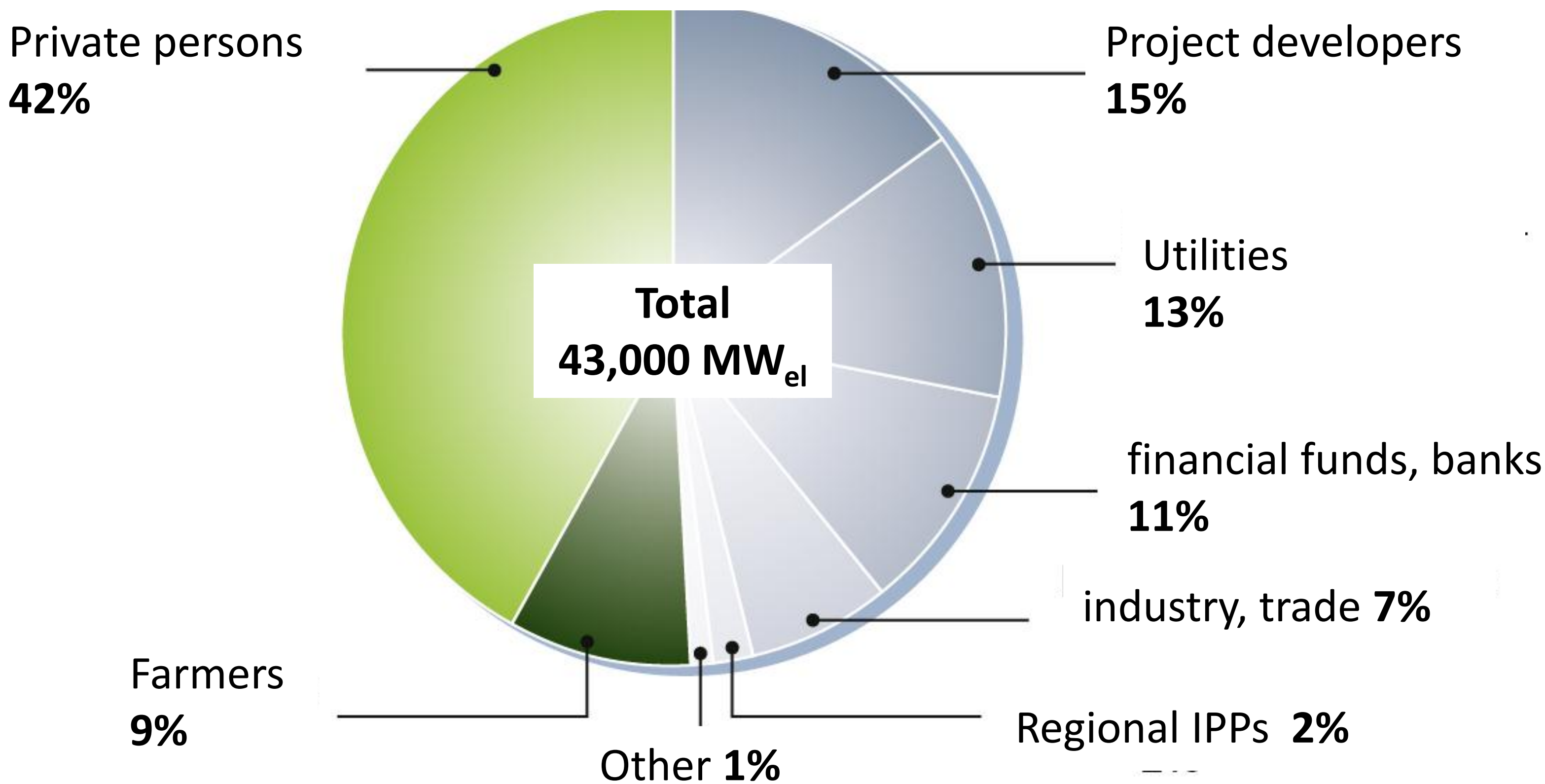
Installations **2011**

New installed capacity 2011:
48% < 100 kW

data: BNetzA 2010

Citizens participation: Distribution of ownership

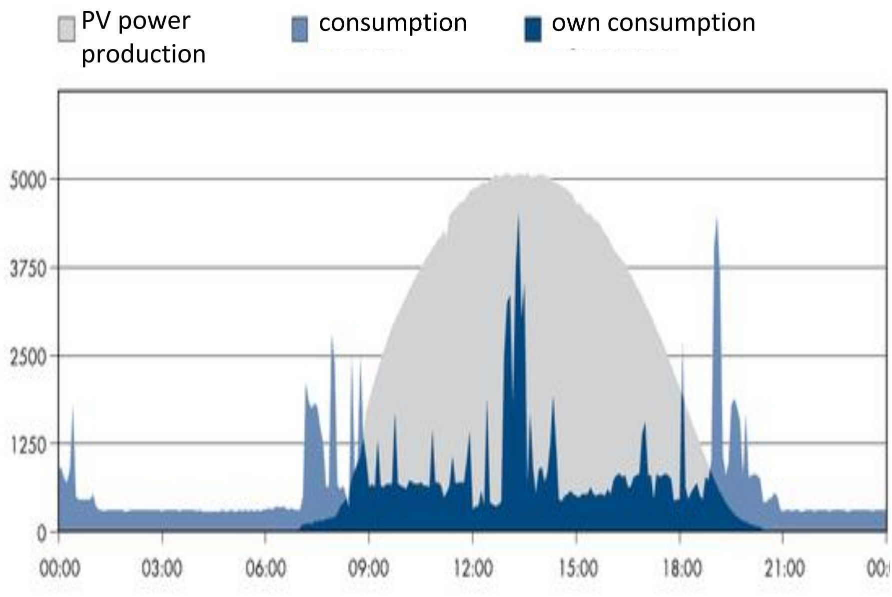
Ownership of installations for renewable electricity production in Germany (2010)

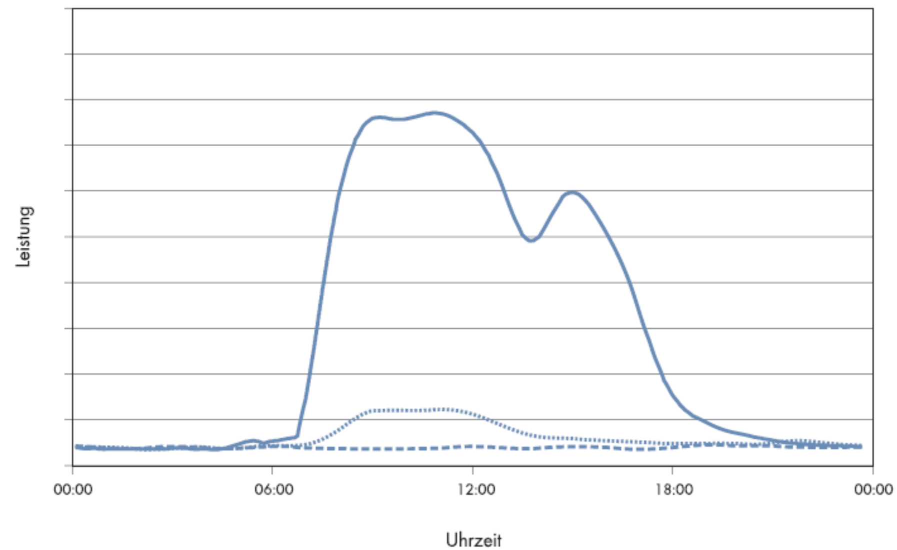


Quelle: trend research 2010; Stand: 10/2010

www.unendlich-viel-energie.de Agentur für Erneuerbare Energien

Power need when the sun does not shine: different potentials for own consumption





Private household

clouless summer day, 4 persons,

PV installation 5 kWp

→ Efforts needed for > 30% of own consumption

Commerce

working day 8-18h

BDEW Lastprofil G1

→ Good conditions for high share of own consumption

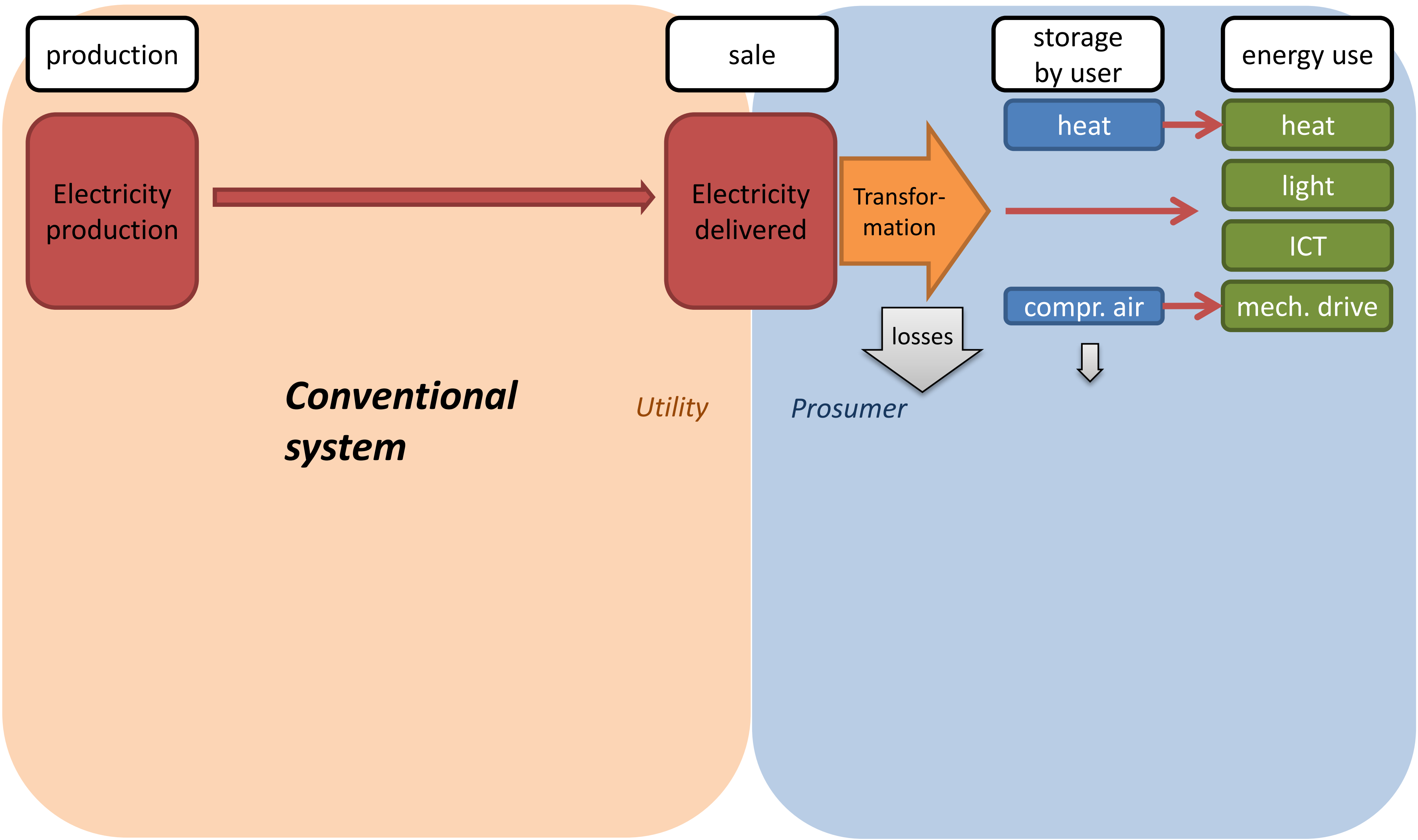
THE EMERGENCE OF BOTTOM-UP FLEXIBILITY

Prosumers start to shift their load into sunshine hours, dealing with fluctuation locally

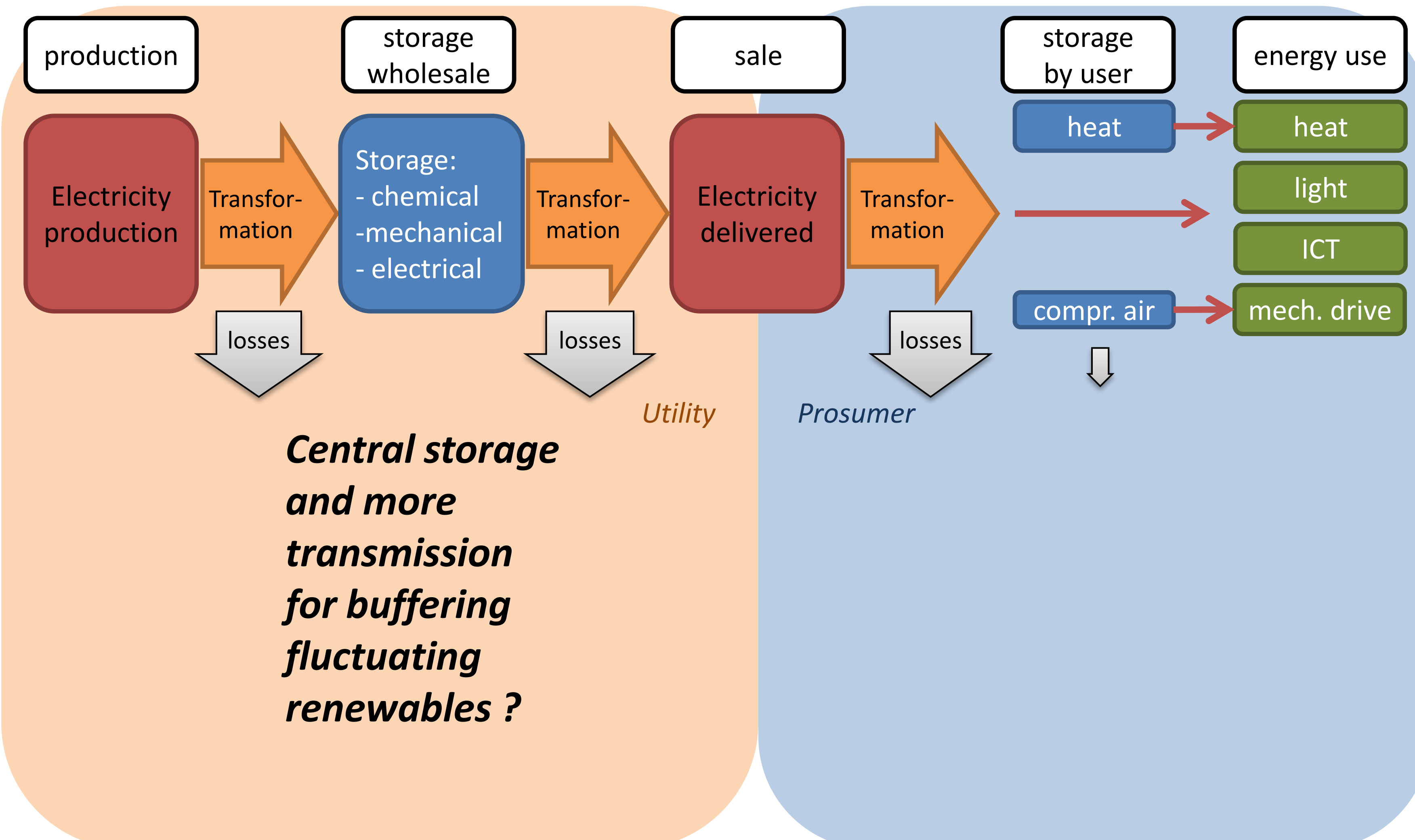
- <u>Load management</u>
  - Temporal shift of operation
  - *Thermal storage* in heating and cooling applications (cooling, air conditioning, warm water, space heating, process heat)
  - *Storage of compressed air* for mechanical applications
  - Combination of different users
- <u>Additional, non time-critical loads</u>
  - Loading electrical vehicles
  - Heat pumps: substitution of other kinds of heat production
  - Production of synth. methane or hydrogen (larger plants)
- <u>Storage of electricity</u>
  - Batteries
  - Flywheels…

➢ Flexibility of the user system increases

Creating flexibility at the bottom of the system →lower costs, higher efficiency



Creating flexibility at the bottom of the system →lower costs, higher efficiency



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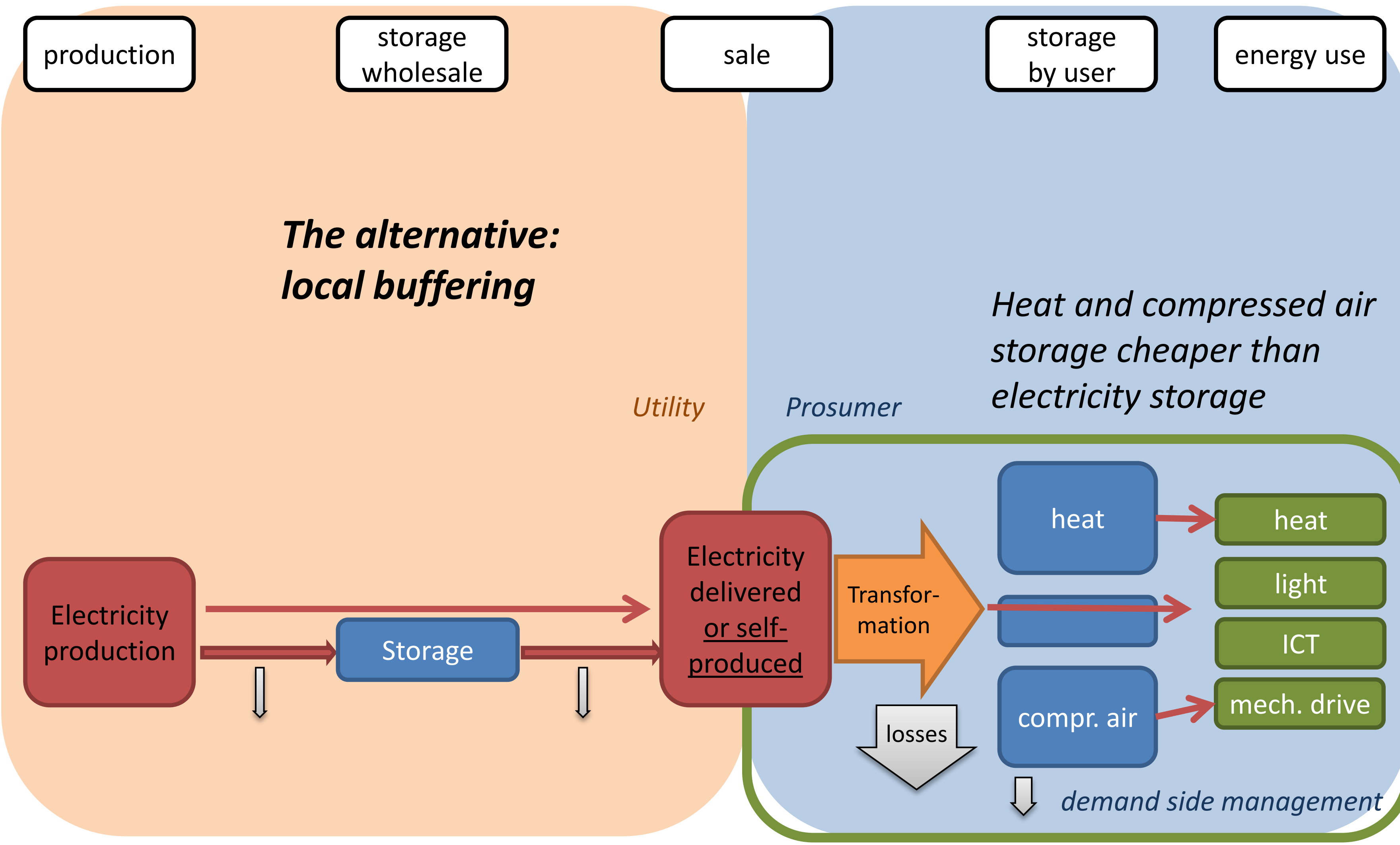

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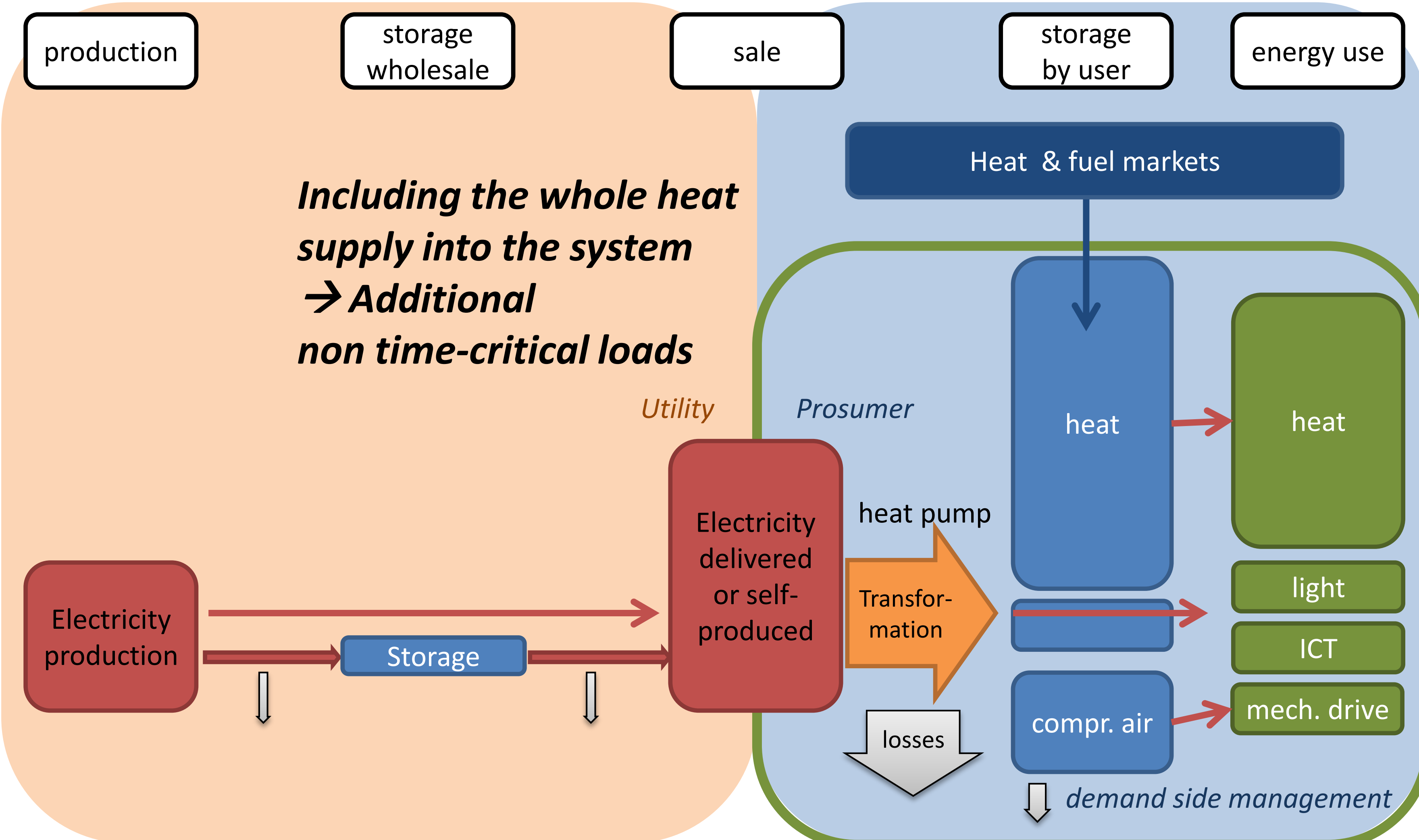

Potential for load management (using different kinds of storage)

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Shares in power consumption 2008 (Germany)

	Heat	Cold	Mech. Energy	ICT	Light	Sum
Industry	7,9%	1,9%	30,6%	1,8%	2,1%	*44,4%*
Trade & services	3,5%	2,1%	5,7%	3,9%	10,6%	*25,9%*
Housholds	13,7%	5,3%	0,6%	4,6%	2,3%	*26,6%*
Transport	0,2%	0,0%	2,7%	0,2%	0,2%	*3,1%*
TOTAL	*25,3%*	*9,4%*	*39,6%*	*10,5%*	*15,2%*	*100,0%*

Options: heat storage, compressed air storage, shifting operation
Overall: high potential for innovation – process owner decides

A new innovation wave: power management technologies

- Until now missing incentives for load management, smart homes, buildings ... → neglected opportunities
  - ICT technologies exist, no large-scale diffusion, missing standards, large companies awaiting 12-digit turnovers
  - New storage technologies emerging
  - Coupling with heat market not developed, heat storage options neglected
  - No priority in the design of production processes, process owners not motivated
  - ➢ Huge neglected development potential
- In two years cheap local PV gives strong incentives for private action → innovation wave

The coming boom: captive power generation

Attractive investments even without incentives

Timeline in Germany:

- <u>In one/two years</u>: PV power for own consumption in commerce and services
- <u>In two/three years</u>: Supplementary investments for increasing the share of own consumption

➢ PV growth independent from incentives

➢ Boom in power management technologies

Still missing but slowly emerging: appropriate business models

- Dealing with high upfront costs
- Structuring of risks
- Segmentation of markets
- Distribution of roles
- Development of step by step approaches

Where will we see them first at large scale?

- in Germany?
- in Italy?
- in Spain?
- in Turkey?
- in India?

TOWARDS A NEW CONTROL LOGIC OF THE ELECTRICITY SYSTEM

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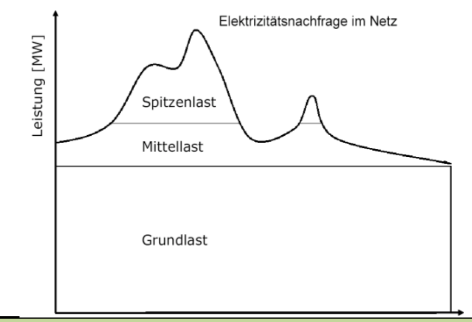
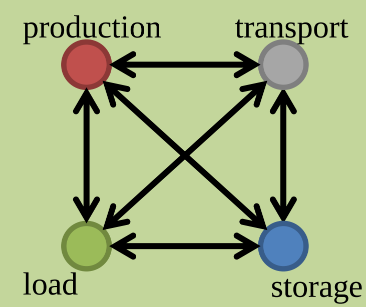
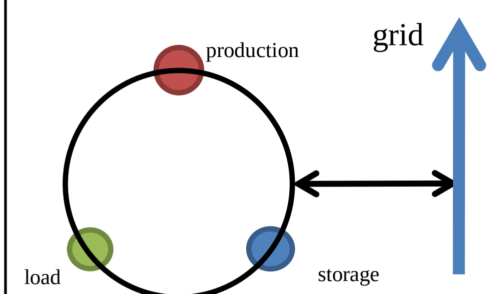
Captive PV Power can support the change of the control logic of the electricity system…

Traditional Large power plants fossil and nuclear Transformation	• Production follows demand: base / middle / peak load • Load management only with large consumers • Central control	
Supply 100% REN Integrated optimisation of the whole system	• Fluctuating production with wind and sun dominates • Load management, storage • Complexity requires optimisation on several levels	
Contribution ***Captive power production*** *Optimisation on the consumption level*	• Optimisation subsystem • Partial buffering of fluctuations at the local level • Facilitation of optimisation at higher levels	

…but without an appropriate framework private optimisation can destabilise the whole system

- Who pays the grid costs not covered by self-supplying ex-consumers?
- What happens if prosumers dump generation peaks into the grid when their storage is full?
- …

- ➢ Time-dependent feed-in and supply tariffs must set incentives for system-stabilising exchange with the grid
- ➢ System needs may vary from place to place as the production-consumption mix varies
- ➢ System responsibility must be decentralised

→ A more differentiated approach in time and space
→ We will need local electricity markets

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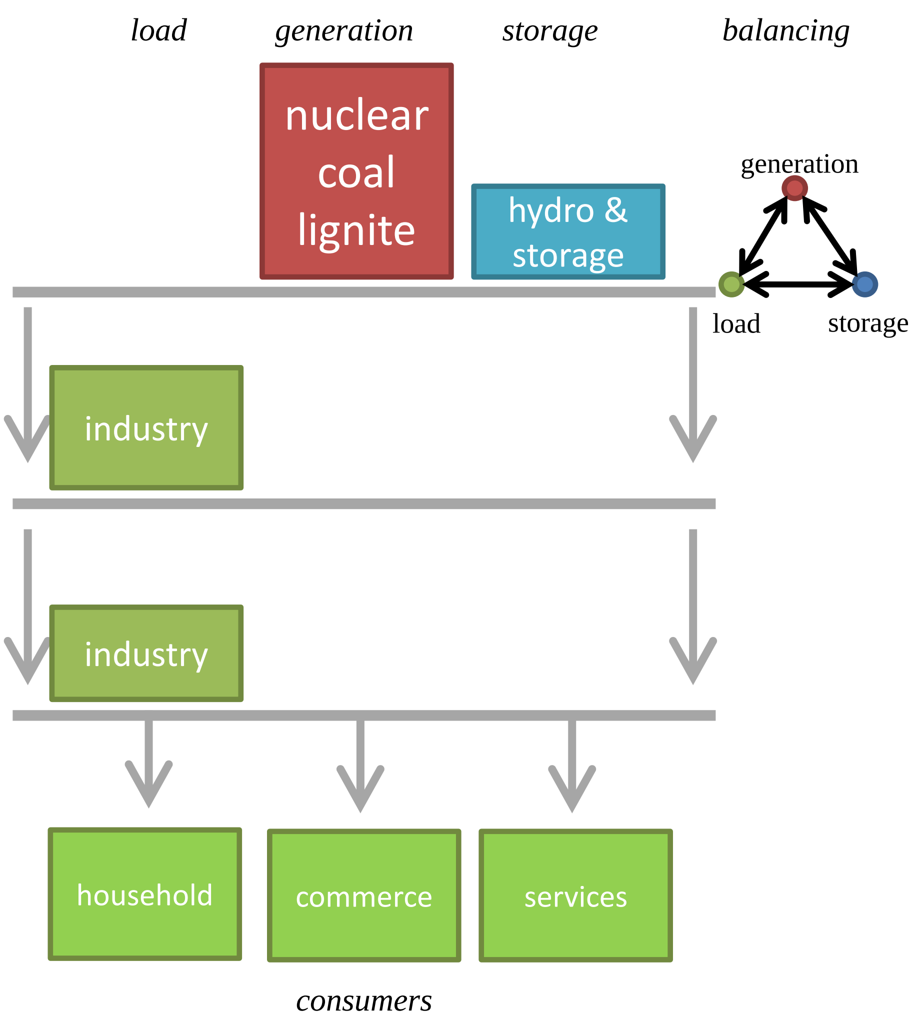
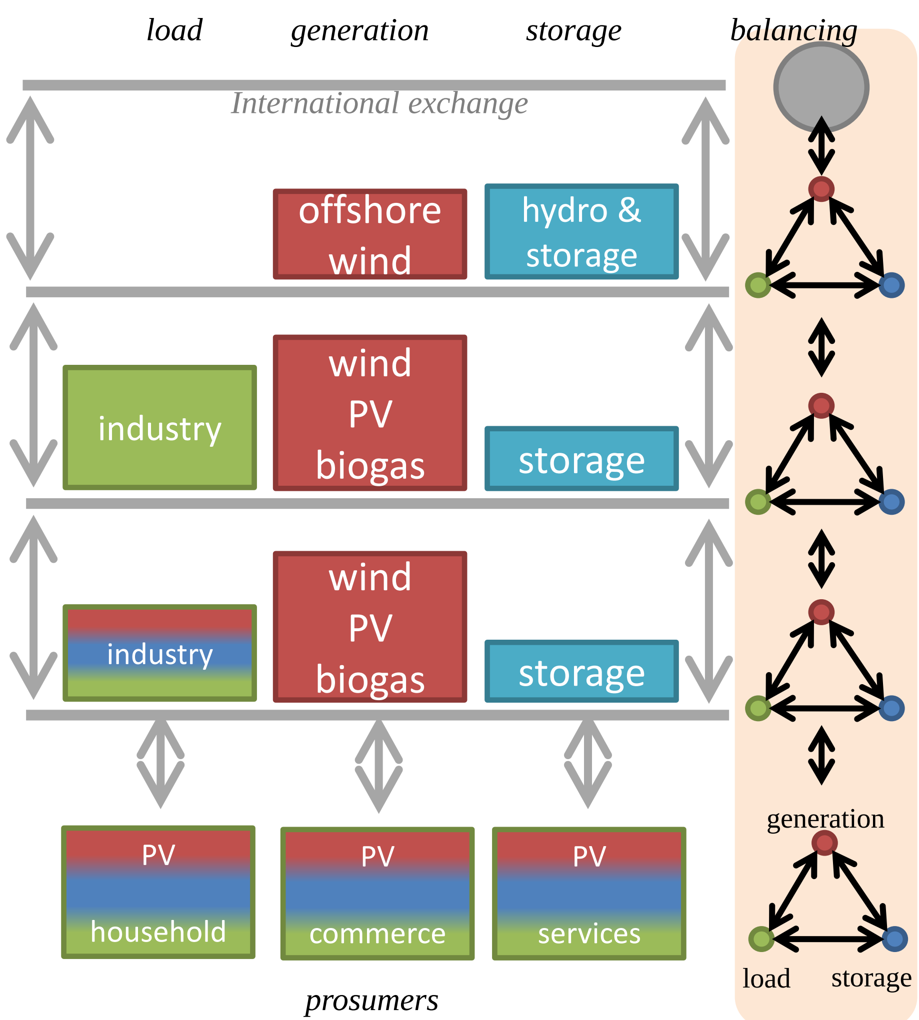
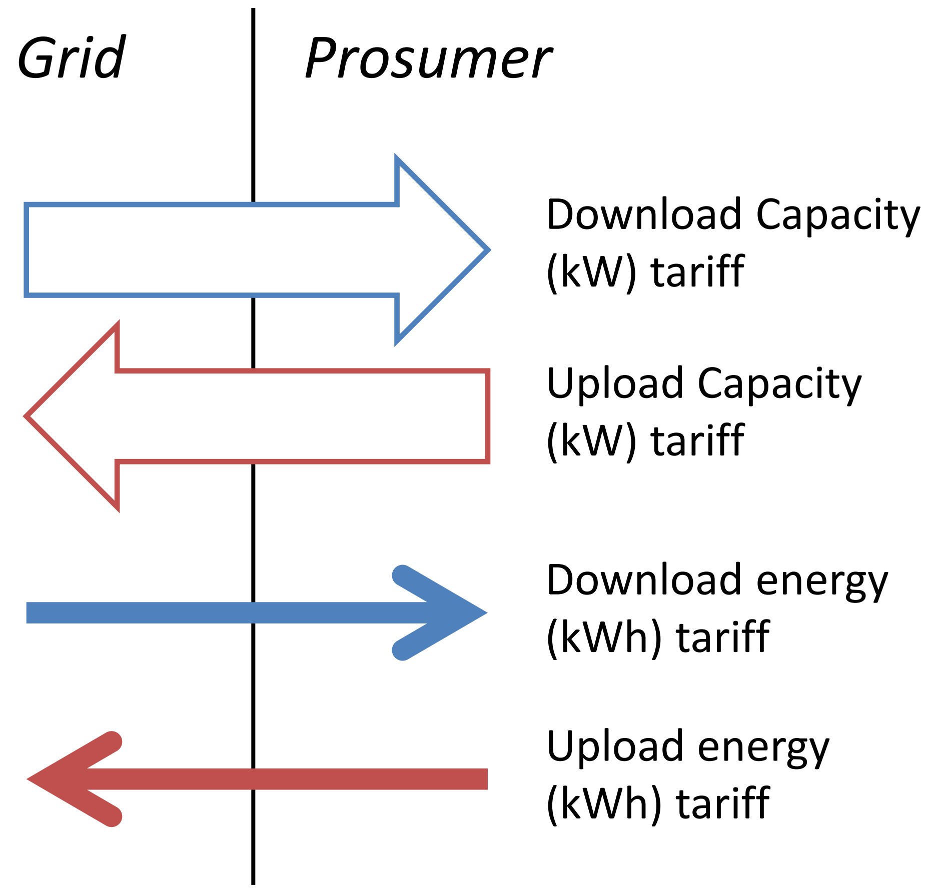
Top-down supply system
(central control)



Multi-level exchange system
(subsidiarity, shared responsibility)



Four basic parameters for steering prosumer's exchange with the grid



The debate about SMART GRIDS is all about introducing a new system logic

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- Distributed intelligence and responsibility
- Multi-dimensional optimisation with the help of market mechanisms
- Involvement of the consumers : demand response, captive power production
- New definition of roles - vertically and horizontally
- Electricity markets also a the distribution level?

➢ An intense fight over a new system and market architecture in a very short time

➢ A clash of cultures: energy business (top-down)
vs. IT (multi-level governance)

➢ A lack of transparency

Managing a Turbulent Transformation

- Accept the challenge of captive power production and organise the electricity system according to the principle of subsidiarity – establishing responsible system coordination at several levels
- Ensure far-reaching transparency concerning infrastructures constituting natural monopolies
- Use market mechanisms for complex optimisation tasks at each level
- Strive for steady development and reliable frame conditions, consider different life-times of investments

Towards a flexible multi-level governance model

- The new system needs to consider new dimensions:
  - new qualities of time and space (fluctuation, storage, grids)
  - new kinds of actors (prosumers, new system roles)
  - accelerated change with differing innovation speeds
  - highly scalable modular generation technologies
  - flexible smart grid infrastructures
  - cheap distributed control intelligence
- For organising a pragmatic transition we need strategic visions
  - for the re-definition of the role of actors at several levels:
    TSOs, IPPs, DSOs, integrated municipal utilities, regulation agencies…
  - for the differentiated use of market mechanisms
  - concerning possible paths of industry development

THANK YOU FOR YOUR ATTENTION

You will find this presentation and more on my website

www.sustainablestrategies.eu

Ruggero Schleicher-Tappeser

See article: "How renewables will change electricity markets in the next five years"
Energy Policy 2012: http://bit.ly/L27haO