sustainable strategies
ruggero schleicher-tappeser

# How Renewables Will Change Energy Markets in the Next Five Years

Ruggero Schleicher-Tappeser

sustainable strategies, Berlin

Climate Policy After Fukushima

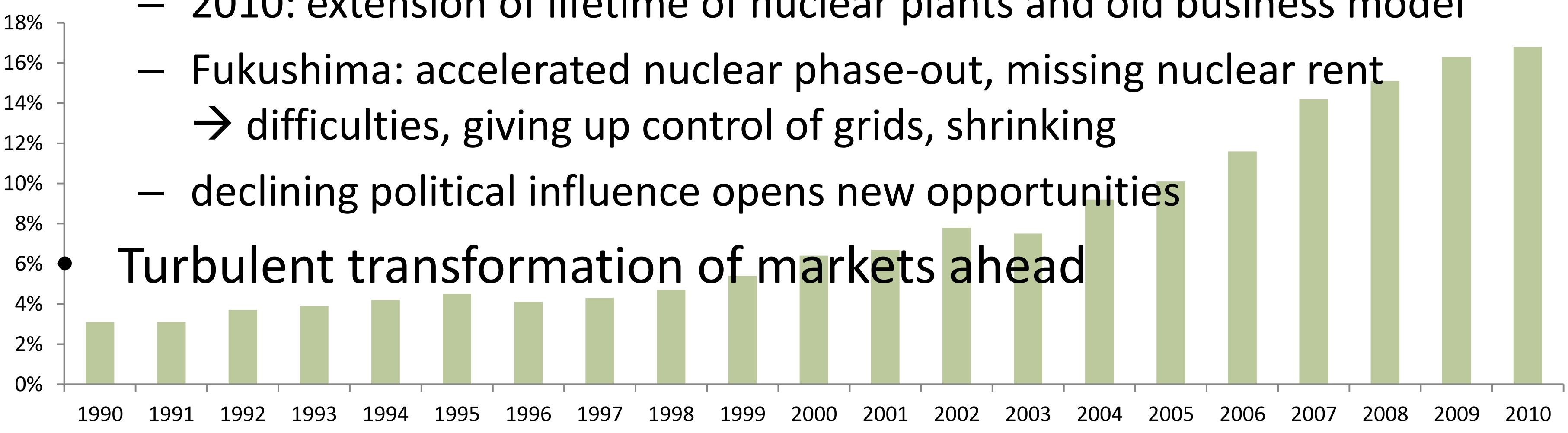
16th meeting of the REFORM group

Schloss Leopoldskron, Salzburg, August 29, 2011

2011-09-14

# Fukushima – the end of the paradigm of central power supply

- Germany: most advanced large country deploying renewables
  - – anti-nuclear movement, sensitivity for climate issues
  - – combination of technical and institutional innovation
  - – sympathy for decentralised solutions
  - ➢ Strong REN growth in electricity:
    3,1% → 17% of total power consumption in 20 years
- Four dominant, centralised, heavily nuclear utilities
  - – 2010: extension of lifetime of nuclear plants and old business model
  - – Fukushima: accelerated nuclear phase-out, missing nuclear rent
    → difficulties, giving up control of grids, shrinking
  - – declining political influence opens new opportunities
- Turbulent transformation of markets ahead



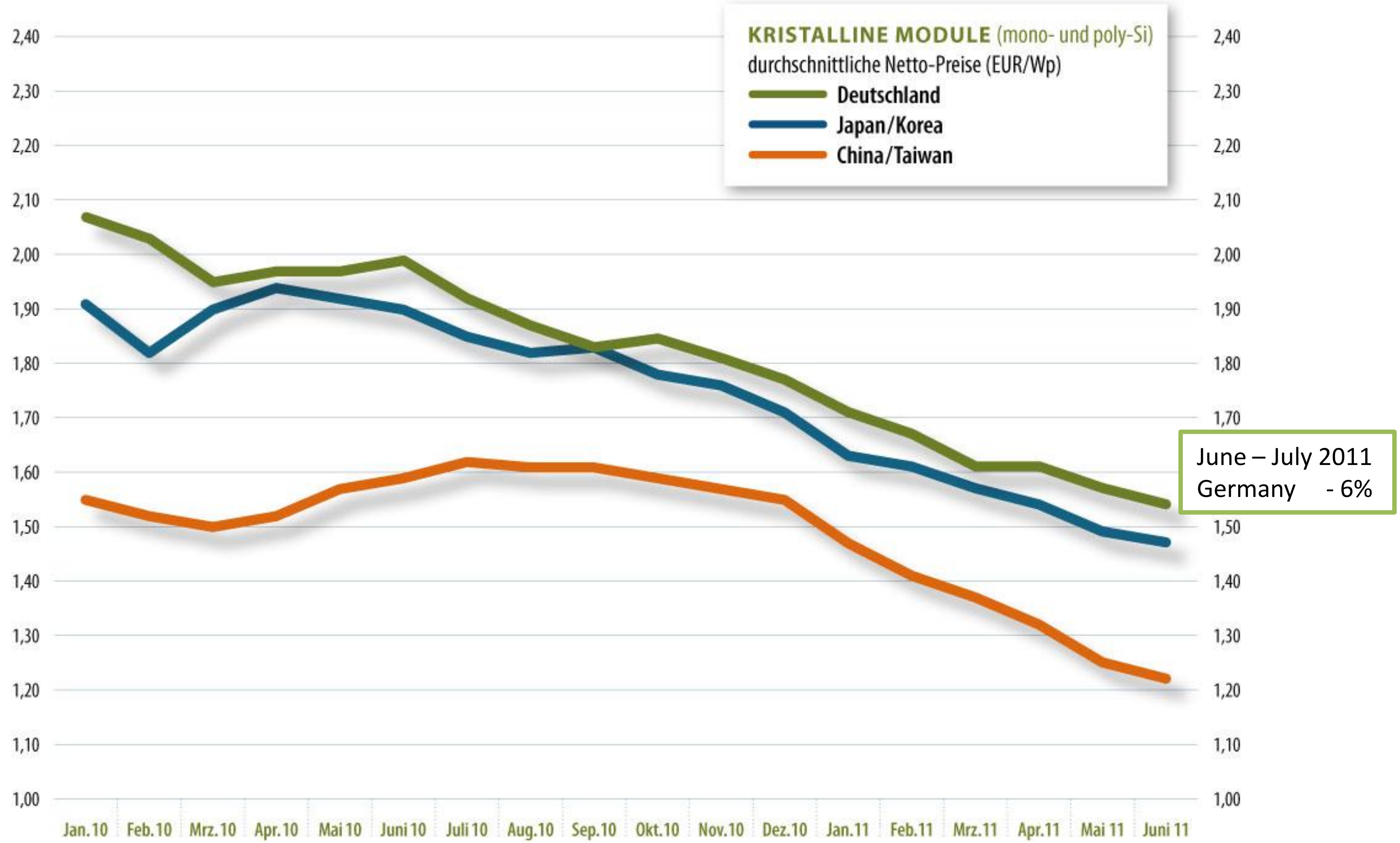
# Transformation of electricity markets: Strong drivers for change

1. End of nuclear, climate change, ↗ energy prices
   → accelerated switch to renewables
2. Wind & solar depend on weather, no variable costs – need to cope with fluctuating production
3. The disruptive character of photovoltaics – steadily falling prices, modularity, prosumers
4. ICT conquers traditional grids – old top-down logic challenged by new concepts

→ Complexity increases, present regulation inadequate, new wave of innovations, rapid & turbulent change

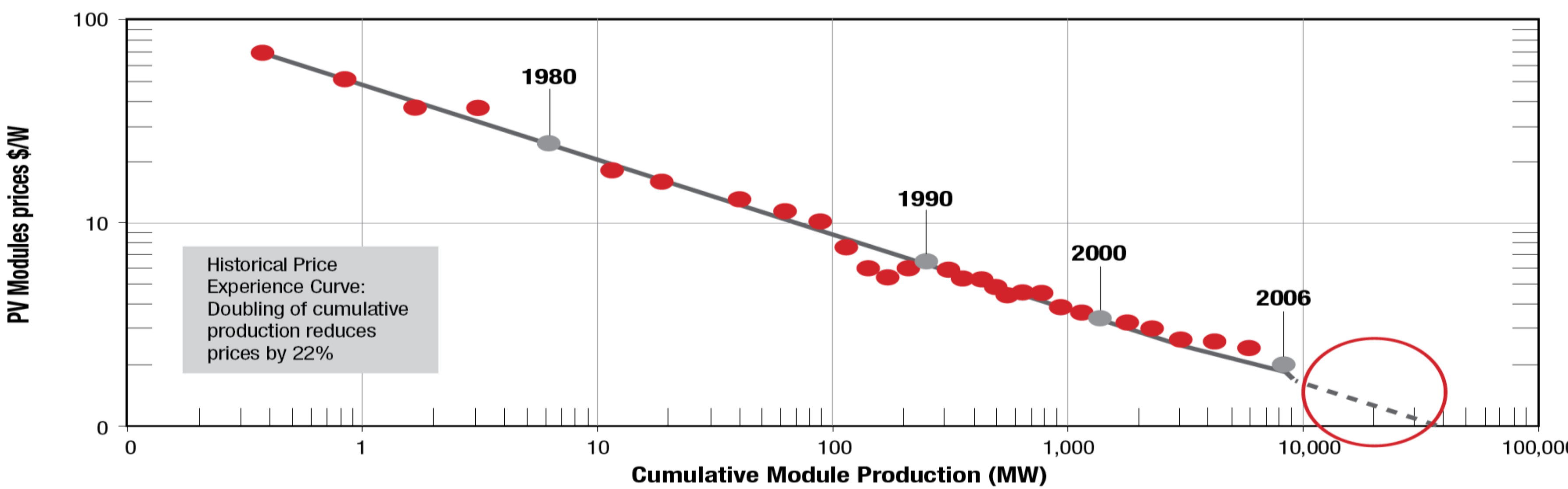
# THE DISRUPTIVE CHARACTER OF PHOTOVOLTAICS

# PV prices continue to fall rapidly: -23% in 12 months



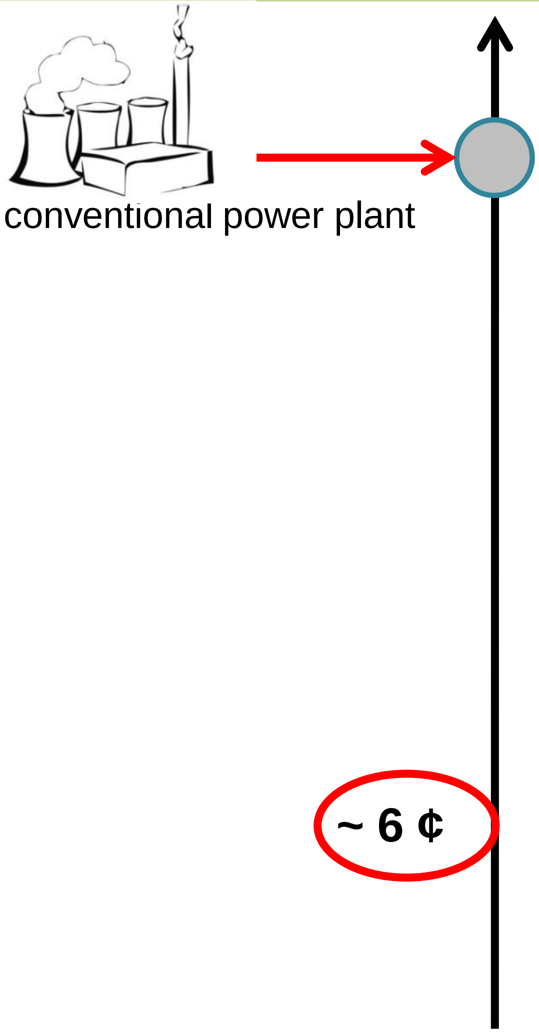
# Price decline will go on

- Learning curve similar to other semiconductor technologies
- 22% cost reduction for every doubling of production
- Plenty of cost-reducing innovations in preparation
- Several competing technologies
- Accelerated growth of markets → accelerated cost reduction




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

# Modular PV technology: competing on the retail side



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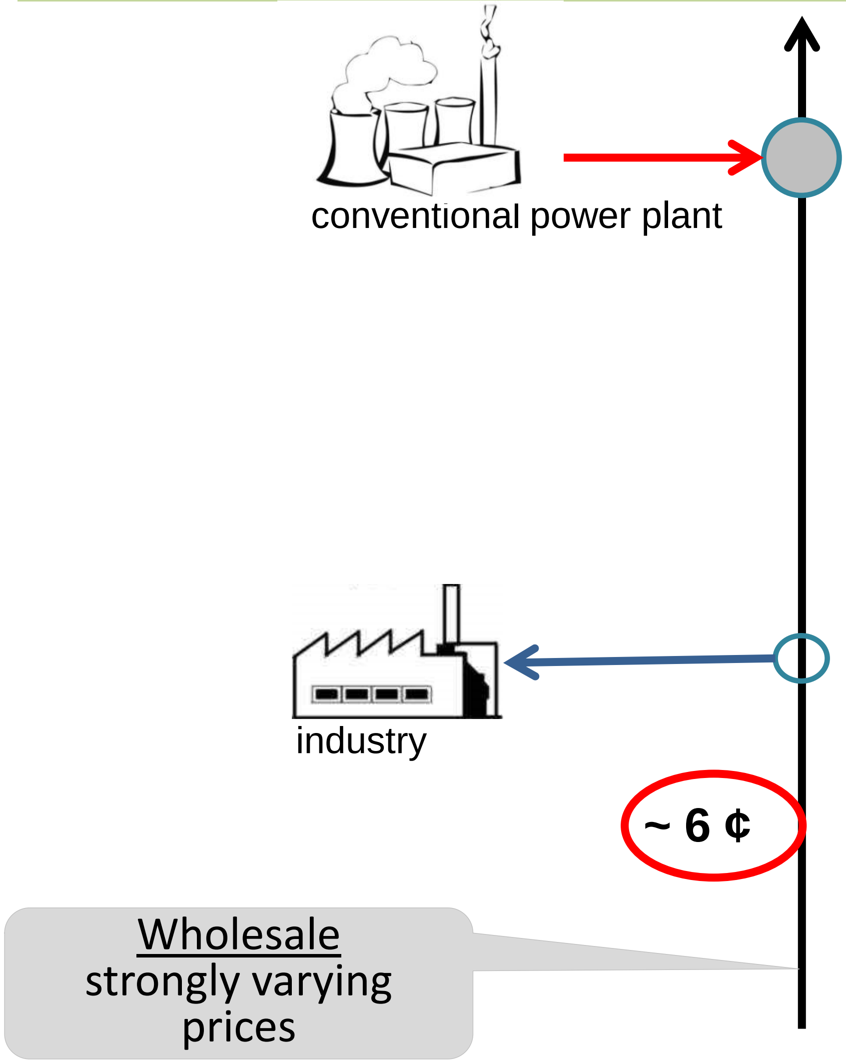

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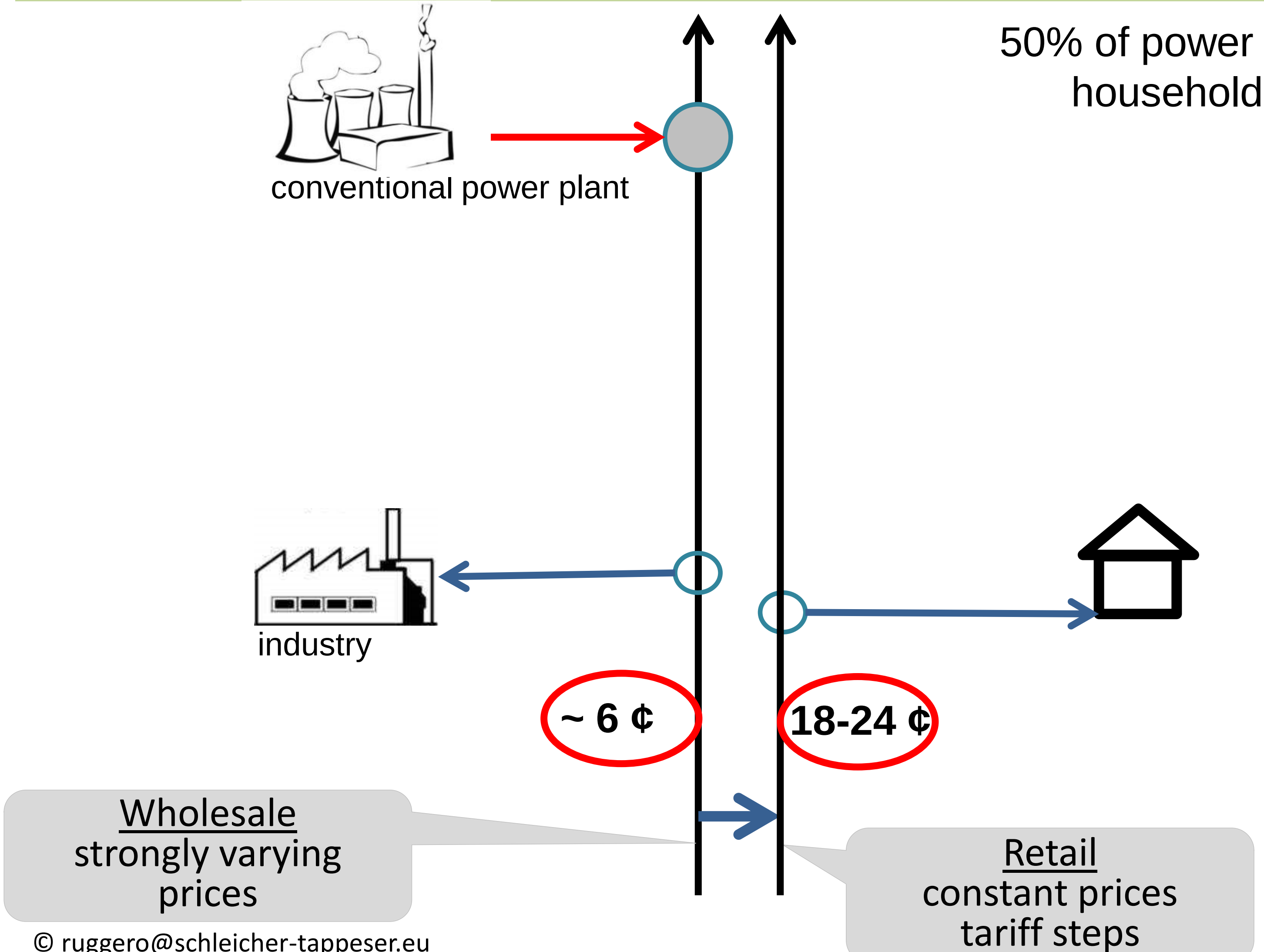
50% of power consumption: households, commerce, services



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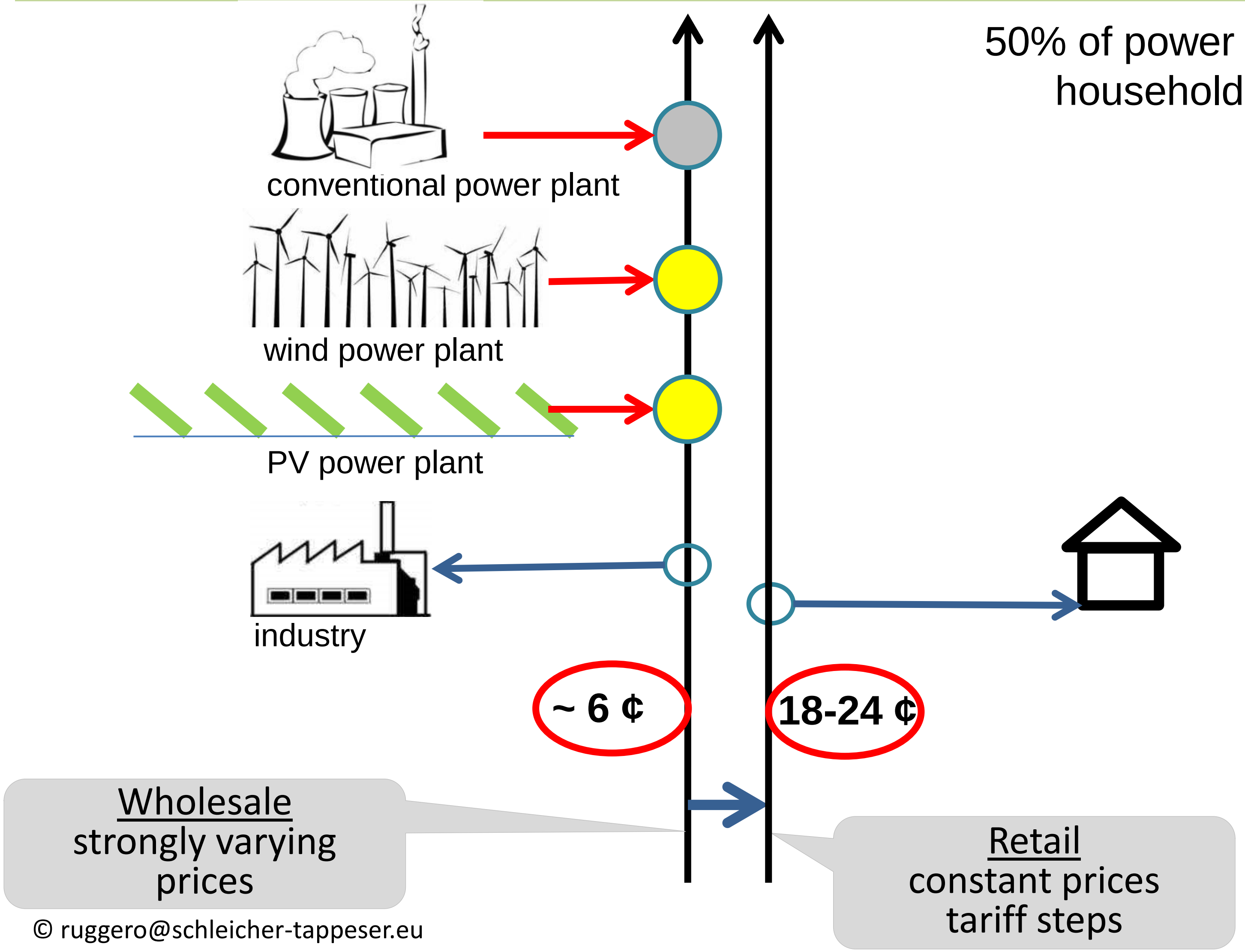

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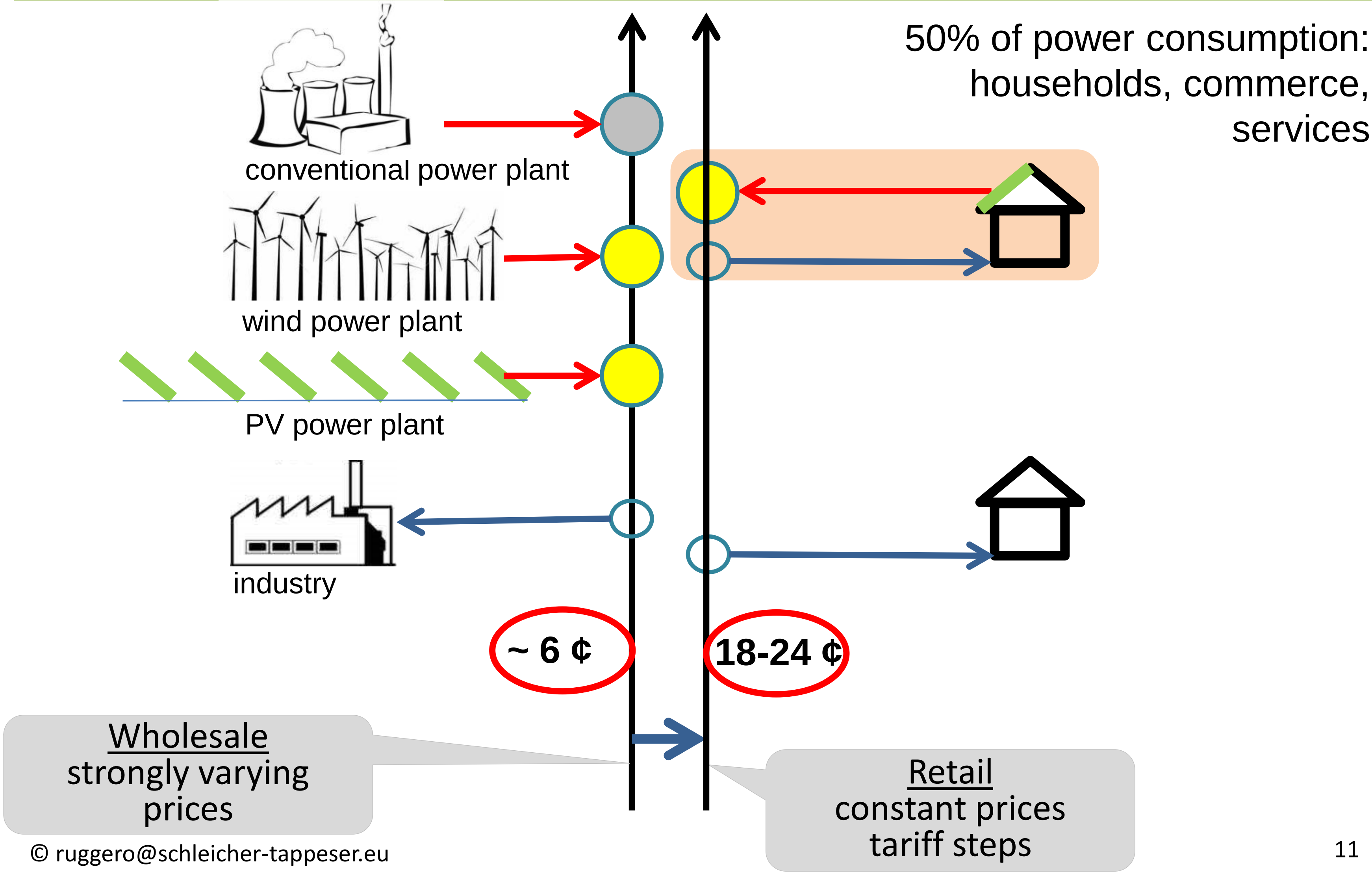

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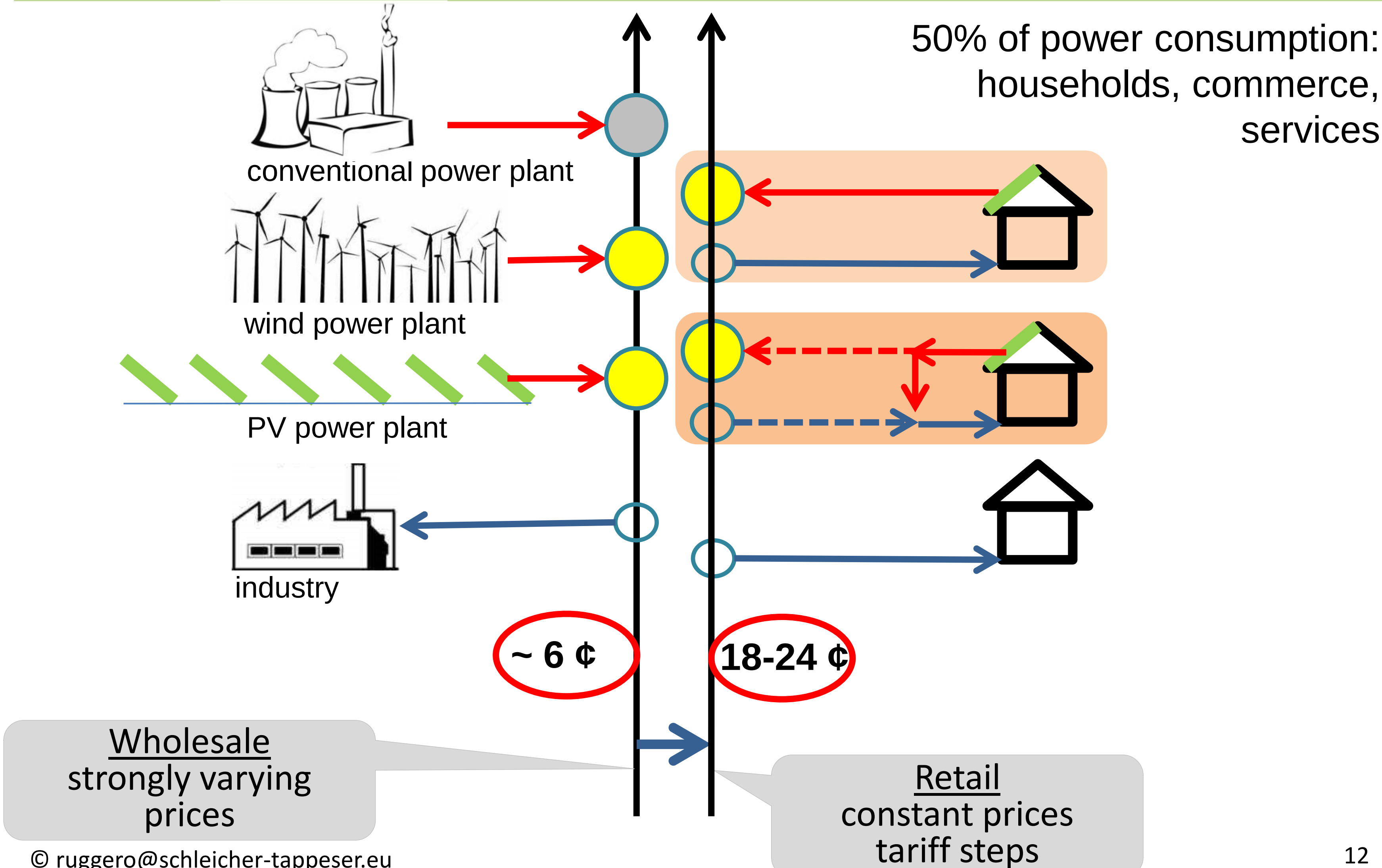

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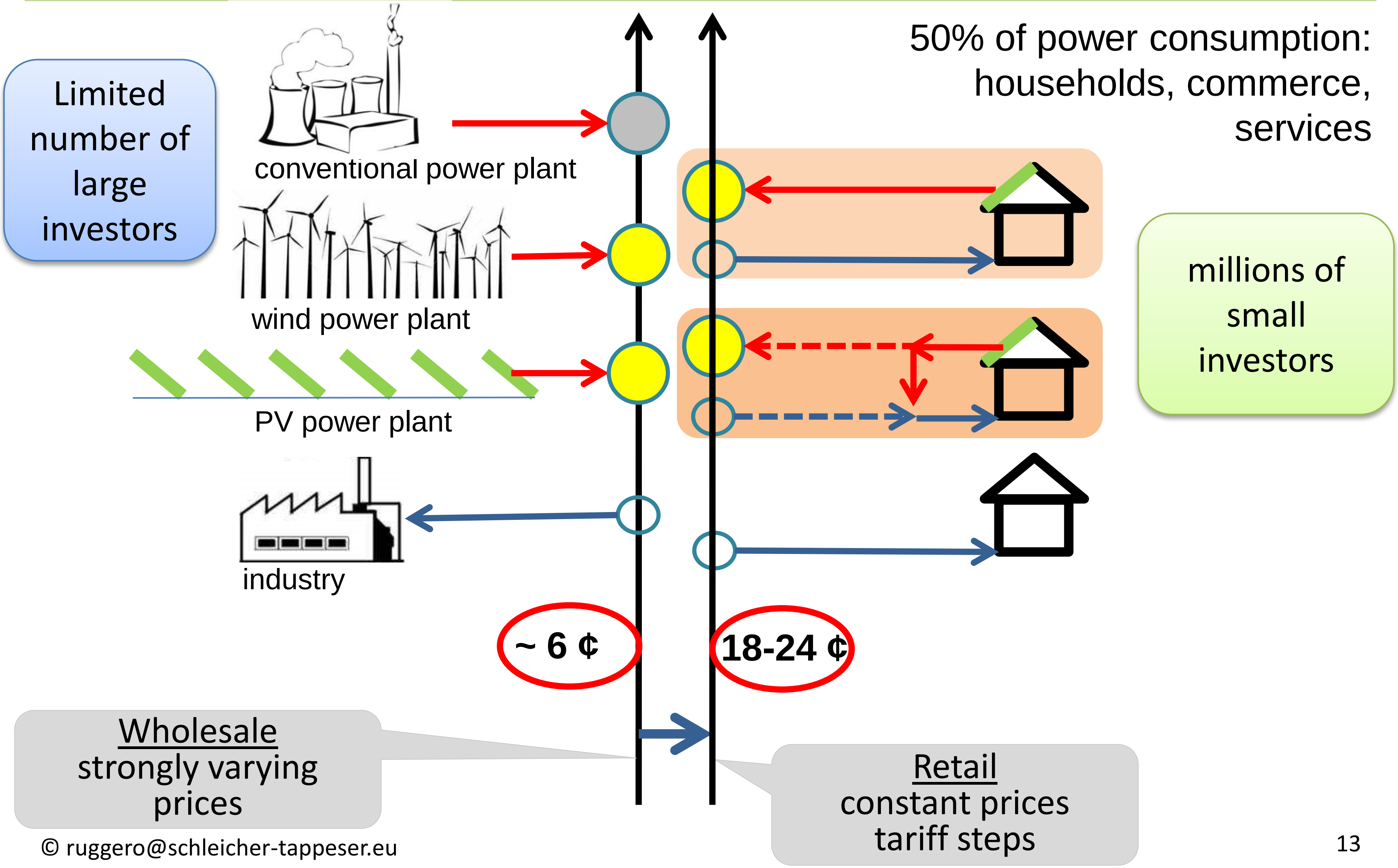

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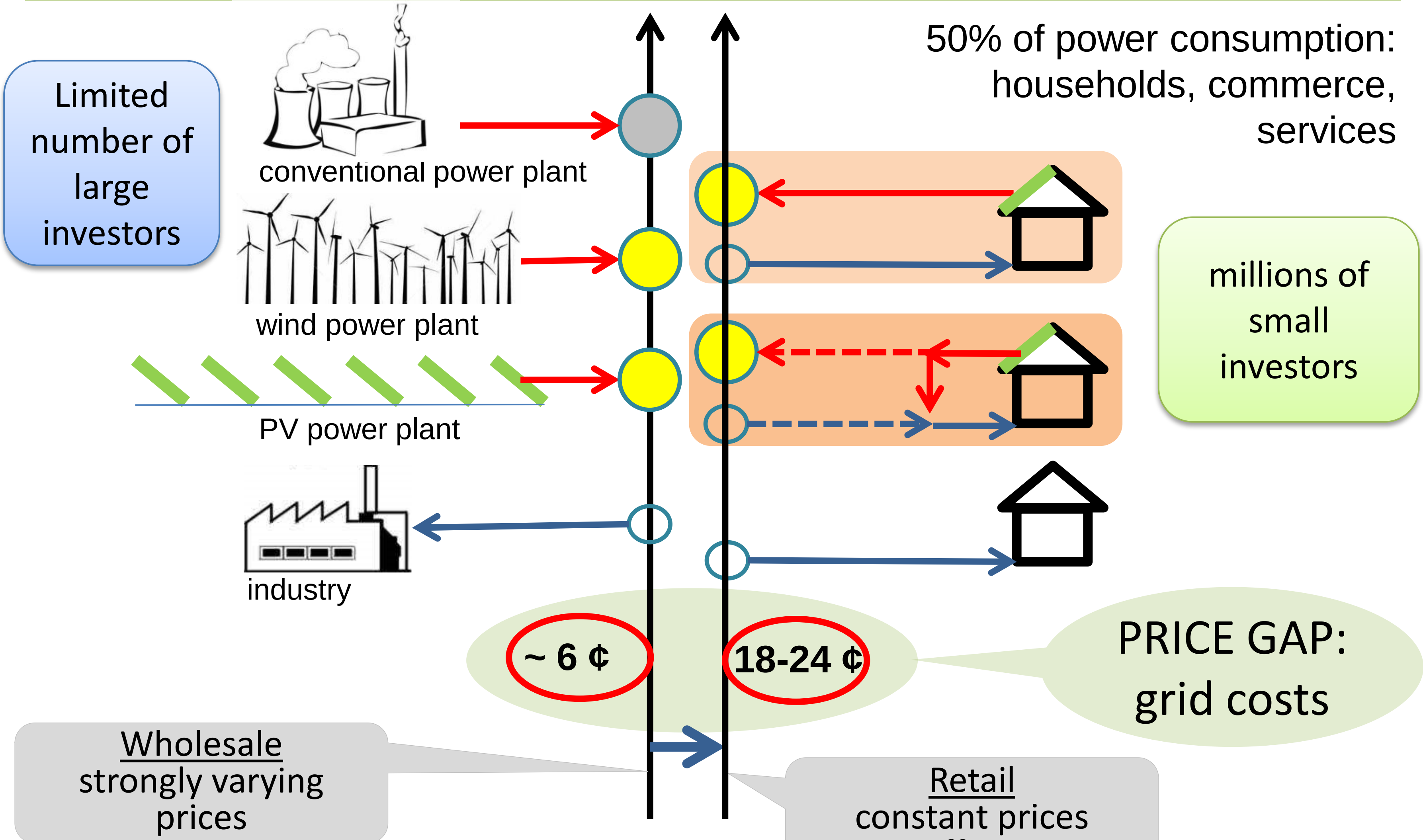
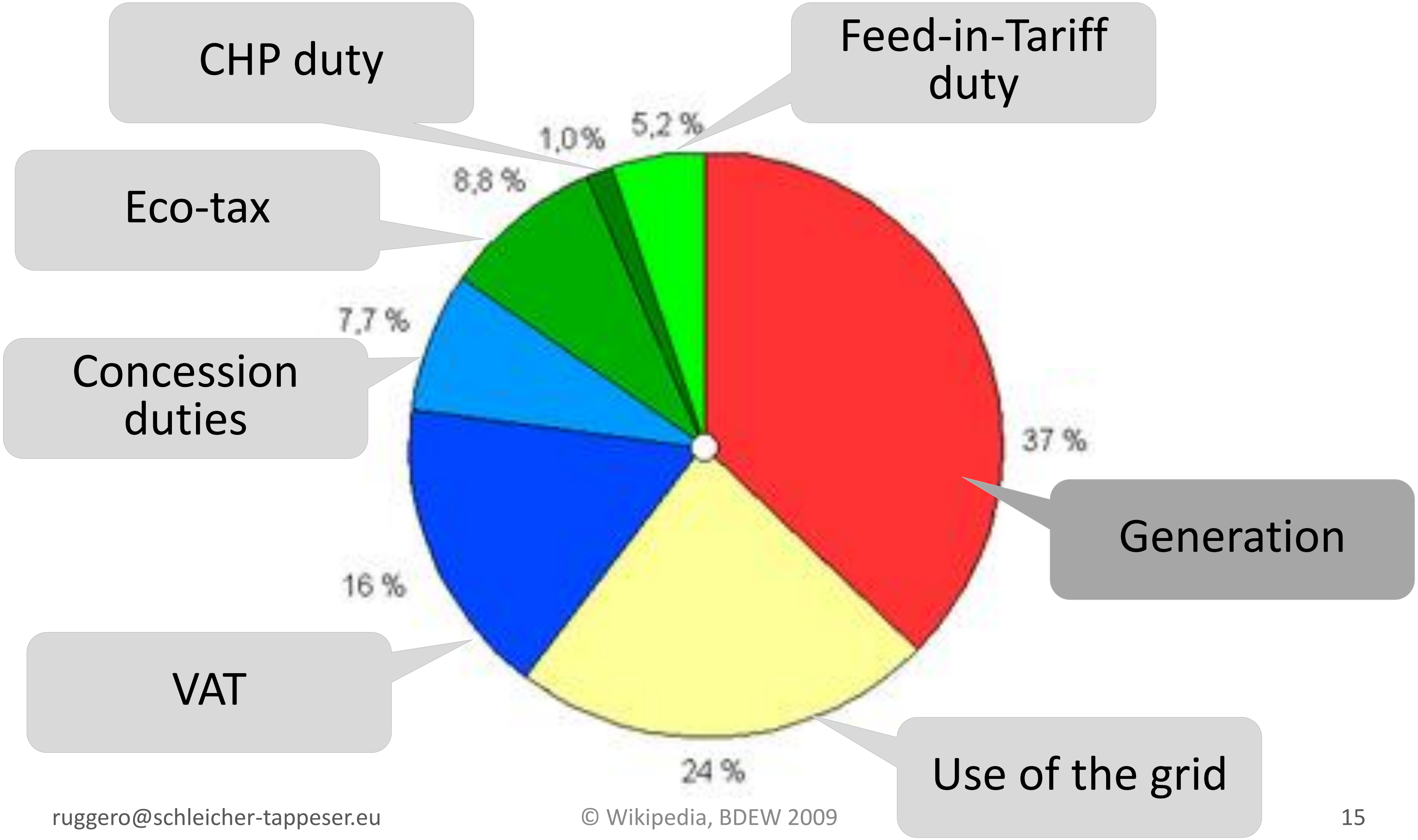
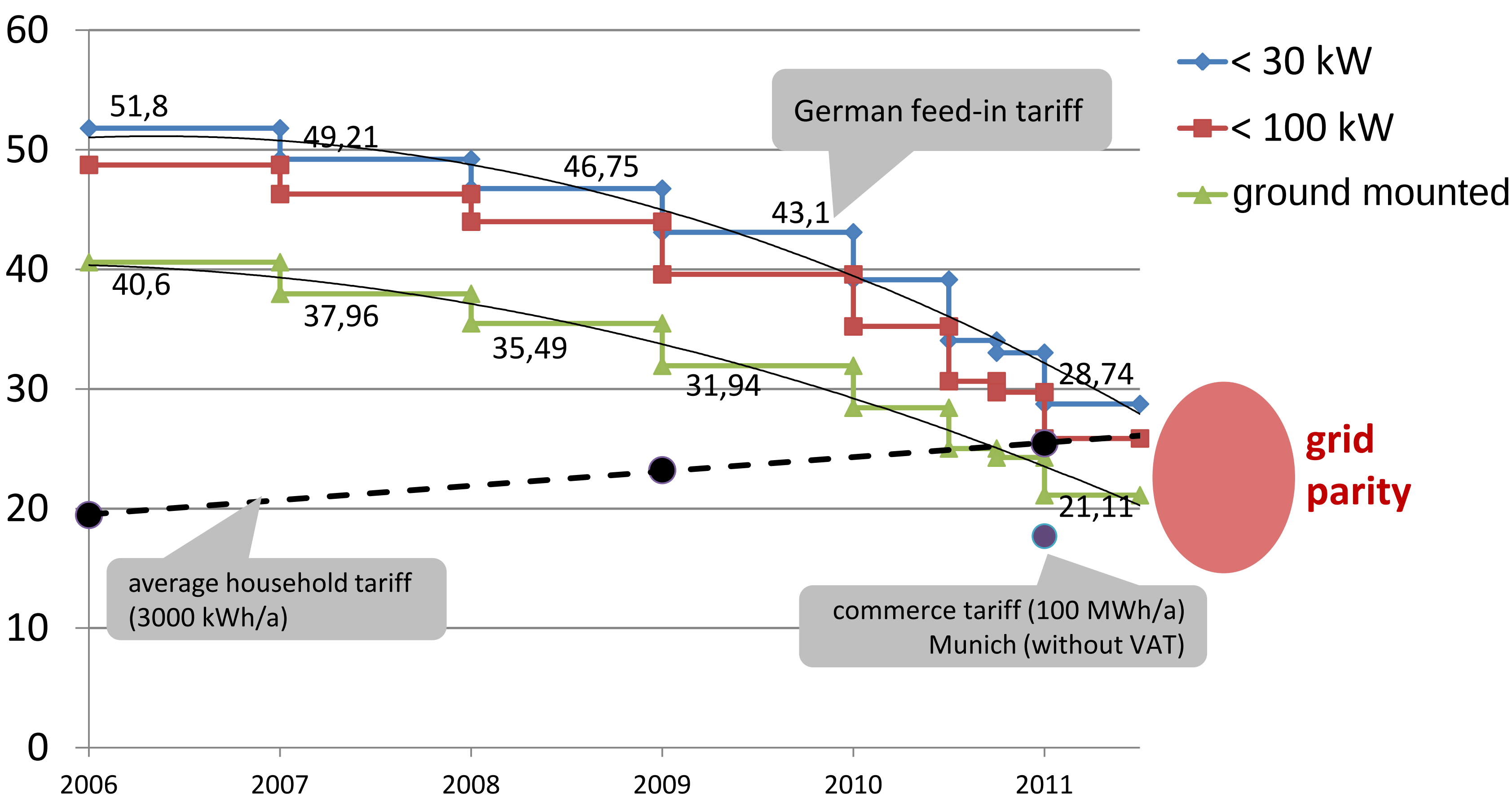


# Composition of the retail price: the costs of the grid



# Rapidly decreasing German feed-in-tariffs: grid parity expected for 2012



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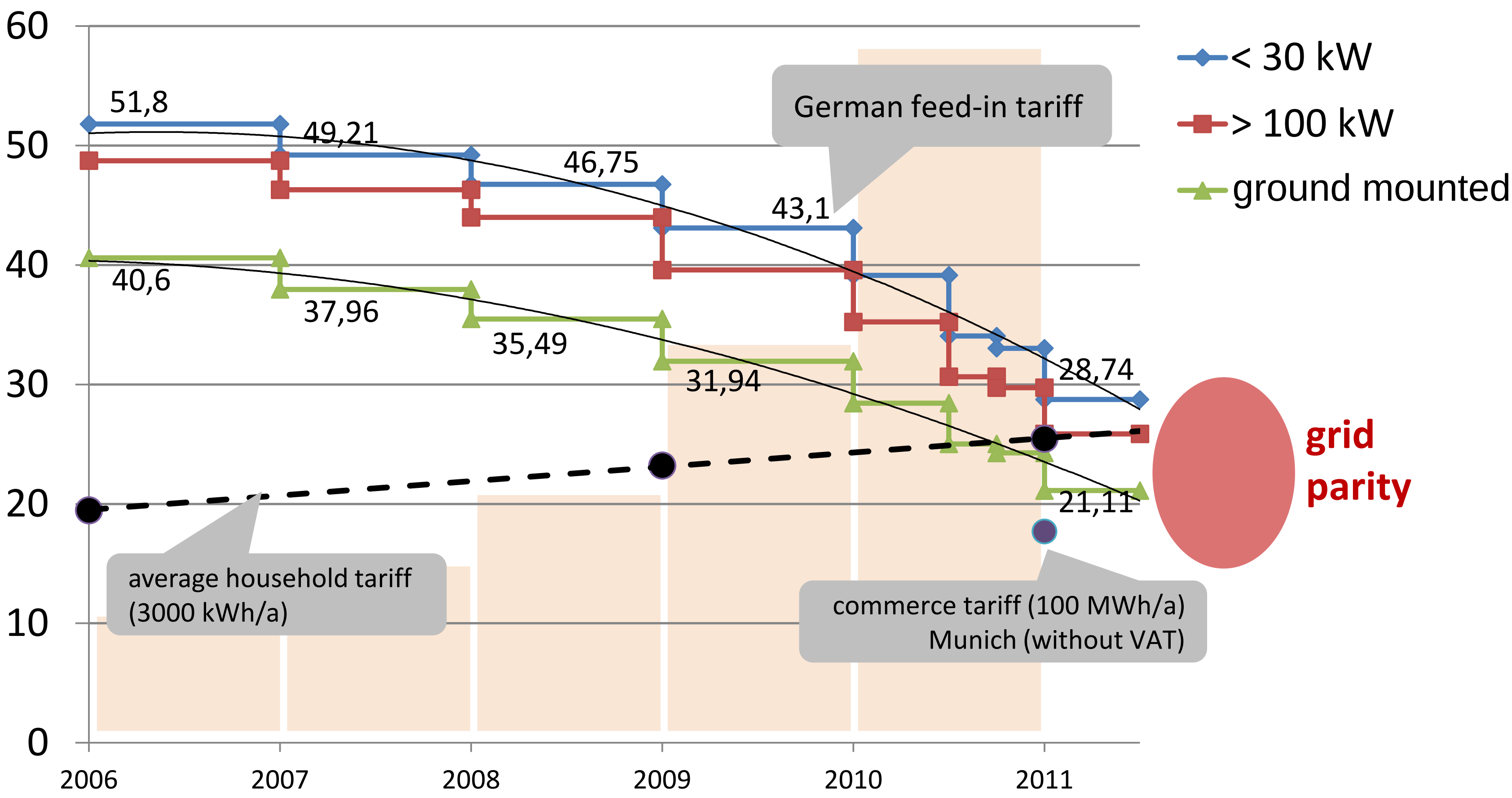
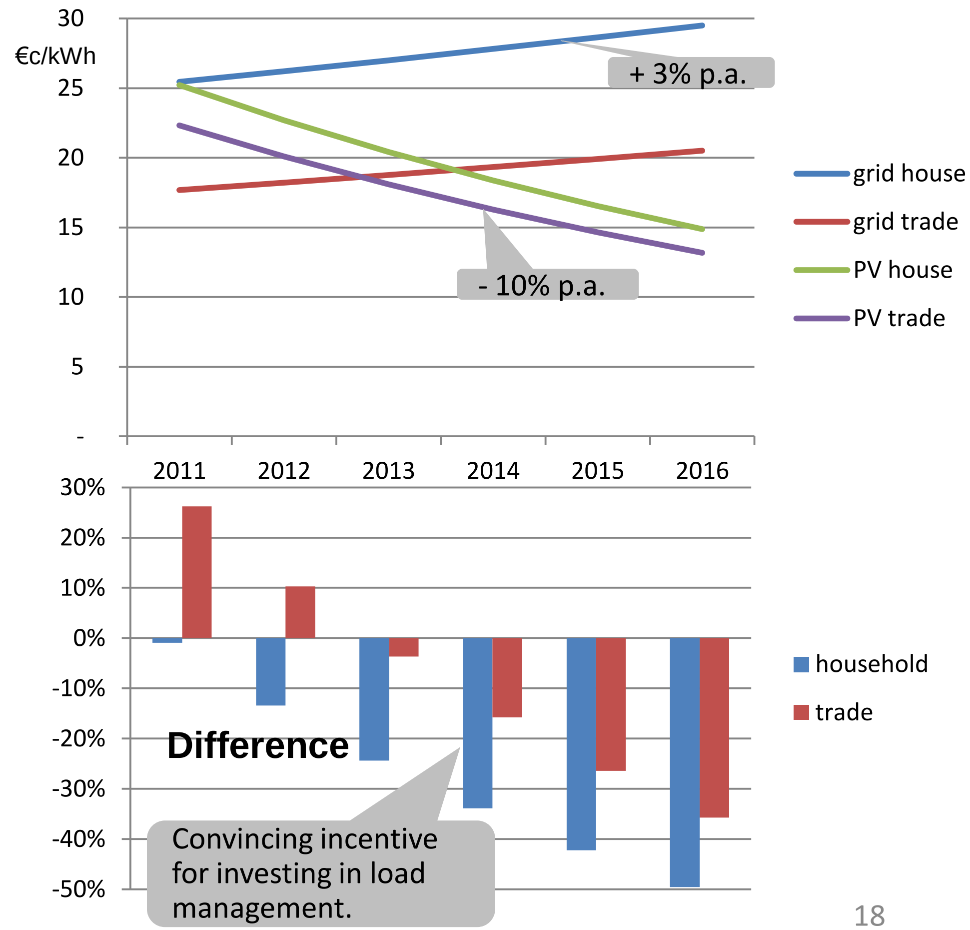


# Scenario for the next five years

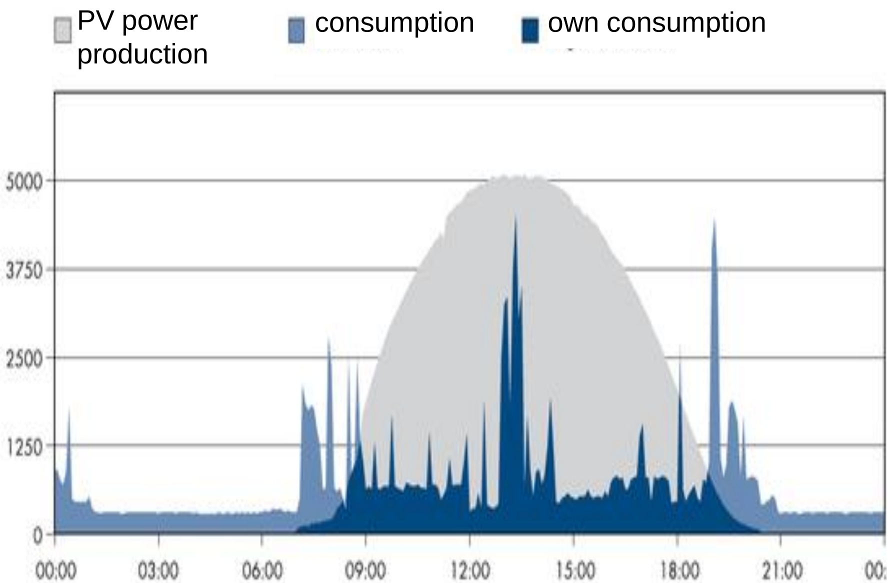
- In the last four years the average PV system price declined by 50% (3Q07-3Q11, <100kWp, Germany) corresponding to *-16% p.a*.
- Scenario assumptions
  - System price development: *-10% p.a*.
  - Power from the grid: + 3% p.a.
  - PV power cost: based on the relation between FiT and system price in 2008 (steady growth conditions)

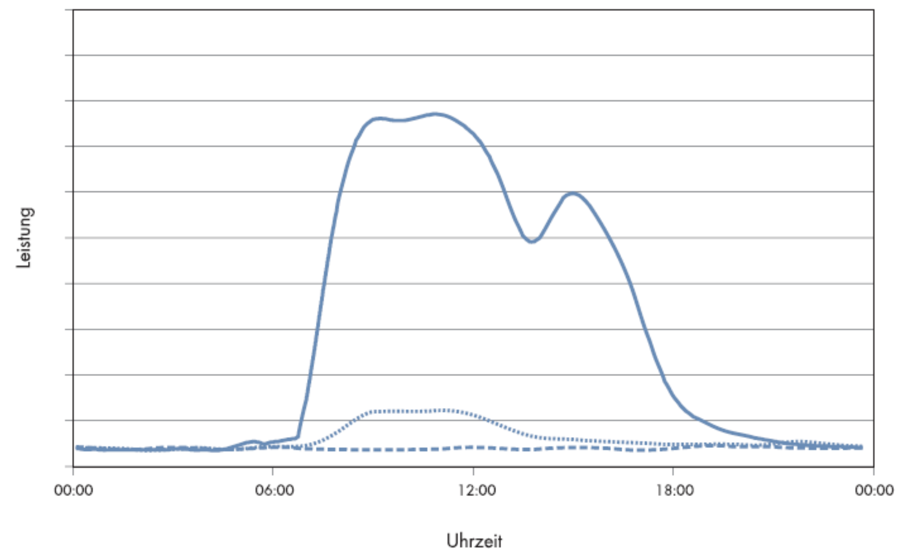
➢ In five years PV power from the roof could cost 40% less than power from the grid

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



# 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 coming boom: captive power generation

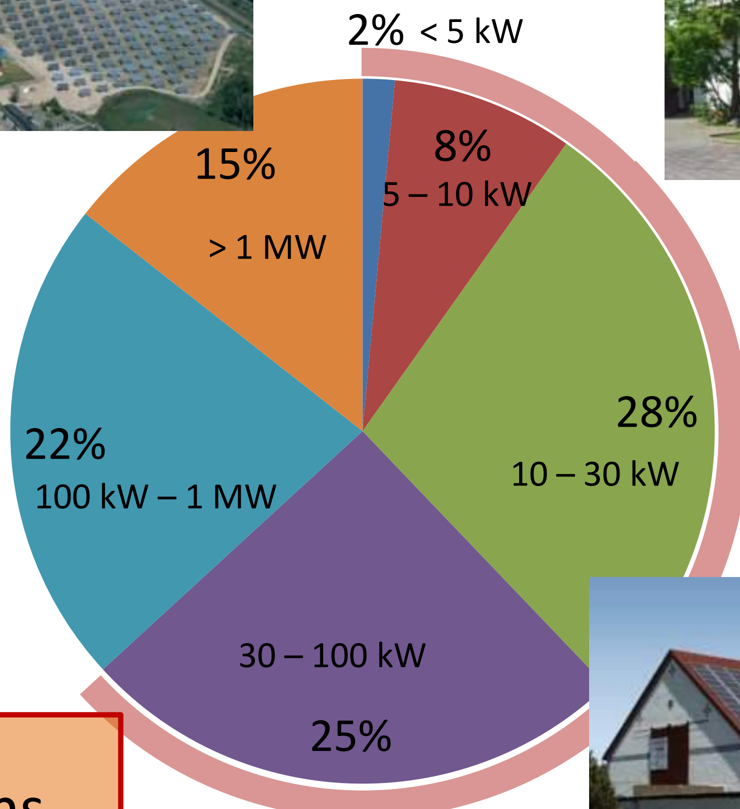
Attractive investments even without incentives:

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

➢ PV growth independent from incentives

➢ Boom in power management technologies

# From 2013: large shares of the German PV market interesting for own consumption




Installations
january – september **2010**

60% of
new installations
< 100 kW

data: BNetzA 2010

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# Across the world grid parity is advancing – key parameters

- Electricitry prices in the country considered — €/kWh

---

- Solar radiation
- Performance of the installation

} kWh/kWp

- Investment costs PV
  - Project development, planning
  - Components
  - Installation
- Financing

} €/kWp

kWh/kWp and €/kWp } €/kWh

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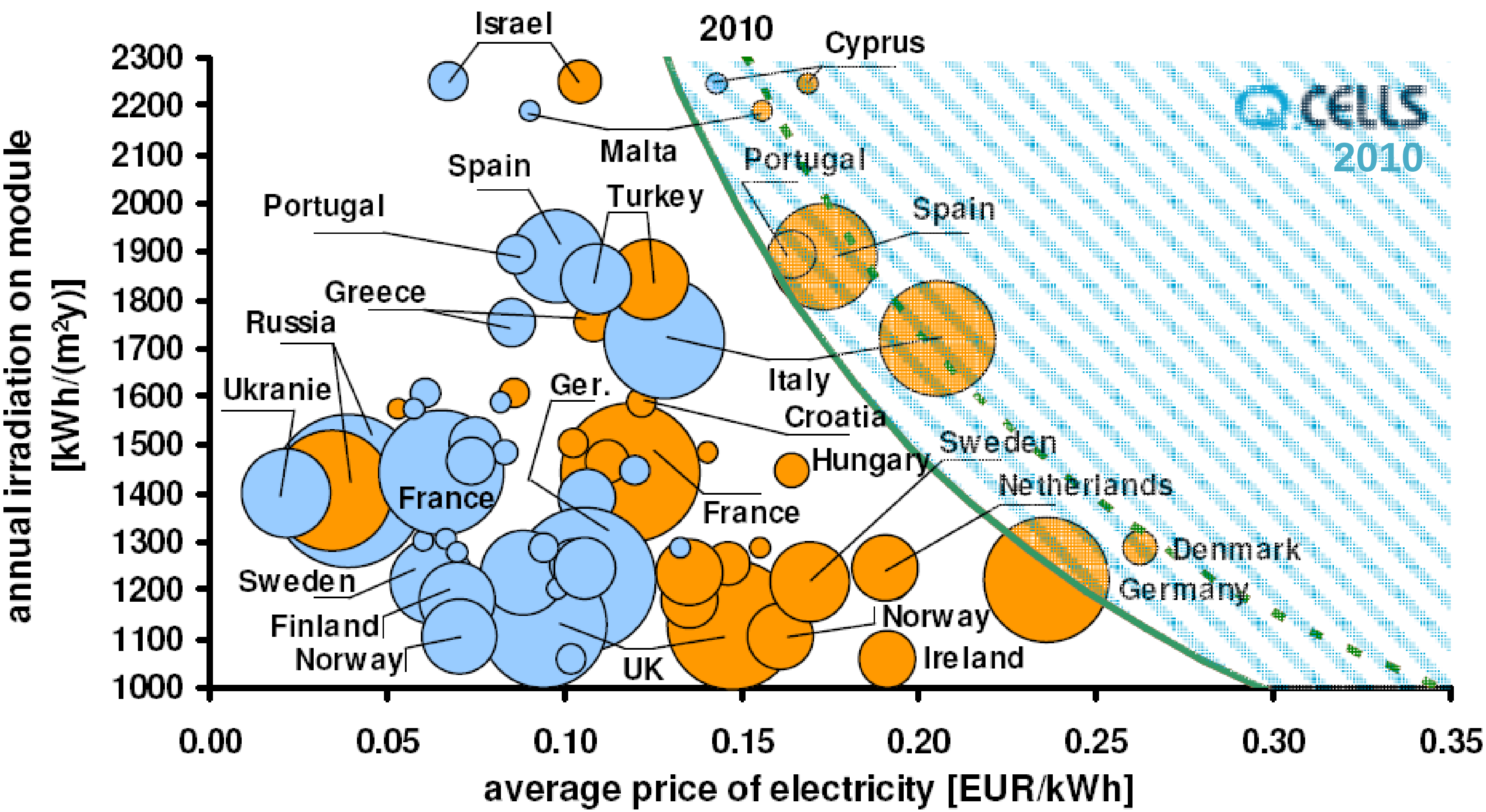
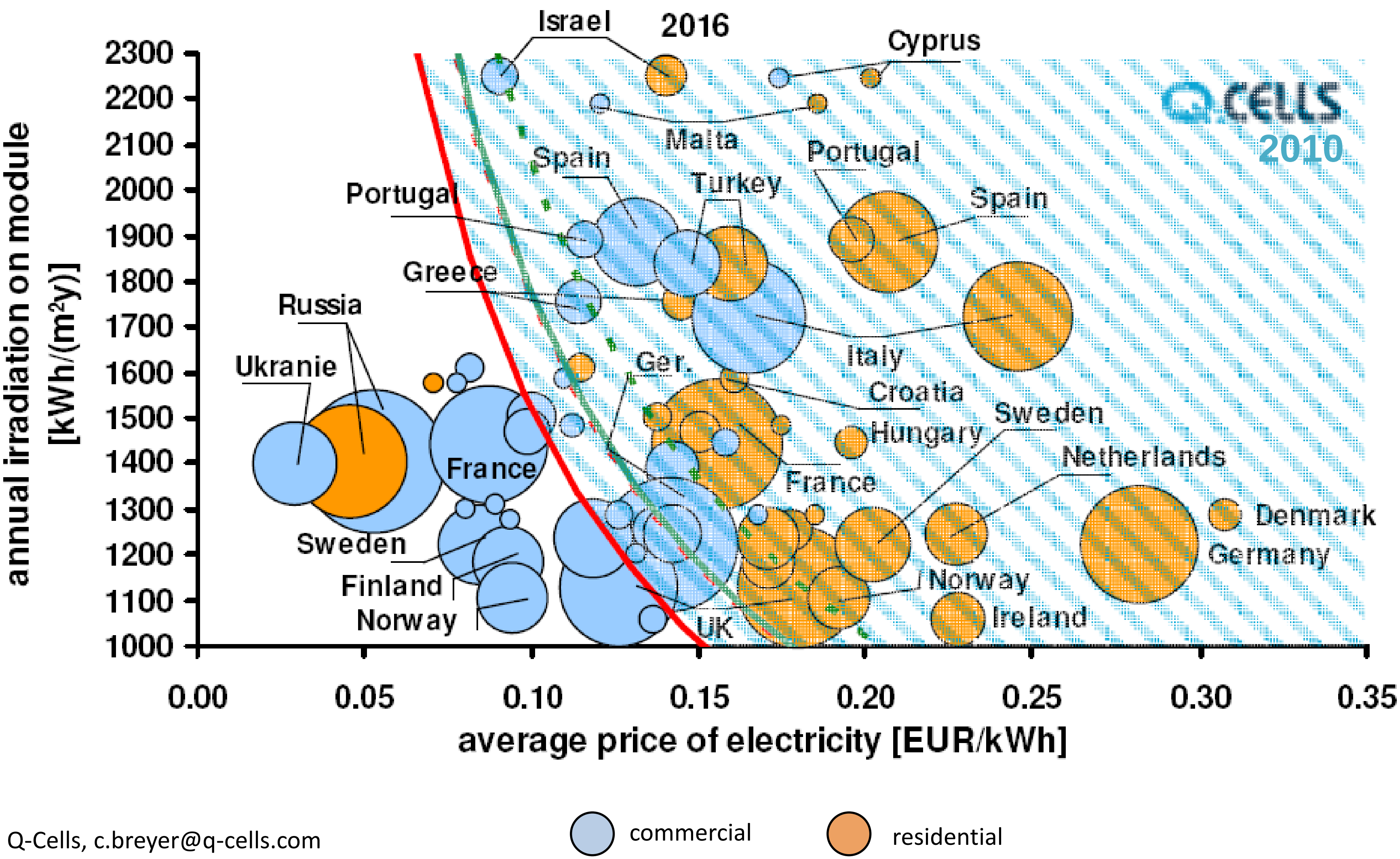
# Grid parity in Europe 2010

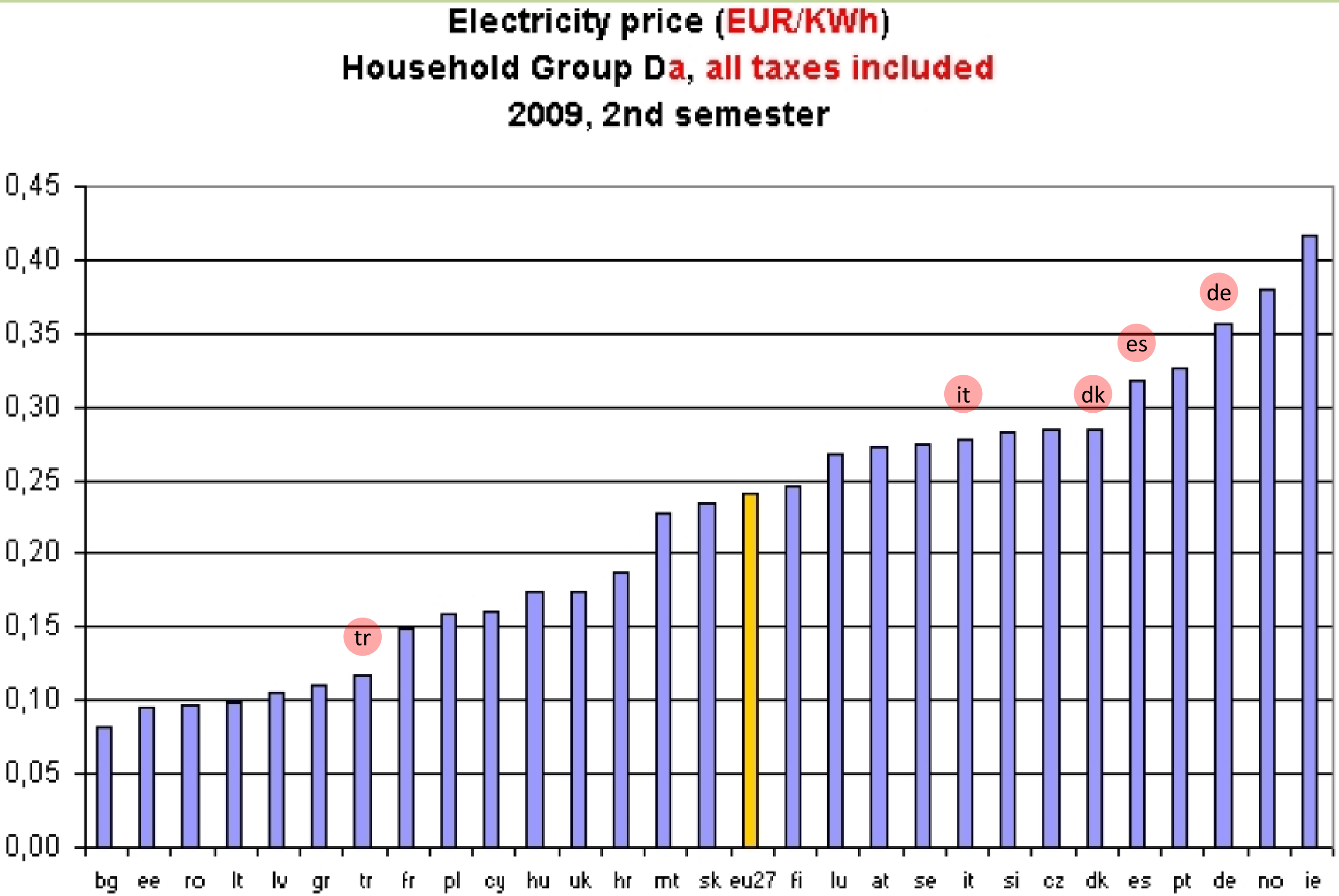



commercial residential

# Grid parity in Europe 2016



# Differences in electricity tariffs are much more important…

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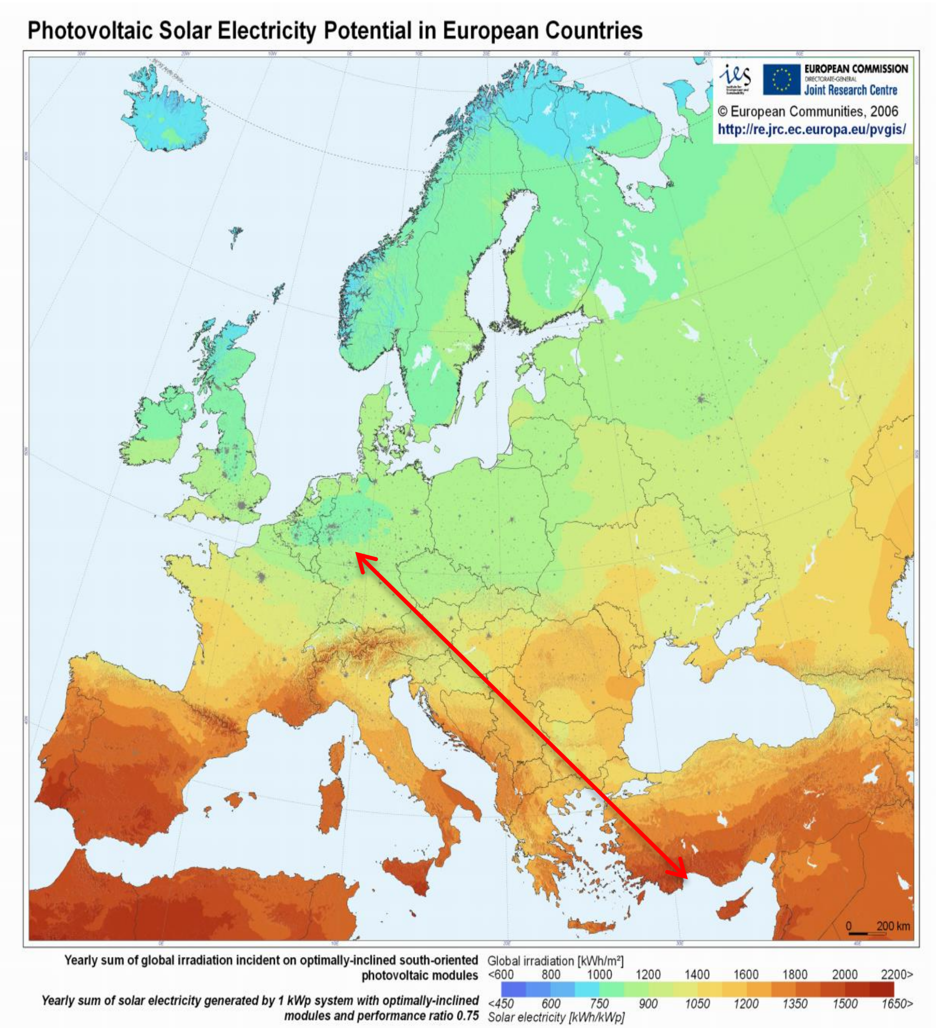
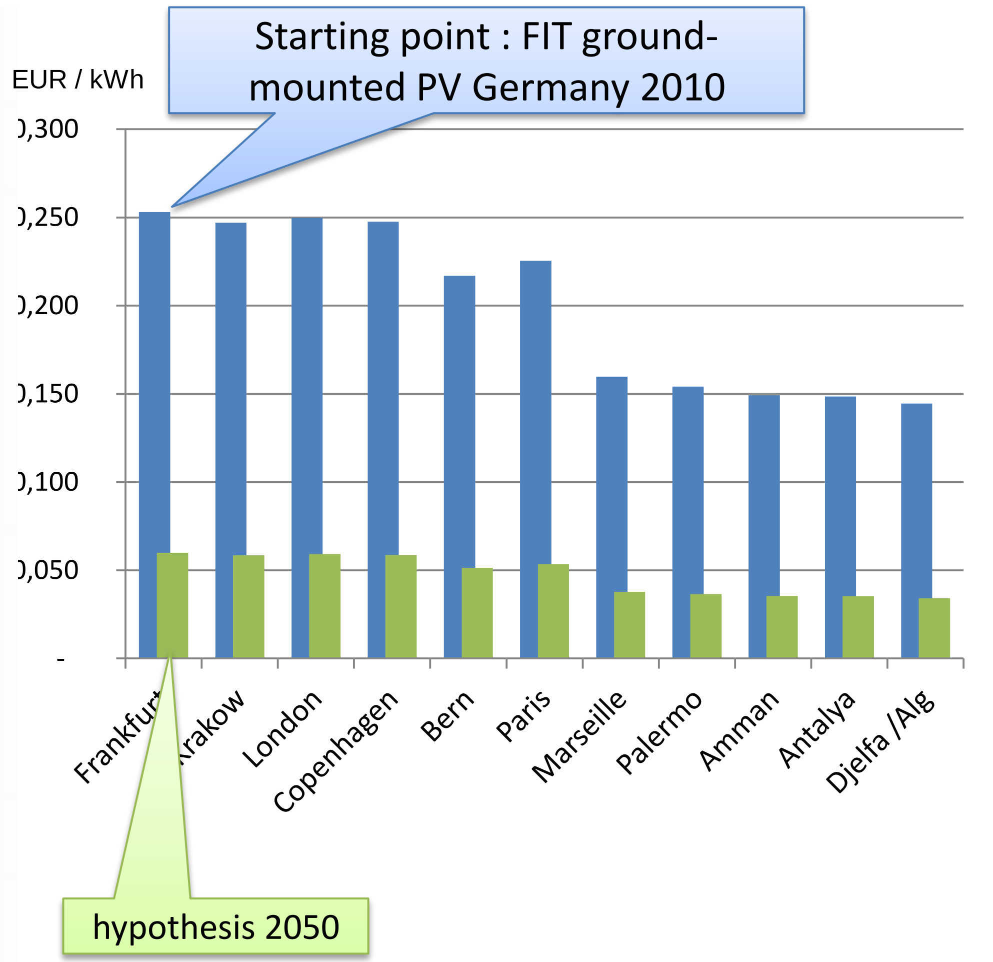
# … than the differences in solar radiation

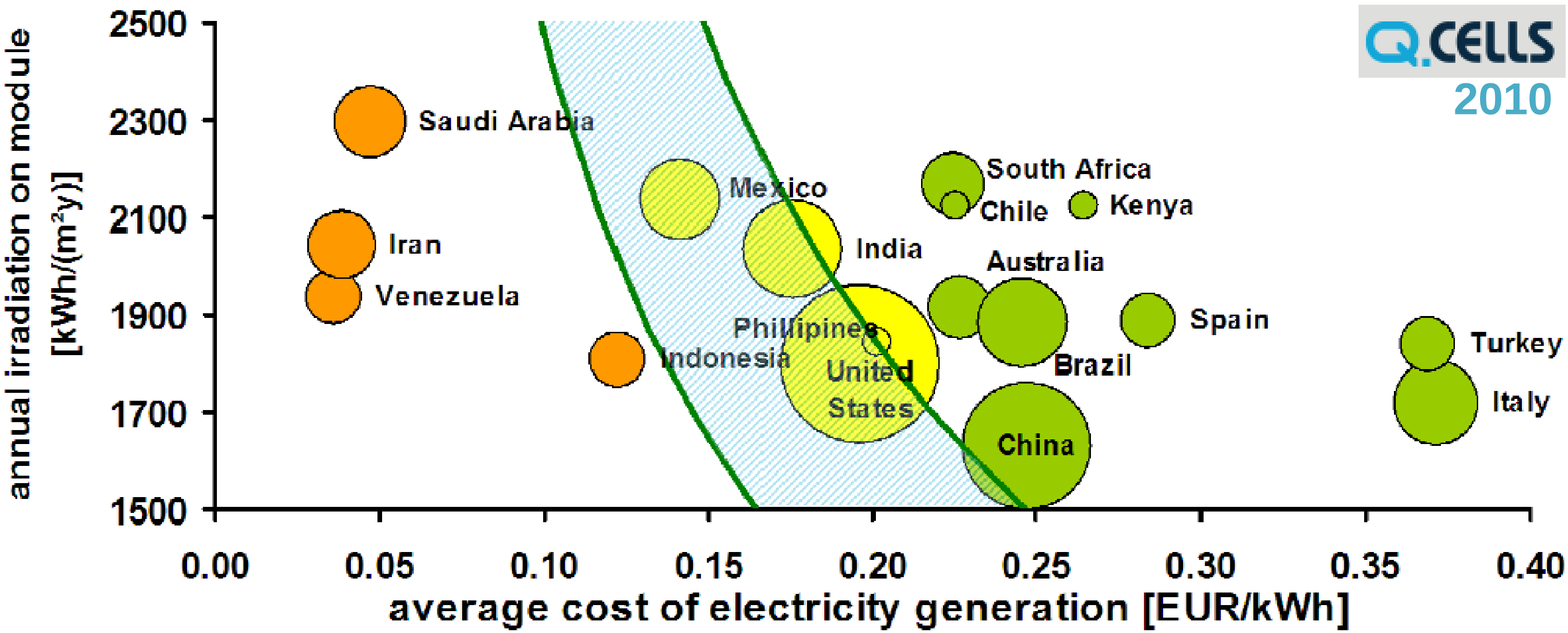




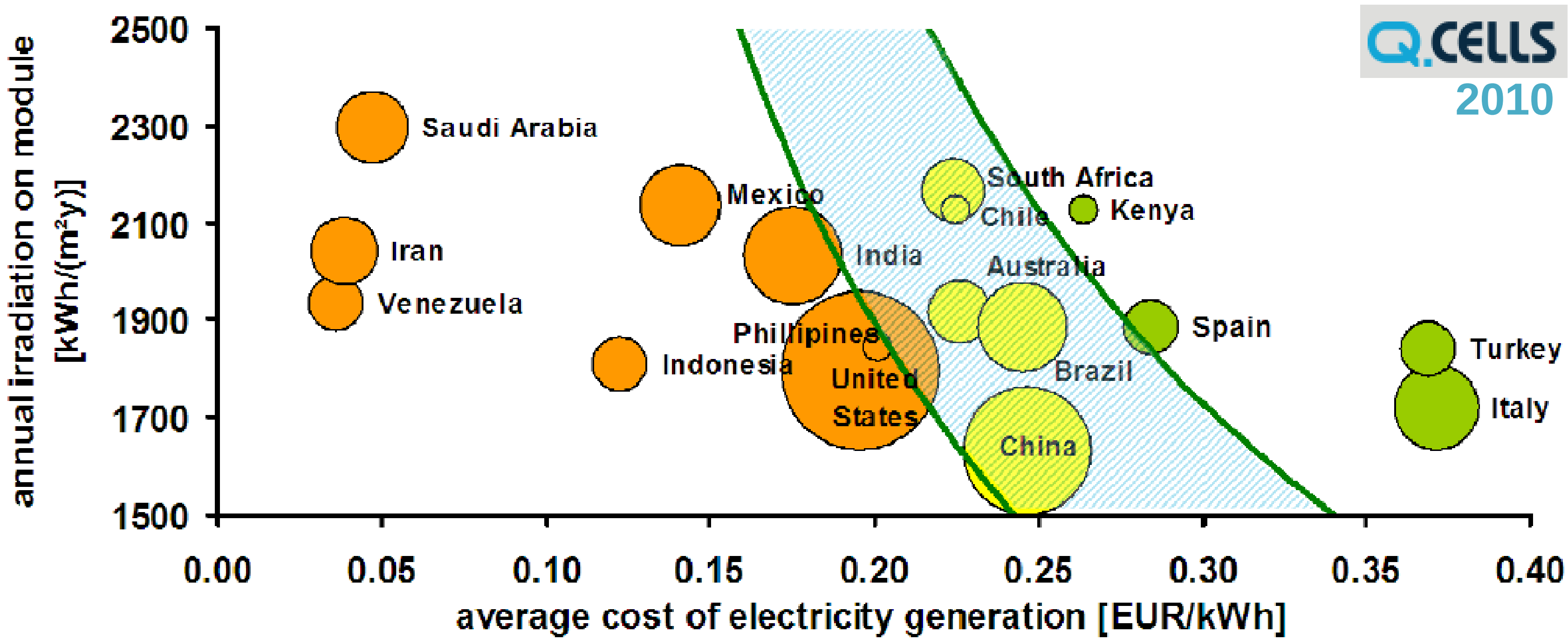

Data: http://sunbird.jrc.it/pvgis

# Decisive where grids are weak: Fuel Parity – PV vs Diesel Generators




assumptions: 2.0...3.0 €/Wp Capex, 6.4% WACC, 25 years lifetime, 75% performance ratio, Diesel full load hours analogue PV, 35% Diesel efficiency, 1.4 $/€, Diesel price data of GTZ

# PV+ Storage versus Diesel Generators




assumptions: 2.0…3.0 €/Wp Capex, 6.4% WACC, 25 years lifetime, 75% performance ratio, redox-flow storage, 150 $/kW and 150 $/kWh Capex, 73% full cycle storage, 50% direct PV power supply and 50% storage, 150% of annual mean day storage size, 1.4 $/€, Diesel price data of GTZ

# TOWARDS A NEW CONTROL LOGIC OF THE ELECTRICITY SYSTEM

# Increasing the share of own consumption: dealing with fluctuation locally

- Load management
  - 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
- Additional, non time-critical loads
  - Loading electrical vehicles
  - Heat pumps: substitution of other kinds of heat production
  - Production of synth. methane or hydrogen (larger plants)
- Storage of electricity
  - Batteries
  - Flywheels

➢ Flexibility of the user system increases

# Potential for load management

## 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% |

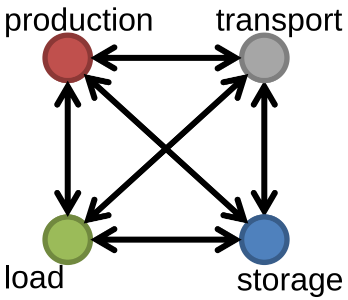
Options: heat storage, compressed air storage, shifting operation

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 three years cheap local PV gives strong incentives → innovation wave

# Captive power production can facilitate the system change




- The critical challenge for the whole system: fluctuating power supply with sun and wind
- Captive power production brings flexibility
- Captive power production can
  - unburden the grids
  - contribute to load management
  - contribute to security of supply
  - strengthen competition
- For this to happen, frame conditions must set appropriate incentives

# ...but this implies a change of the control logic of the electricity system

<table>
<tr>
<td>Traditional<br>Large power plants fossil and nuclear<br><br>Transformation</td>
<td>

- Production follows demand: base / middle / peak load
- Load management only with large consumers
- Central control

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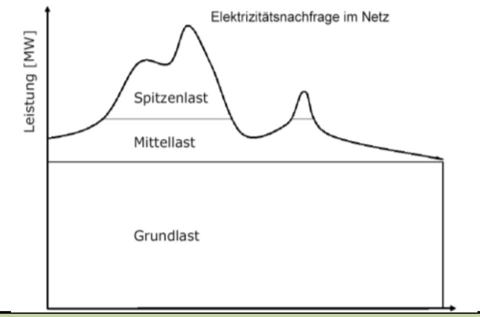
<td>
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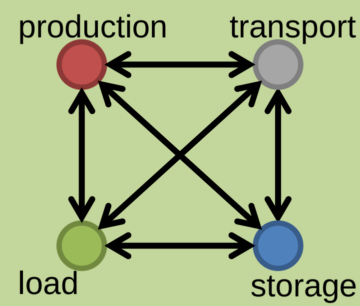
<tr>
<td>Supply 100% REN<br>Integrated optimisation of the whole system</td>
<td>

- Fluctuating production with wind and sun dominates
- Load management, storage
- Complexity requires optimisation on several levels

</td>
<td>
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<tr>
<td>Contribution<br><br>Captive power production<br>Optimisation on the consumption level</td>
<td>

- Optimisation subsystem
- Partial buffering of fluctuations at the local level
- Facilitation of optimisation at higher levels

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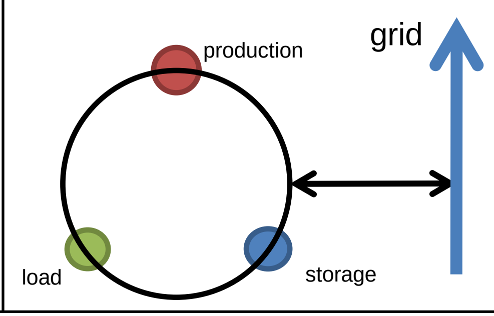
<td>
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# Captive power production challenges present market & control structures

- Grid increasingly reduced to buffer function → rising costs per kWh → need to use consumer flexibility for own optimisation
- Present tariffs favour new peak grid loads (in and out)
- FiT level looses control over PV growth
- FiT remains essential for installations with low own consumption

➢ Need for time-dependent and power-limiting tariffs guiding the input/output optimisation of private systems

❖ Every distribution grid has its own optimisation requirements: grid pattern, generation and consumption structures differ

→ → Under present rules, optimised private systems may rapidly produce new heavy burdens to the public grid infrastructure

# Centralistic approach getting unsustainable

- Traditionally national monopolistic utilities planned central generation and corresponding grids for a given demand → coherent systems
- Liberalisation:
  - competition for use of conventional generation plants at national level
  - regulated monopolistic planning for construction and use of grids
  - slow unbundling of grid planning and power plant siting
- Feed-in-tariffs:
  - renewable power use: regulated priority for fluctuating sources
  - free choice of location for investors
- ➢ The real grid is not a copper plate – geography matters!
  - Plant siting not coherent with existing grid
  - Fluctuating renewables permanently change flow patterns
  - ❖ PV prosumers change demand patterns – but could mitigate fluctuations
- ➢ Need to consider existing grid structure → location-dependent prices
- ➢ Need for stronger coupling with European partners

# Approaches for matching production and consumption of electricity

| | **conventional approach**<br>**central power plants** | **future approach ?**<br>**fluctuating renewables** |
|---|---|---|
| **Production management** | central management | only in extreme cases, leads to losses |
| **Spatial compensation over grids** | central approach: predictable average loads | long distances: weather variations less important |
| **Demand side management** | widely abandoned, nearly no incentives | at all levels huge innovation potential |
| **Storage** | Central pump storage for buffering baseload nuclear | at all levels high innovation potential |

# From top-down command to multi-level co-ordination

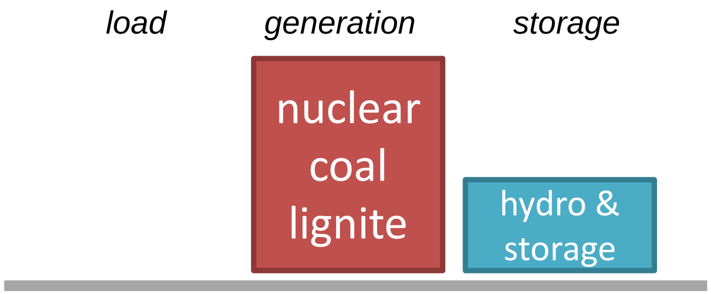
*load* *generation* *storage*

# From top-down command to multi-level co-ordination

*load* *generation* *storage*

nuclear
coal
lignite

# From top-down command to multi-level co-ordination



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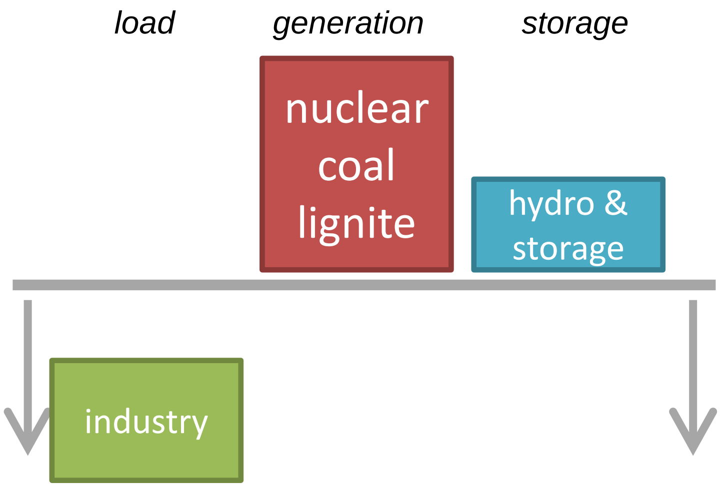

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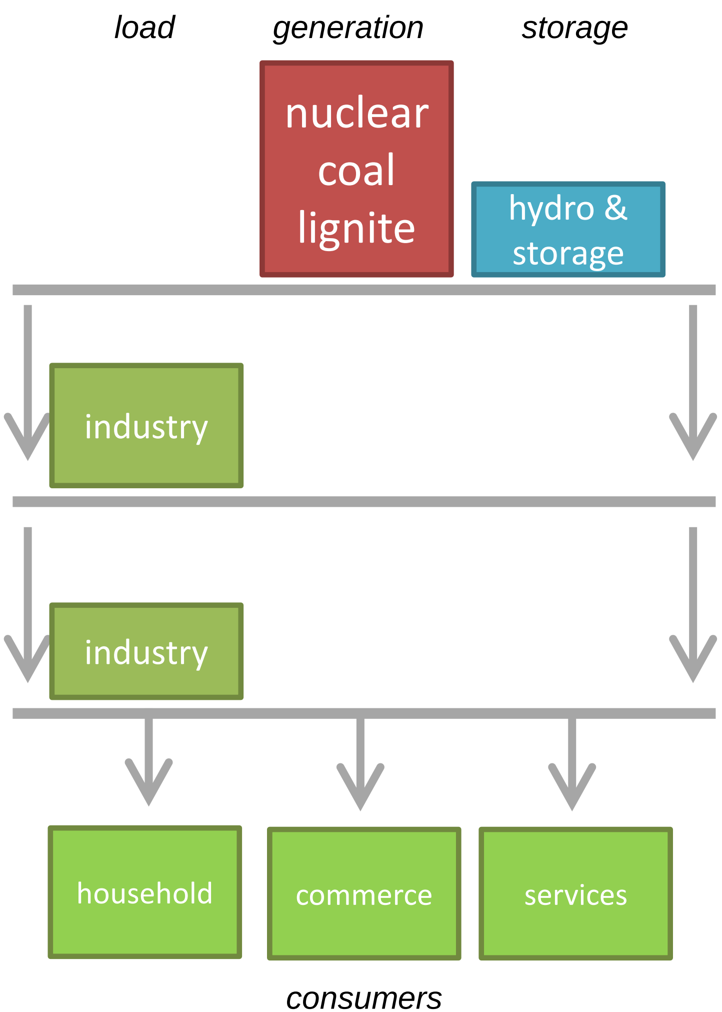

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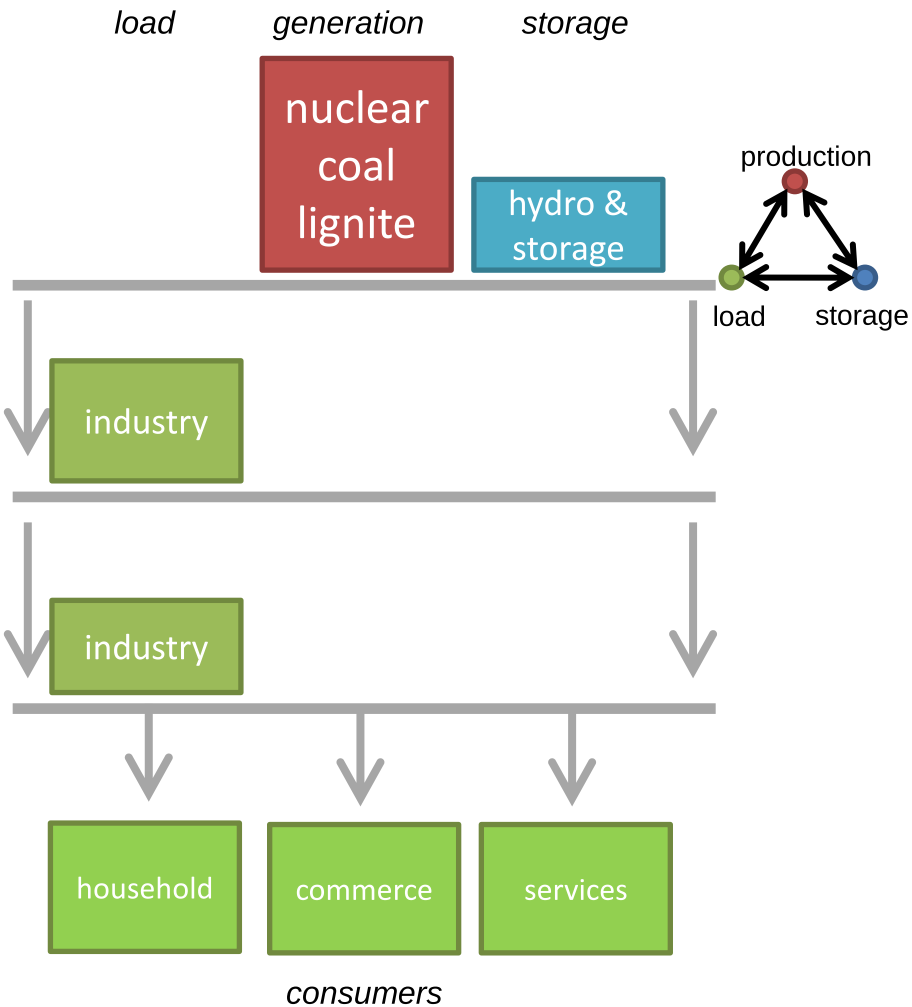

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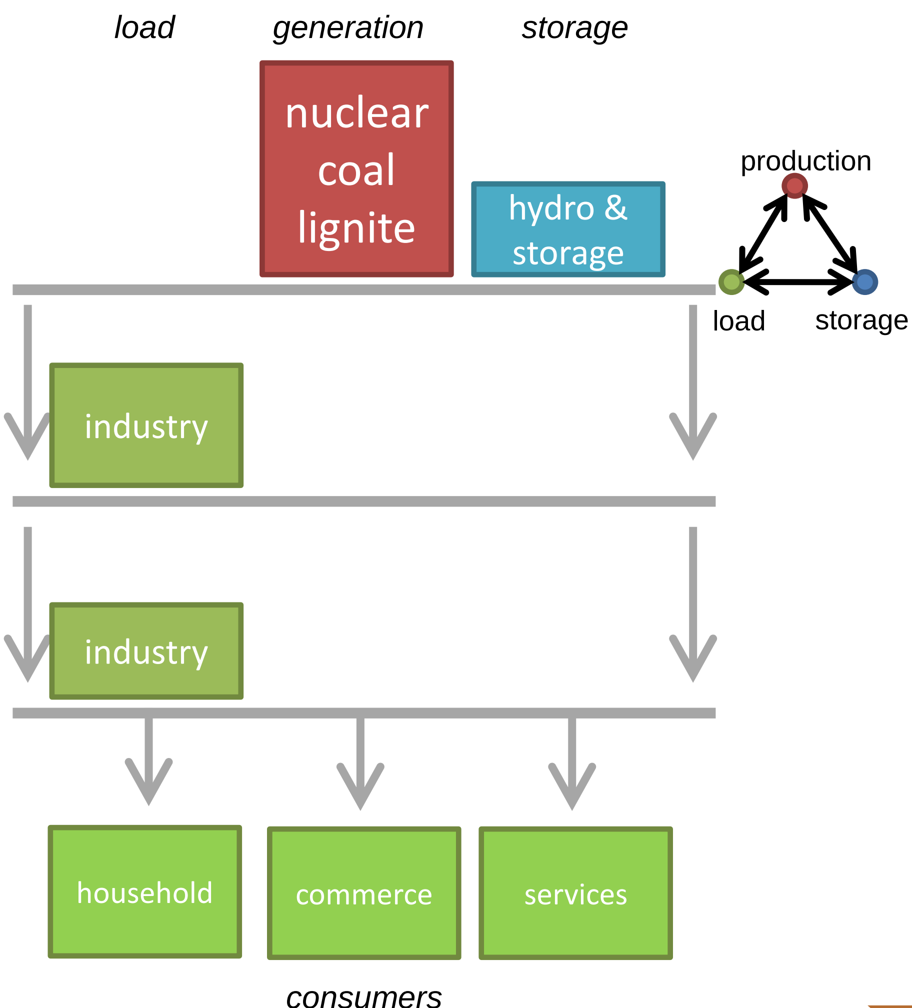


*load* *generation* *storage*

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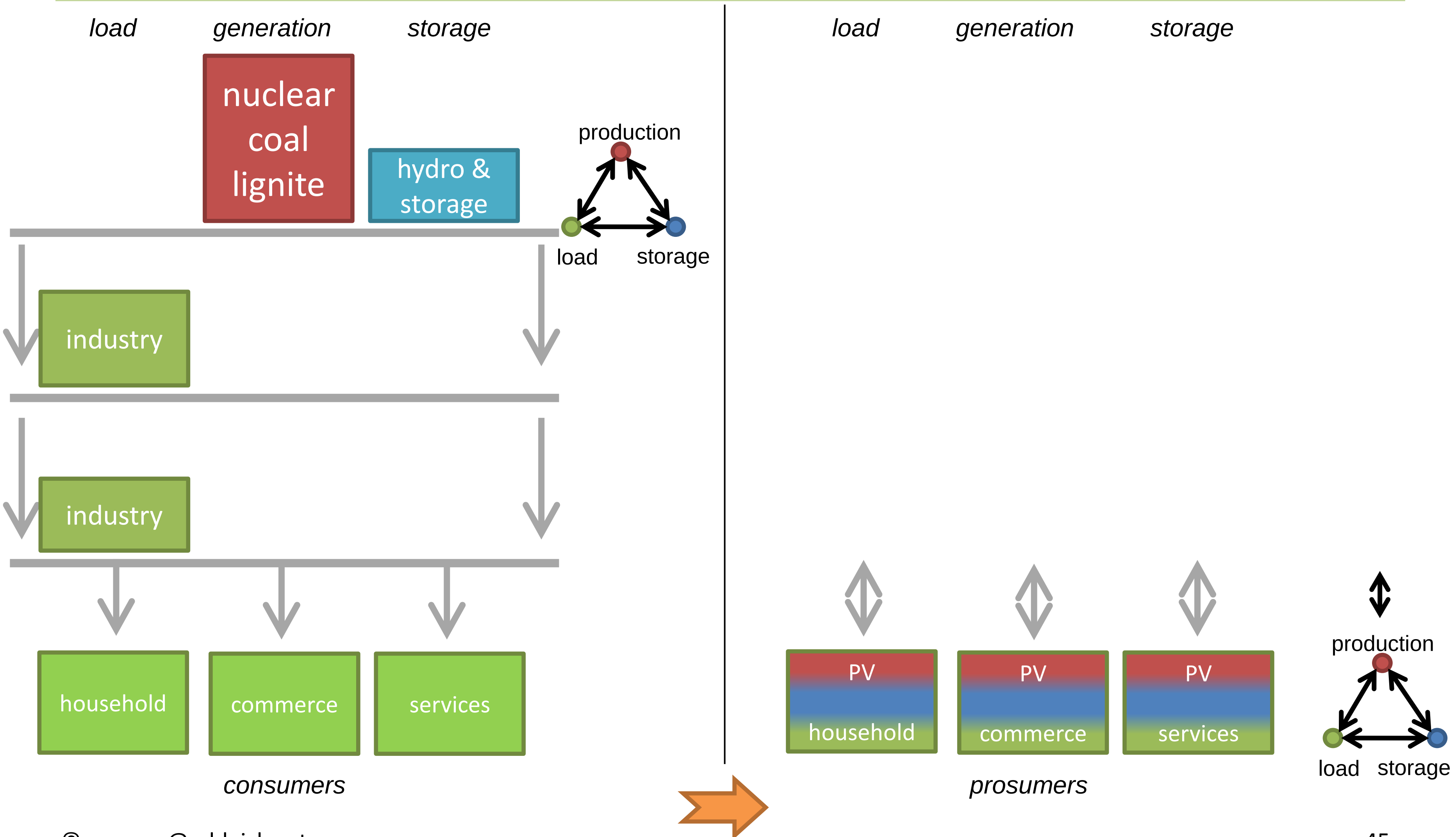

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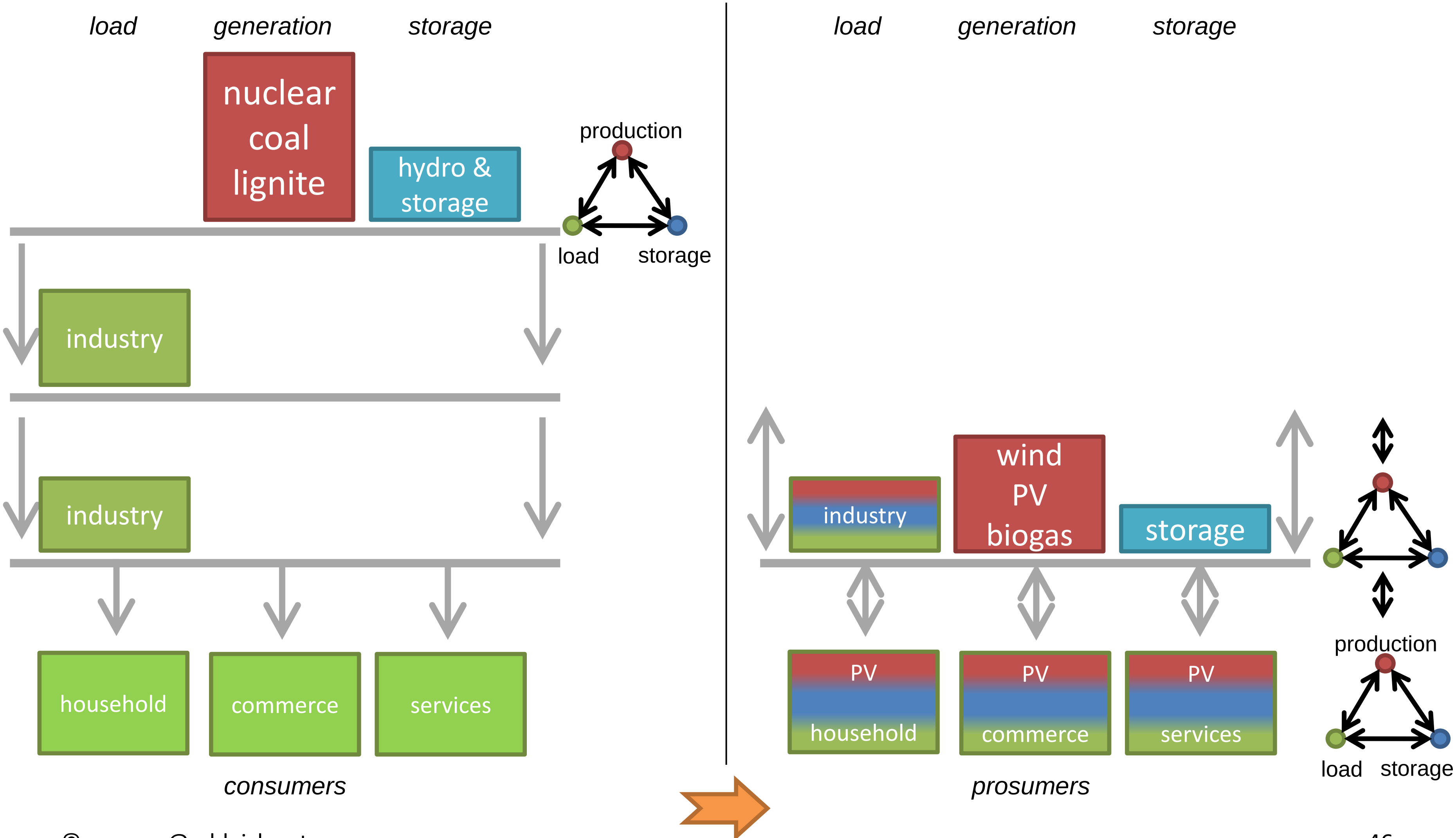

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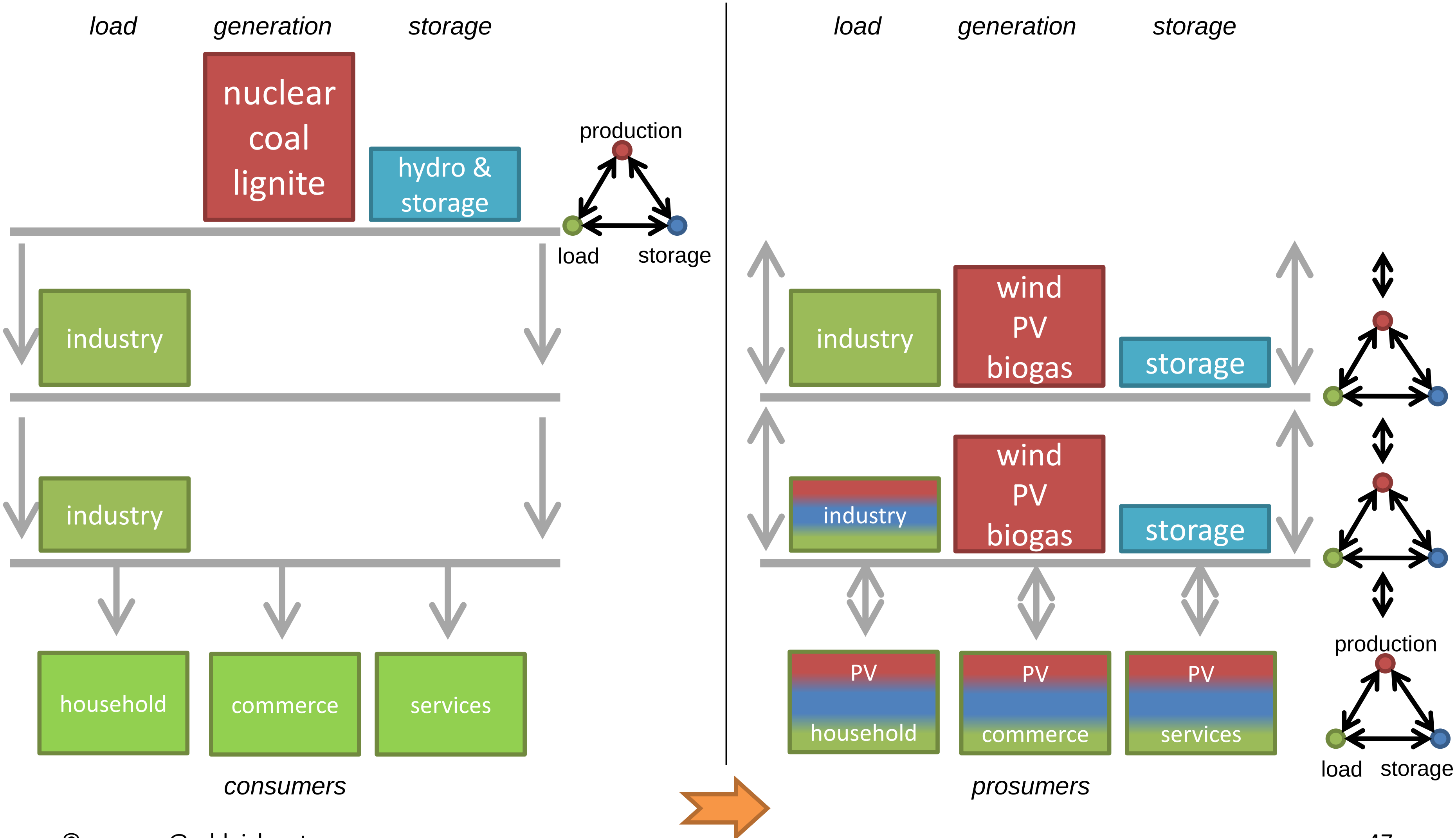

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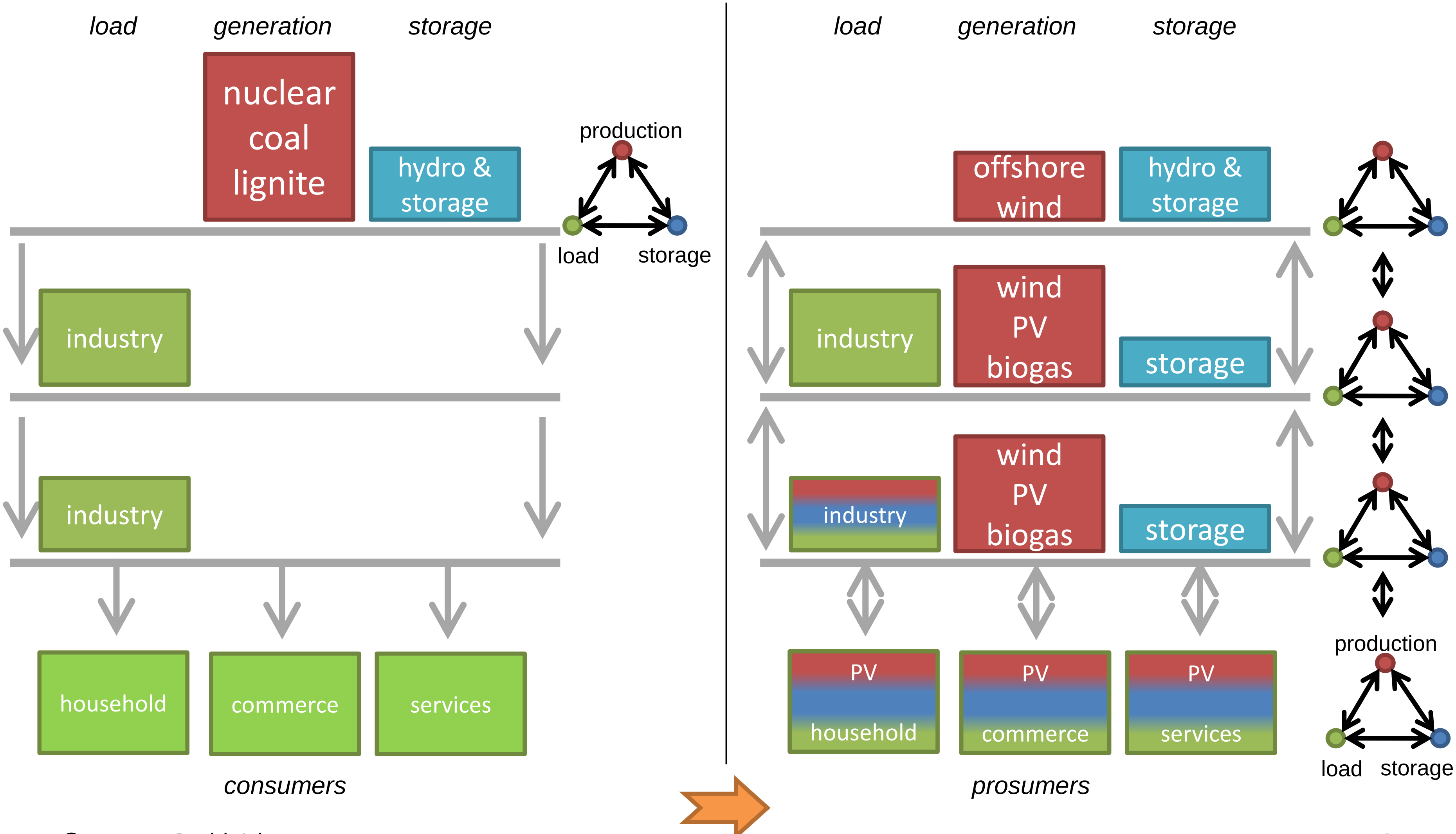


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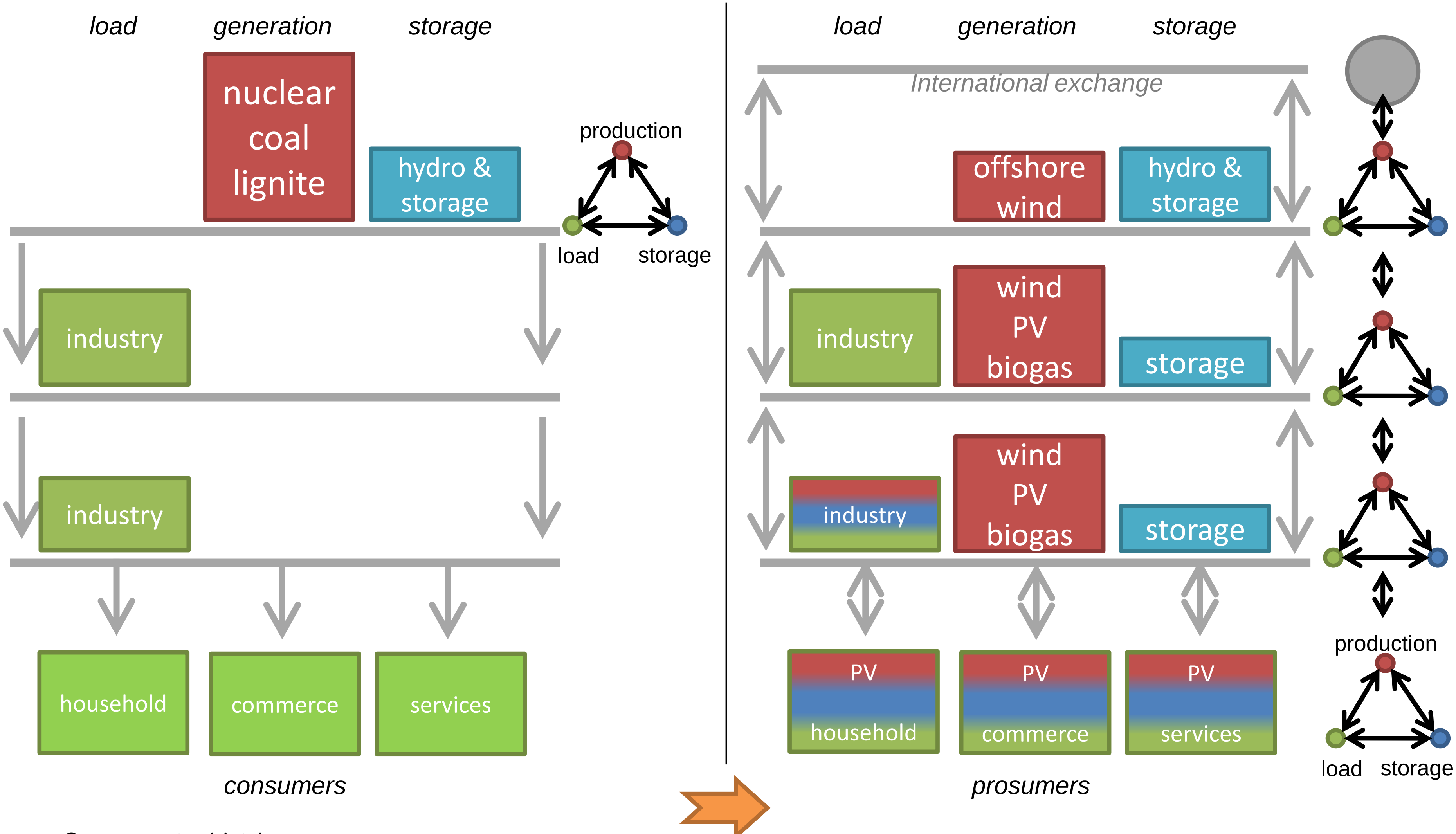

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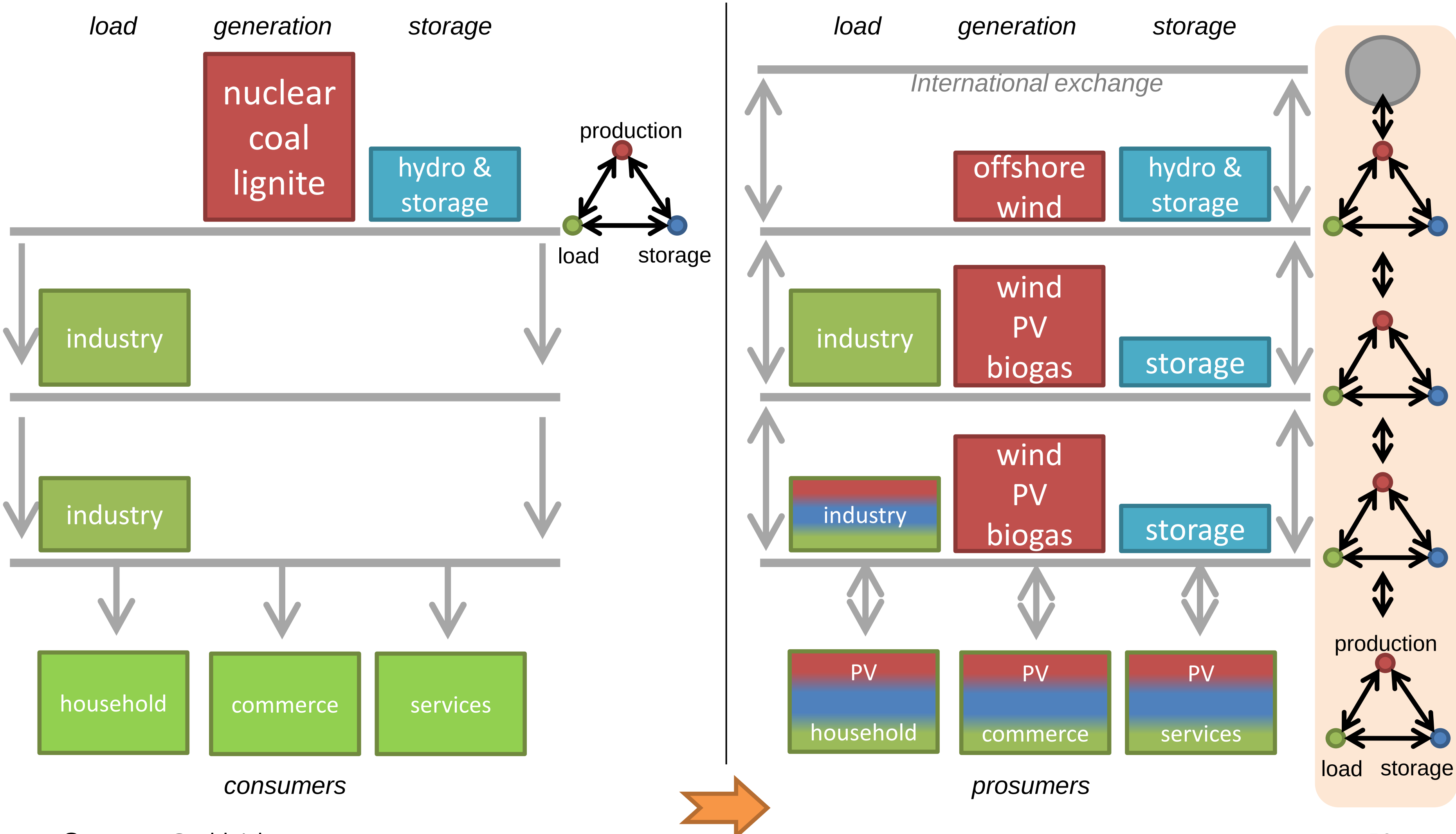

# Maintaining a centralistic approach…

*load* *generation* *storage* *load* *generation* *storage*

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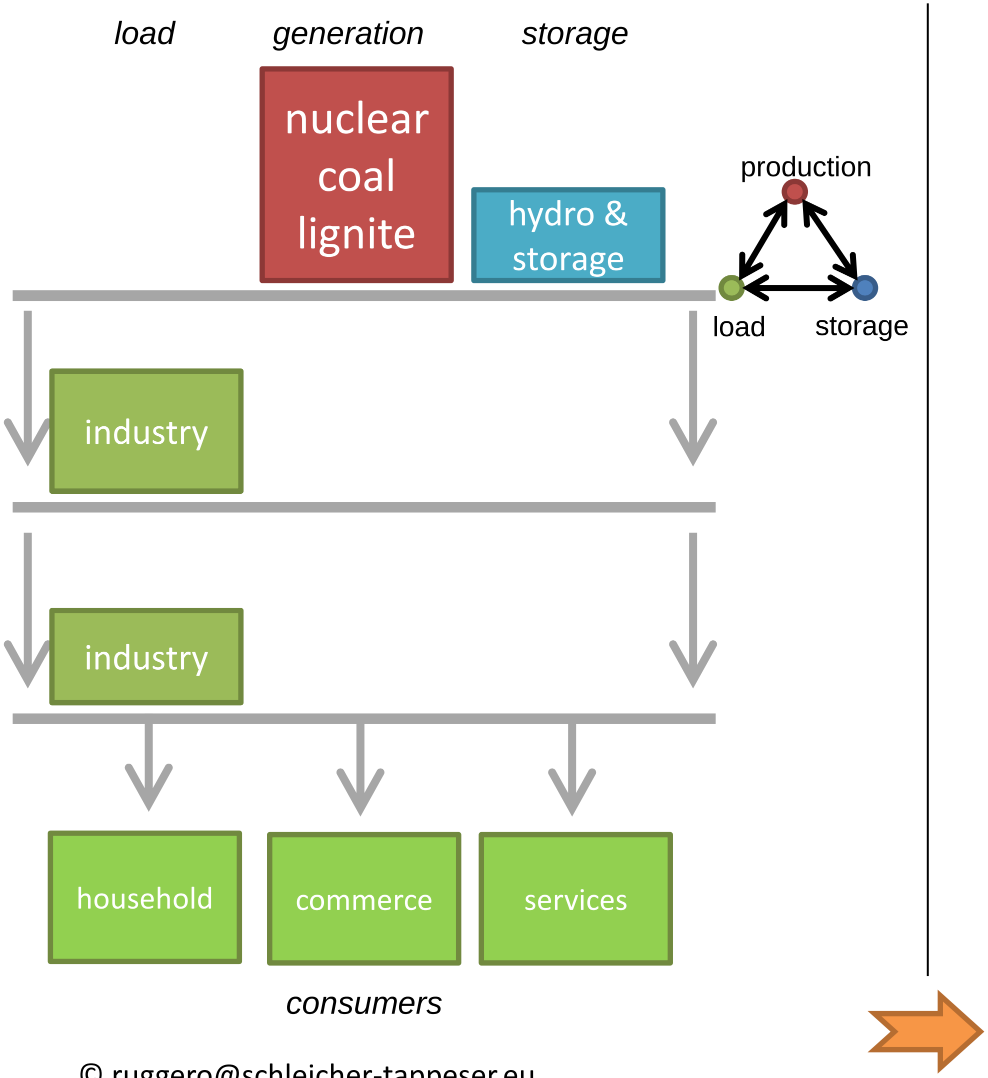

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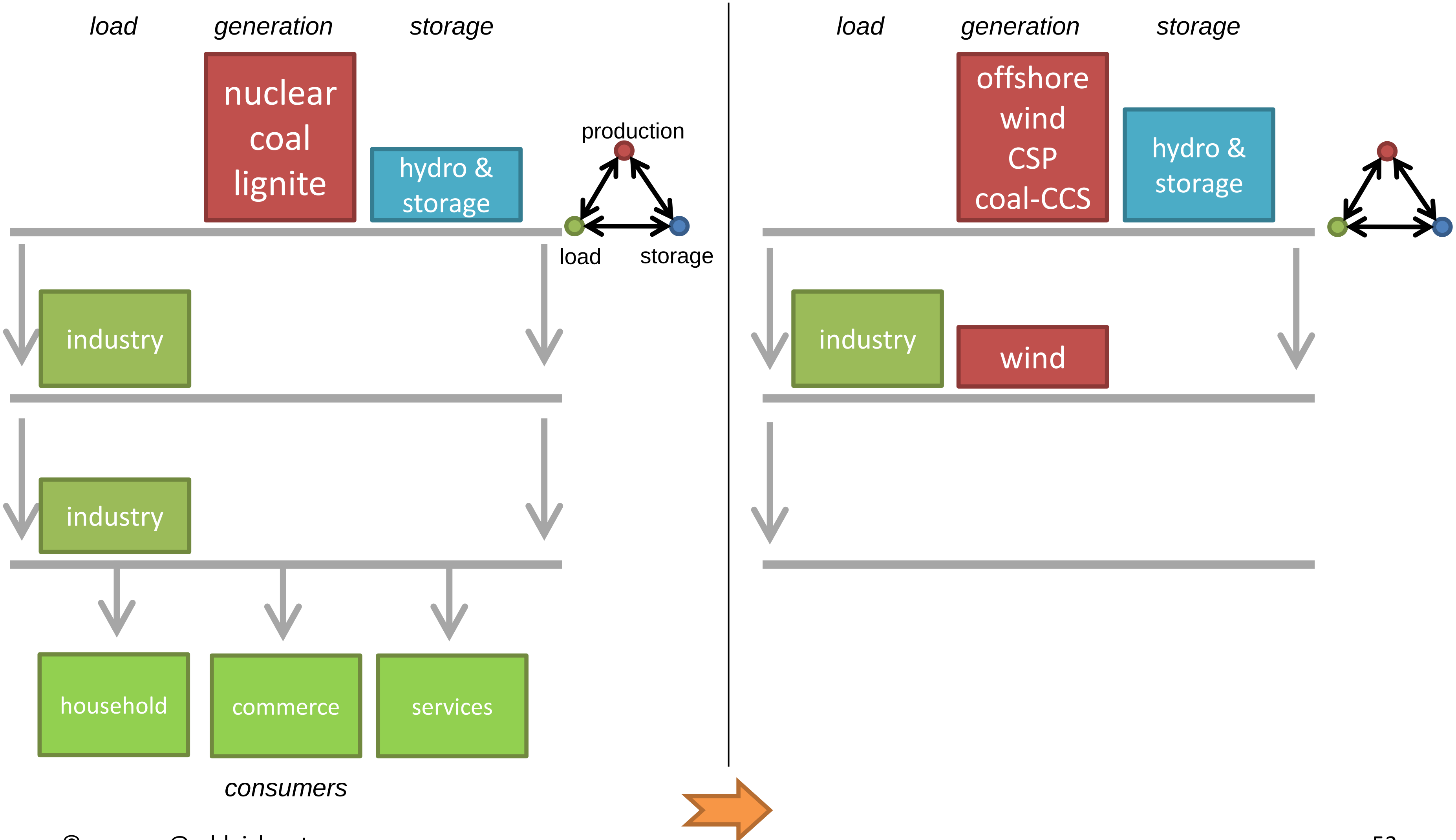
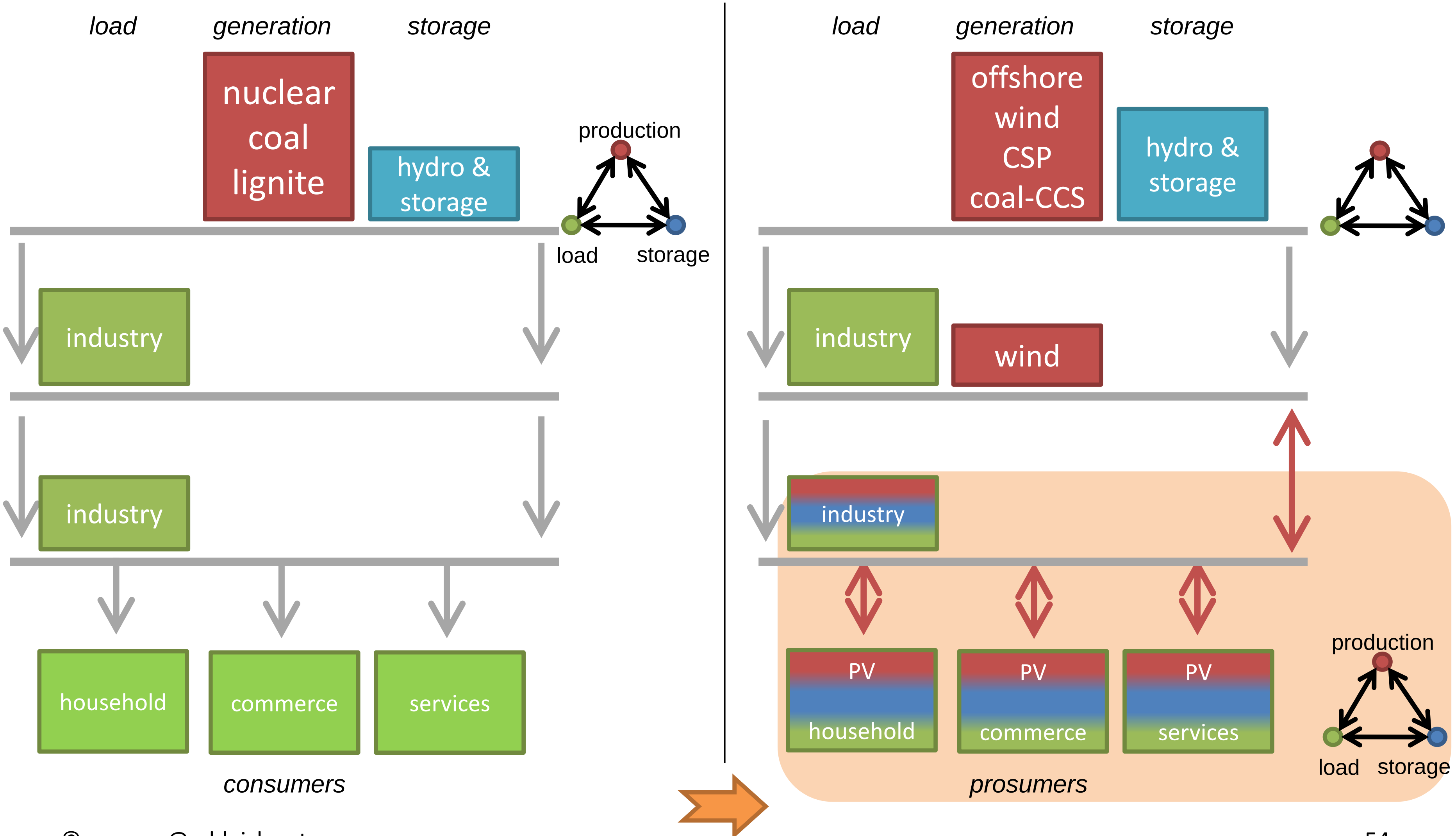


# Maintaining a centralistic approach… …does not work



# MANAGING A TURBULENT TRANSFORMATION

# Complexity increases … … predictability decreases

- Optimising the combination of generation/ demand side management/ storage /geographical compensation is a complex task with no final solution
- Innovation and cost reduction in wind turbines/ photovoltaics/ storage technologies/ demand side management/ smart grids … have different speeds and are much more rapid than in conventional technologies
- Nevertheless many investments have long liftimes
- The speeds depend on global market developments

➢ Conventional planning of the future energy mix or of the technology mix for dealing with fluctuations makes no sense

Turbulent transformation – What are lasting key orientations ?

# The Semiconductor Revolution now reaches the energy business

## Semiconductors

- Short innovation cycles, steep learning curves
- microtechnology: scalable from very small to very large applications
- competitive mass production of small standardised modular elements
- large scope for reduction of materials: miniaturisation, thinner layers …
- large scope for cost reduction (several technological paths)

## Photovoltaics

- direct conversion of light into electricity, no moving parts, no fuel, negligible maintenance and variable costs, no exhausts
- Scalable from very small to very large applications

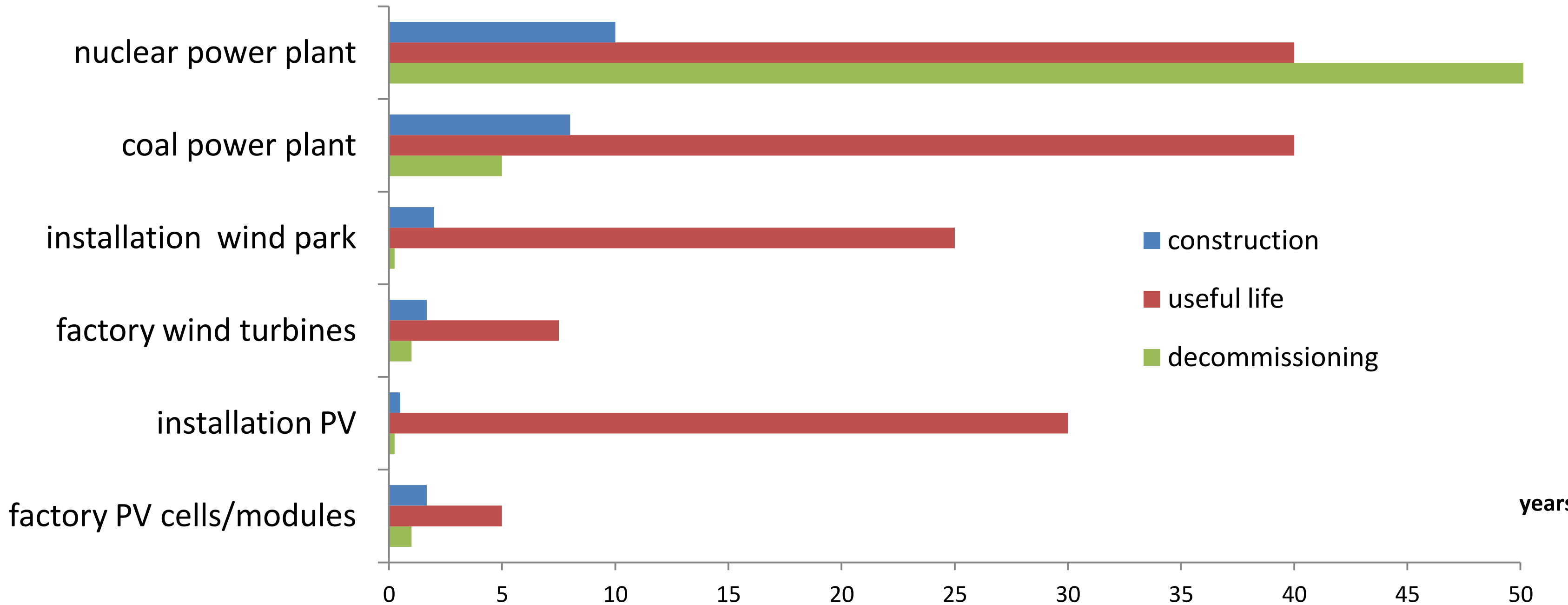
## ICT, power control, power electronics

- smart grids, smart homes, smart buildings… cheap distributed intelligence
- solid state transformers, power electronics boost efficiency and flexibility of power flow control as well as grid stability

# Unfamiliar to energy business: 4 to 10 times shorter innovation cycles

→ More rapid build-up of capacities
→ More rapid decrease of costs
→ More rapid transformation of the electricity sector

Dramatic acceleration compared to traditional energy technologies



# Industry policy

- Since three years renewable energies have become a hot issue in international industry policy
- As early mover Germany has been successful in building up leading PV companies and creating considerable employment
- Now heavy shakeout: booming global markets and strong investment have led to Asian leadership in PV mass production, while Europe is still leading in production technology
- Integrating PV in electrical systems and buildings will be the key to success for EU and US industries in coming years
- Large companies start to heavily invest in this direction
  Total (oil), Bosch (not yet in power market), GE (power sector incumbent) make multi-billion investments in PV production; Siemens and ABB step up appropriate control technologies, Toshiba buys Landis& Gyr …

# 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 multi-level governance

- The new system needs to <u>consider new dimensions</u>:
  - 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 <u>strategic visions</u>
  - for the <u>re-definition of the role of actors at several levels</u>:<br>TSOs, IPPs, DSOs, integrated municipal utilities, regulation agencies…
  - for the <u>differentiated use of market mechanisms</u>
  - concerning possible paths of <u>industry development</u>

# THANK YOU

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