Federal Ministry
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AHK Deutsch-Emiratische Industrie- und Handelskammer
المجلس الألماني الإماراتي المشترك للصناعة و التجارة

Energy

Photovoltaics on the verge of competitiveness: The need for new business models and regulatory framework

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sustainable strategies, Berlin

United Arab Emirates & Germany
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renewables Made in Germany

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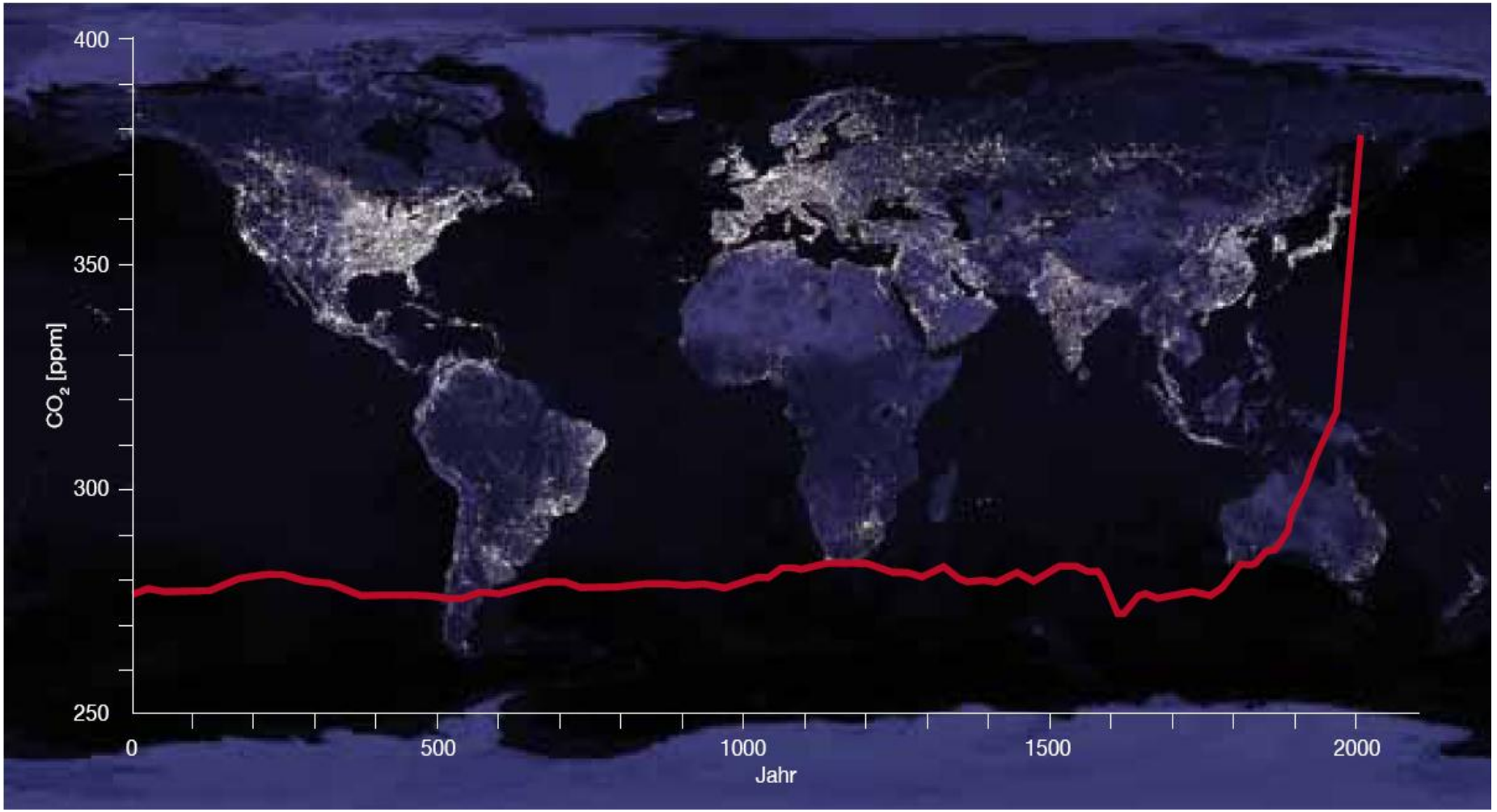

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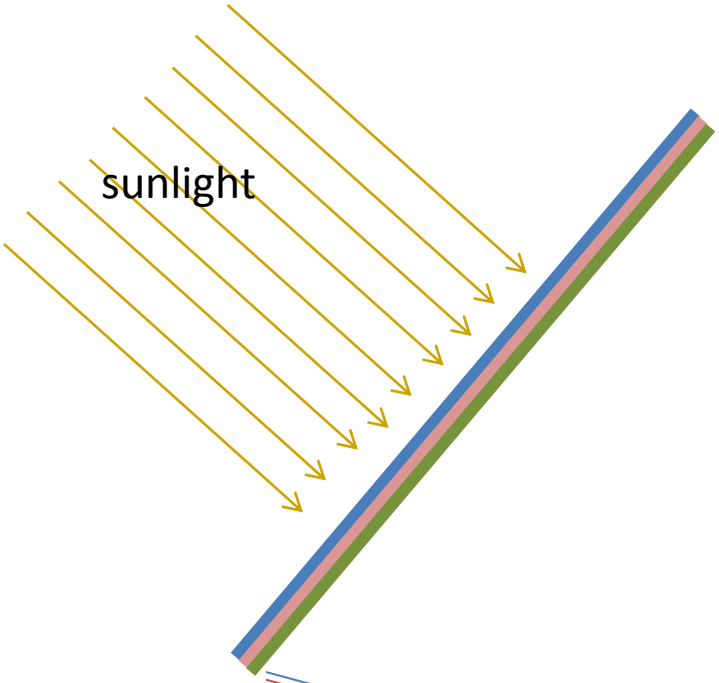
PHOTOVOLTAICS –
A DISRUPTIVE TECHNOLOGY

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

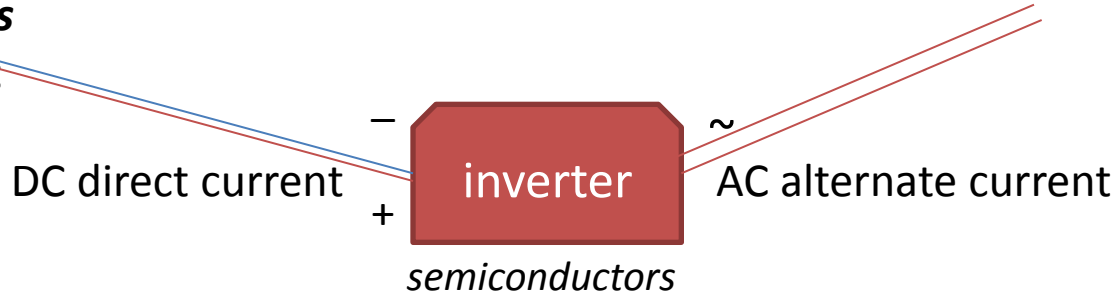


- **no moving parts**
- **no maintenance**
- **no fuel**
- **high cost reduction potential**

several layers of semiconductors

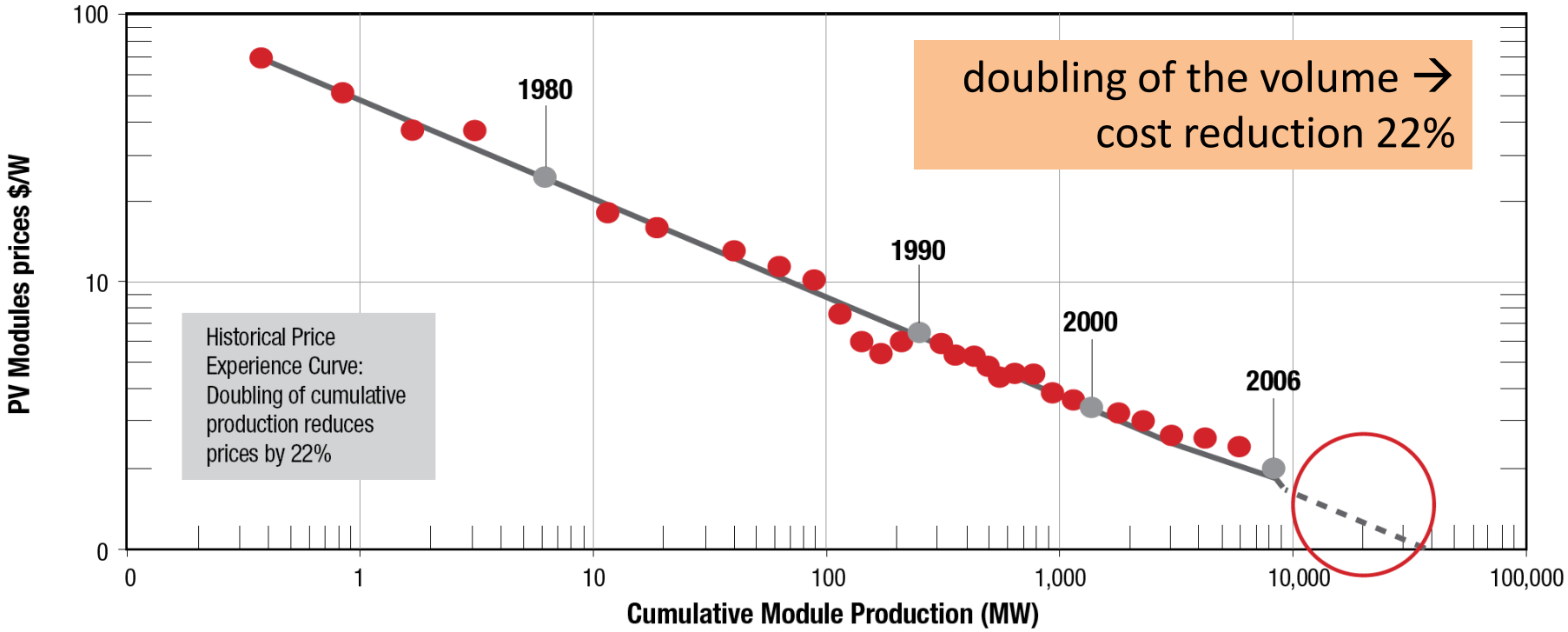
variety of different technologies:

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



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

Rapidly decreasing Costs: The historical learning curve of PV

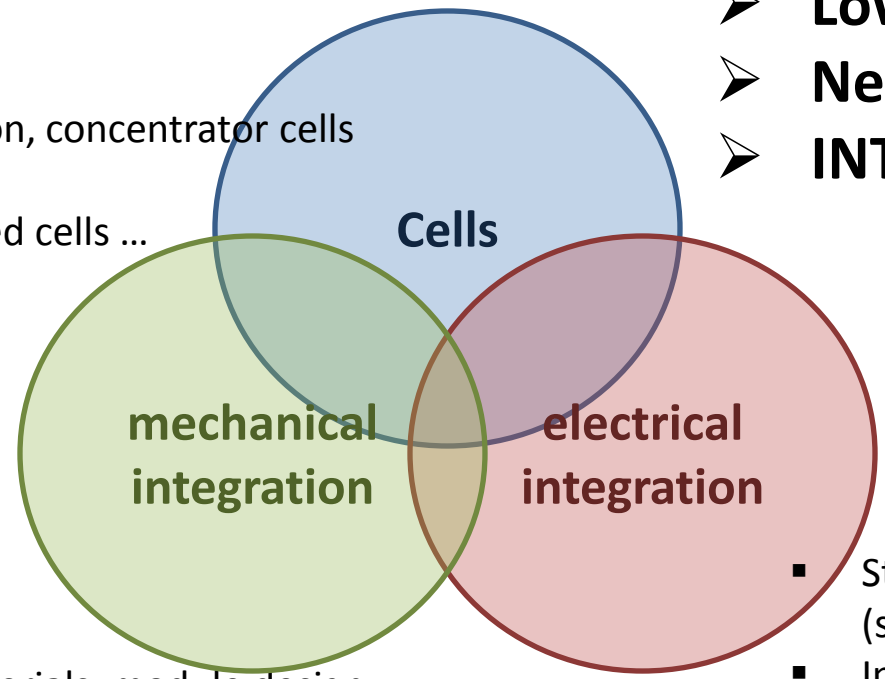


Sources: EU Joint Research Centre - EIA - National Renewable Energy Laboratory - A.T. Kearney analysis.

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 …

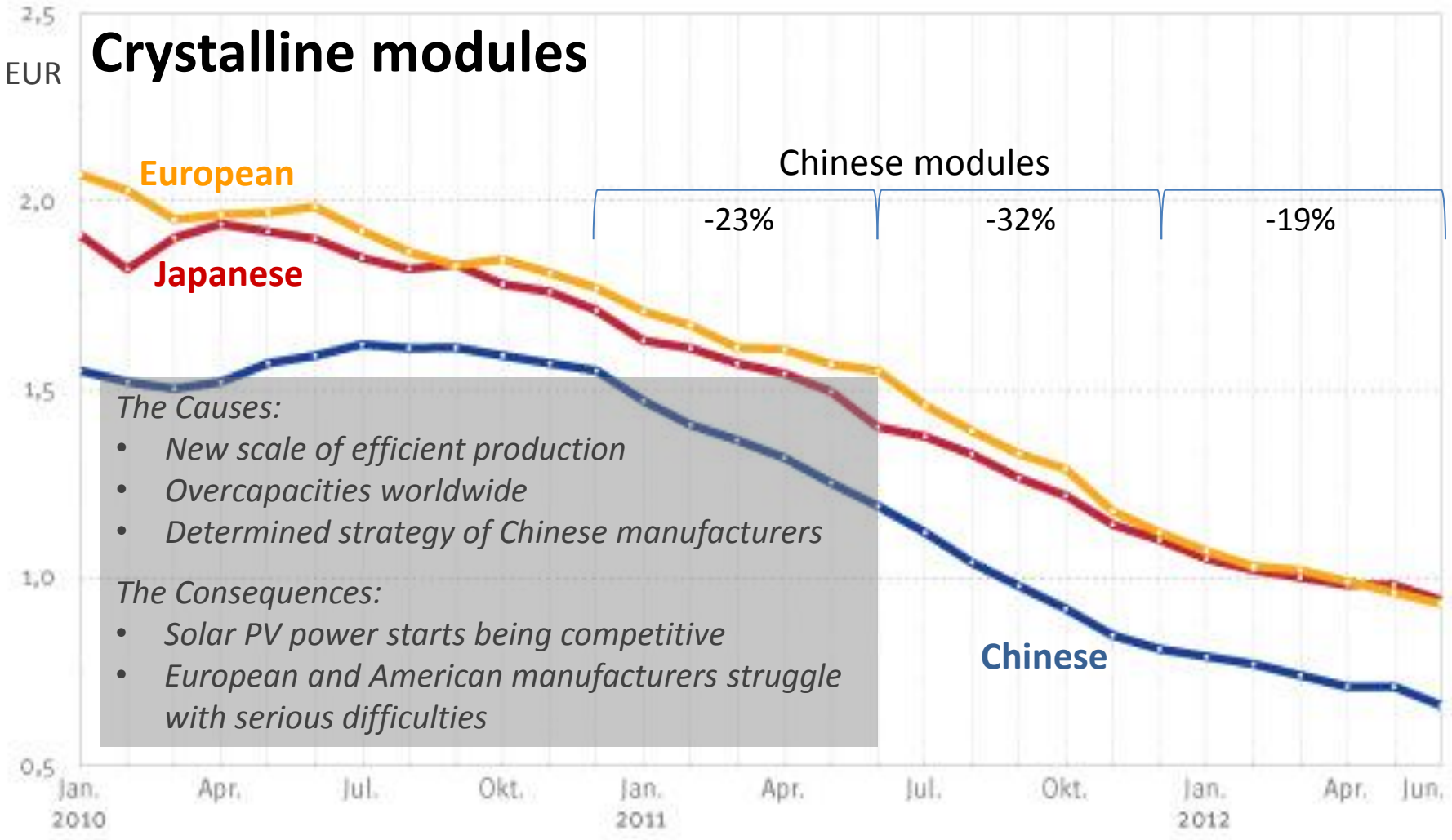
- **Higher efficiency**
- **Lower production costs**
- **New application fields**
- **INTEGRATION**



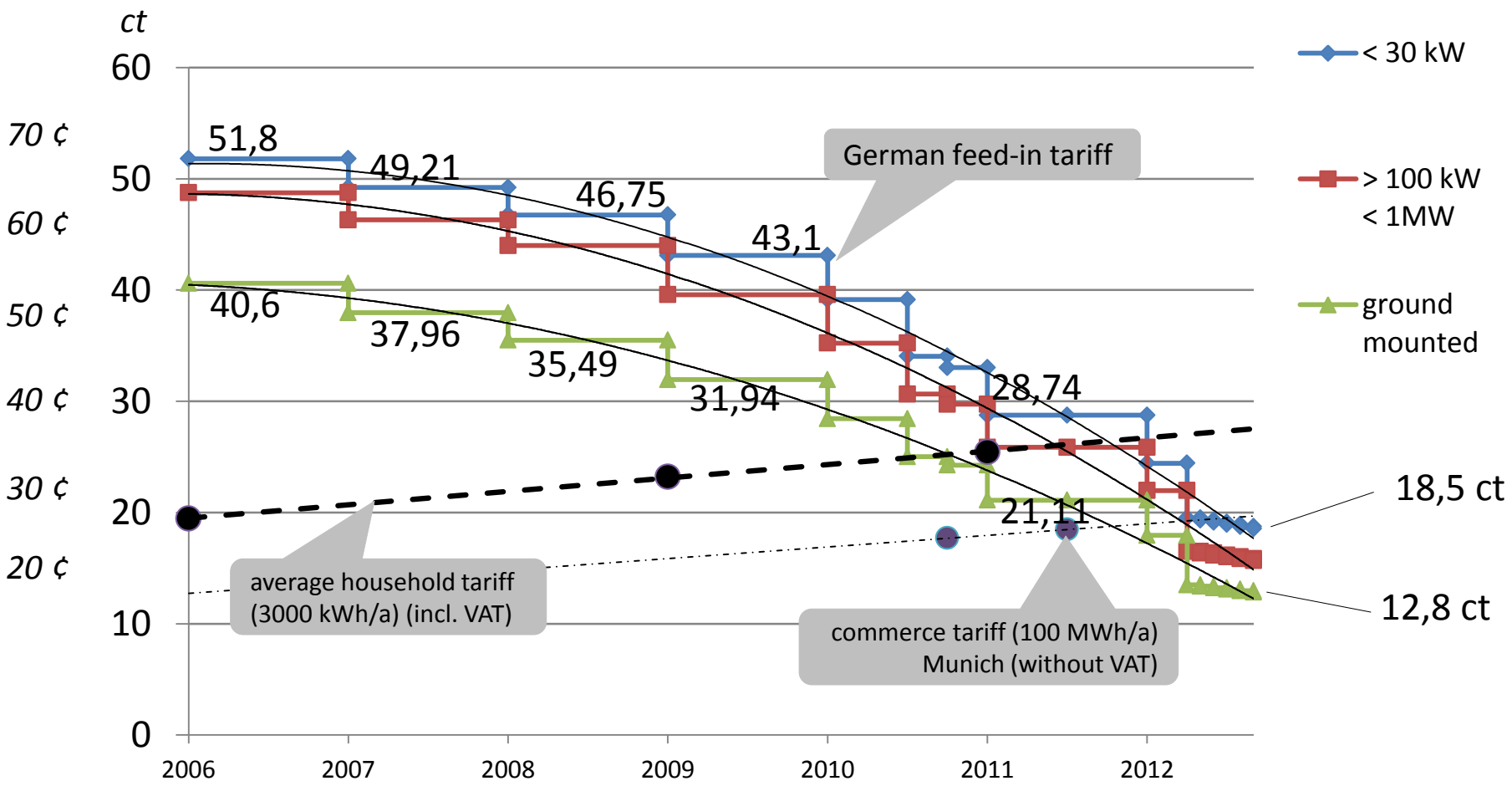
- Carrying materials, module design
- Concentrators, tracker systems
- BIPV: integration in buildings, construction elements
- in appliances, in vehicles
- Free space, traffic areas, roofing

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

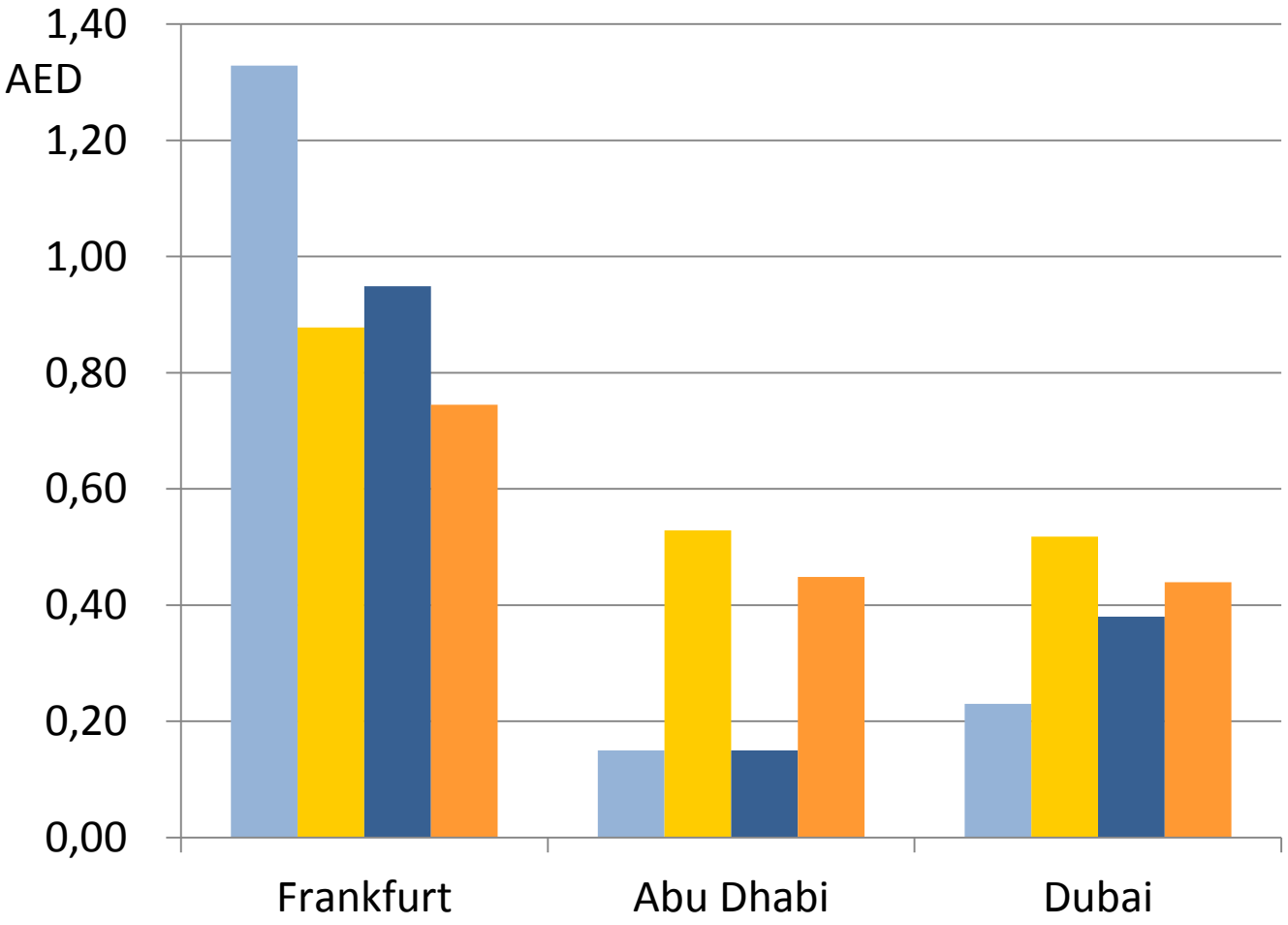
Heavy PV module price drop since 2010: - 45% in 12 months



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



In the UAE: more solar radiation but subsidised grid electricity



***Assumption*:**
UAE system prices as in Germany

Solar yield (kWh/kW$_{peak}$/yr) :

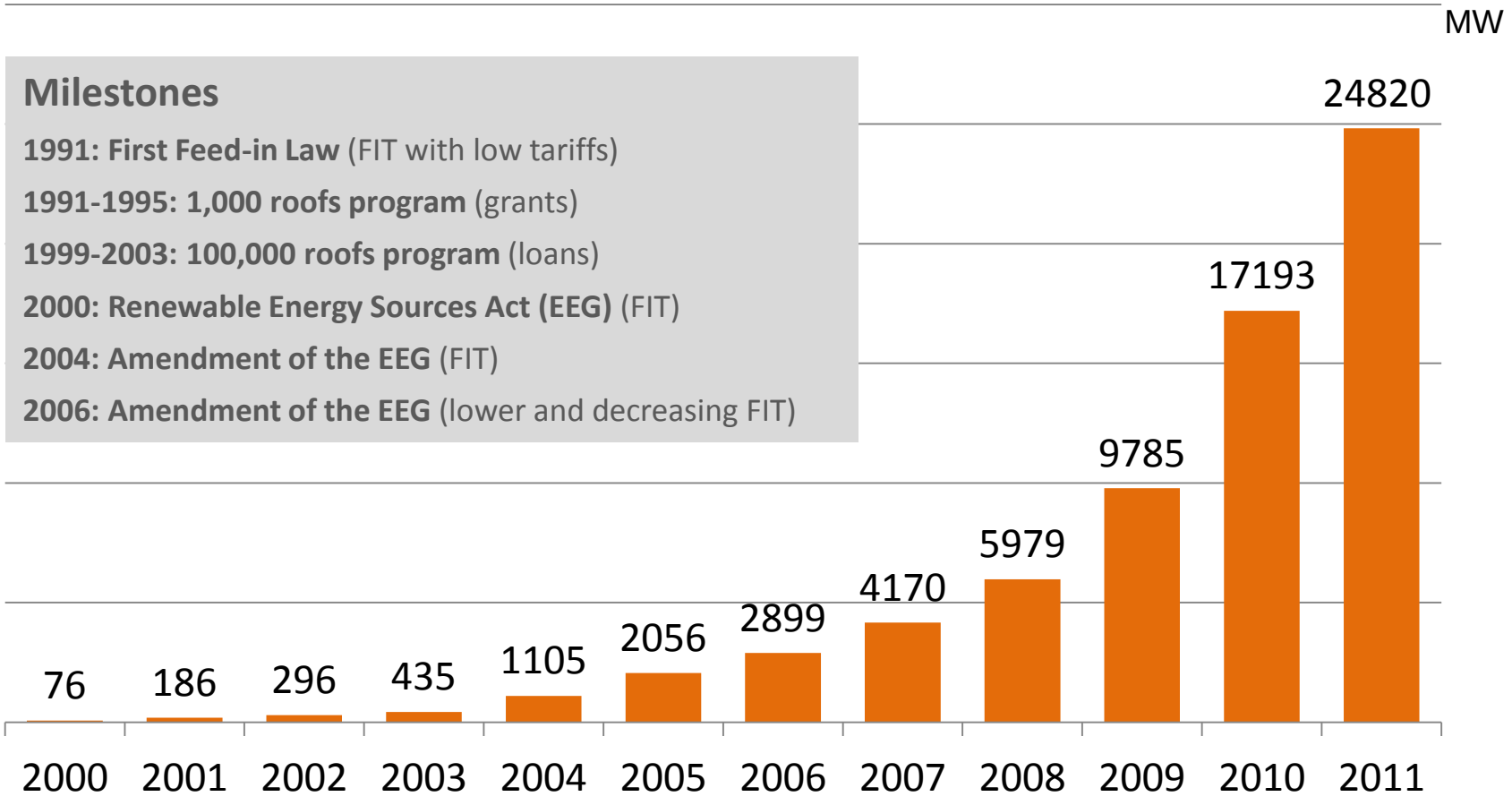
Frankfurt	*879*
Abu Dhabi	*1460*
Dubai	*1490*

1 AED = 0,21 EUR

DEVELOPING GLOBAL MARKETS

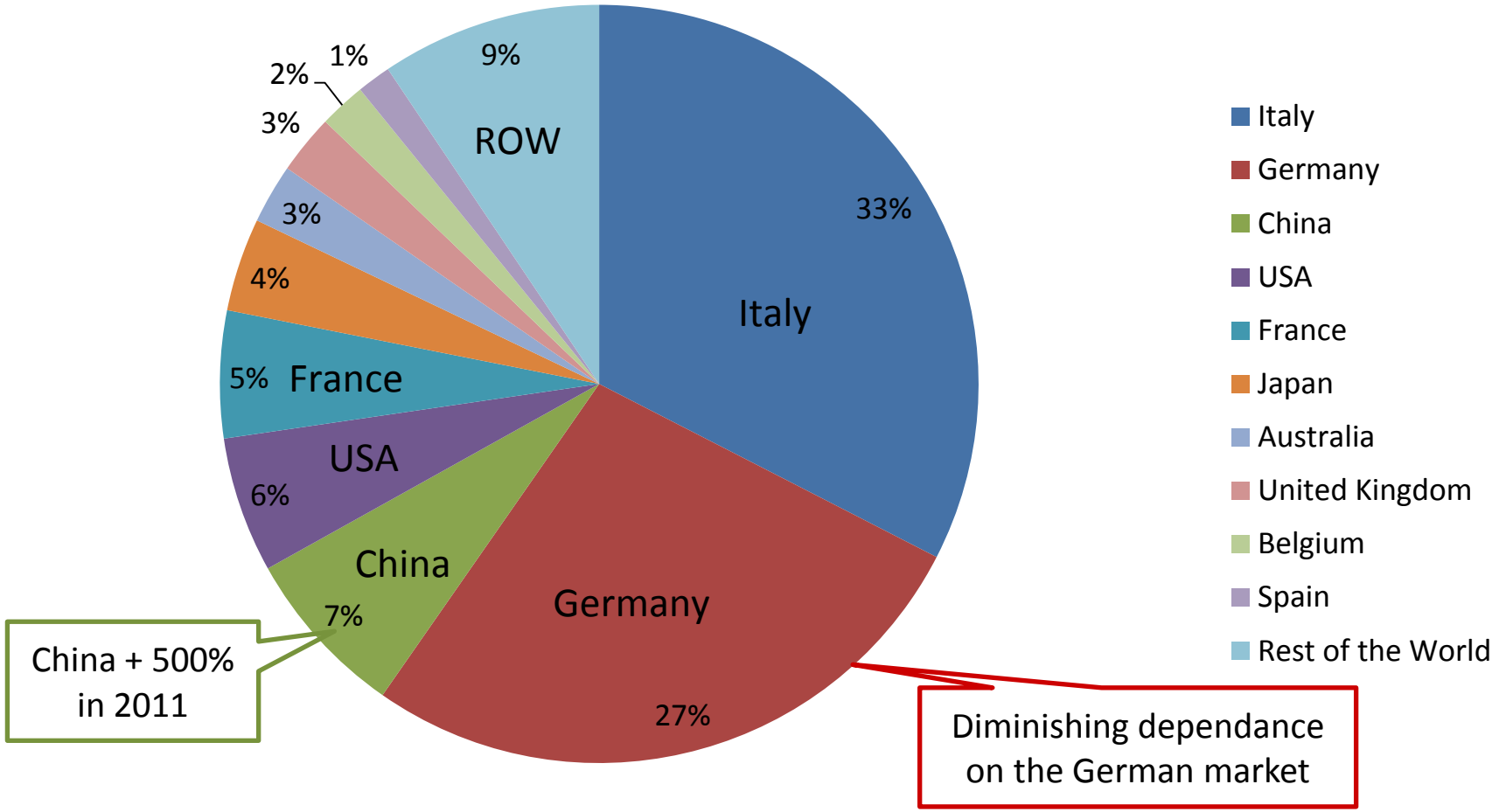
Germany has triggered the take-off of the world PV market

Total PV capacity installed in Germany



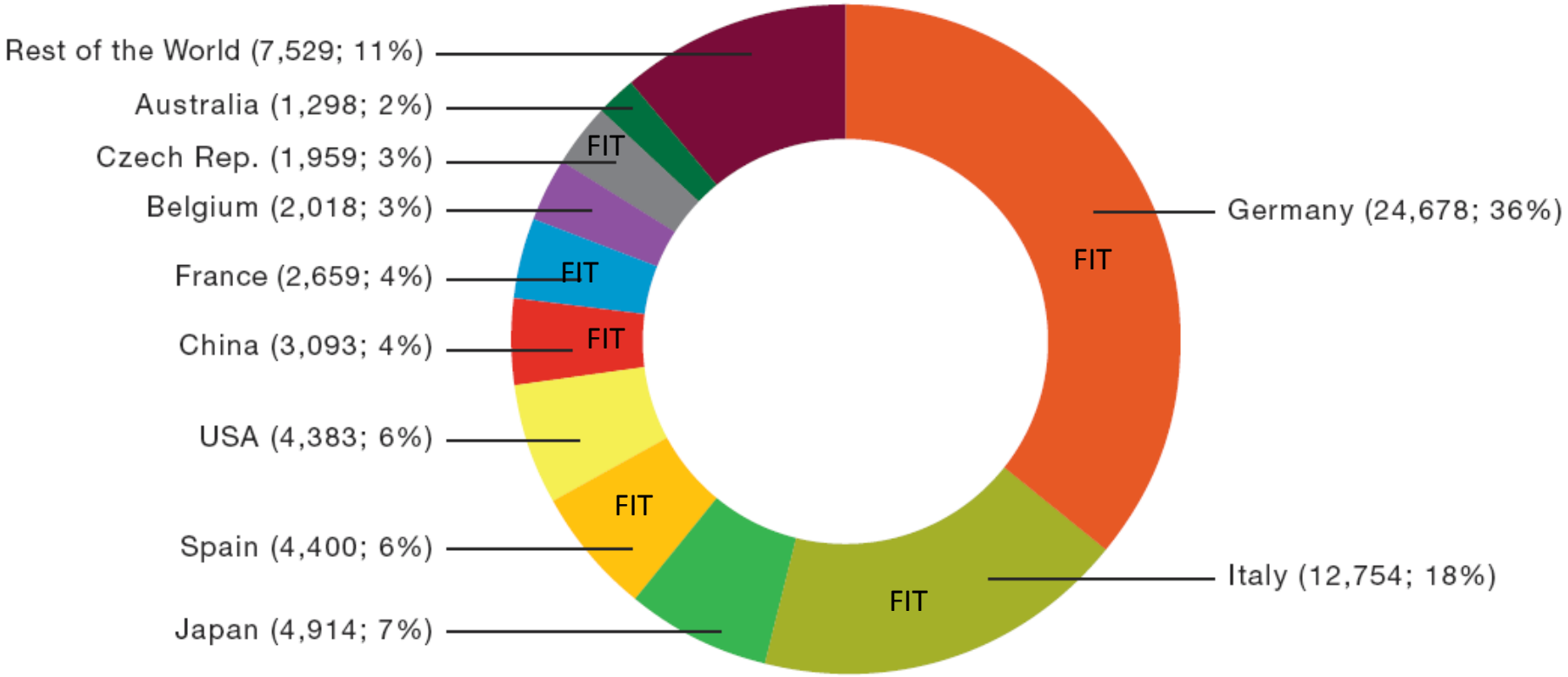
Source: BMU, BSW

The global PV market in 2011 (27.000 MW)



Feed-in-tariffs (FIT) have boosted markets globally

Global cumulative installed capacity share 2011



Success factors during the start-up phase in Germany

- A reliable investment context with guaranteed feed-in tariffs for 20 years after installation
- Continuous adaptation of the FIT for new systems to market development → steady growth
- A simple scheme: no other incentives, just FiT
- No complicated permitting procedures

➢ Banks have learned that PV investments are low risk → low capital costs

➢ Industry and craftsmen have invested in production and training → reliable quality, low system price

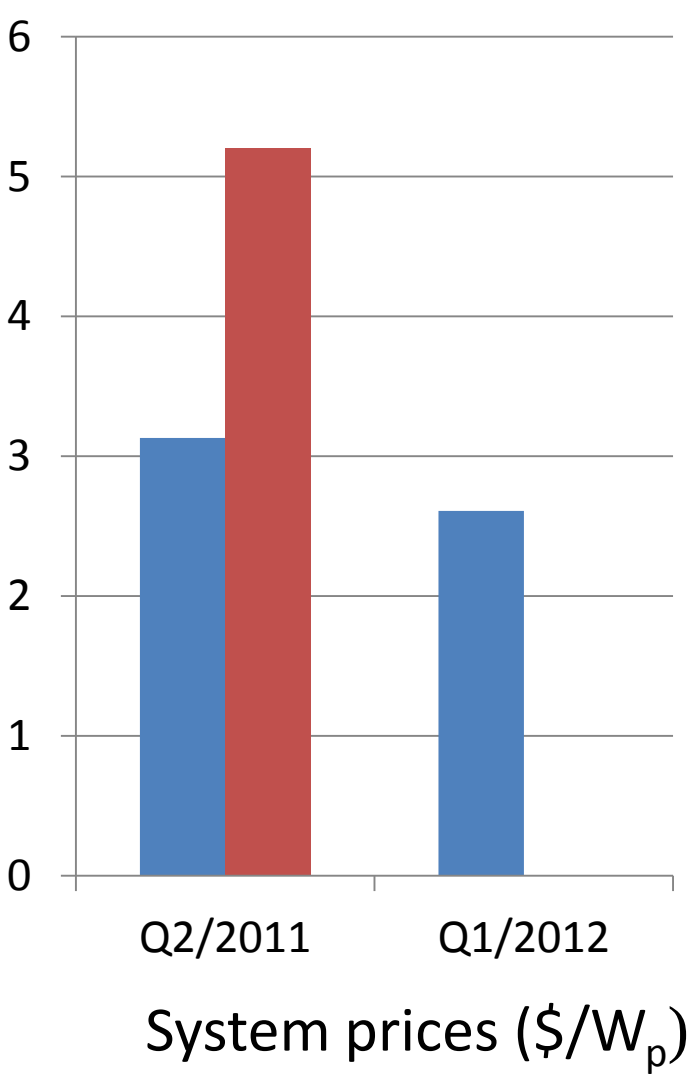
➢ Hundreds of thousands of new private investors

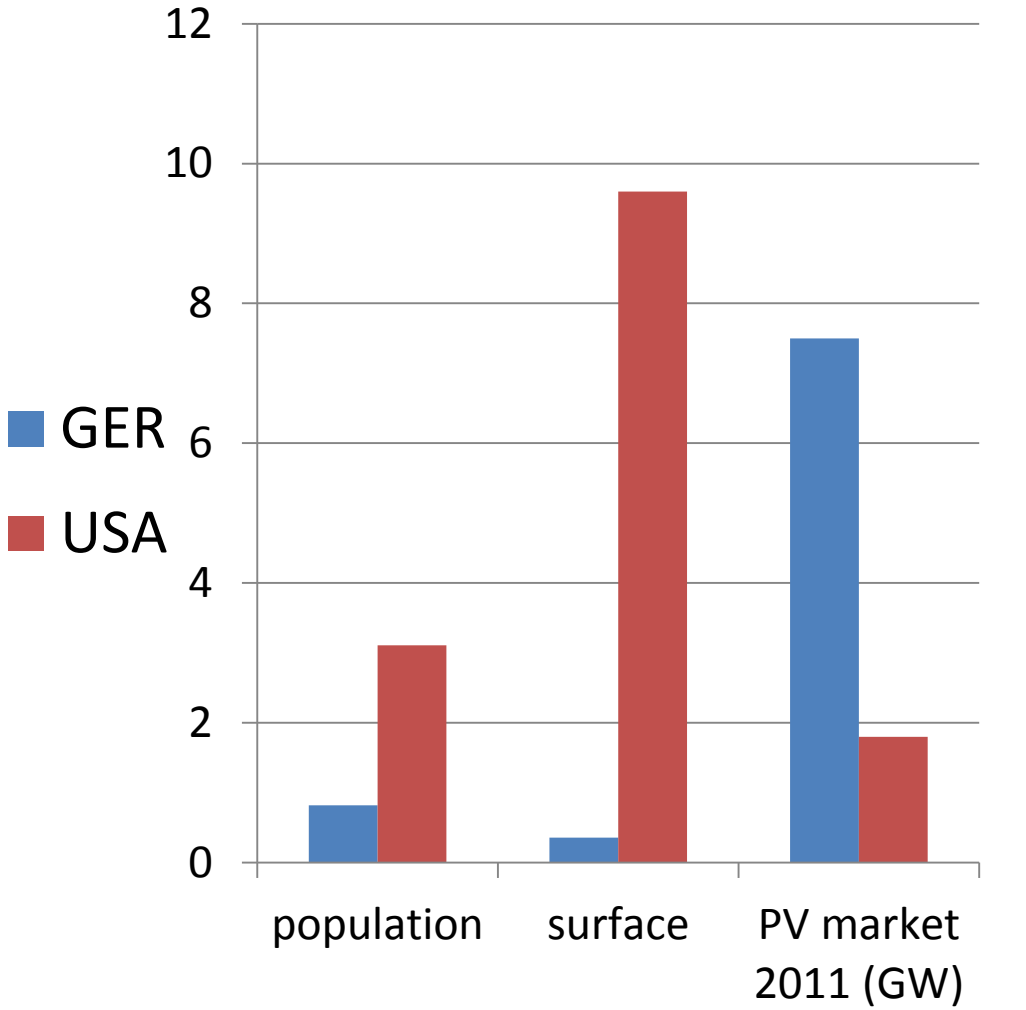
Building the value chain takes time

- ↓ Research institutes — international
- ↓ Manufacturers of production plants — international
- ↓ Banks and financing companies — can be local
- ↓ Manufacturers
  - silicon — international
  - wafers, cells — international
  - modules — can be local
- ↓ Traders — can be local
- ↓ System integrators, EPC contractors — can be local
- ↓ craftsmen in the construction business — local
- ■ operating company — can be local

smaller installations – more opportunities for local added value

System prices depend on the maturity of the market





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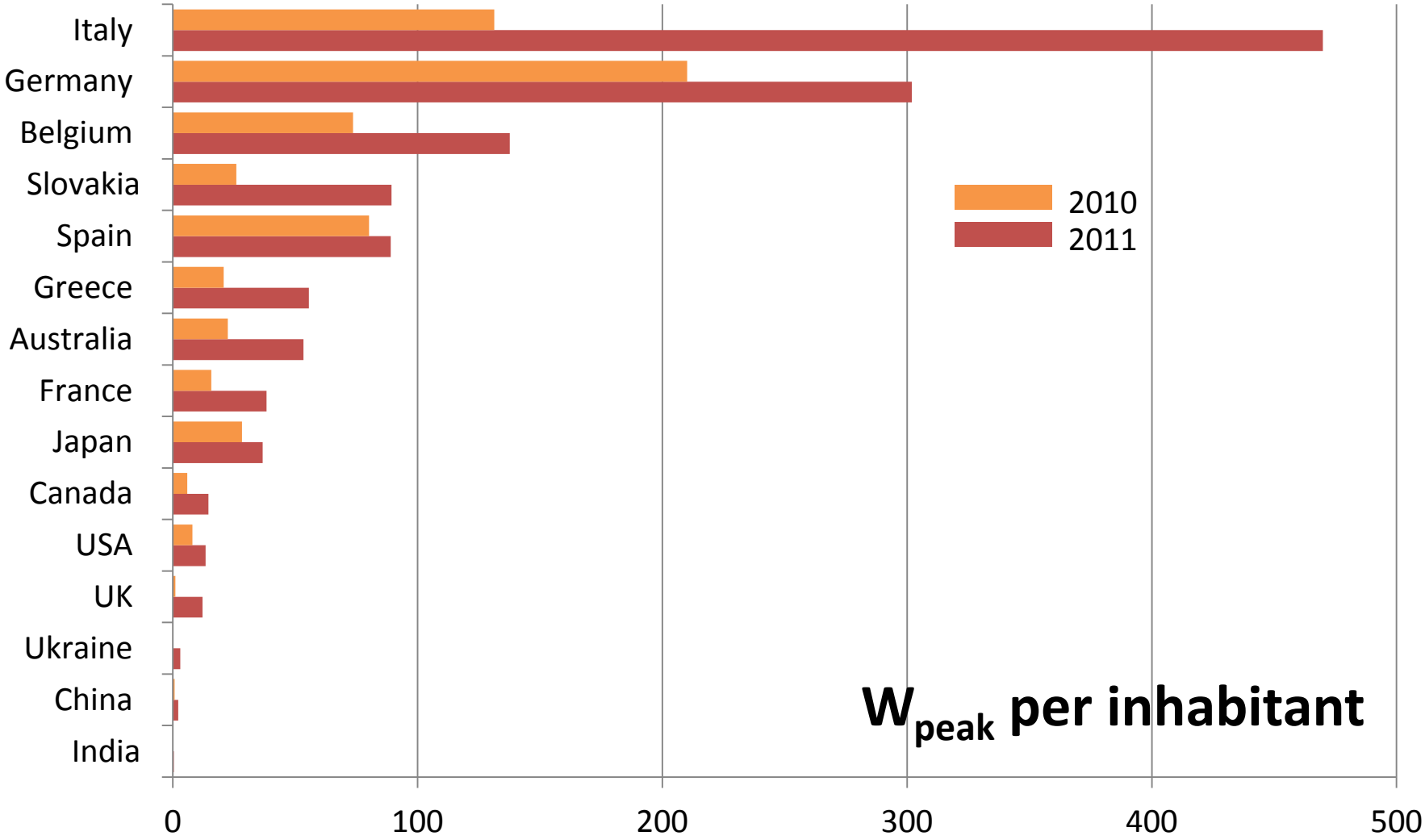
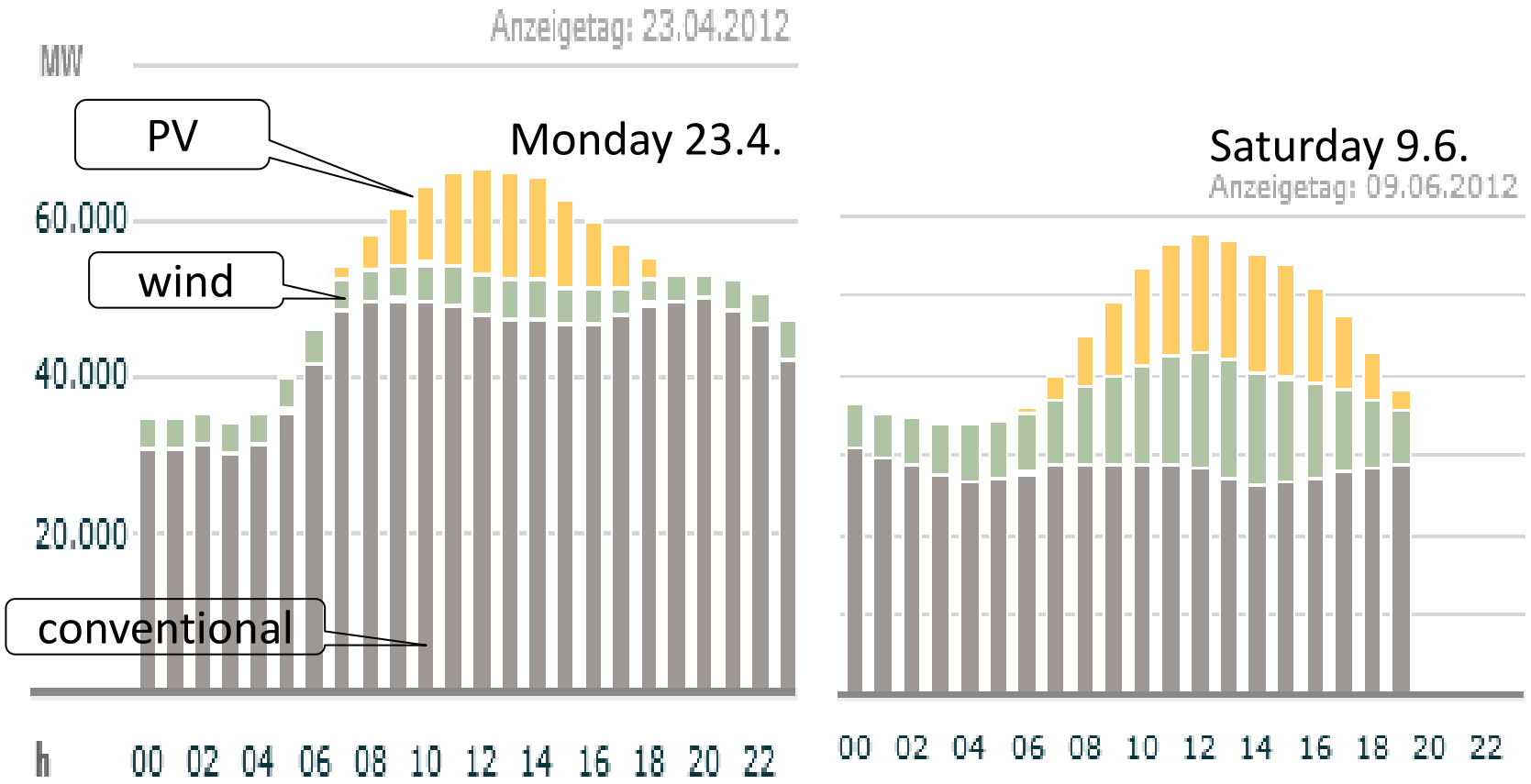
AN UNPRECEDENTED CHALLENGE FOR THE ELECTRICITY SYSTEM

Germany one of the first countries 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. Fluctuating power generation:
   Power generation directly depends on changing natural input
   - ➢ Forecasting production is a challenge
   - ➢ Flexible compensation needed
2. No marginal costs:
   Wind and solar power need no fuel
   - ➢ Dispatch priority
3. Distributed generation:
   Photovoltaics and onshore wind: essentially distributed
   - ➢ "Distribution" grid changes role
   - ➢ Captive power generation: Prosumers emerge as new actors

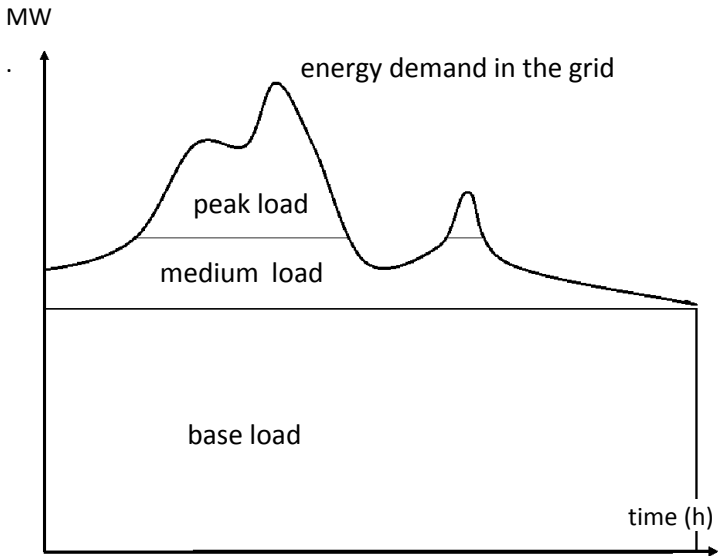
Fluctuation of wind and solar power requires flexibility instead of base load

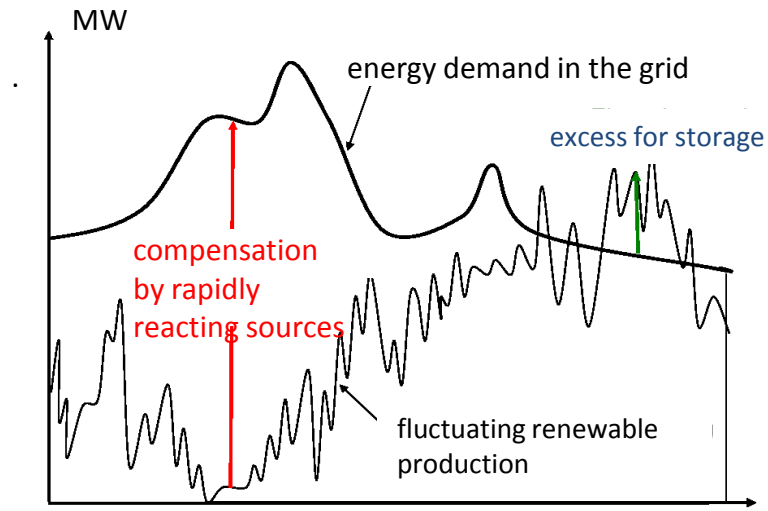
The old base load concept:

- cheap base load electricity from large plants
- expensive peak load from more variable sources

The new paradigm:

- Variable production from renewables with zero marginal cost
- Compensation with rapidly reacting sources (hydro, gas turbines)
- Storage becomes important
- Load management becomes important (smart grid)
- No need for baseload plants

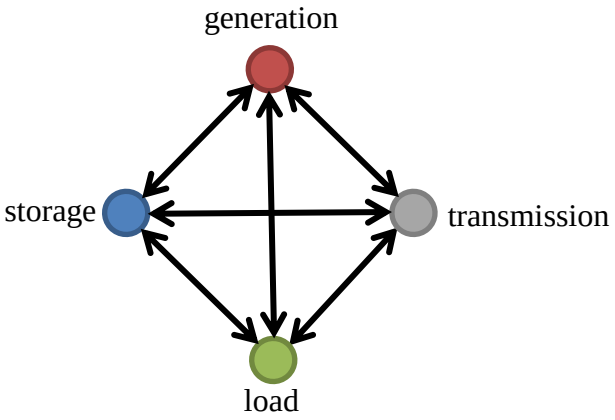




The system gets much more complex: more flexibility – four options

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

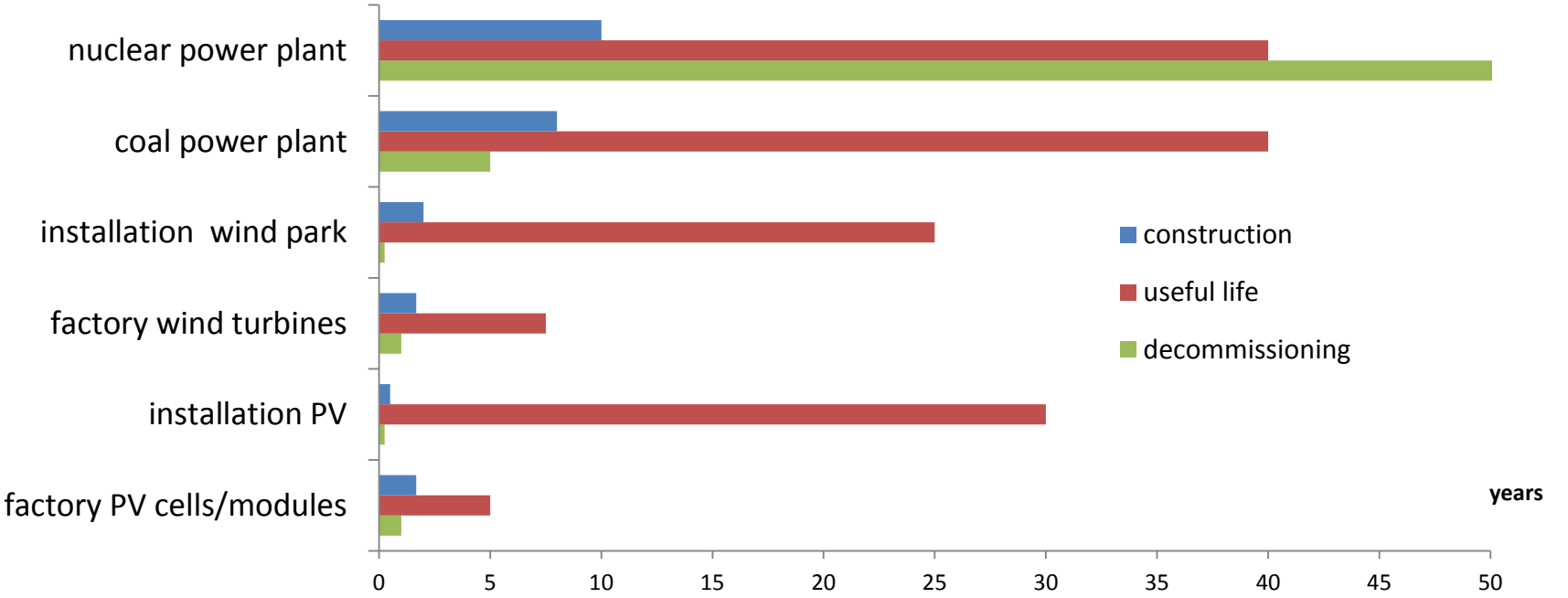
1. Flexible backup generation
   - traditional approach, limited when needing fossil fuel
   - old technologies not flexible enough
   - new technologies: gas turbines, distributed CHP, fuel cells
   - today: natural gas, tomorrow: renewable fuel – SNG
2. Increased transmission
   - compensates local 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

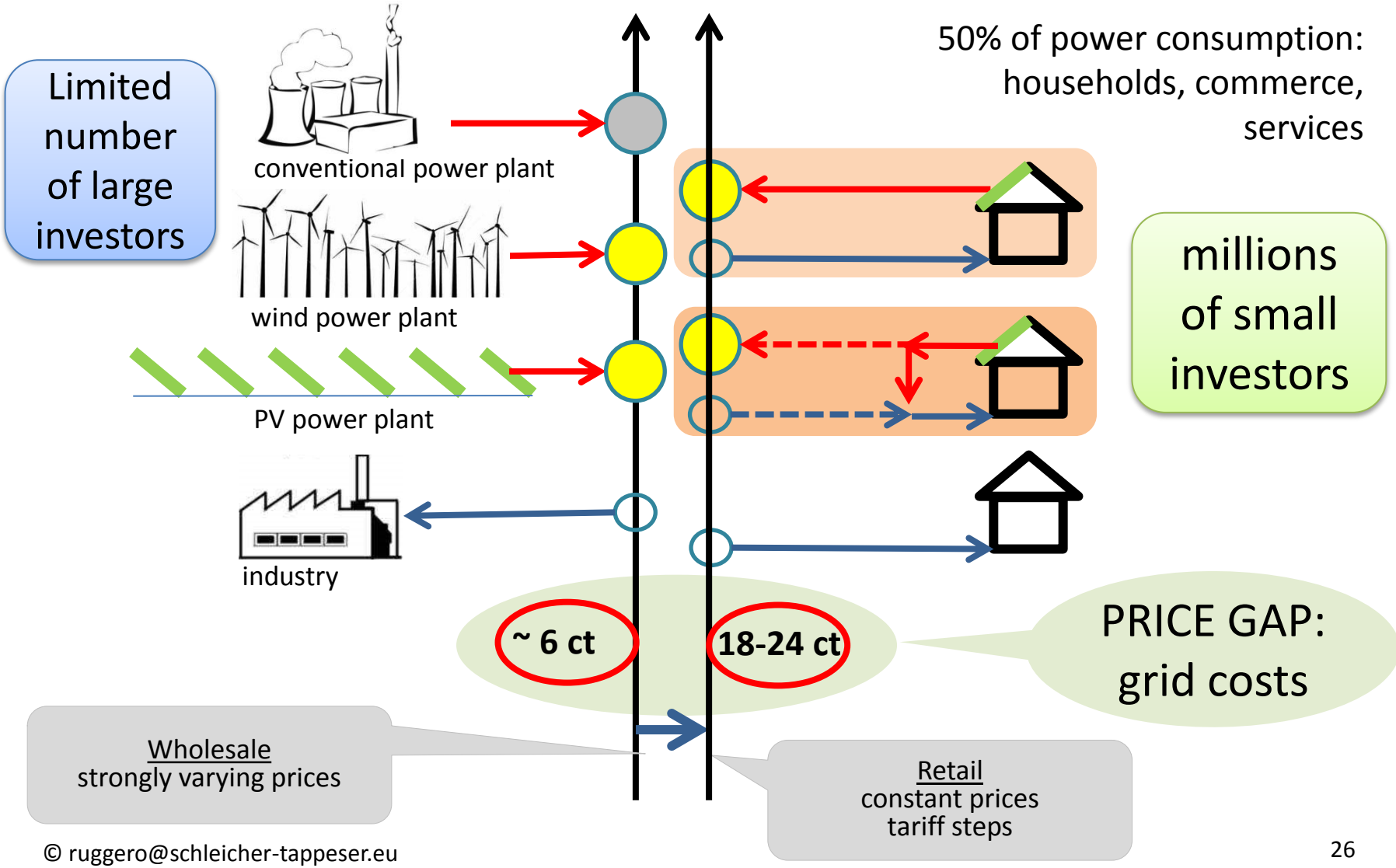
- → More rapid build-up of capacities (e.g. Dec. 2011 in Germany: 3,5 GW PV)
- → More rapid decrease of costs
- → More rapid transformation of the electricity sector

Dramatic acceleration compared to traditional energy technologies

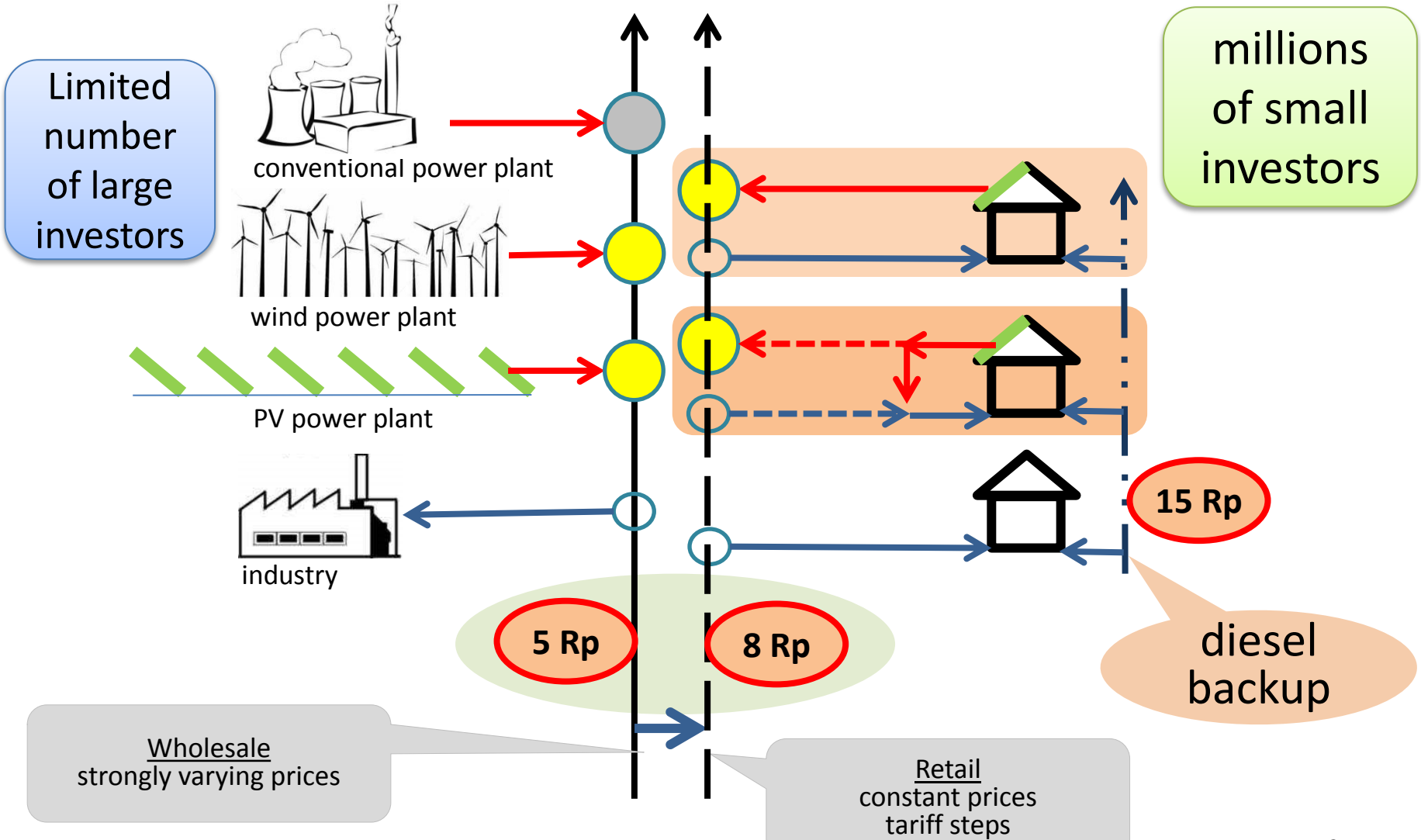


CAPTIVE POWER GENERATION CHANGES THE GAME

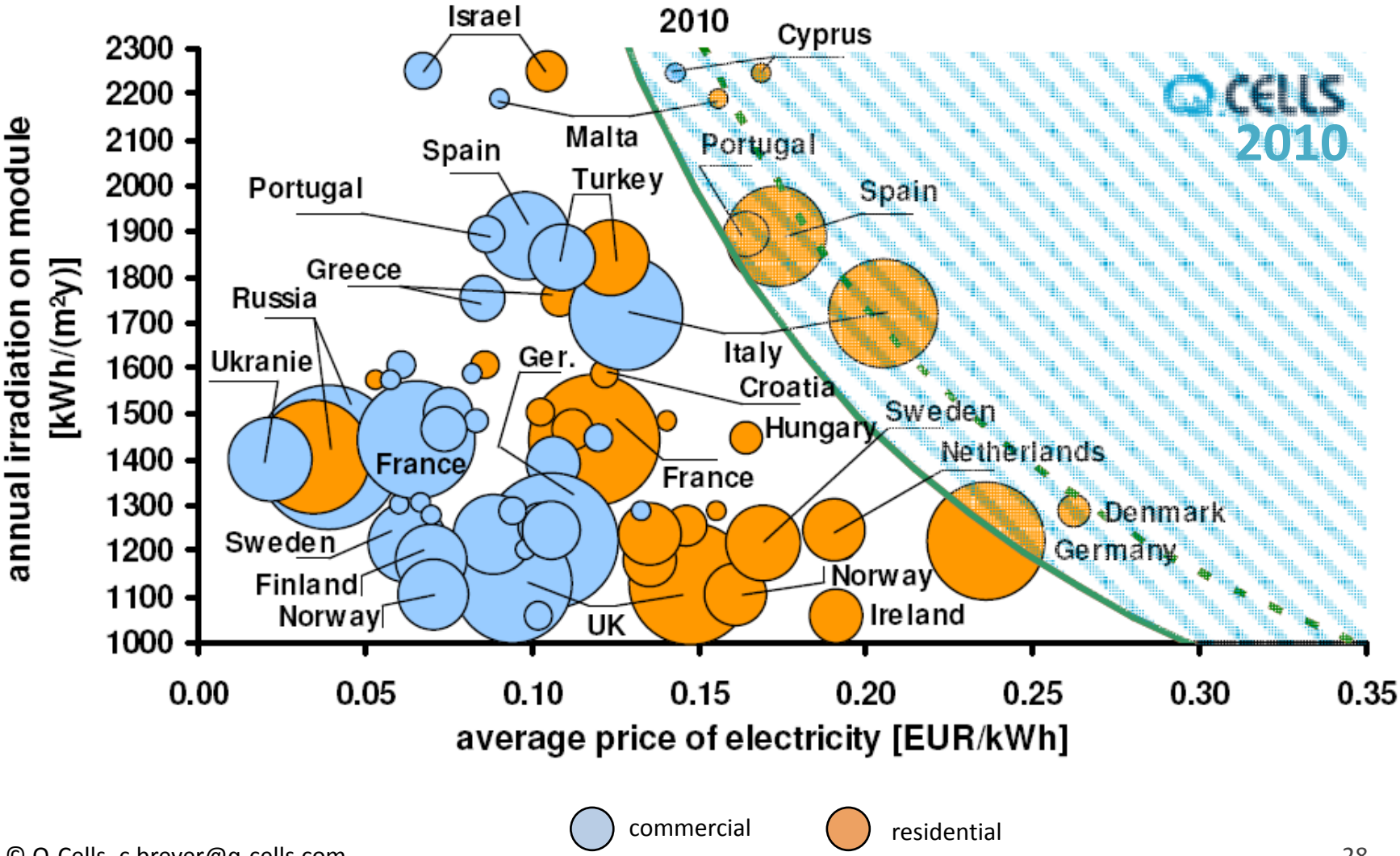
Photovoltaics is a modular technology: competing on the retail side



India: Photovoltaics in weak grids competing against diesel backup

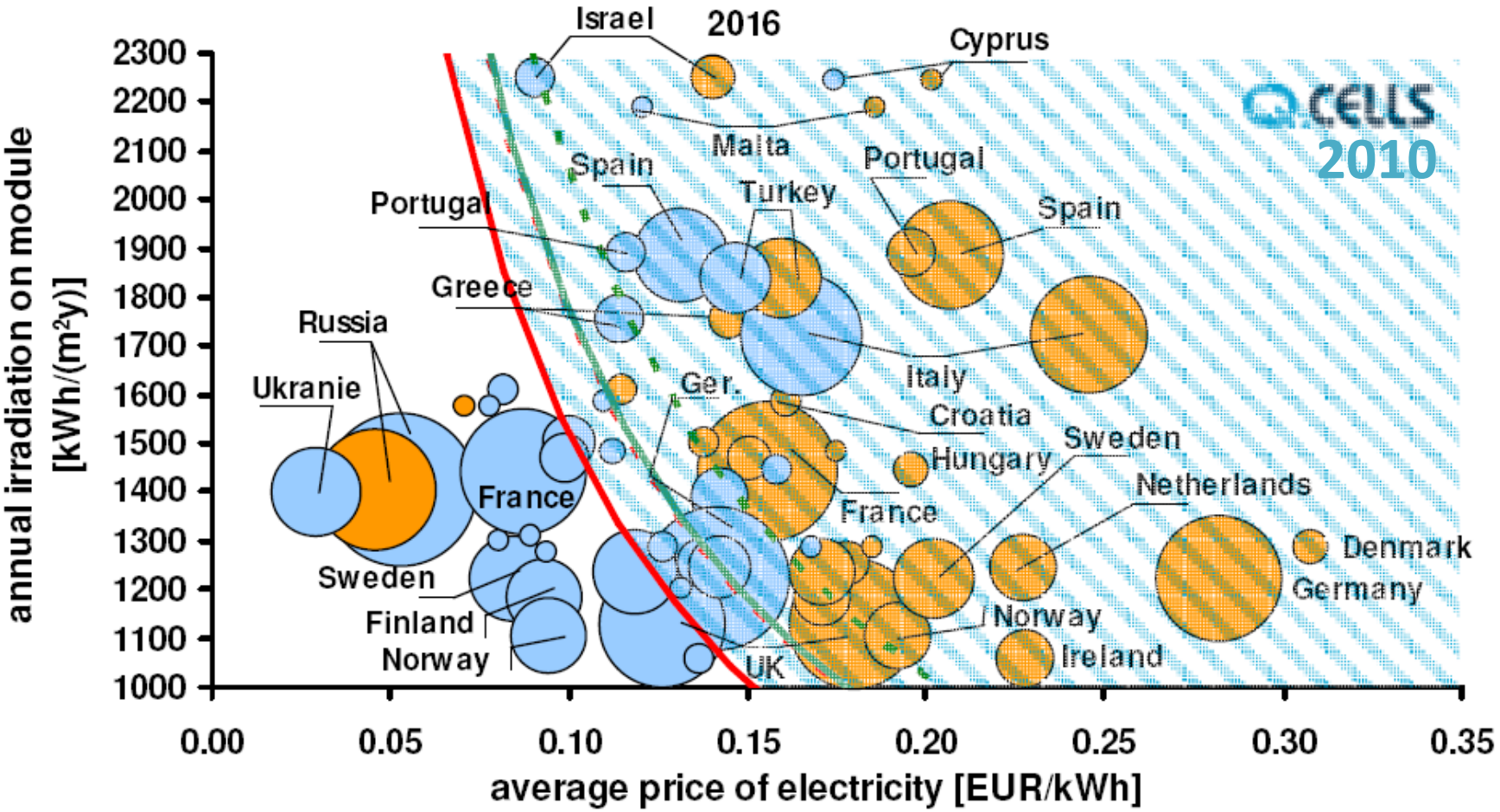


Grid parity in Europe 2010



Grid parity in Europe 2013?

(forecast in 2010 for 2016)



commercial residential

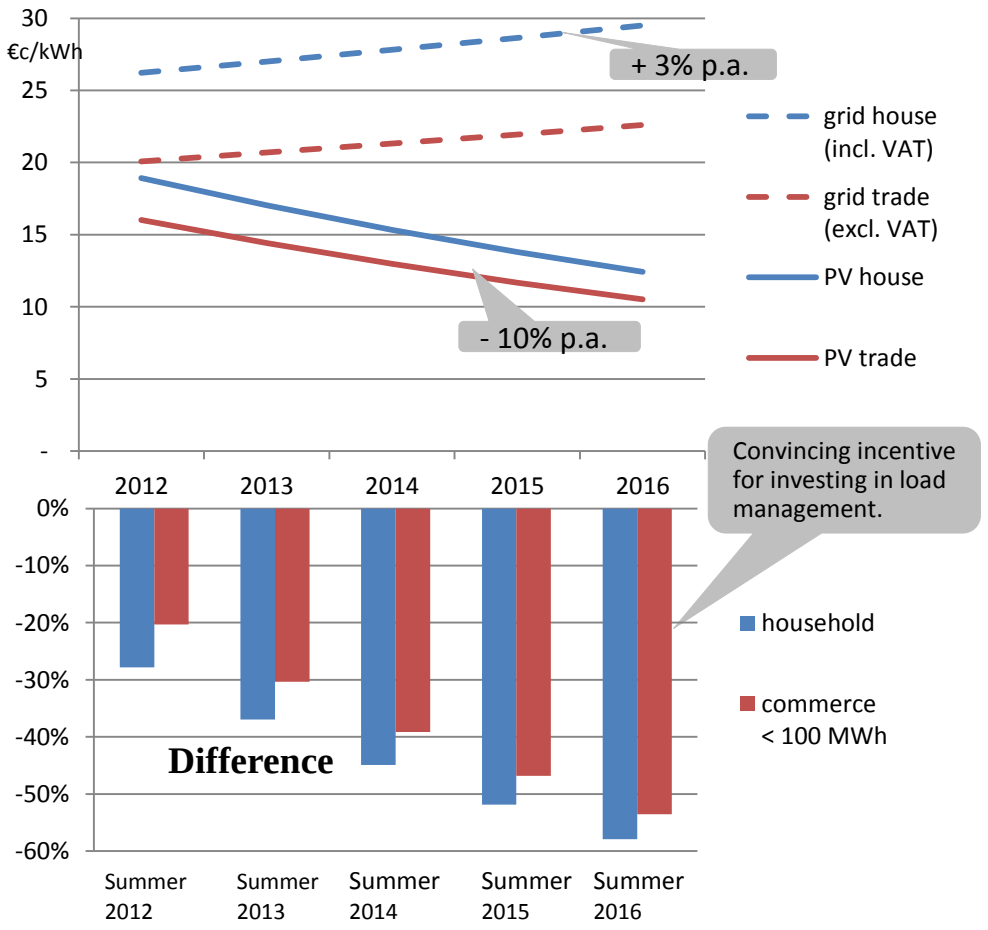
Attractiveness for own power production: Germany - Scenario for the next four years

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

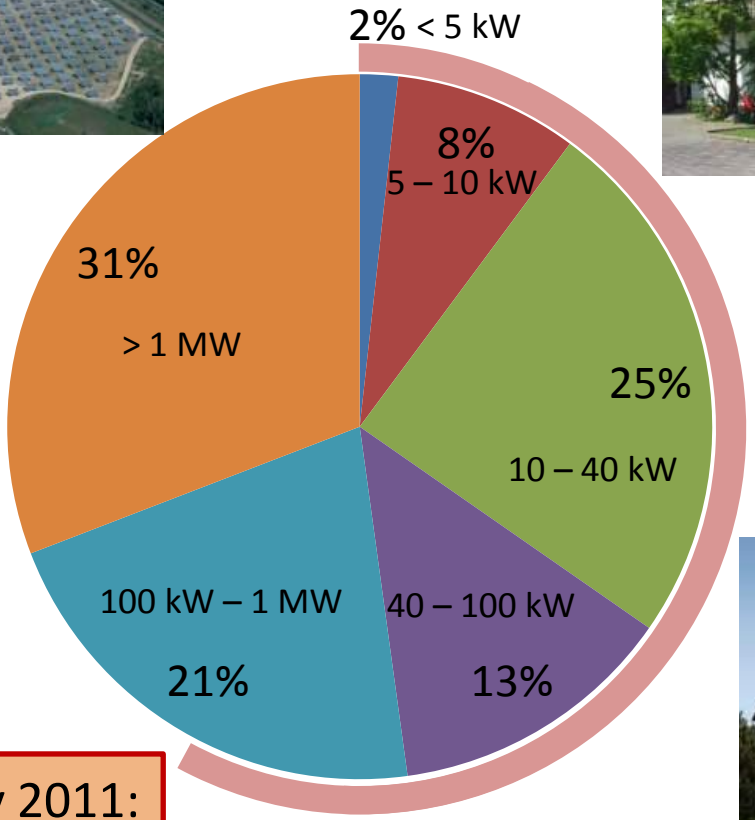
- Scenario assumptions
  - System price development: *-10% p.a*.
  - Power from the grid: + 3% p.a.
  - FIT July 2012 in Germany represents present PV power costs

➢ 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

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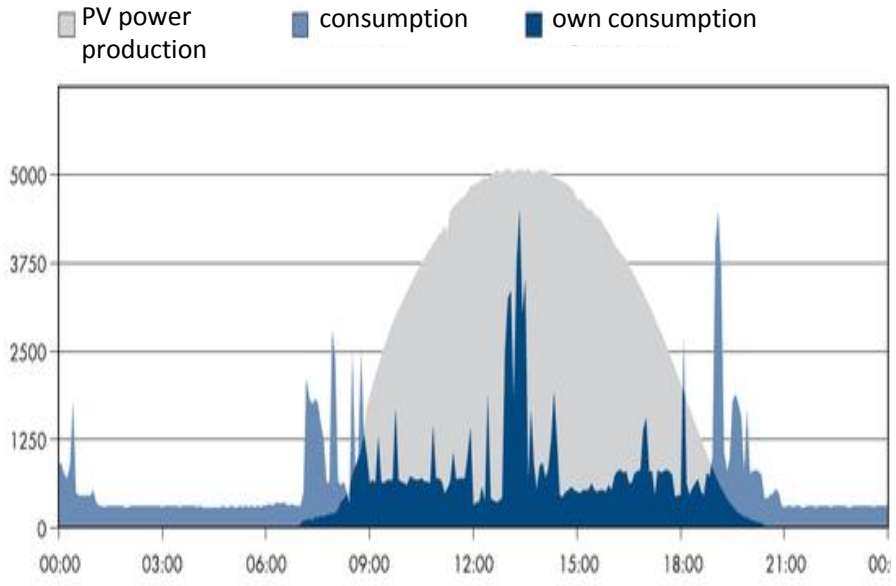
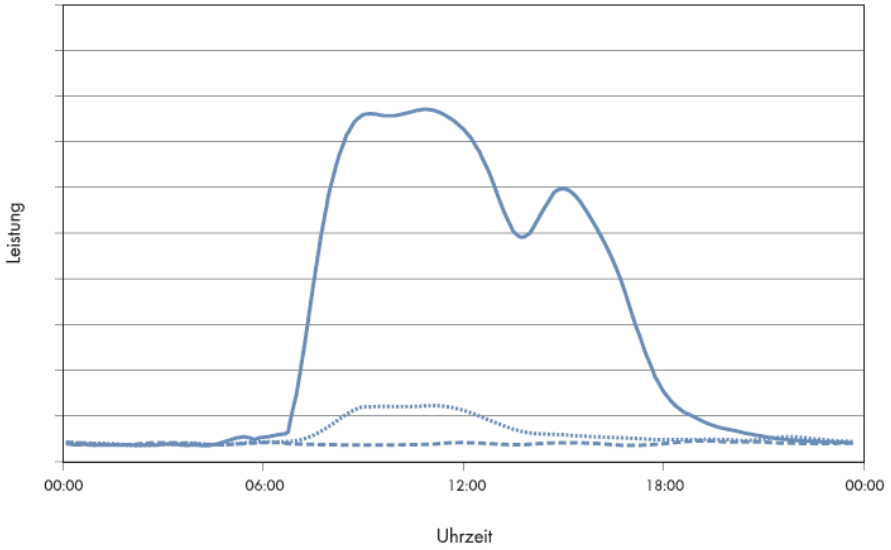
Power need when the sun does not shine: different potentials for own consumption





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

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

- Storage of electricity
  - Batteries
  - Flywheels…
- 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)

Cheaper than electricity storage

➢ Flexibility of the user system increases

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:

- In one/two years: PV power for own consumption in commerce and services
- In two/three years: 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

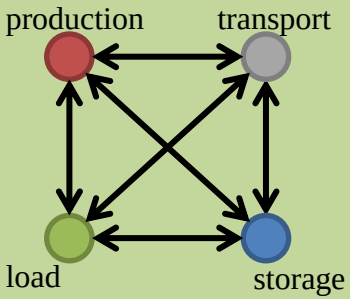
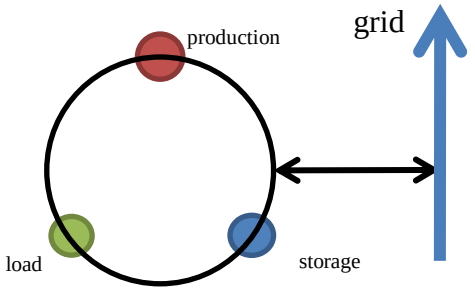
- Dealing with high upfront costs
- Structuring of risks
- Segmentation of markets
- Distribution of roles
- Development of step by step approaches

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

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

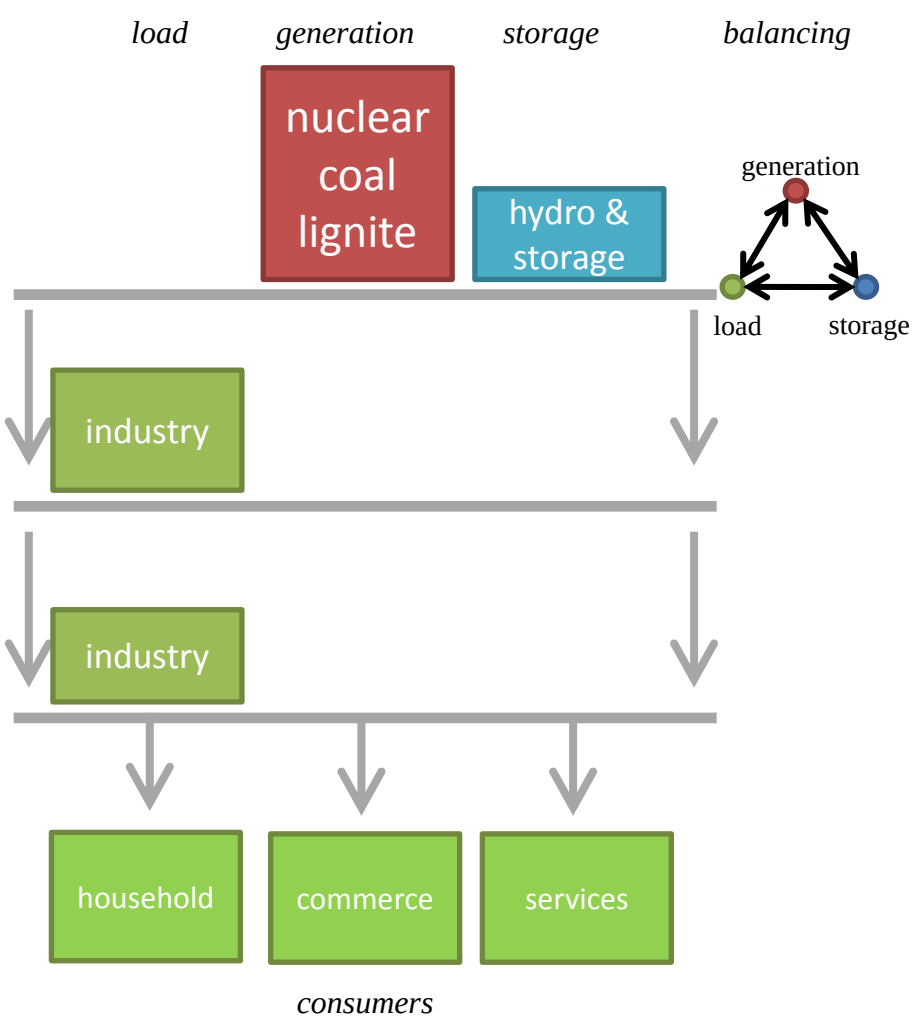
➢ System needs may vary from place to place as the production-consumption mix varies

➢ System responsibility must be decentralised

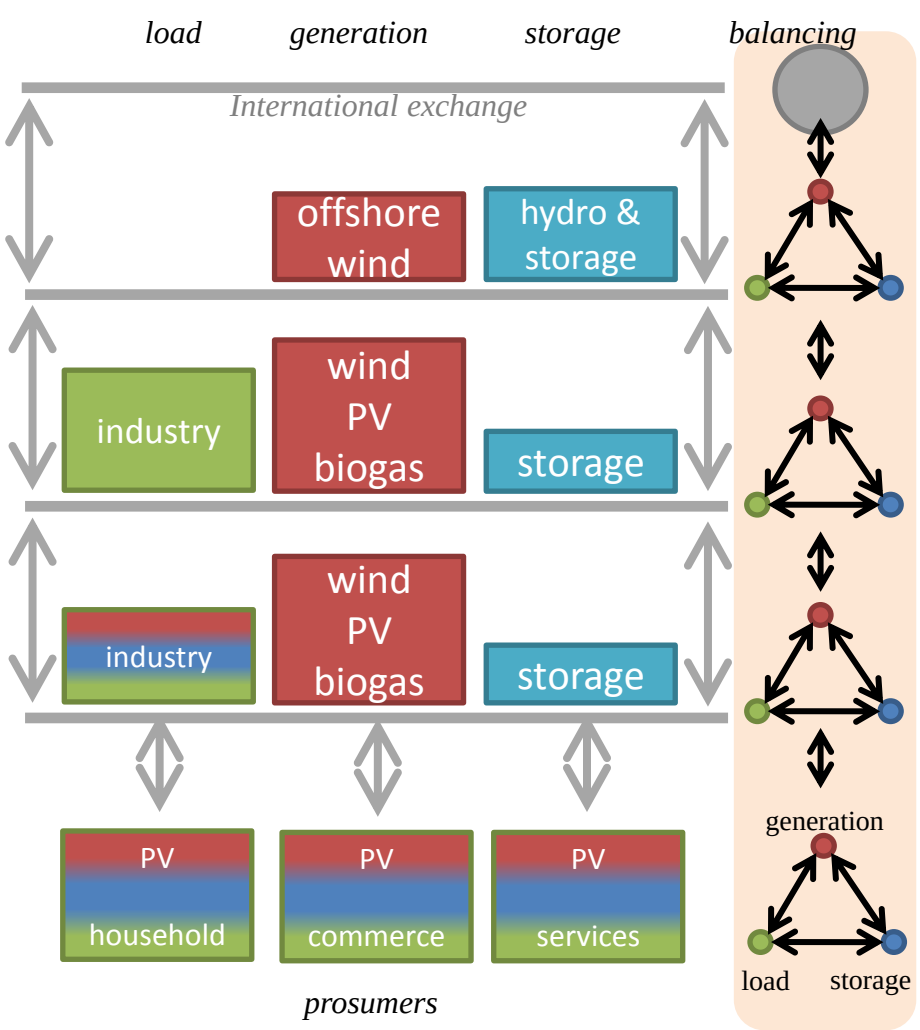
→ **A more differentiated approach in time and space**

→ **We will need local electricity markets**

Top-down supply system
(central control)



Multi-level exchange system
(subsidiarity, shared responsibility)



Navigating through a turbulent transformation period

- Business and government have difficulties with the speed & uncertainties of change, but slowing down the transition towards renewables is no option:
  - rapid growth of emerging markets
  - international technology development
  - danger of catastrophic climate change

- Accept the challenge of competitive distributed power generation:
  - bottom-up logic of the electricity system, principle of subsidiarity
  - responsible system control, intelligent devices & power generation at several levels
- The complex tasks of flexible optimisation at each level will increasingly require the use of market mechanisms
- Integrated energy management at the building level will become particularly interesting as load management becomes important
- Building up the solar value chain takes time: start immediately
- Strive for steady development and reliable frame conditions despite a turbulent environment:
  - create stable sub-systems

The semiconductor revolution is reaching the power business – new strategies needed

- Renewables to take over: after market creation by politics, industrial dynamics and technology innovation now push for change
- semiconductor technologies transform power generation, energy management and the grids at unprecedented speed
- Distributed solar power generation will play an important role
- System competence will become most important at all levels, new players are entering the game
- New business models and adapted regulatory frameworks are urgently needed
- A collective international learning process is needed for managing the transition

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 interest

You will find this presentation and more on my website
www.sustainablestrategies.eu

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

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