Federal Ministry of Economics and Technology

AHK Deutsch-Türkische Industrie- und Handelskammer
Alman-Türk Ticaret ve Sanayi Odası

Energy

Photovoltaics - A Disruptive Technology: Changing Global Markets, Policies, Players and Technology Prospects

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AHK, Istanbul, February 22, 2011

renewables Made in Germany

BSW

sustainable strategies ruggero schleicher-tappeser

eclareon

Urging problems lead to a rapid paradigm change

- Accelerating climate change
- Depleting oil and gas resources
- Increasing energy demand in emerging and developing economies

►A rapid transformation of the energy system is needed

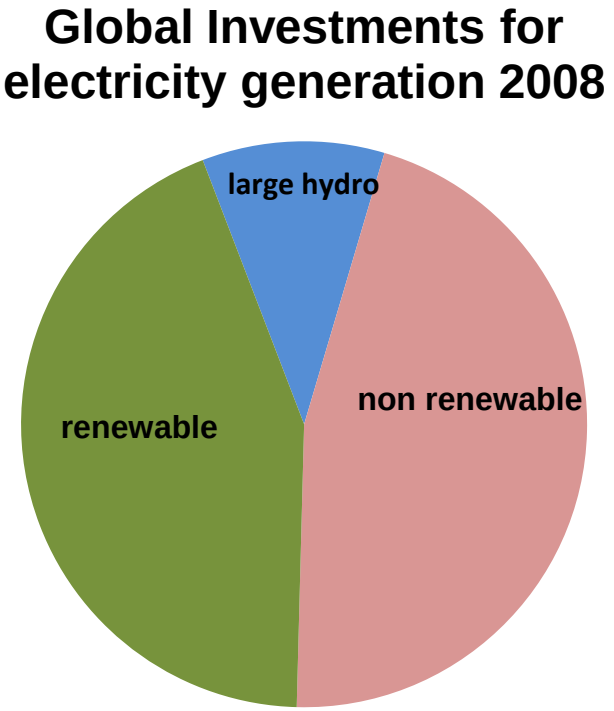
►Governments create markets for new technologies

►New technologies change the energy markets

- PV is the most disruptive of the new technologies:
  - Fastest growth
  - steepest learning curve
  - biggest potential
  - but still small
- Solar Thermal : a still sleeping giant

Dramatic shift in perceptions: Renewable energy – the only way out

- Important investments in renewable electricity generation
  - 2008: US$ 155 bn
  - Four-fold increase since 2004
  - Solar 2008: 49% growth
- High priority in economic recovery programmes
- In 2009 wind capacity in China 12,0 → 25,8 GW

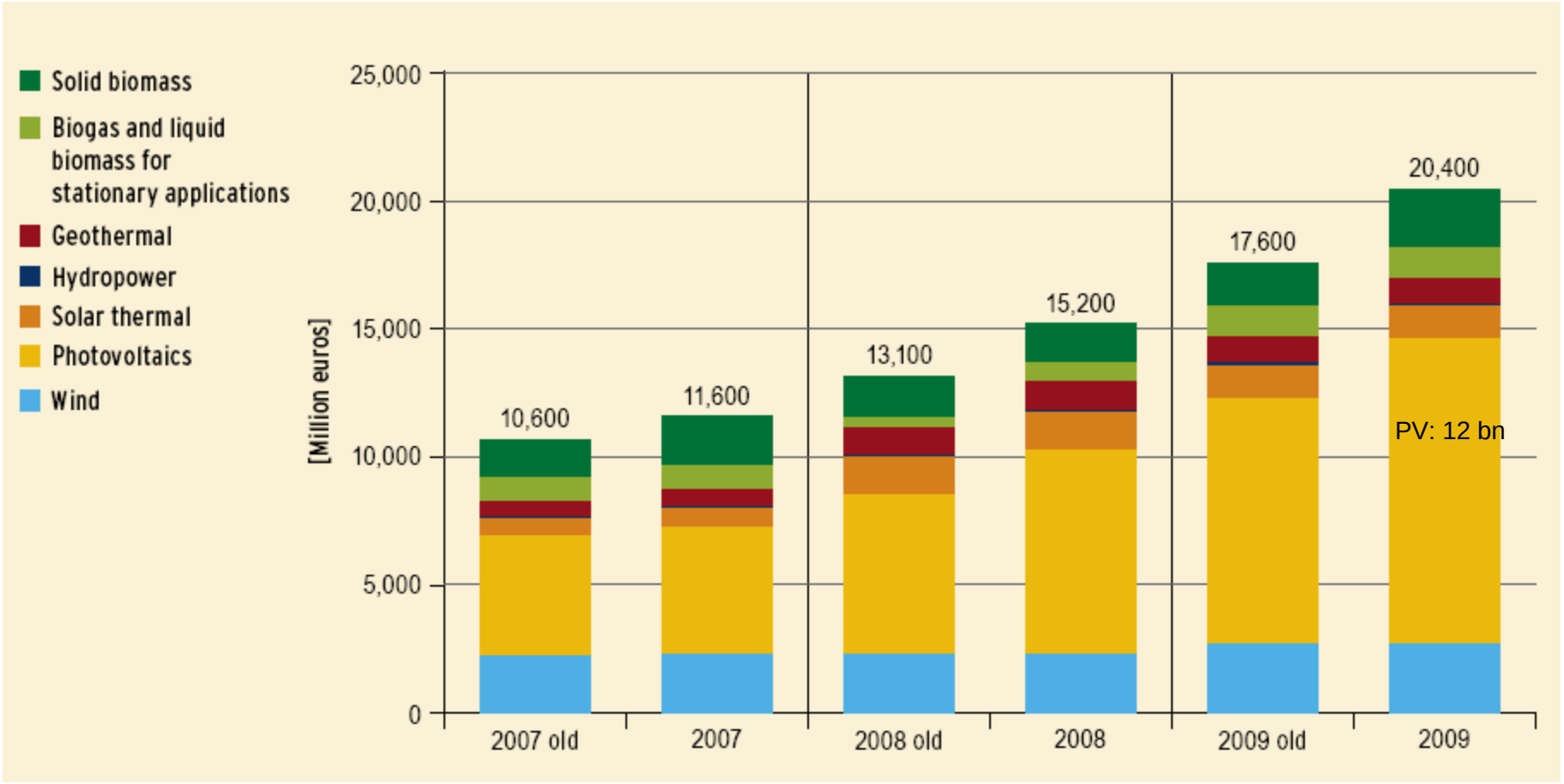


- 145 countries joined the new International Renewable Energy Agency IRENA
- In 2009 Renewable Energy has definitely become a top issue in international industry policy (China, USA, Japan, India, EU)

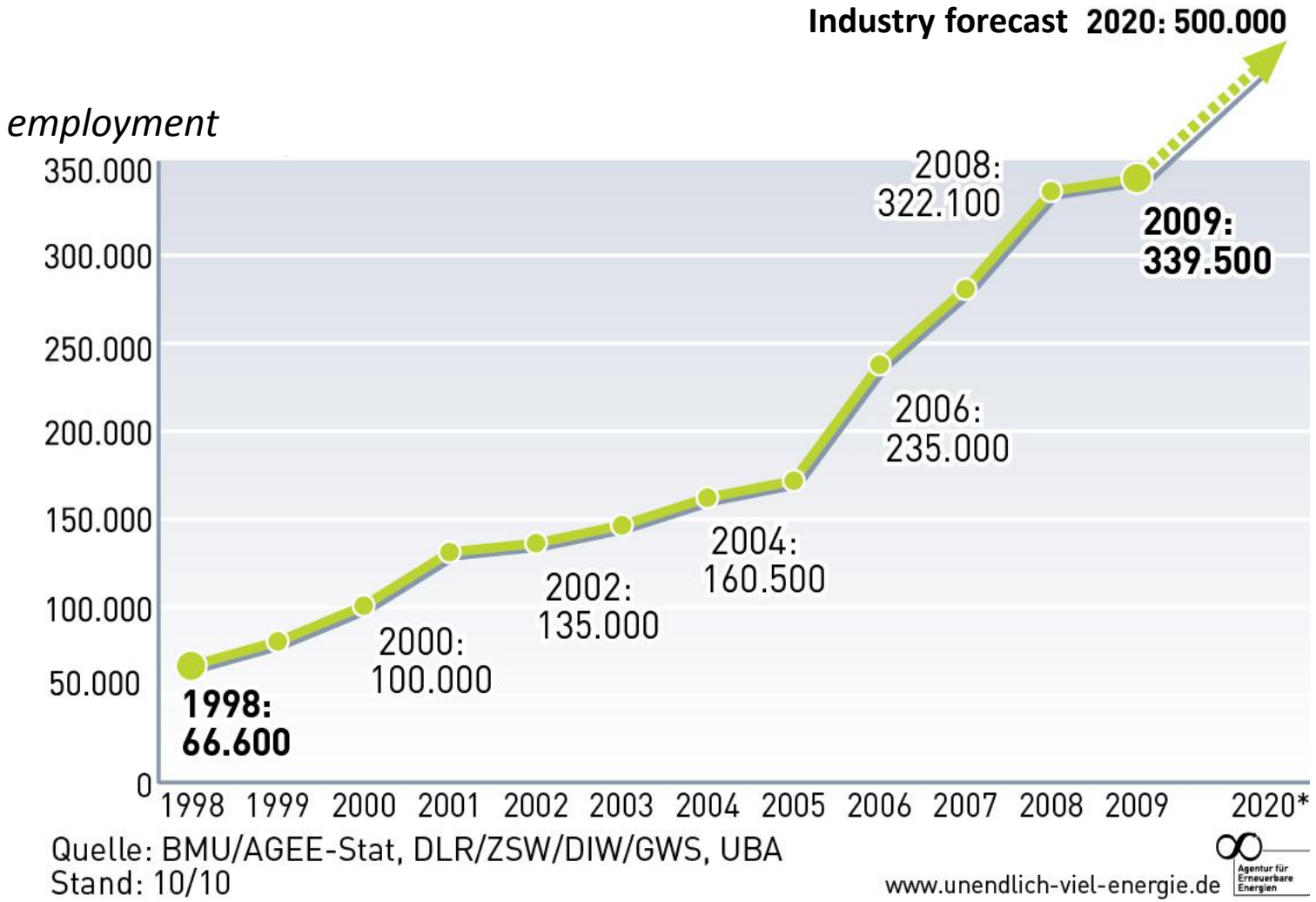
Objectives are getting more ambitious

- EU decision in 2009, compulsory:
  20% renewable energy in Europe 2020
- German RE Industry Association
  2008: 47% renewable electricity in GER 2020
- German environmental minister Röttgen 2010:
  his aim: 100% renewable electricity in GER 2050
- EREC (European RE Industry Association) 2010:
  100% renewable Energy in Europe 2050
- EU Commission Energy scenarios 2010:
  ??? % in Europe 2050

Investments in renewable energy in Germany

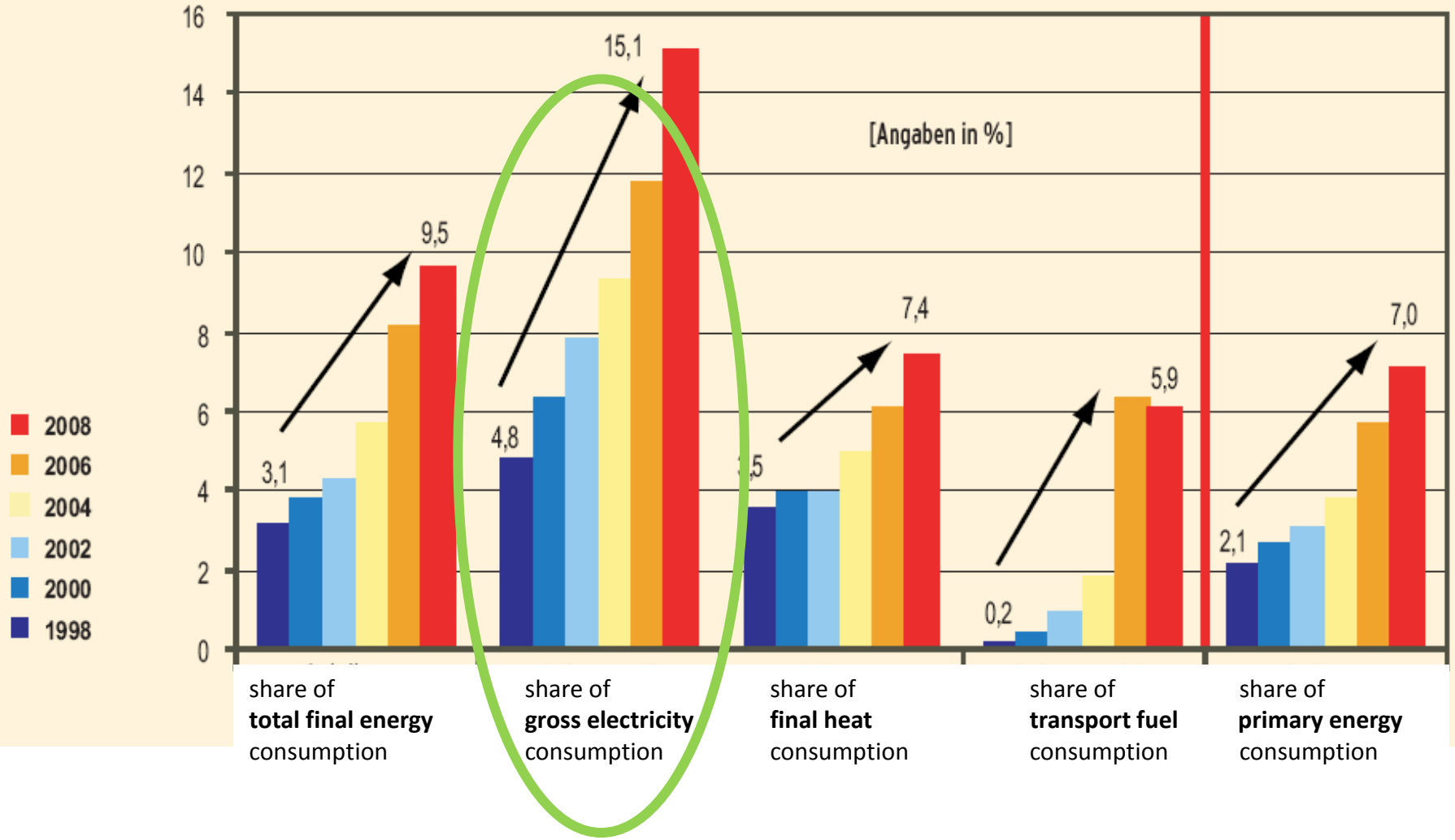


Employment in renewable energies in Germany

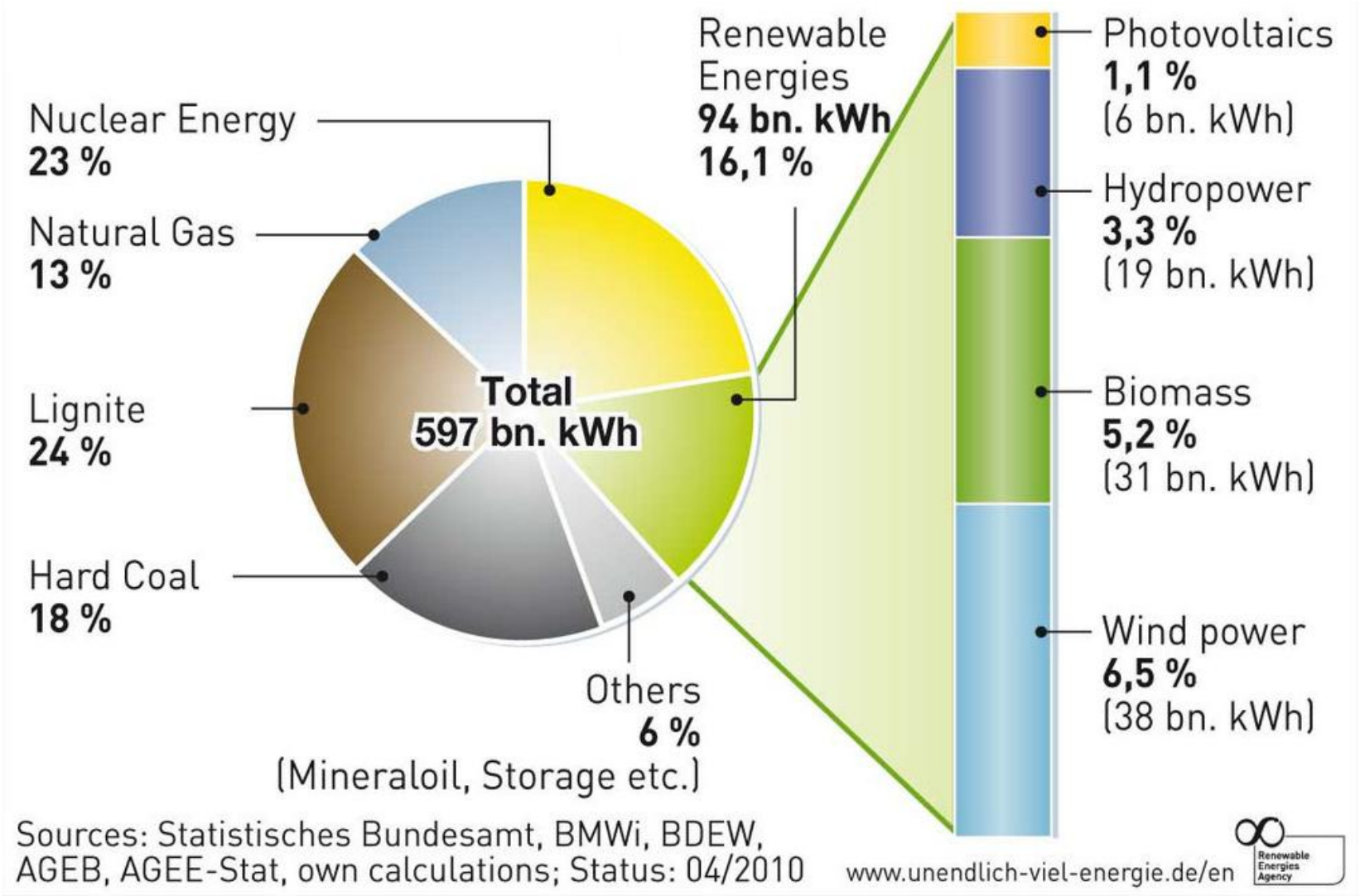


PHOTOVOLTAICS – A DISRUPTIVE SEMICONDUCTOR TECHNOLOGY

Renewable share in final energy consumption in Germany



Electricity production in Germany 2008

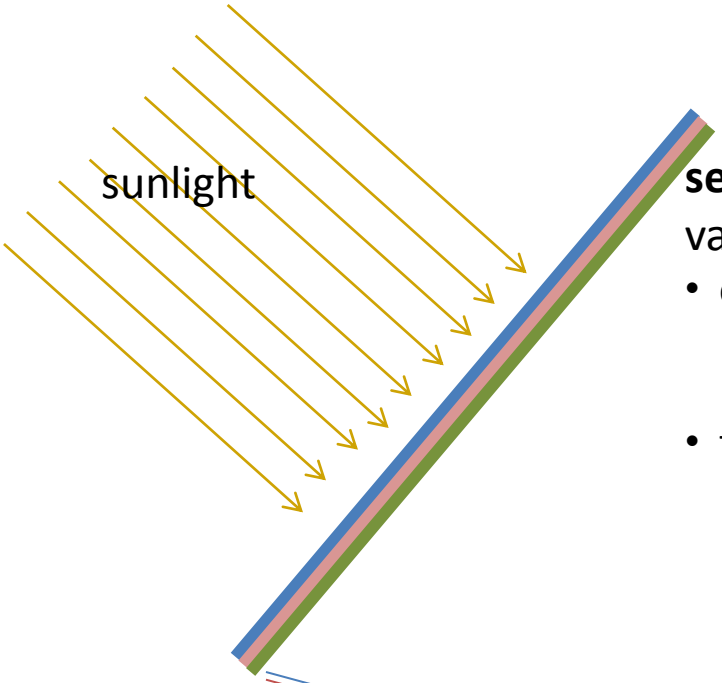


Why promote photovoltaics ?

A method for the production of electricity with exceptional advantages:

- Applicable anywhere in the world
- Applicable at all scales, grid-connected and off-grid
- No problems for the environment
- Costs coming down rapidly, starts become competitive with traditional electricity production
- A practically unlimited potential

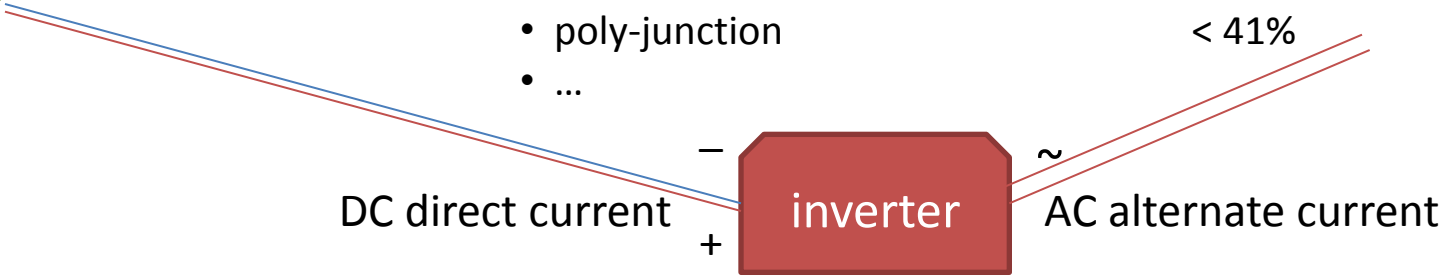
Direct transformation of sunlight into electricity
PV is a Semiconductor technology



several layers of semiconductors

variety of different technologies:

- crystalline silicon c-Si (ingot-wafer)
  - monocristalline < 24% efficiency
  - polycristalline < 20%
- thin-film technologies
  - amorphous Silicon a-Si, also comb. < 12%
  - CdTe Cadmium-Telluride < 16%
  - CIGS, different combinations < 20%
  - GaAs, Gallium-Arsenide < 24%
  - poly-junction < 41%
  - …



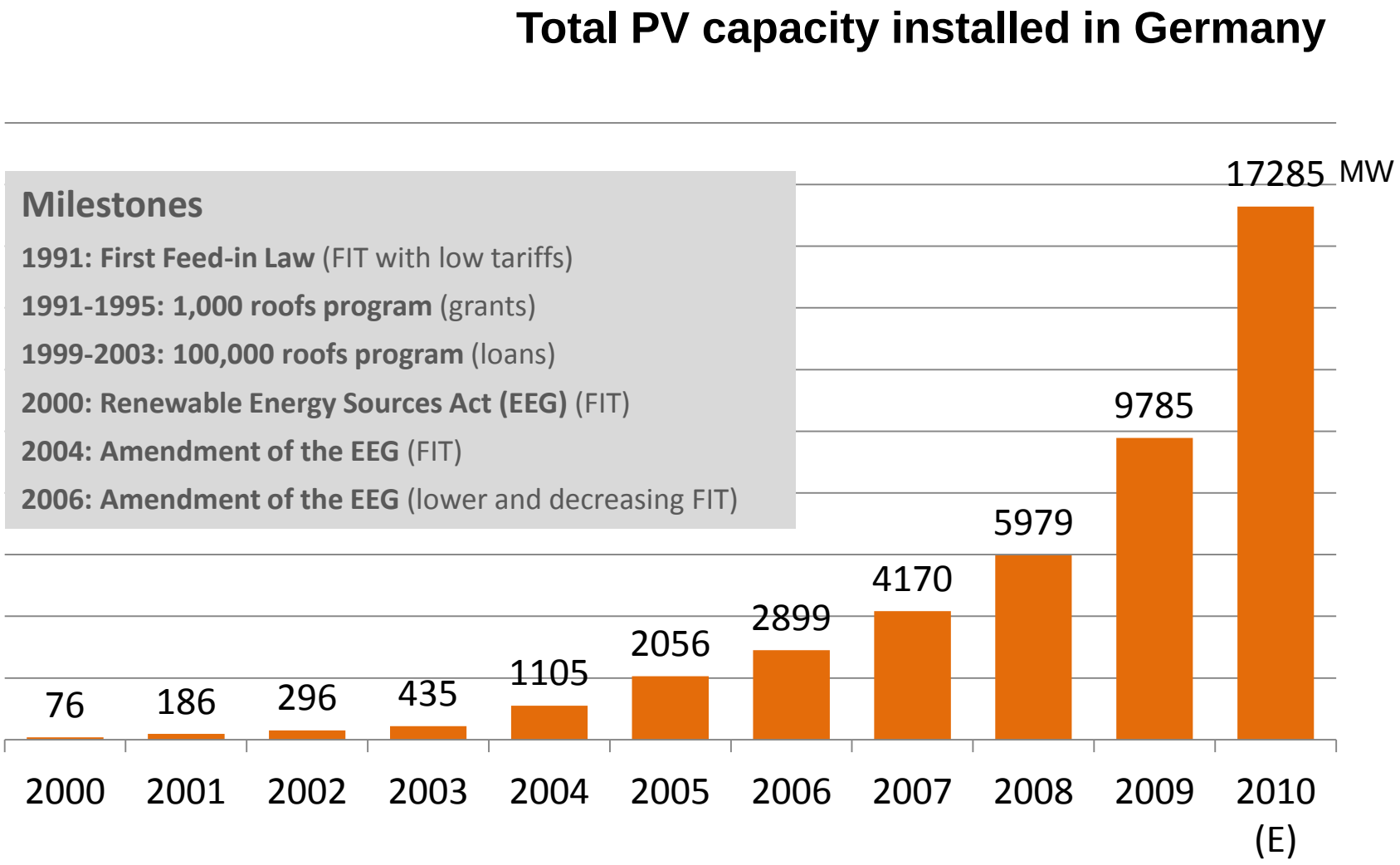
Typical photovoltaic systems

Profitability of PV plants: influencing factors

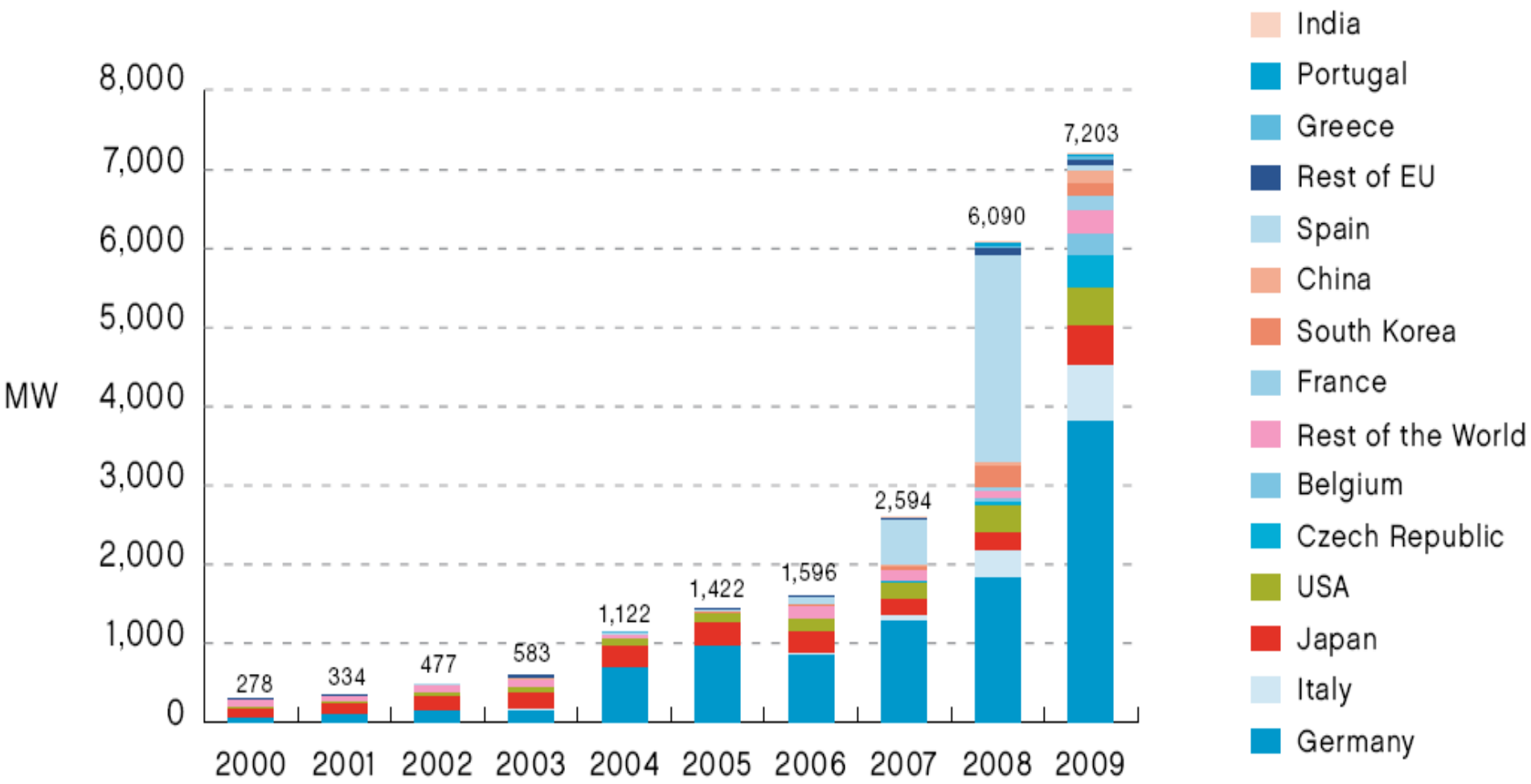
- Costs of the system (modules [ca. 50%], rest of the system, installation): presently ca. 3000€/kWpeak for small systems
- Running costs (ca. 1% p.a.: maintenance, insurance; taxes)
- Electricity yield of the system (location, orientation, quality of the installation)
- Duration of the installation, of the warranty (20-25a)
- Financing, e.g. bank credit: amount / structure / interests
- Cost of alternative electricity supply (grid, off-grid system)
- Feed-in-tariff: amount / duration
- Financial support for investment (taxes, other subsidies)

GROWTH DYNAMICS OF THE PHOTOVOLTAIC MARKET

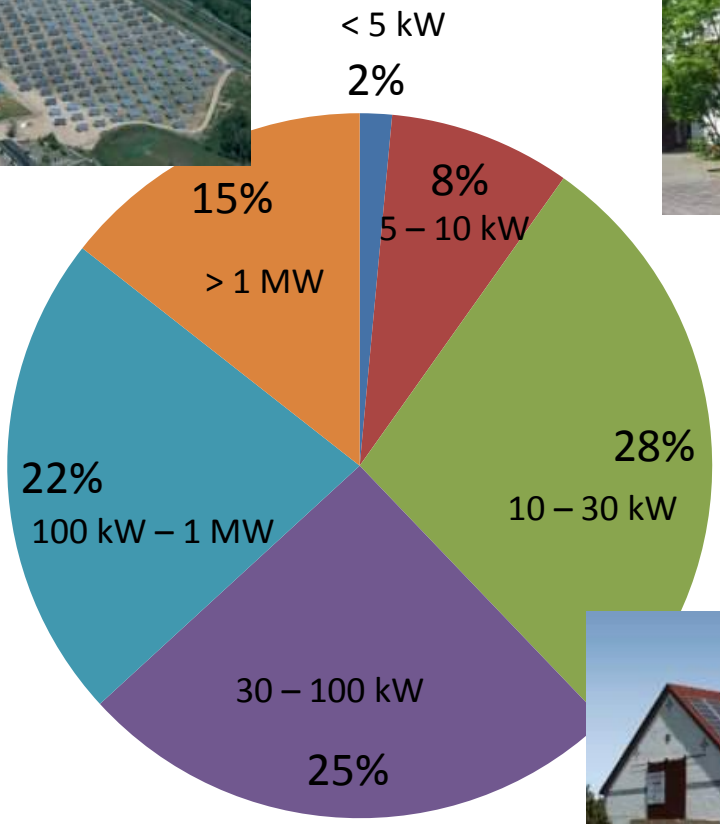
Germany has triggered the take-off of the world PV market



Development of the world photovoltaic market



Market segments in the German PV market: small and medium sizes dominate



Installations
january – september 2010

data: BNetzA 2010

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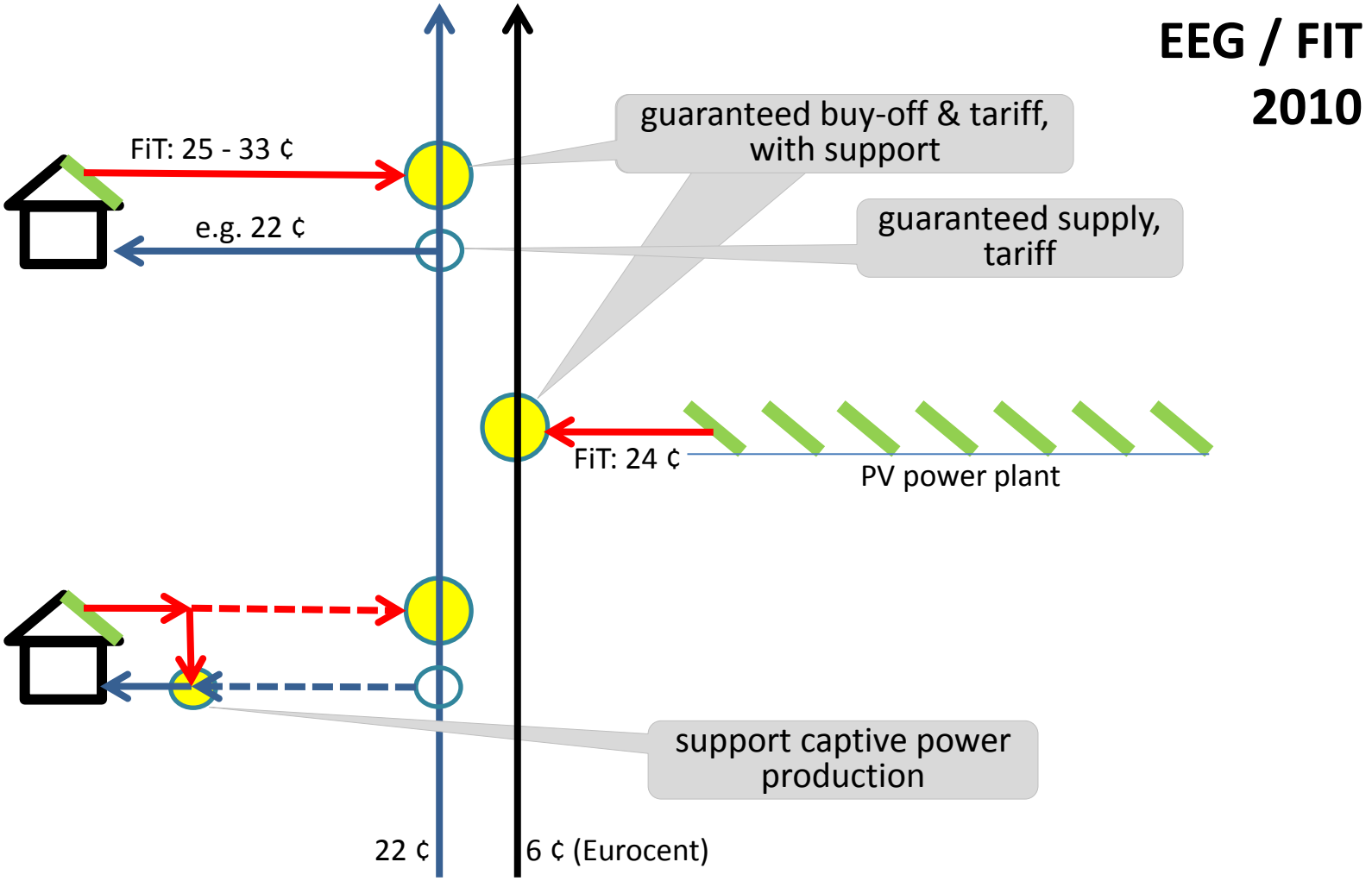
Typical system in Spain (Menorca): 3.2 MWp

Building equilibrated market structures and competencies along the value chain takes time

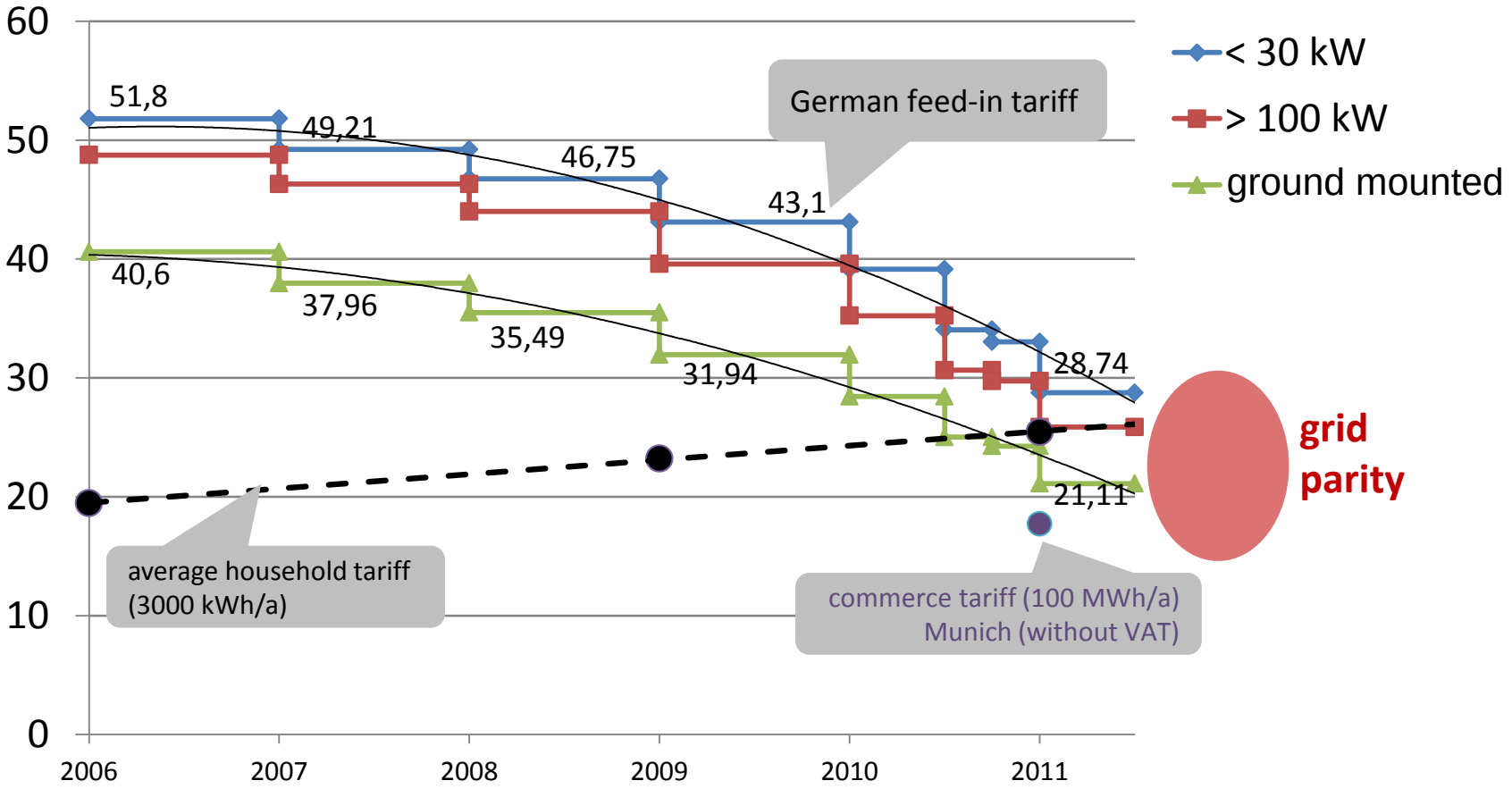
- Equilibrated market structure with many private investors in DE → rather good resistance during the financial crisis
- Long history of the German PV market → established competencies along the whole value creation chain including:
  - research institutes
  - equipment producers
  - banks and investors
  - silicon, cell and module producers
  - system integrators
  - a large number of specialised craftsmen in the construction business
- Building up advocacy groups for renewables that can face established interests in the traditional energy business is essential and takes time

UNEXPECTED SUCCESS OF THE PROMOTION SYSTEM: GRID PARITY IS IMMINENT

The feed-in-tariff system in Germany 2010

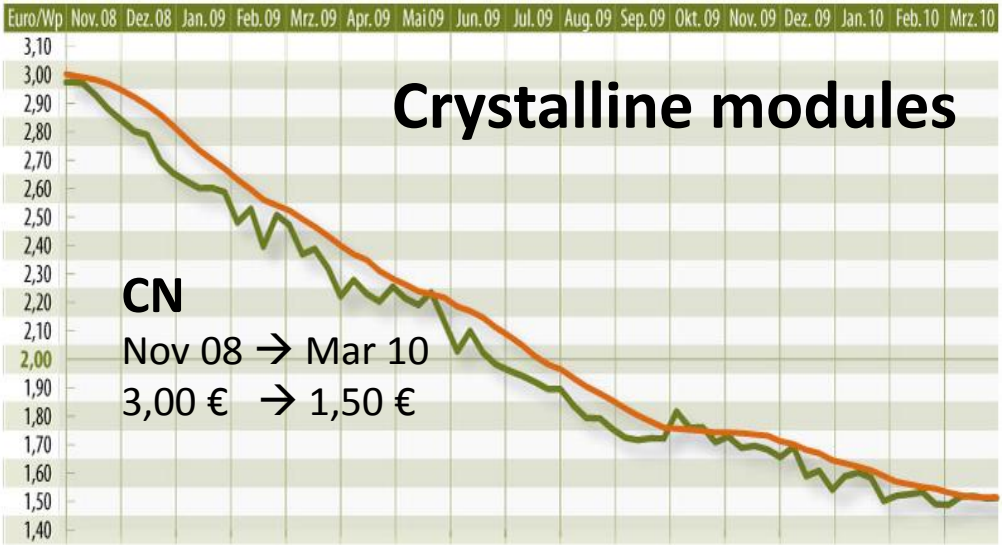


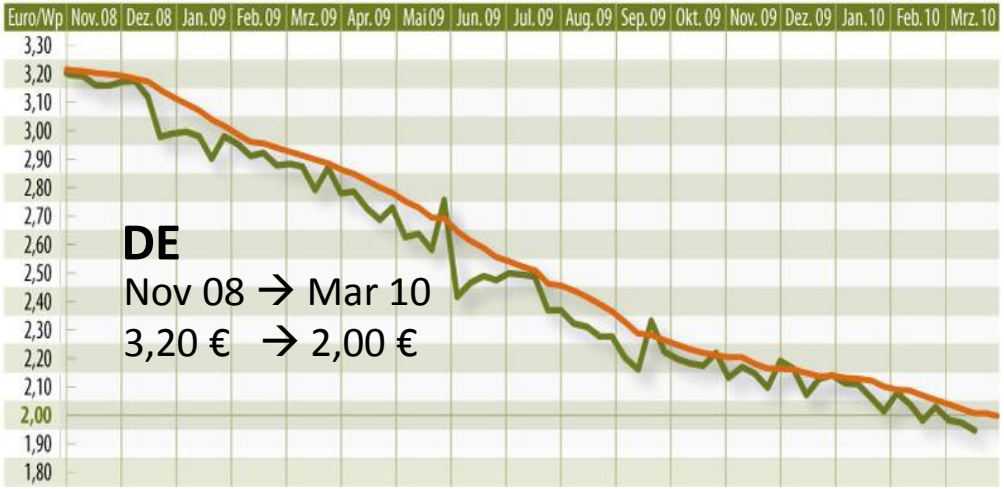
Rapidly decreasing German feed-in-tariffs: grid parity expected for 2012



Sudden rapid price decline has changed world PV markets

- Sudden rapid price decline:
  - Sufficient Si supply after completion of new facilities
  - Breakdown of the Spanish market, credit crunch
  - Massive capacity build-up, key-turn factories
  - Determined Chinese strategy to conquer markets
- Prices do not correspond to lowest available production costs. Lowest module production costs:
  - today: around 1€/Wp
  - end 2010: <0,60 €/Wp

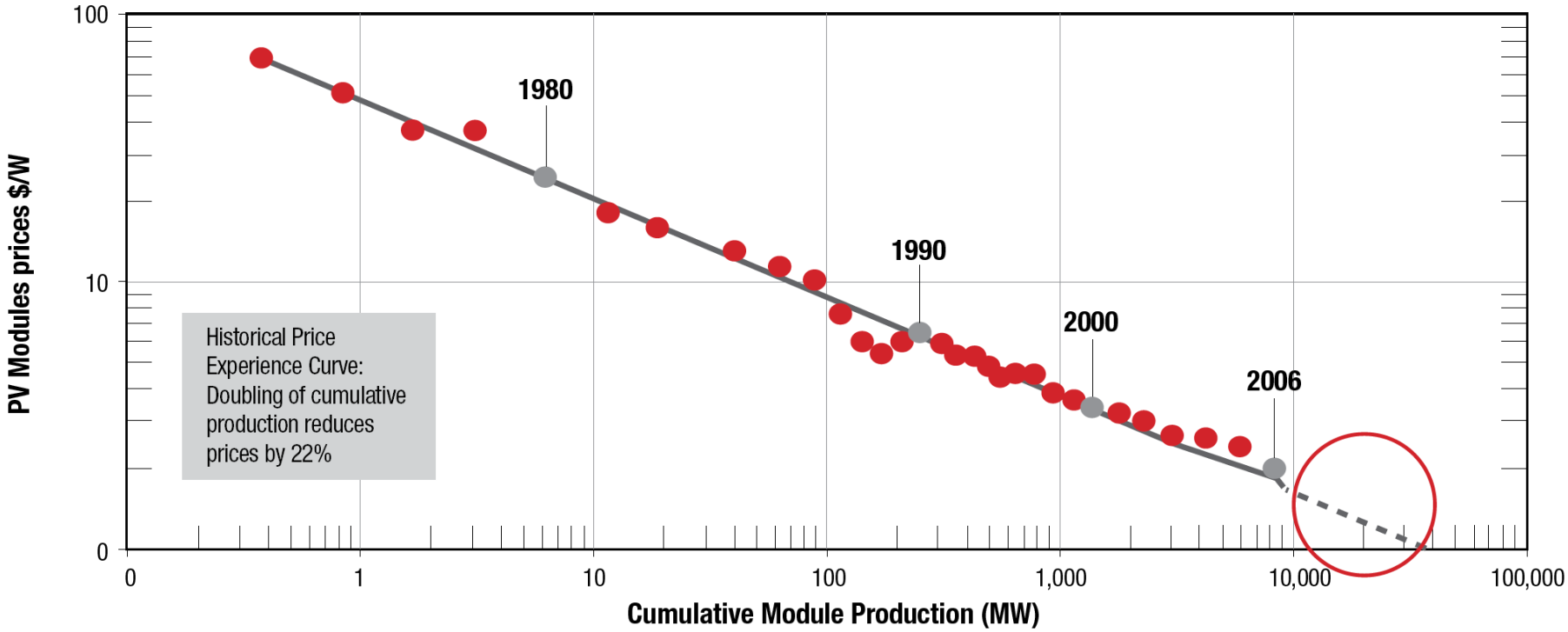




Restructuring of the PV industry

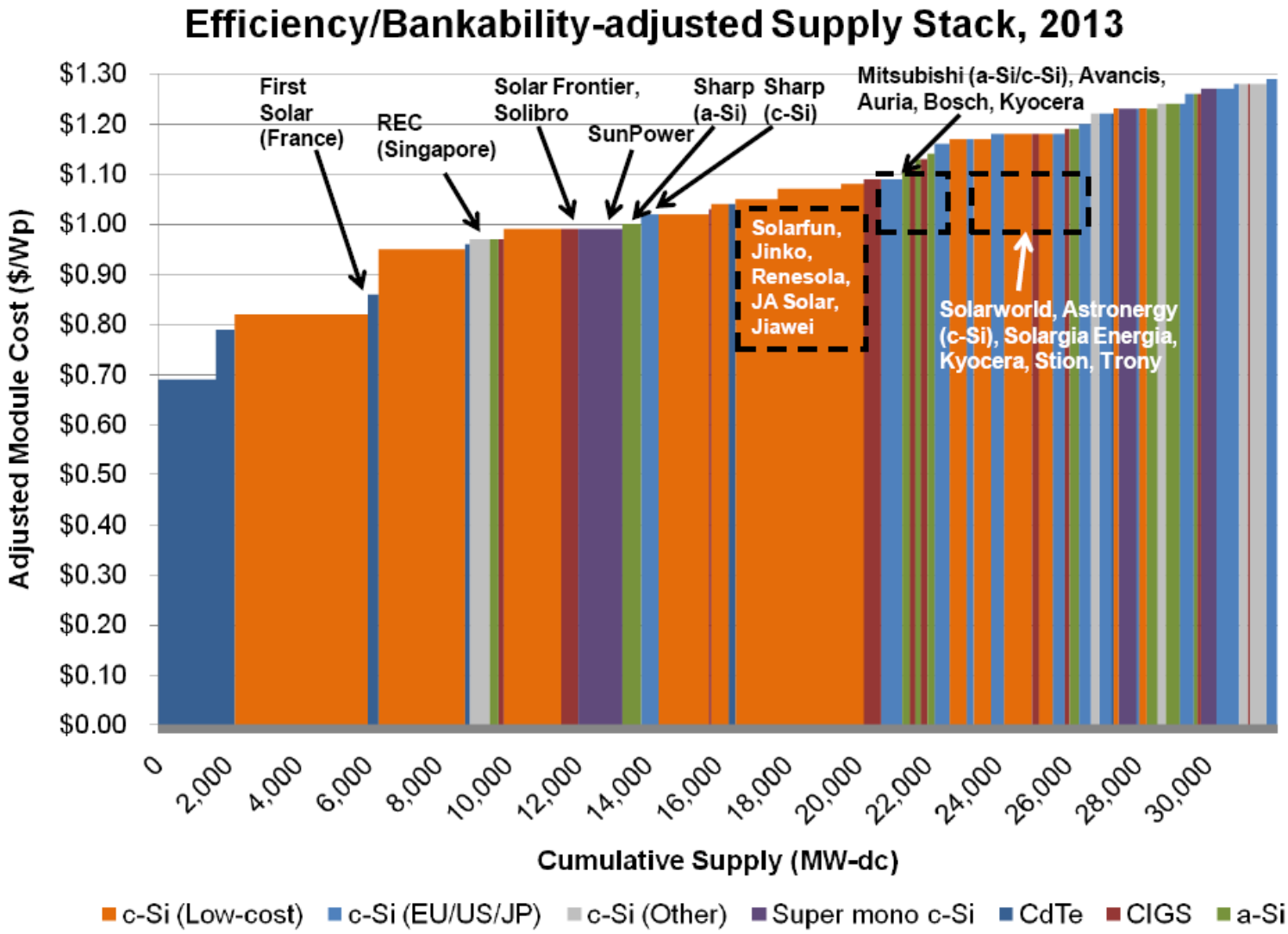
- Strong competition leads to industry shake-out
- Large German companies building up mass production in Asia (Q-Cells, Solon), revise business models
- Increasing importance of larger players with strong capital background (Bosch, Schott, Sharp)
- European equipment suppliers provide integrated solutions and maintain global technological lead
- Larger industrial units require more international cooperation

The PV learning curve

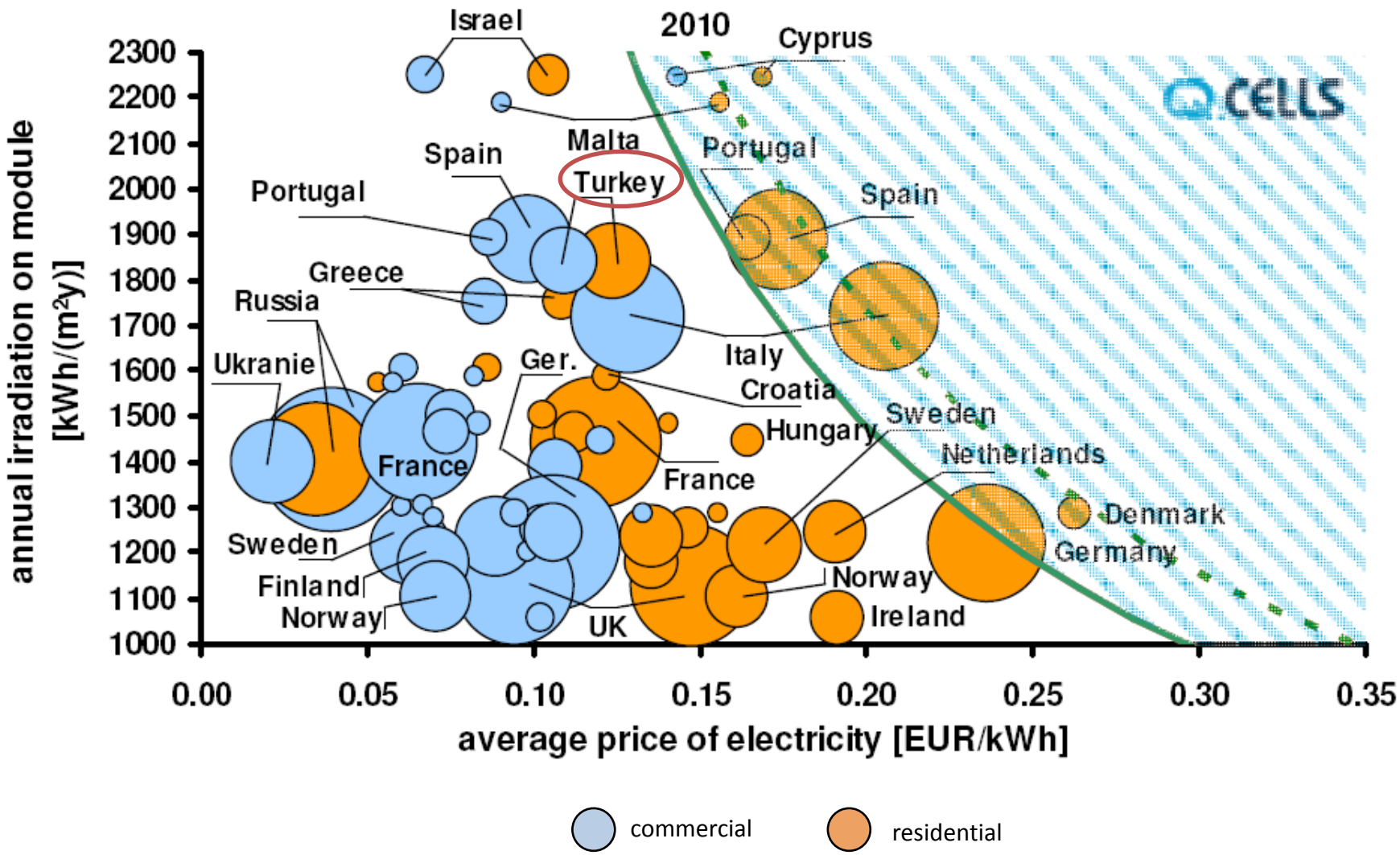


Sources: EU Joint Research Centre - EIA - National Renewable Energy Laboratory - A.T. Kearney analysis.

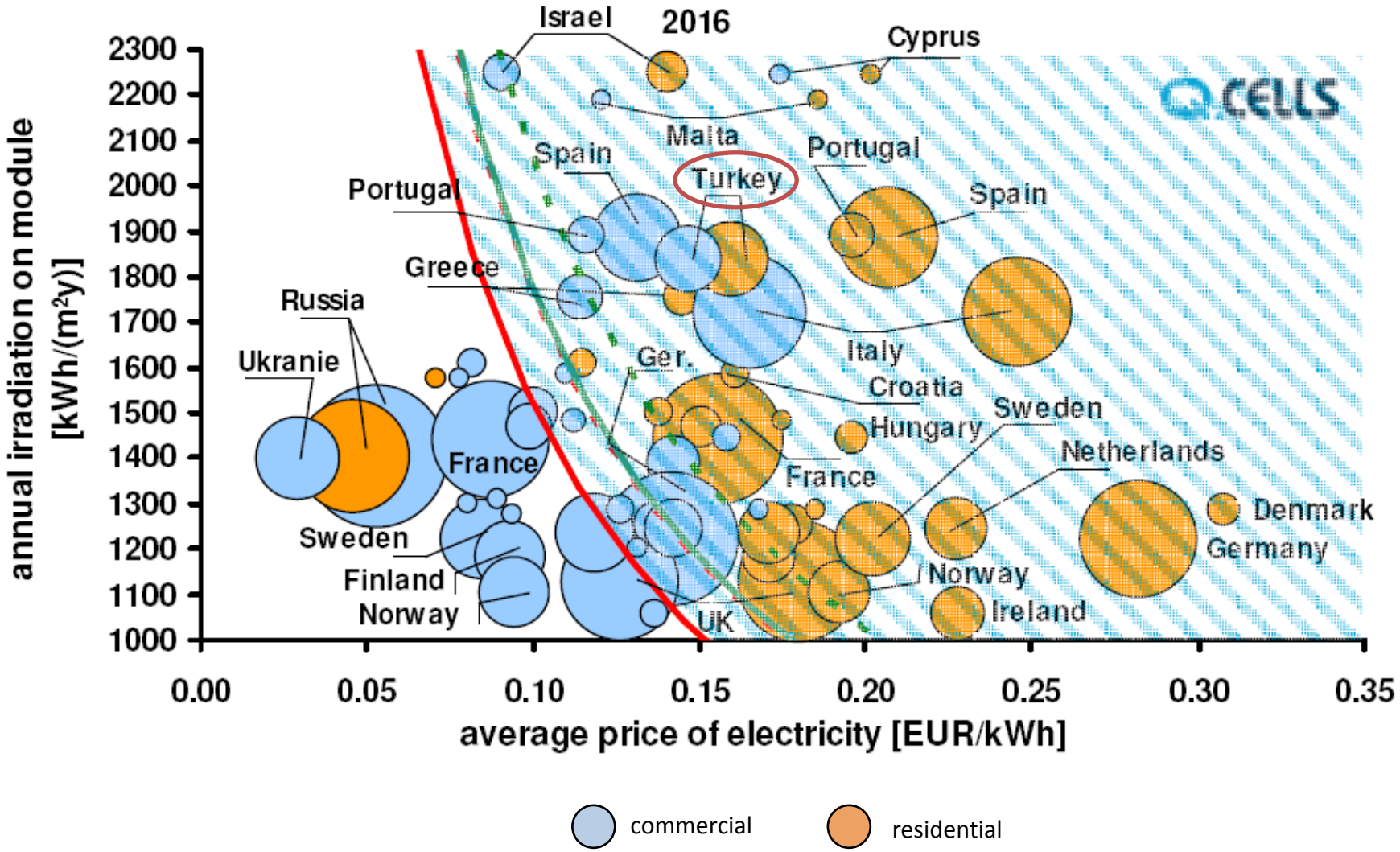
Offer in 2013: costs adjusted for efficiency, bankability



Grid parity in Europe 2010

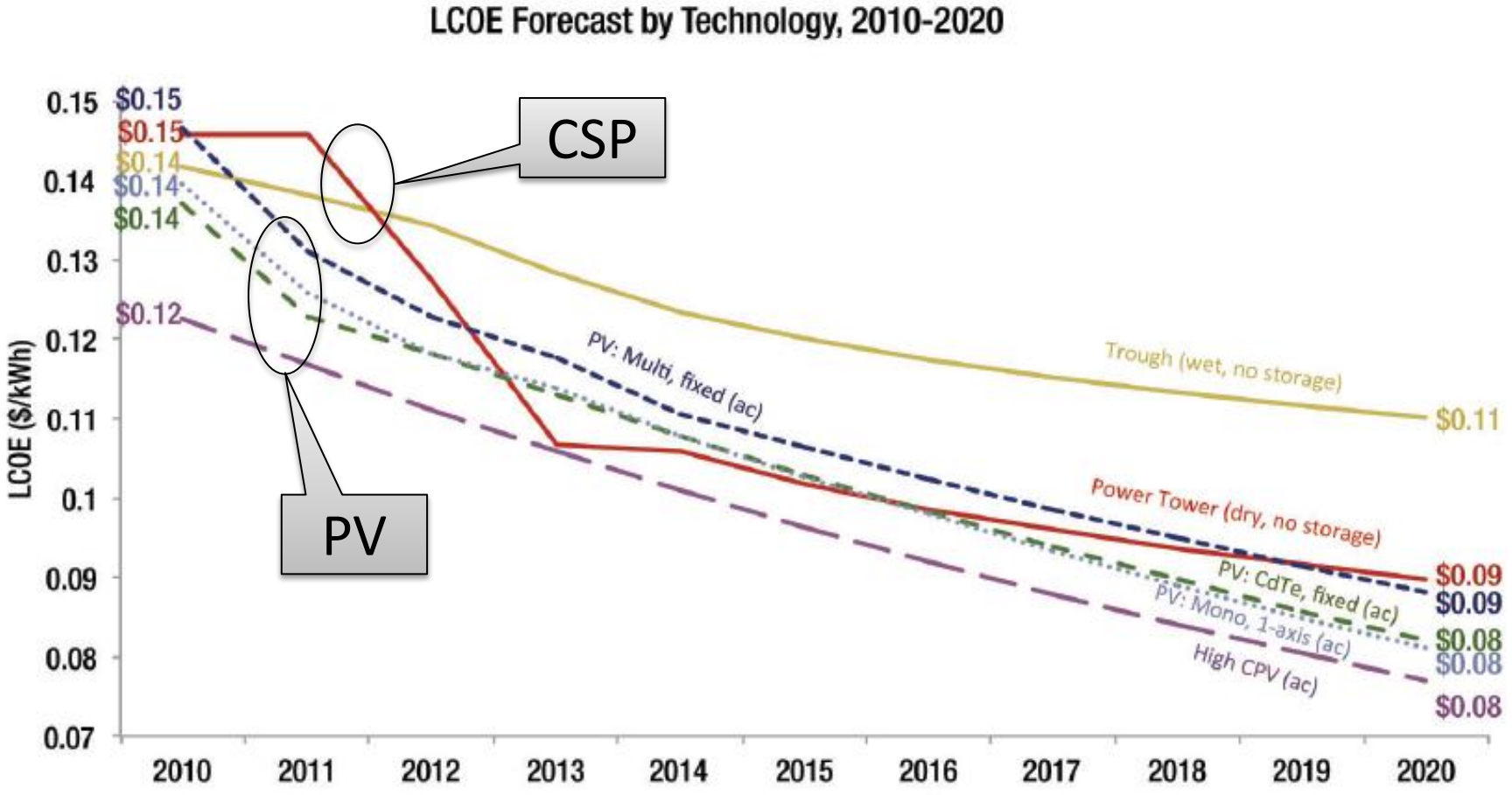


Grid parity in Europe 2016



Bis hier ok

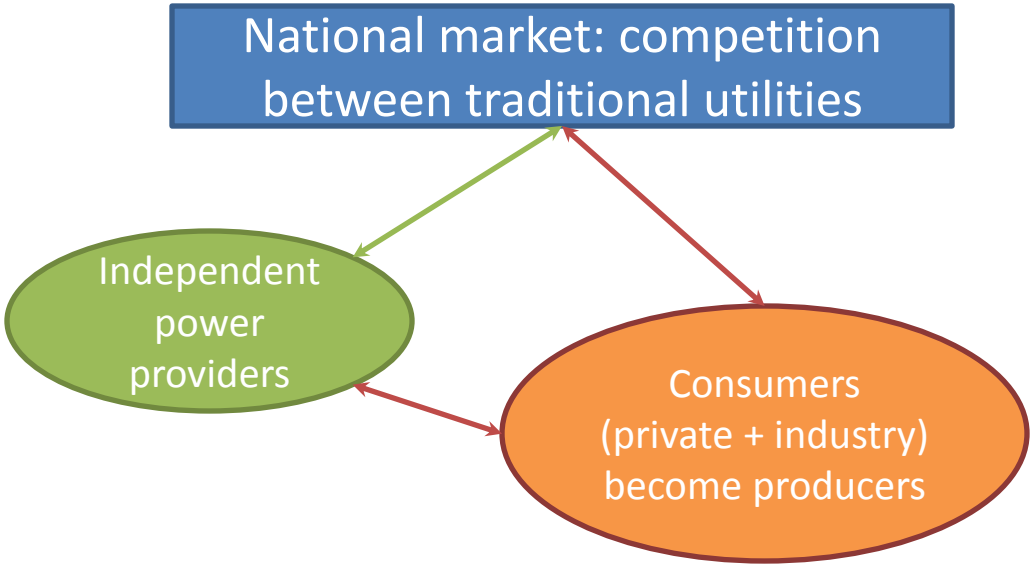
pment of levelised costs of electricity for different technologies



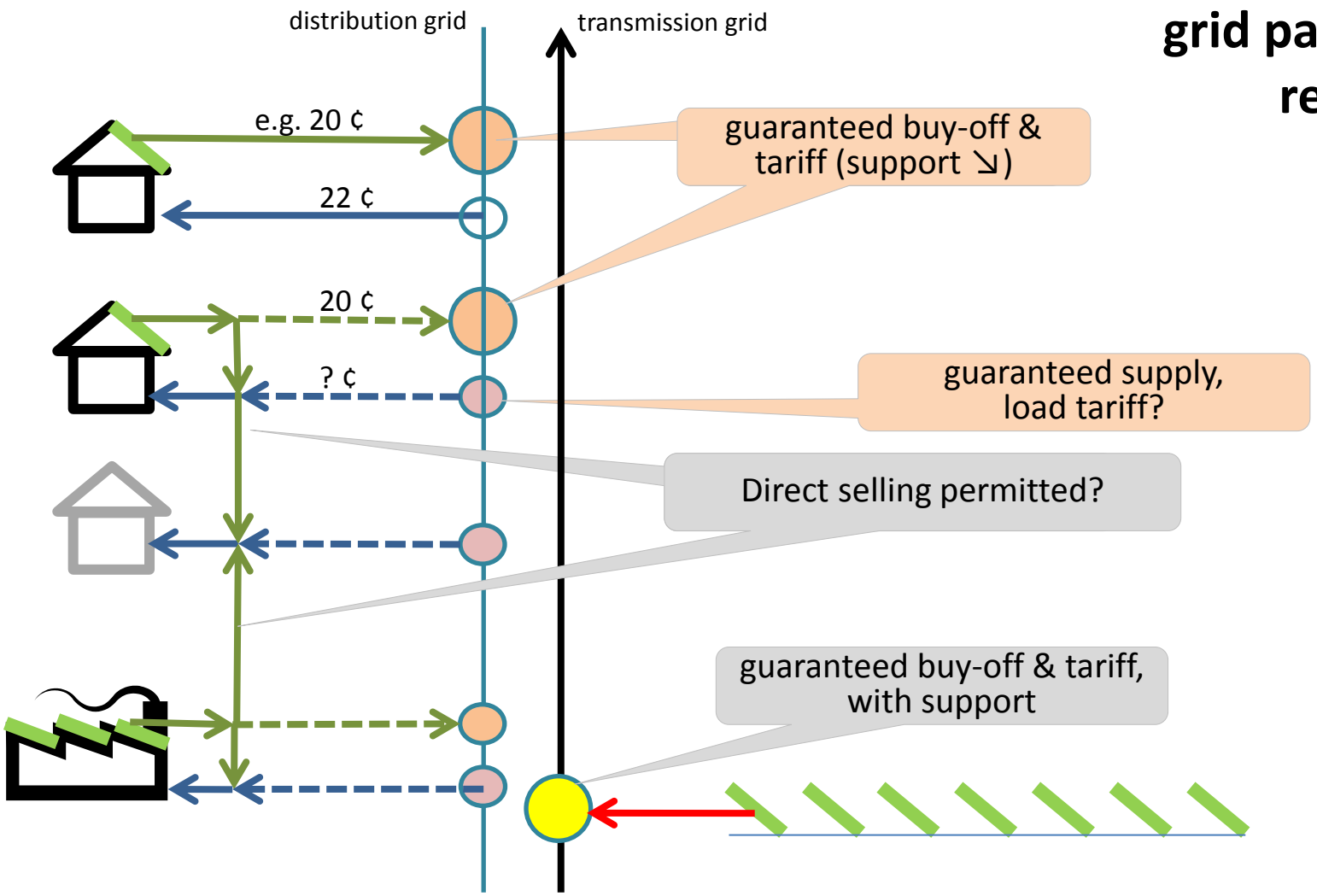
© GTM Research: Concentrating Solar Power 2011

Grid parity for consumers will change the game

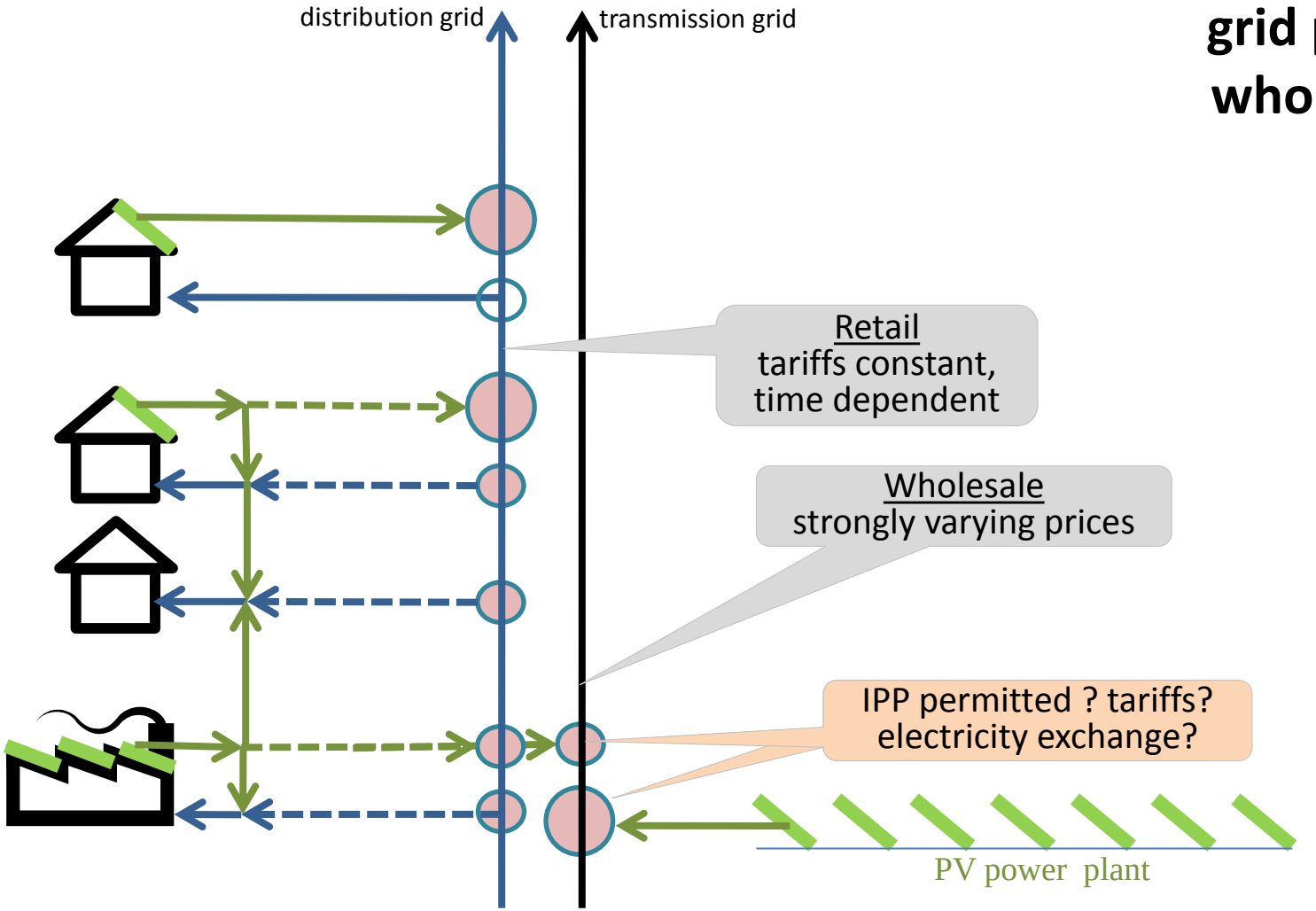
- New technologies provide an alternative at the level of the wall outlet
- A new market at this level will affect traditional utilities and regulation
- Captive power production will increase, the amount of utility provided electricity will decrease



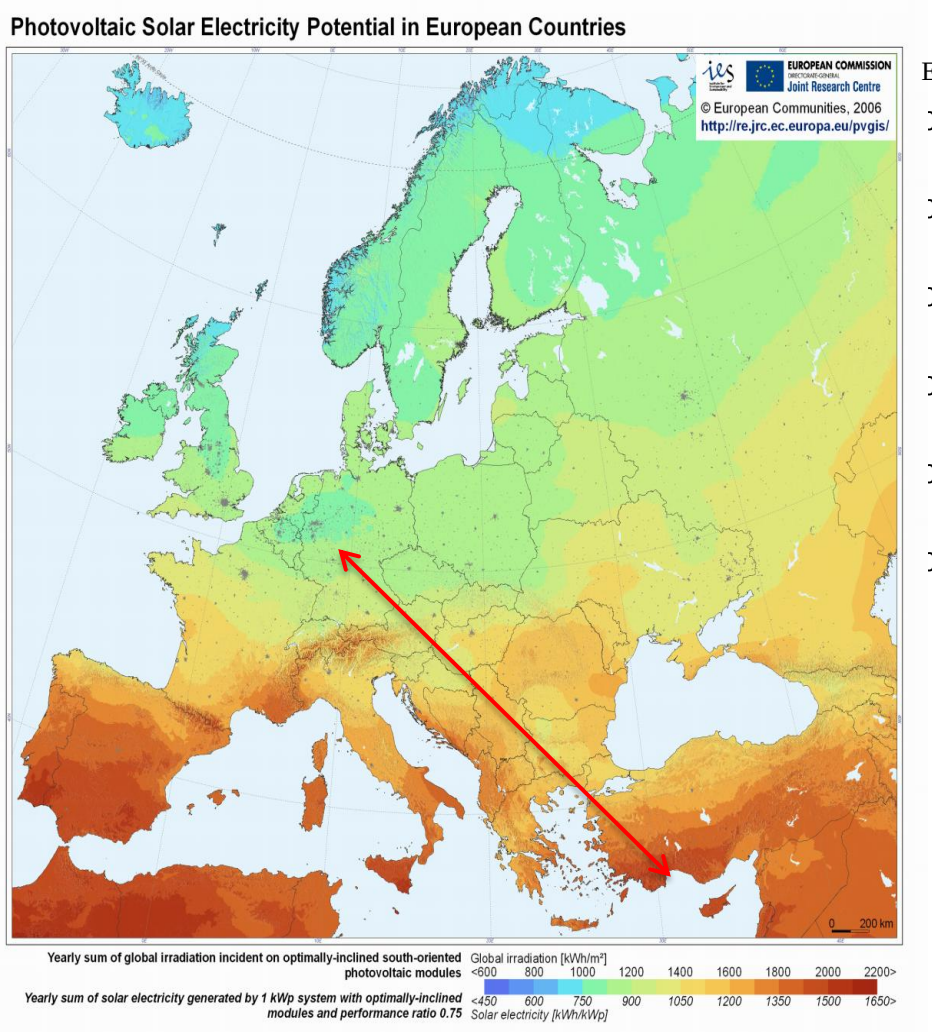
Grid parity retail in markets with support: Regulation and support remain most important

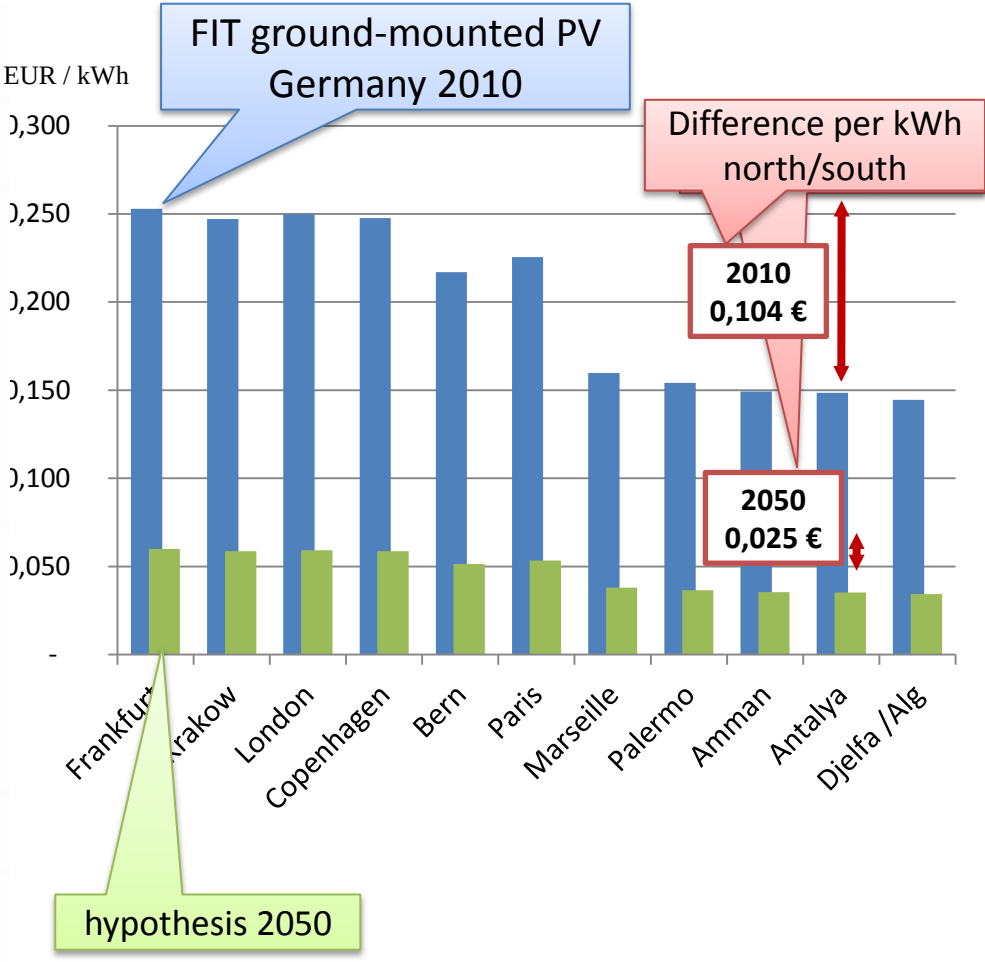


Grid parity wholesale



The influence of differences in solar radiation



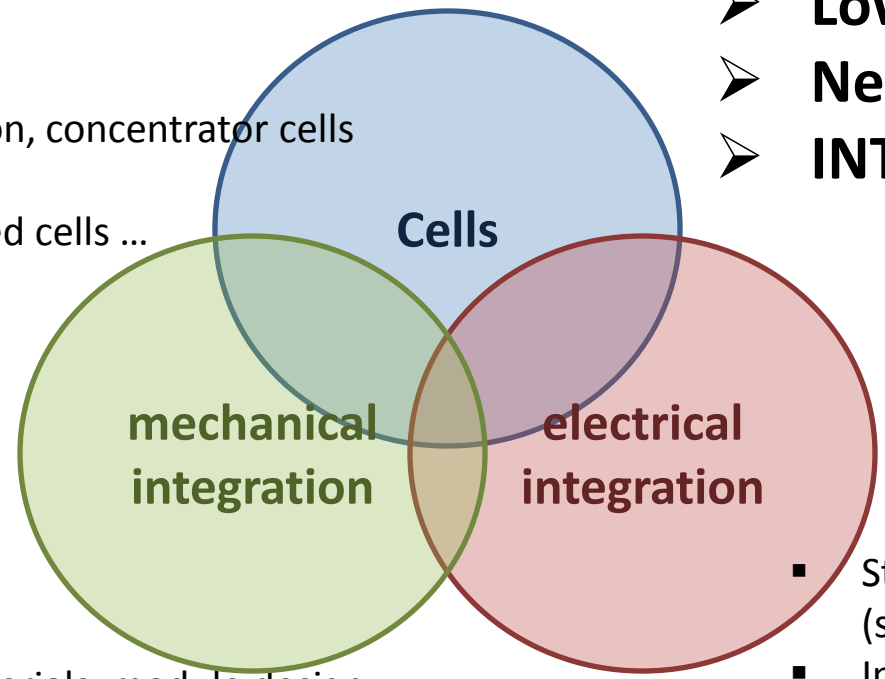


STRONG INNOVATION ALLOWS FOR SUSTAINED GROWTH

Innovations in PV development: a large variety guarantees considerable 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
- 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

Building Integrated PV (BIPV)

- Whole roofs as a first step
- Other components of the building shell require more sophisticated solutions / integration with
  - standard building components
  - planning and building processes
  - construction industry
- Very high potential but little commercial progress in the last years
- New opportunities with thin film products

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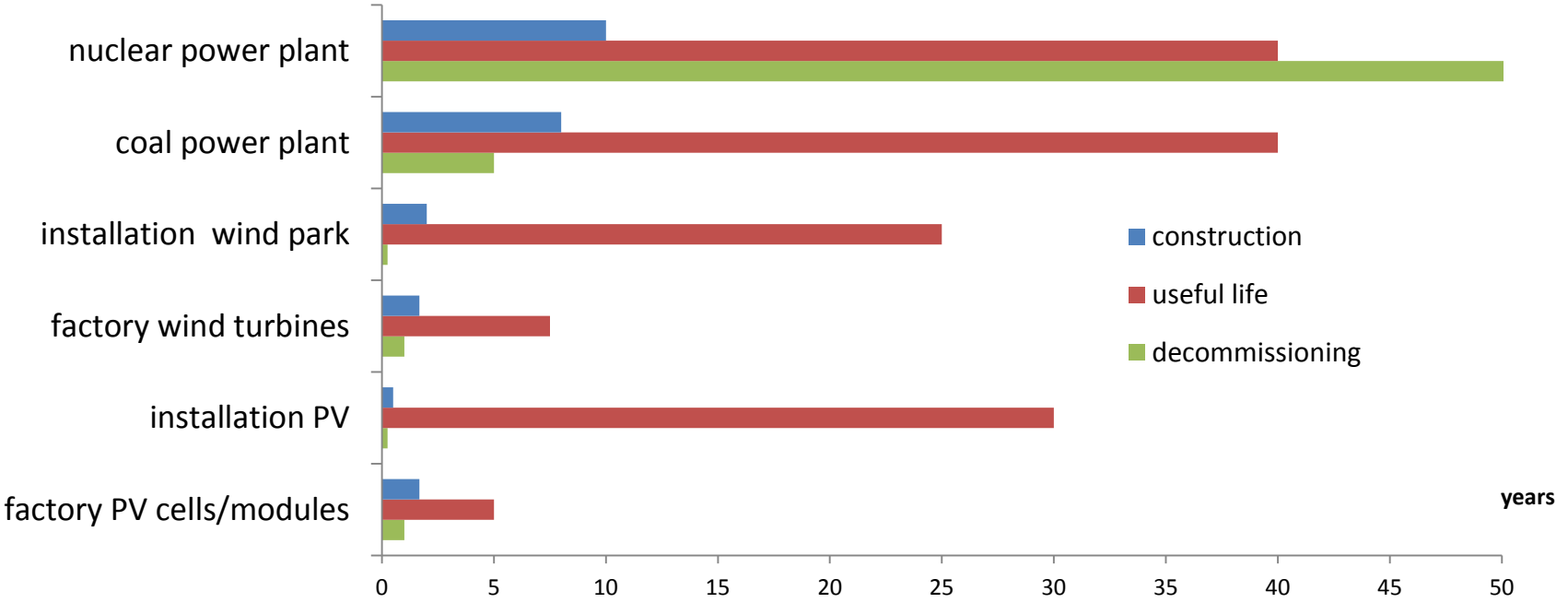
Construction times / Innovation cycles

Radical acceleration of the rhythm of change compared to traditional energy technologies:

→ More rapid build-up of capacities

→ More rapid decrease of costs

→ More rapid transformation of the electricity sector

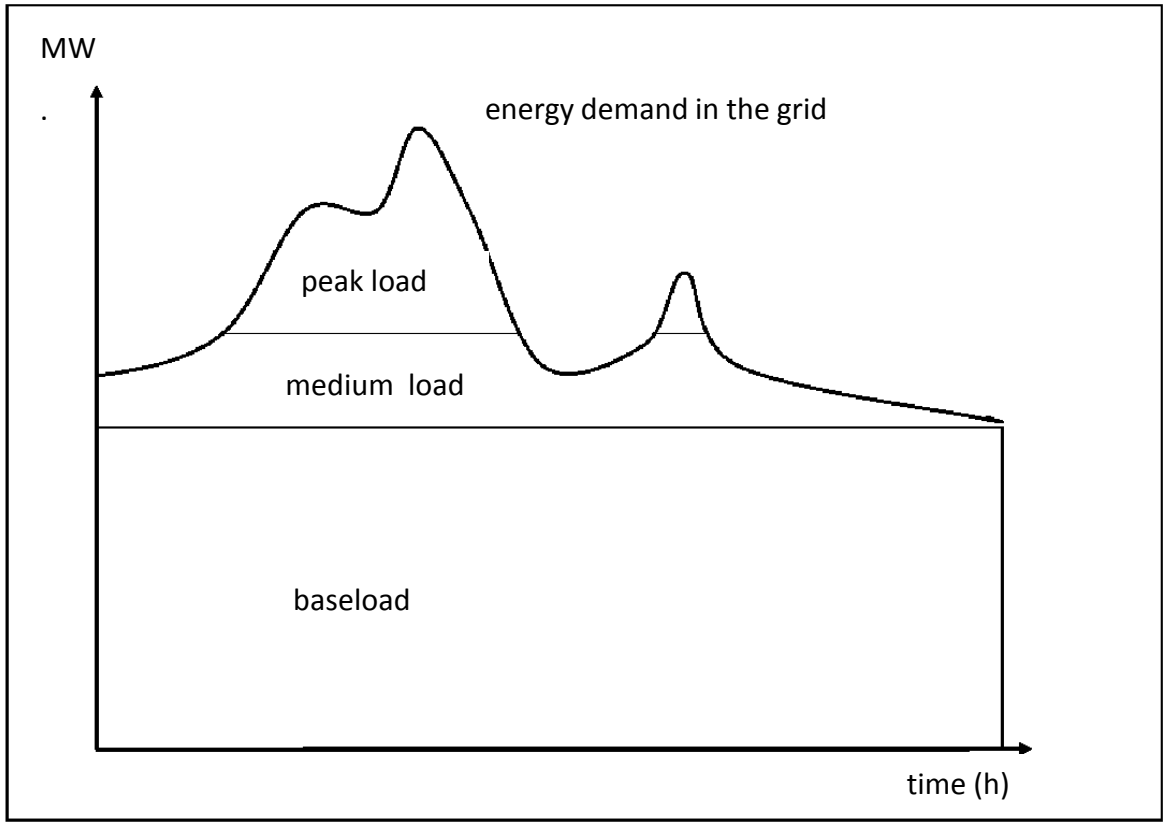


Electricity from renewable energy sources: Scaling-up times

- Industry can maintain growth rates of over 30%
- Growth is not limited by natural potentials and resources
- To ensure a rapid, continuous growth is a considerable challenge for politics and regulators
- Decisive is the rapid integration of a high share of fluctuating power production

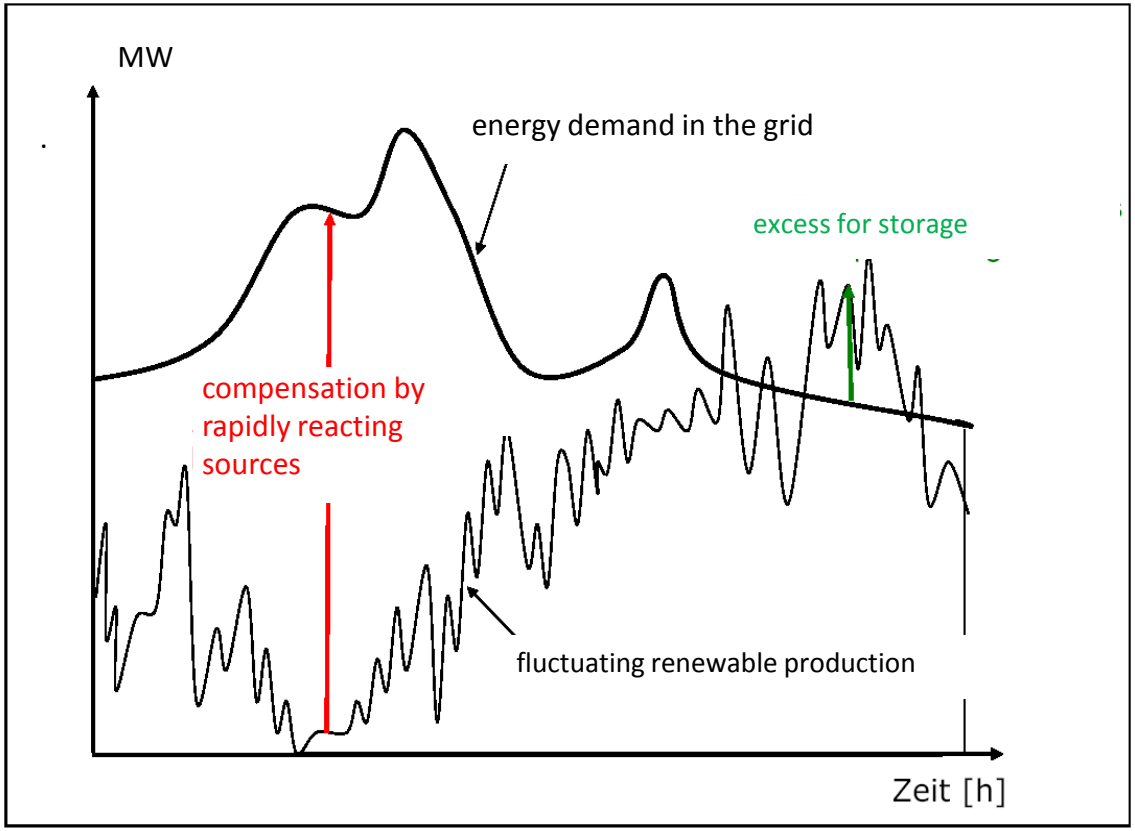
The old base load concept

- cheap baseload electricity from large plants
- expensive peakload 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 BIG CHALLENGE:
THE COMPLETE TRANSFORMATION OF THE ENERGY SYSTEM

Strategies for the Transition – a huge task

- 100% renewable energy in Europe 2050 for electricity, heat and transport is necessary and possible – McKinsey study for ECF confirms economic viability for the electricity sector
- After market creation by politics, industrial dynamics and technology innovation now push for change
- After the breakthrough of wind energy, PV breakthrough with grid parity is only three years away
- New players are entering the game, local and European levels become more important
- New business models and adapted regulatory frameworks are urgently needed – resistance by traditional structures risks to end in losses or decline
- A collective international learning process is needed for managing the transition

CHALLENGES
for the industry

- To develop new knowledge and capacities in preparation for a coming boom in photovoltaics
- To cooperate internationally while creating local added value considering all steps of the value chain
- To cooperate along the value chain: finding innovative and strong partners
- To cooperate with the administration for developing efficient regulation, appropriate support and simple procedures
- To develop competencies and alliances for system integration
  - Integration into buildings, vehicles, structures, construction processes
  - Integration into energy systems
    (buildings, production processes, smart grids, coupling with heat …)
- To develop new business models, e.g. for captive power generation

CHALLENGES
for the utilities

- To integrate
  - a large and increasing share of fluctuating electricity production
  - new actors in a more complex market for energy services
- To develop new roles for different parts of the classical utility
- To develop new business models, cooperating with a wide range of different actors in the market
- To accept the challenge of developing an integrated management of energy production and consumption
- Support clients in developing integrated energy management
- To develop more intelligent systems: smart grids, smart controls
- To push forward the transformation of the control logic of the system and prepare staff to work with a new paradigm

CHALLENGES
for government and administration

- To develop a vision for the energy system of the future:
  - Rapid substitution of hydrocarbons by renewables:
    endless resources at declining prices
  - fluctuating electricity production changes system logic
  - local value added instead of imports: creation of employment and wealth
  - distributed power production changes the power supply paradigm:
    grid topology, ownership, management requirements …
- To create stable investment conditions for new actors in the market
- To ensure strong and steady market growth – low entrance barriers, decreasing subsidies
- Ensure an appropriate reliable infrastructure at the service of all actors
- Ensure acceptable electricity prices for consumers
- Encourage innovation

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