Federal Ministry of Economics and Technology

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sustainable strategies

Energy

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

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AHK, Skopje, April 27, 2010

renewables Made in Germany

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

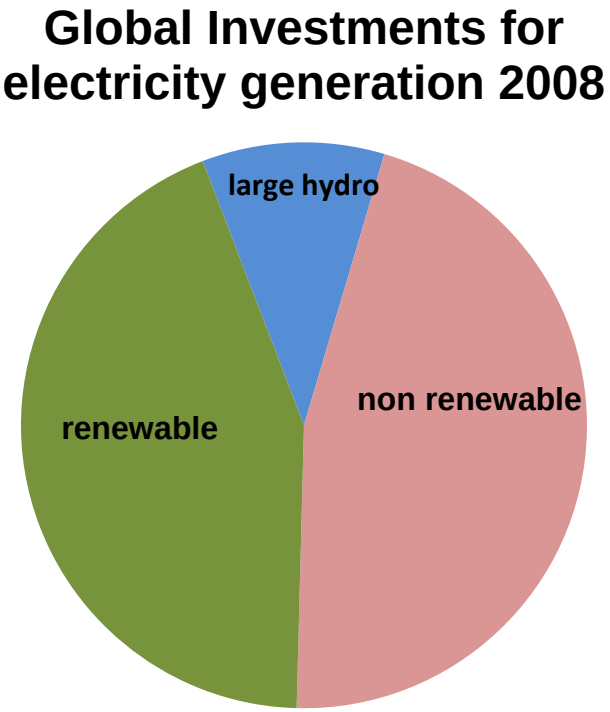
►Governments create markets for new technologies

►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

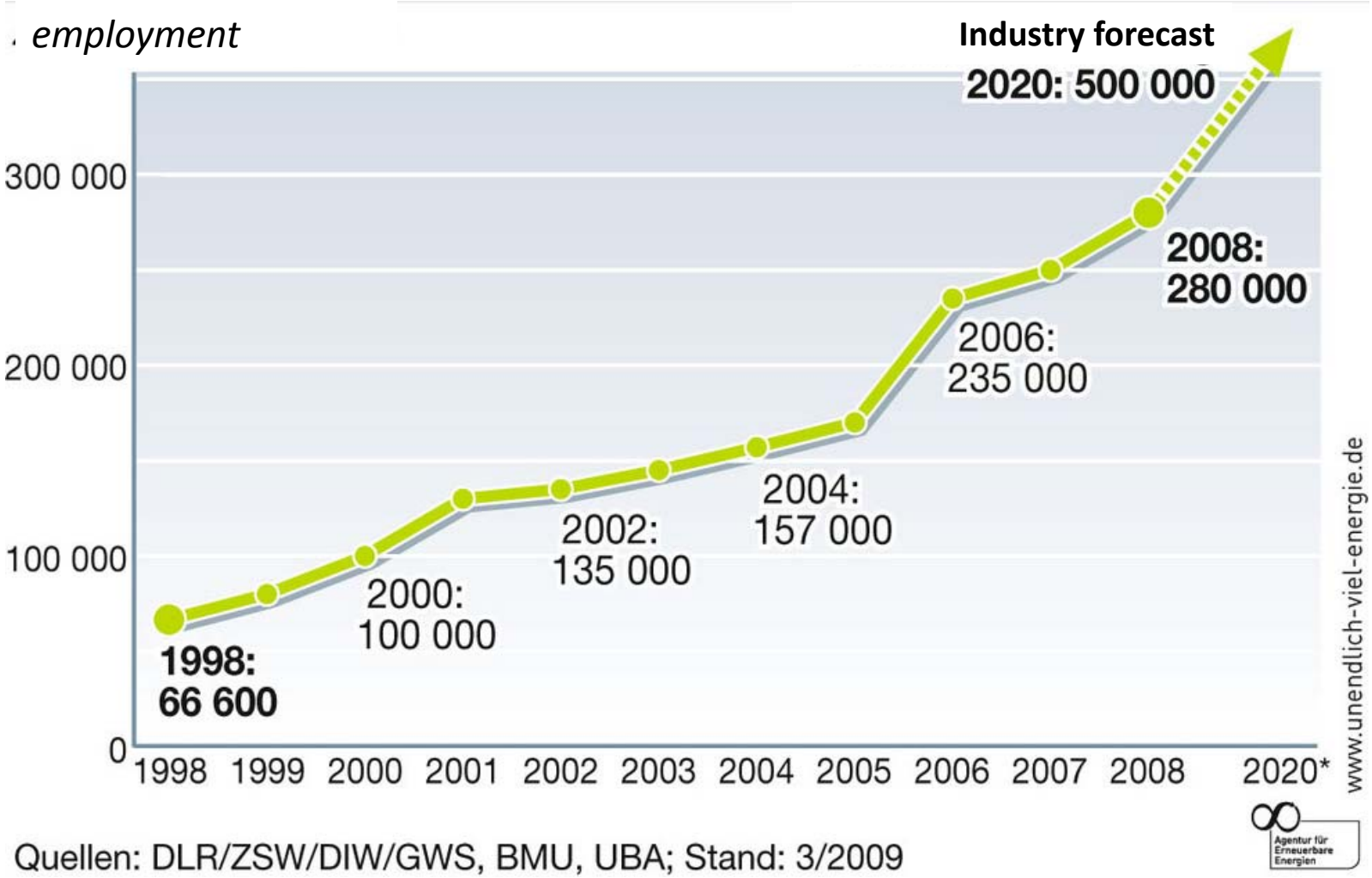


- 142 countries joined the new International Renewable Energy Agency IRENA
- In 2009 Renewable Energy has definitely become a top issue in international industry policy (China, USA, Japan, India, EU)

Objectives are getting more ambitious

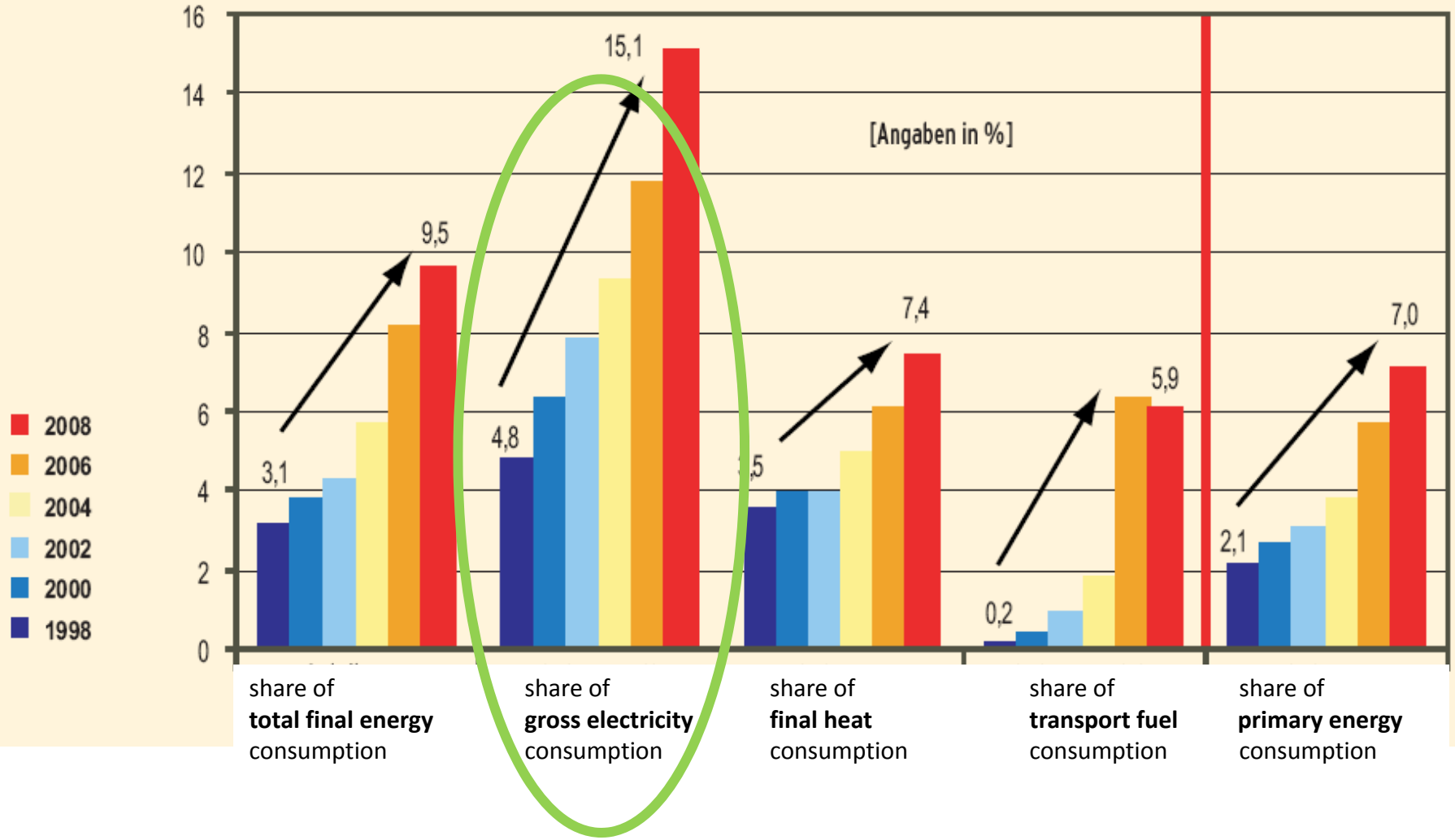
- EU decision in 2009, compulsory:
  20% renewable energy in Europe 2020
- German RE Industry Association
  2008: 47% renewable electricity in GER 2020
- German environmental minister Röttgen 2010:
  aim: 100% renewable electricity in GER 2050
- EREC (European RE Industry Association) 2010:
  100% renewable Energy in Europe 2050
- European Climate Foundation/ McKinsey 2010:
  100% renewable electricity EU 2050 is technically and economically viable
- EU Commission Energy scenarios 2010:
  ??? % in Europe 2050

Employment in renewable energies in Germany

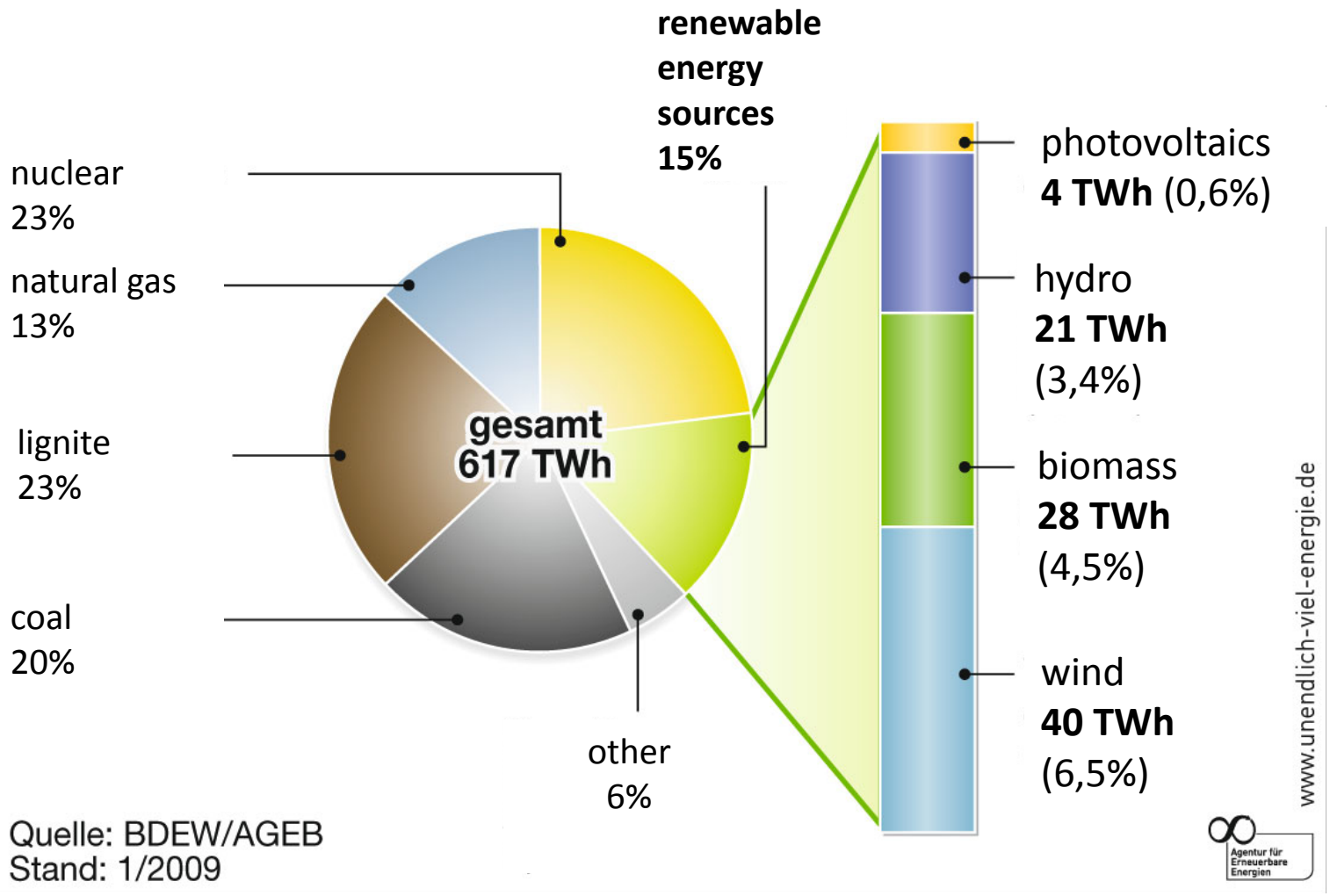


PHOTOVOLTAICS – A DISRUPTIVE SEMICONDUCTOR TECHNOLOGY

Renewable share in final energy consumption in Germany



Electricity production in Germany 2008

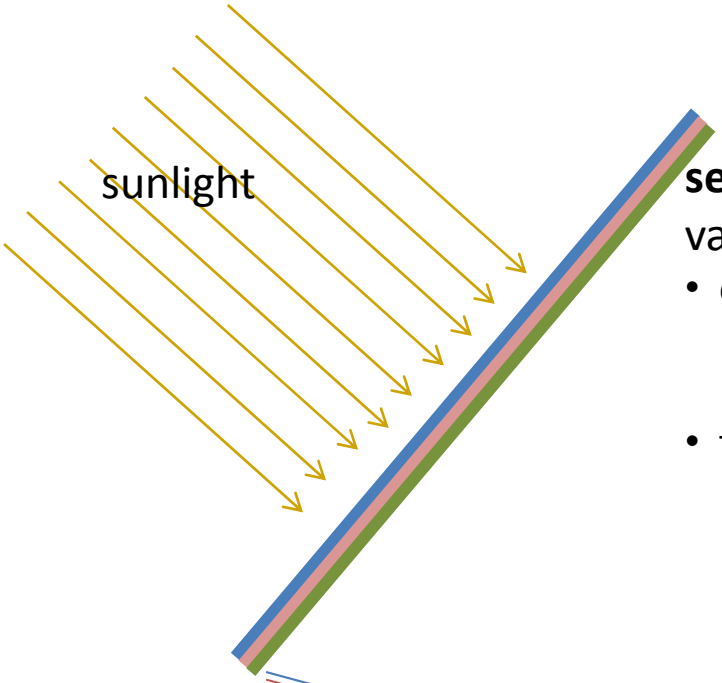


Why promote photovoltaics ?

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

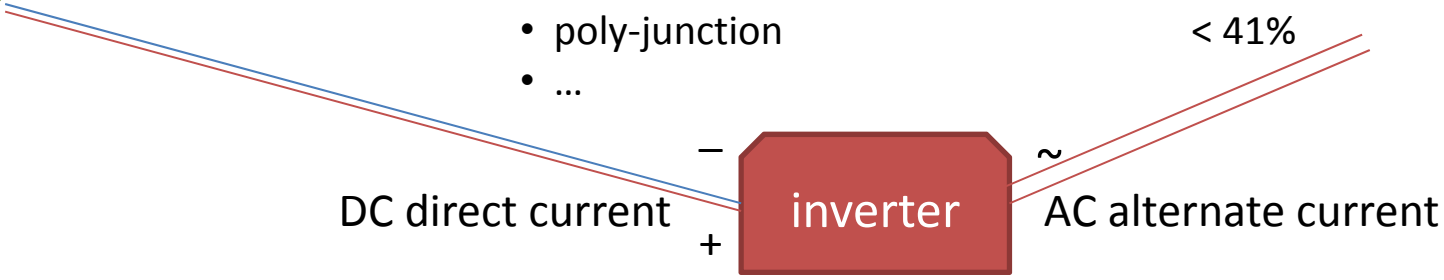
Direct transformation of sunlight into electricity
PV is a Semiconductor technology



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 < 19%
  - GaAs, Gallium-Arsenide < 24%
  - poly-junction < 41%
  - …



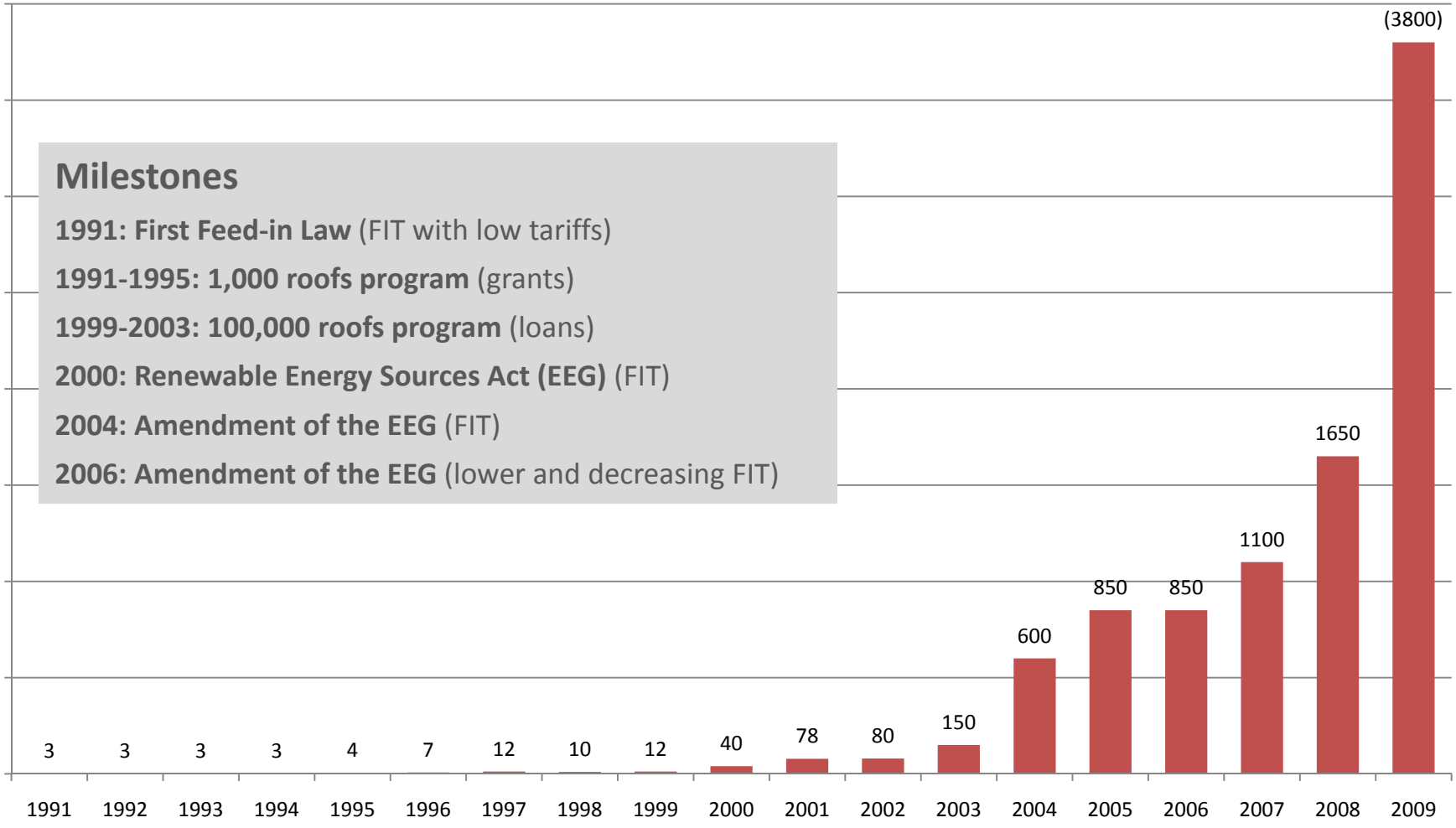
Typical photovoltaic systems

Profitability of PV plants: influencing factors

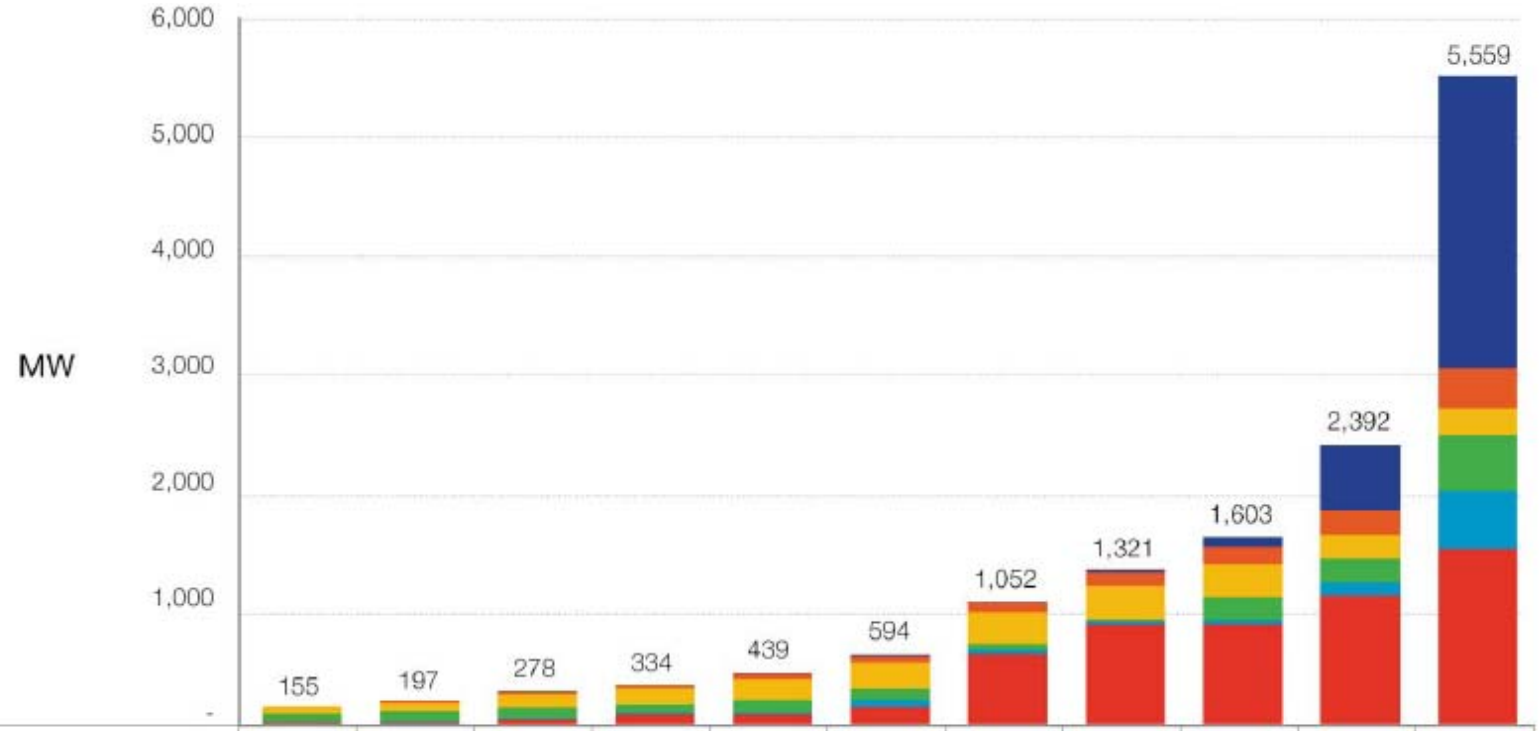
- Costs of the system (modules [ca. 50%], rest of the system, installation): presently ca. 3000€/kWpeak for small systems
- Running costs (ca. 1% p.a.: maintenance, insurance; taxes)
- Electricity yield of the system (location, orientation, quality of the installation)
- Duration of the installation, 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



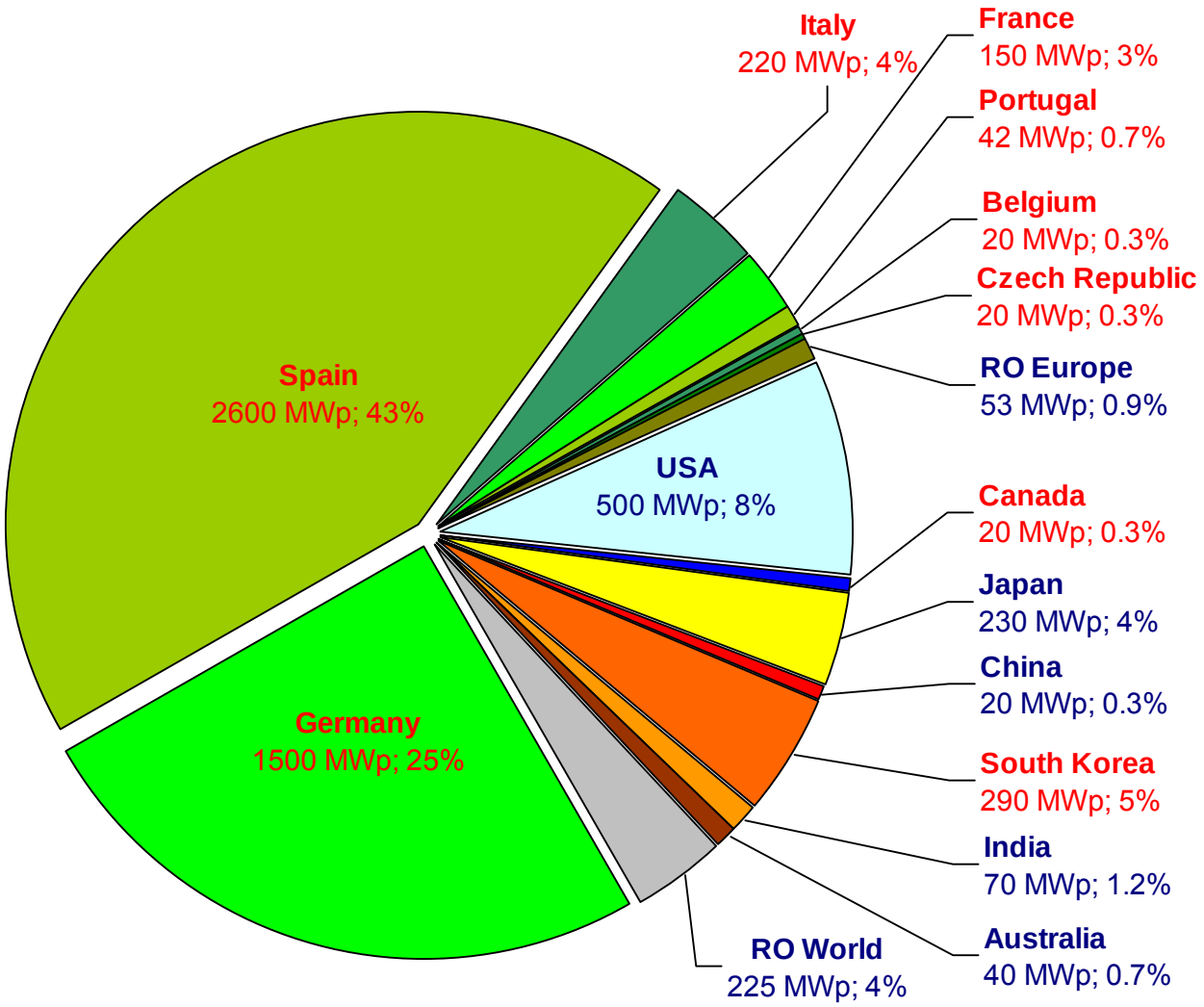
Development of the world photovoltaic market



MW	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Spain	0	1	-	2	9	10	6	26	88	560	2,511
USA	-	17	22	29	44	63	90	114	145	207	342
Japan	69	72	112	135	185	223	272	290	287	210	230
Rest of the world	68	84	94	75	104	98	53	12	196	207	485
Rest of Europe	8	11	10	16	16	50	30	30	37	108	492
Germany	10	12	40	78	80	150	600	850	850	1,100	1,500
TOTAL	155	197	278	334	439	594	1,052	1,321	1,603	2,392	5,559

2009:
> 7 GW

Photovoltaic World Market 2008



New installed PV Power

2006: 1600 MWp

2007: 2650 MWp (+66%)

2008: 6000 MWp (+126%)

Red Letters: Countries with Feed-in tariff schemes

Source: Preliminary figures of National PV Associations, Stryi-Hipp, Feb 26th 2009

Typical system in Spain (Menorca): 3.2 MWp

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

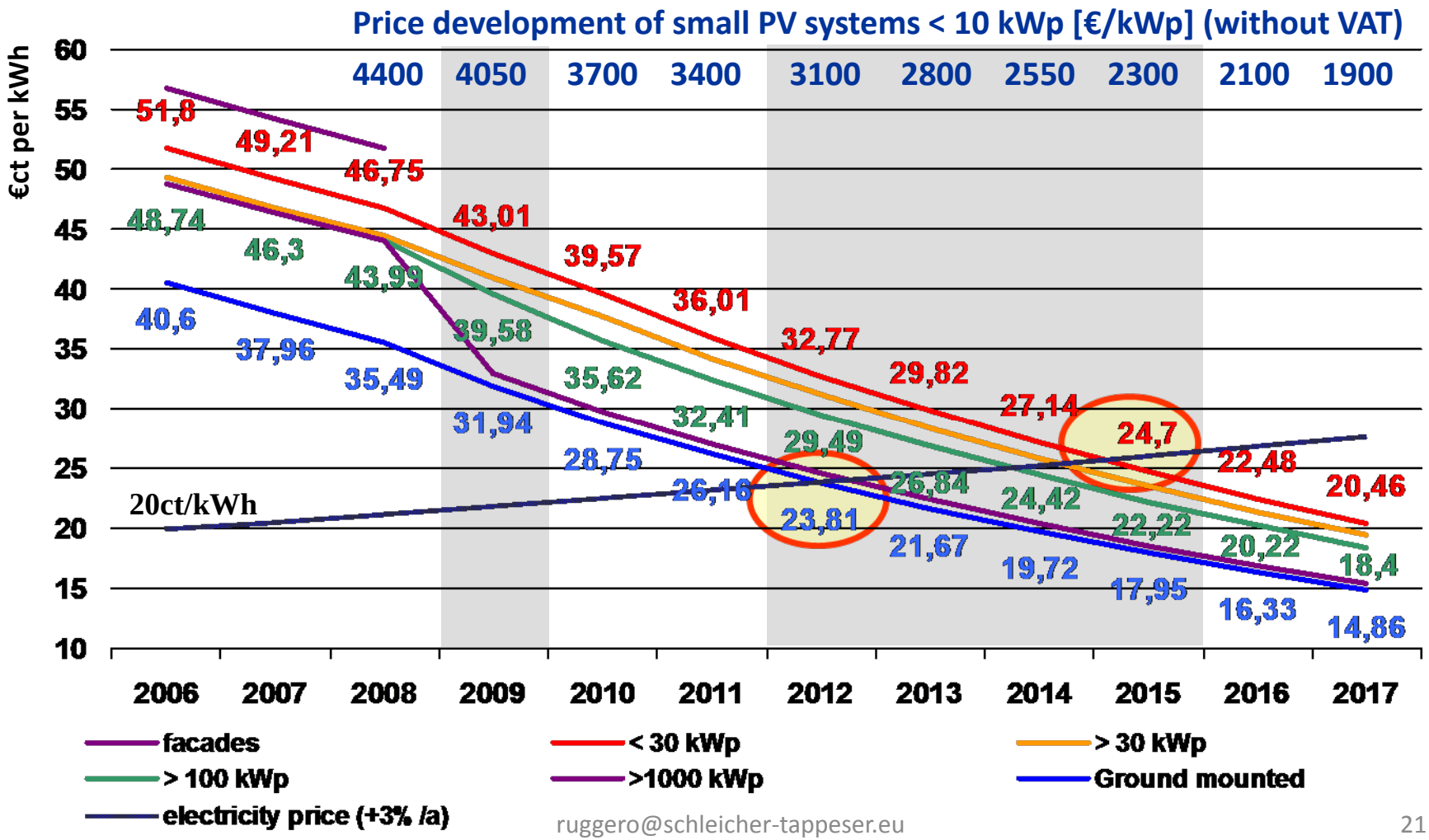
Building equilibrated market structures and competencies along the value chain takes time

- 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
- Countries starting market development will need several years to develop similar structures and competencies → as gird parity approaches, there is no time to loose

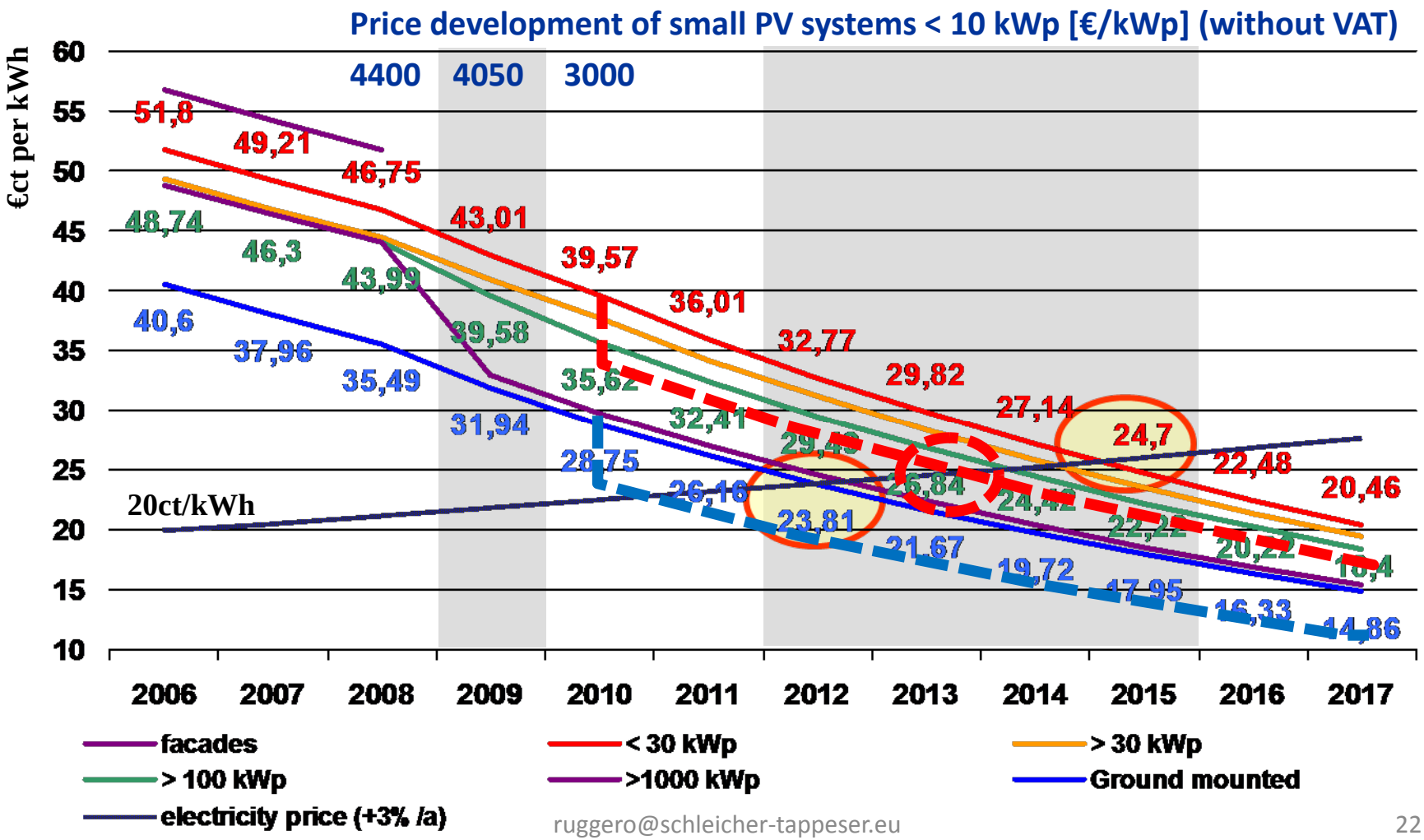
GRID PARITY COMING SOON

Decrease of feed-in-tariffs for PV in Germany: law since June 2008 (EEG)

Corresponding to the feed-in law amendment of June 6, 2008

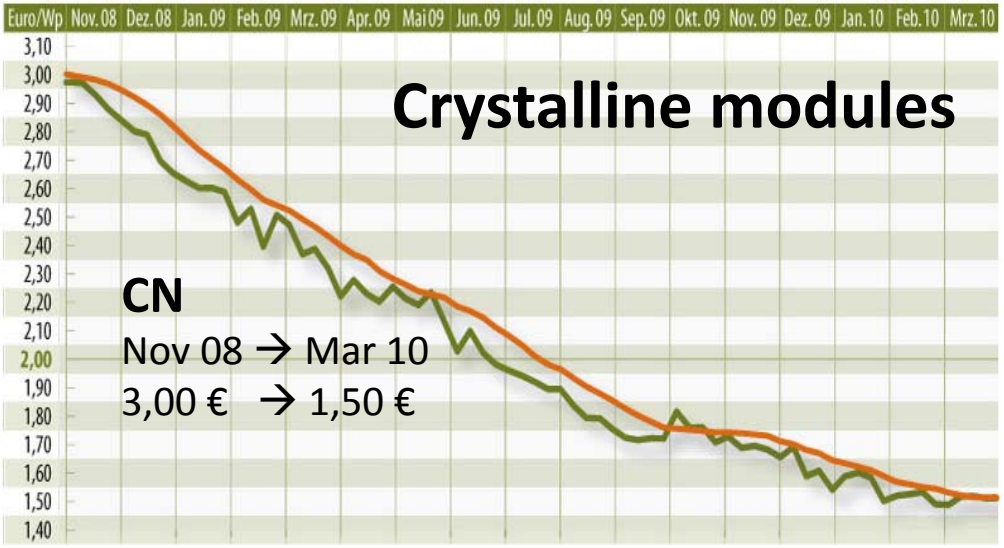


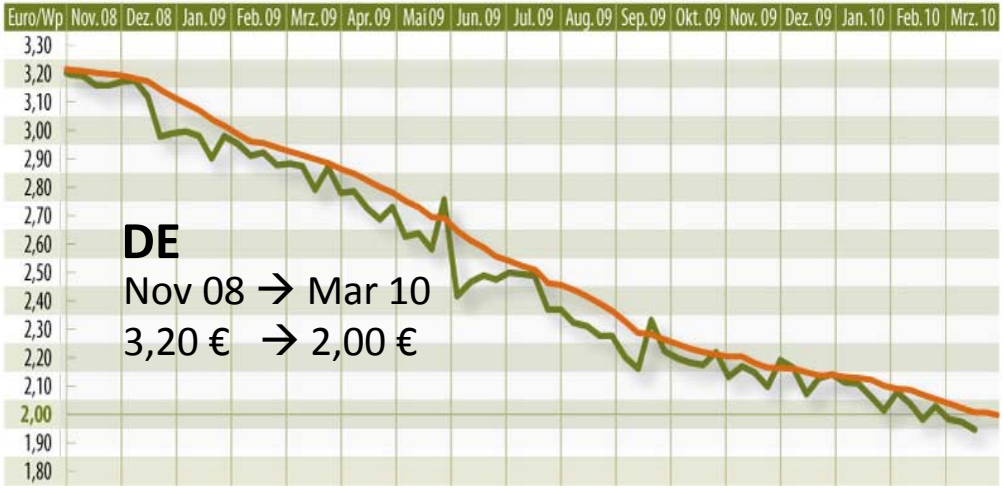
Decrease of feed-in-tariffs for PV in Germany: proposed changes by government 2010



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

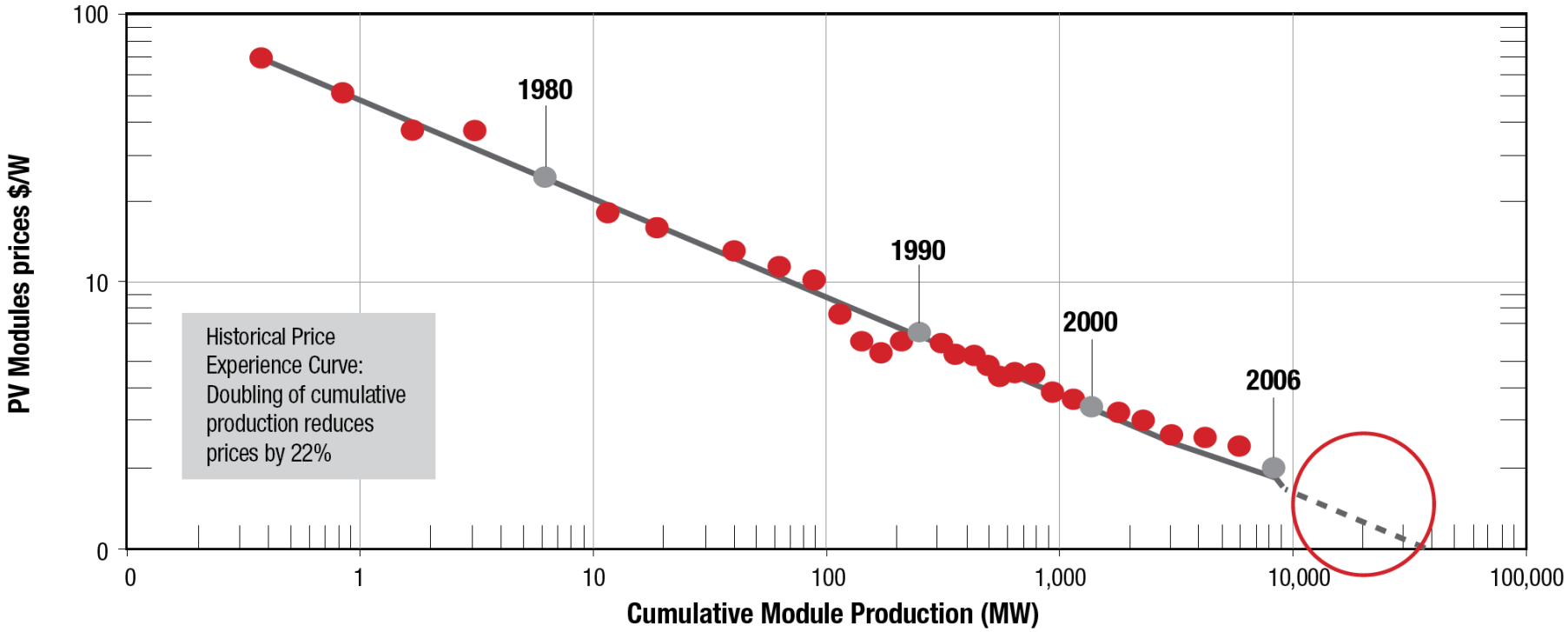




Restructuring of the PV industry

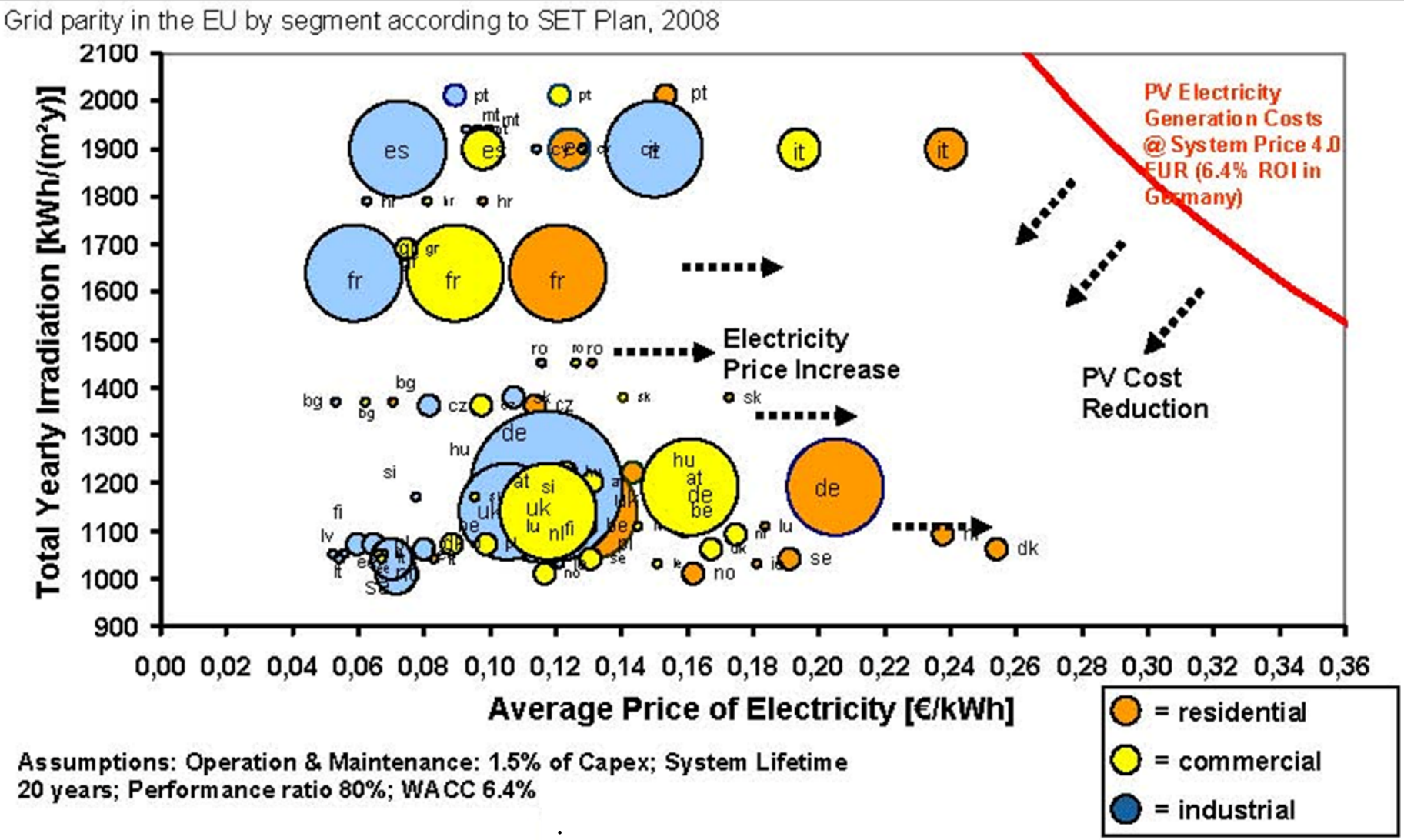
- Strong competition leads to industry shake-out
- Large German companies building up mass production in Asia (Q-Cells, Solon), revise business models
- Increasing importance of larger players with strong capital background (Bosch, Schott, Sharp)
- European equipment suppliers provide integrated solutions 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.

Grid parity coming soon: The situation early 2009



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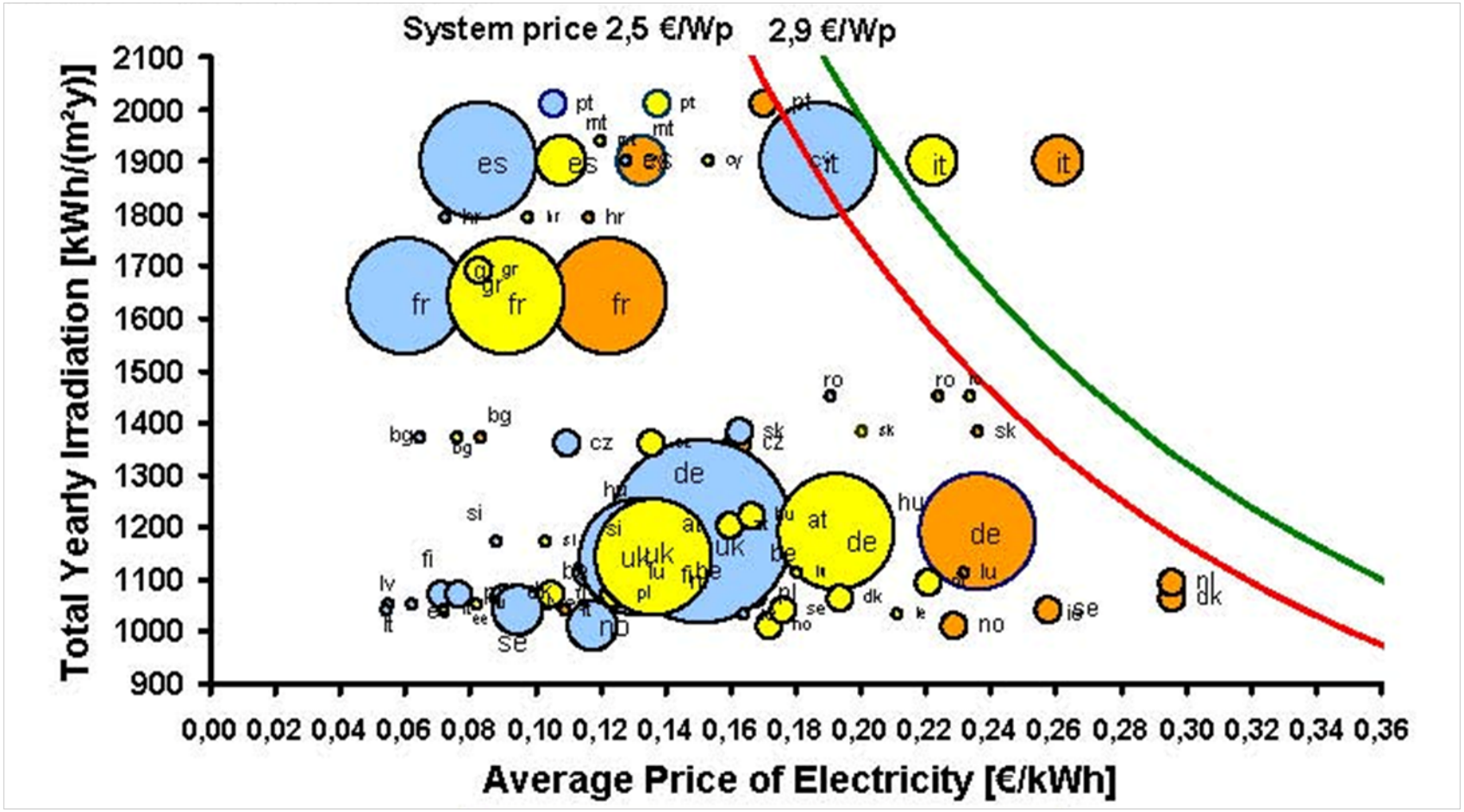
Grid parity coming soon: Outlook mid 2010



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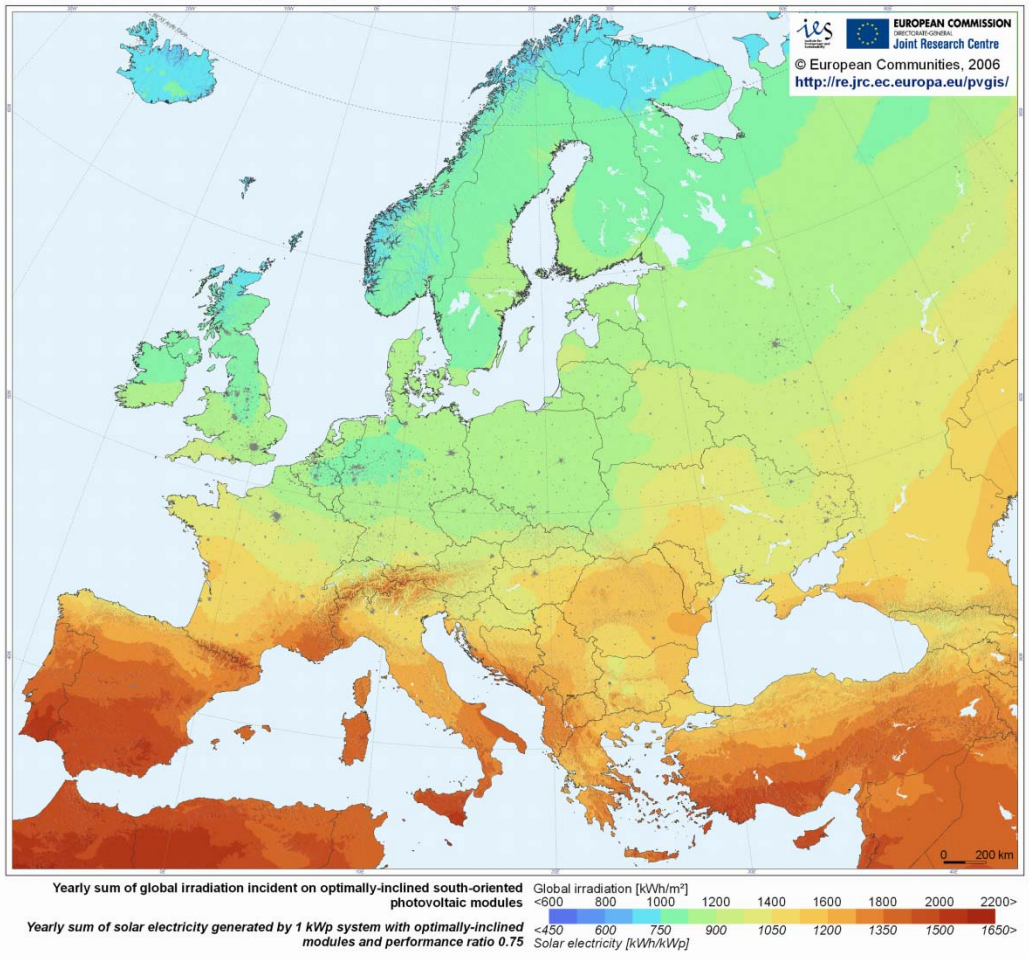
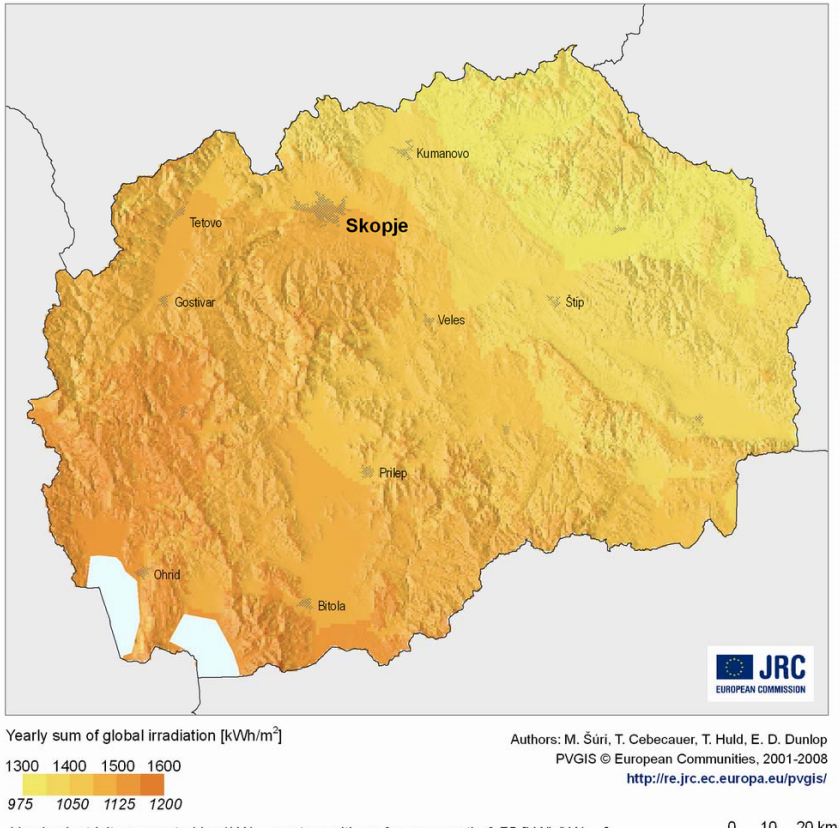
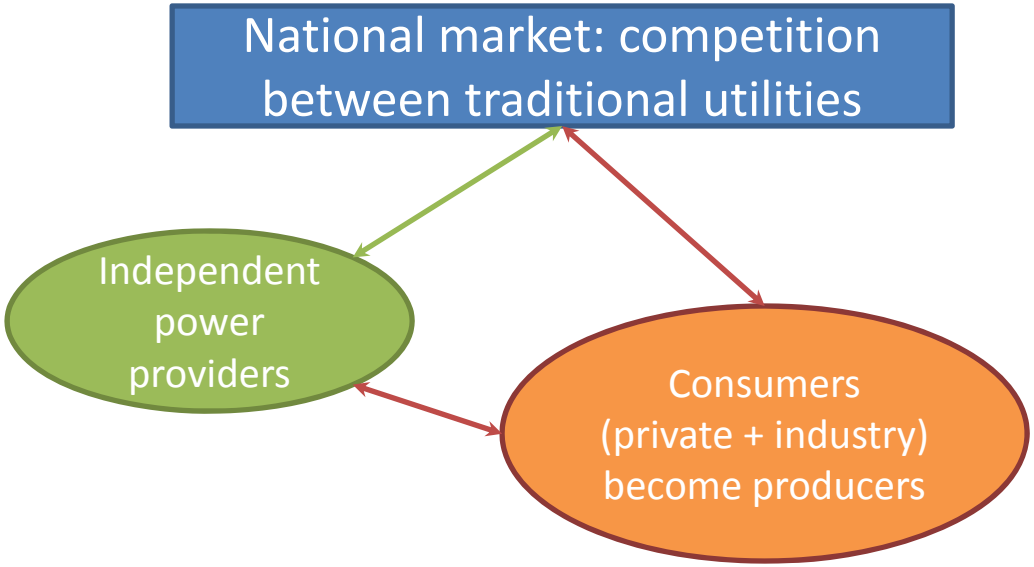
Macedonia: excellent PV potential





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



EPIA is ambitious: Towards PV competitiveness in Europe

European Photovoltaic Industry Association EPIA:

- Realistic learning curve:
  100% increase of installed PV → 20% cost reduction

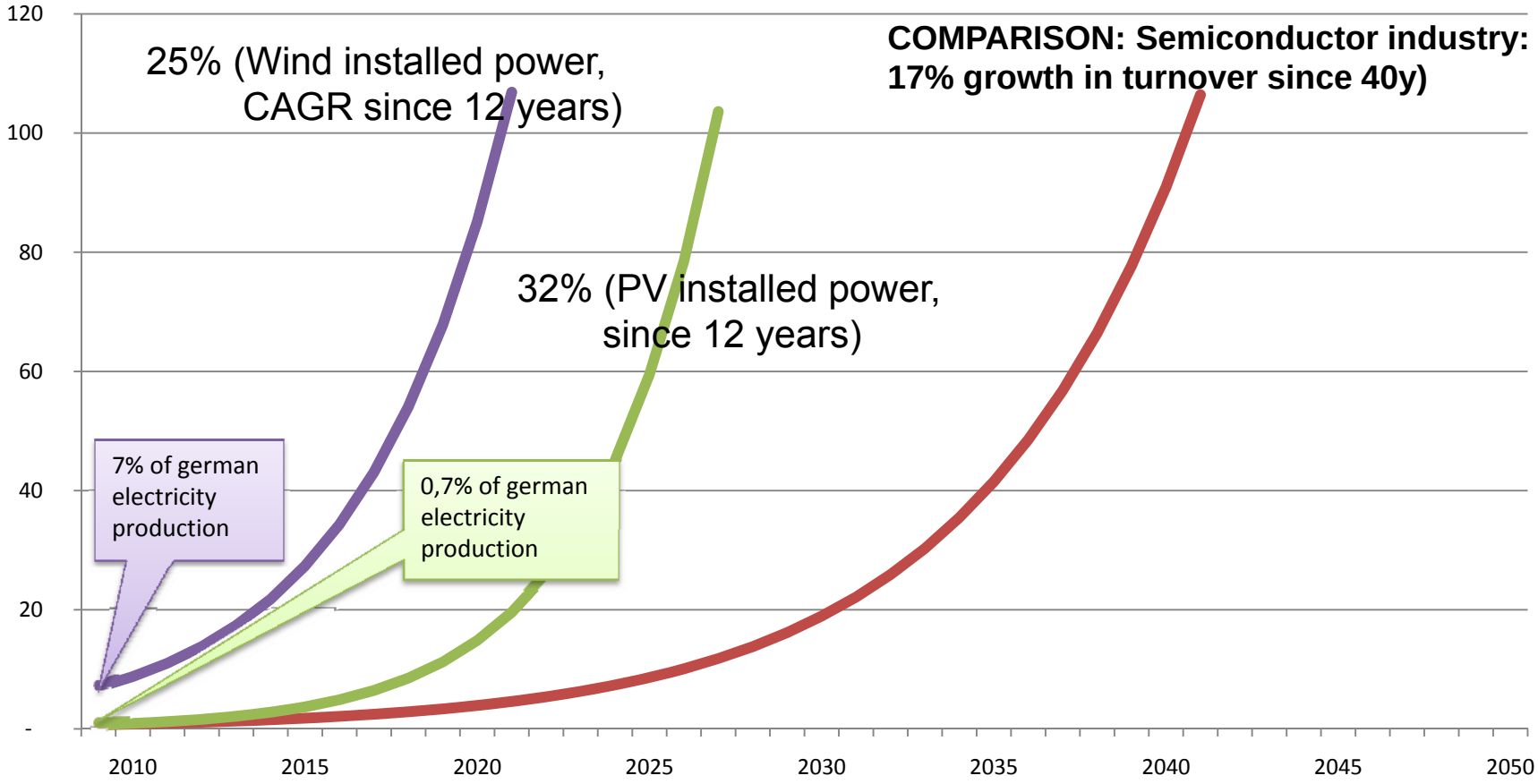
→ Step by step grid parity will be reached in all important markets in the coming years

	2008	2012	2016	2020
Share of EU electricity markets where grid parity is reached	0%	10%	50%	90%

EPIA proposes as target for EU policies :

- Cumulative PV installed in Europe 2020 : 350 GWp
- PV share of EU electricity generation : 12%
- Annual growth rate of installed PV base : 40%

Extrapolation of past exponential growth: High growth rates can rapidly change the system

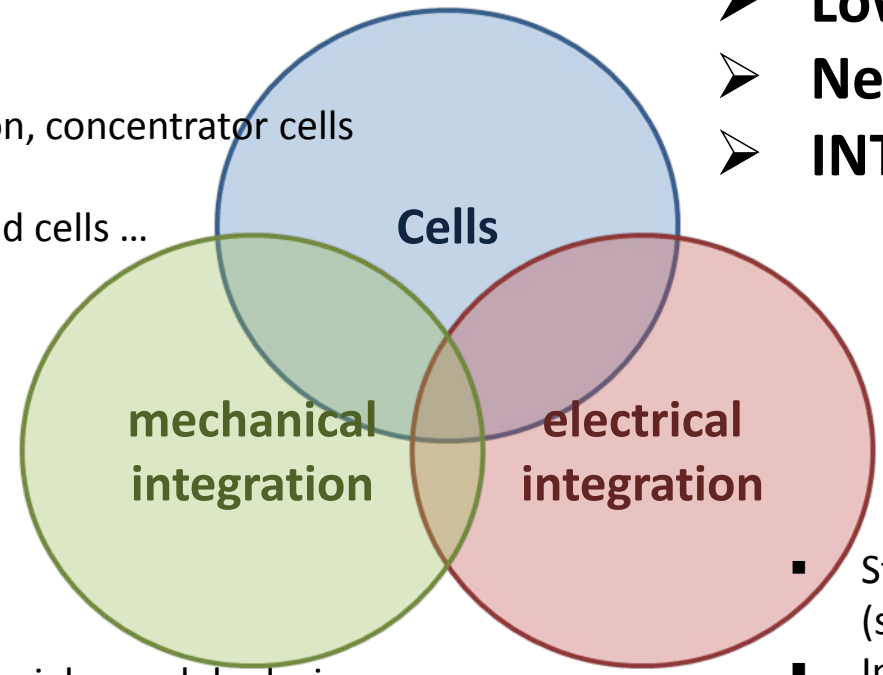


STRONG INNOVATION ALLOWS FOR SUSTAINED GROWTH

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

Concentrating Photovoltaic Systems CPV

- Low-concentration (factor < 10) and high-concentration (factor >100) systems
- Low concentration modules (10x) with conventional Si-cells: high yield with low system costs
  Germany: Archimedes (ZEW Stuttgart spin-off)
- New high-yield cells open new prospects
  - World record 40,8% efficiency with triple-junction cells
- Integrated concentrator modules (500x) promise low costs for sunny regions
  - 5,6 MW plant near Sevilla with Concentrix fresnel-lens modules shows 23% efficiency (Concentrix is an ISE spin-off with Albengoa capital)
  - new Concentrix modules: efficiency over 27%, energy payback time <1 year
  - automated 25 MW production line opened Sept 2008 in Freiburg

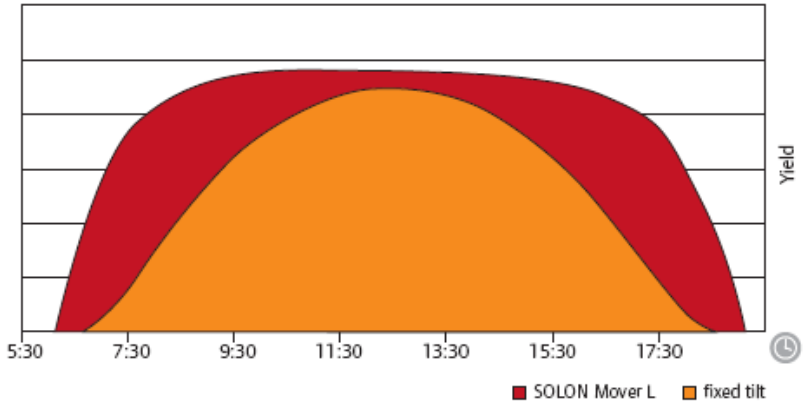
© Archimedes

© Concentrix

Two axis tracker systems

- Higher yield
- Higher costs
- More surface required

  (5ha/MWp)



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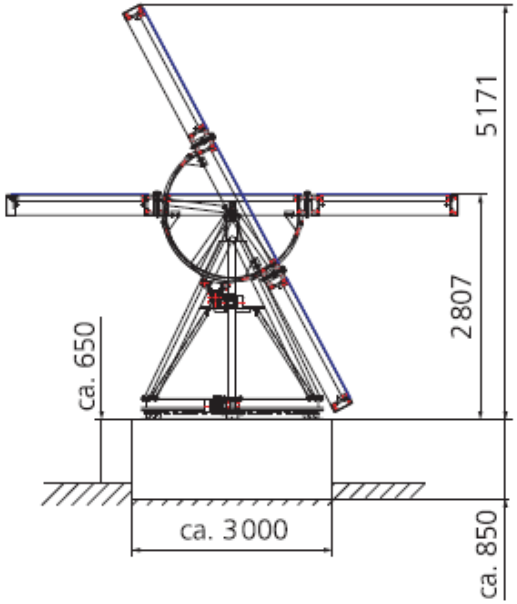

© Solon SE

Single axis tracker systems

- Lower additional costs (system, installation, maintenance)
- Lower surface requirements (2,5 ha/MWp)

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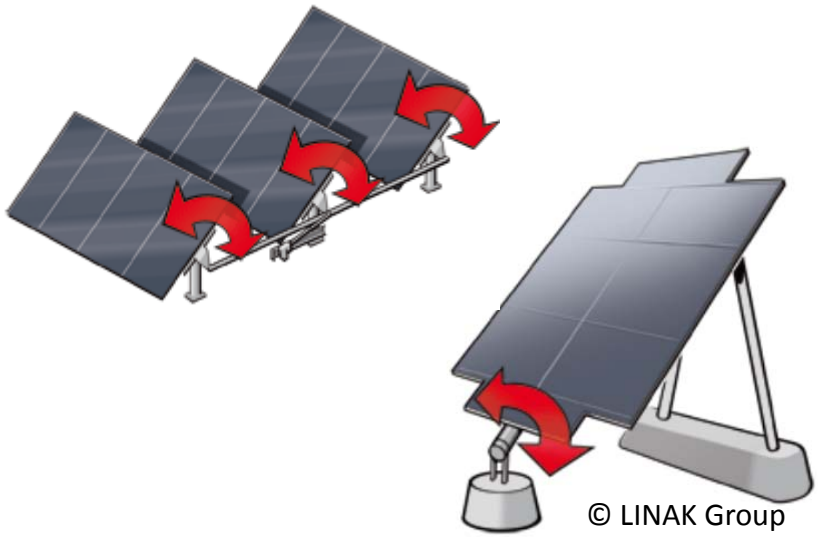

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Building Integrated PV (BIPV)

- 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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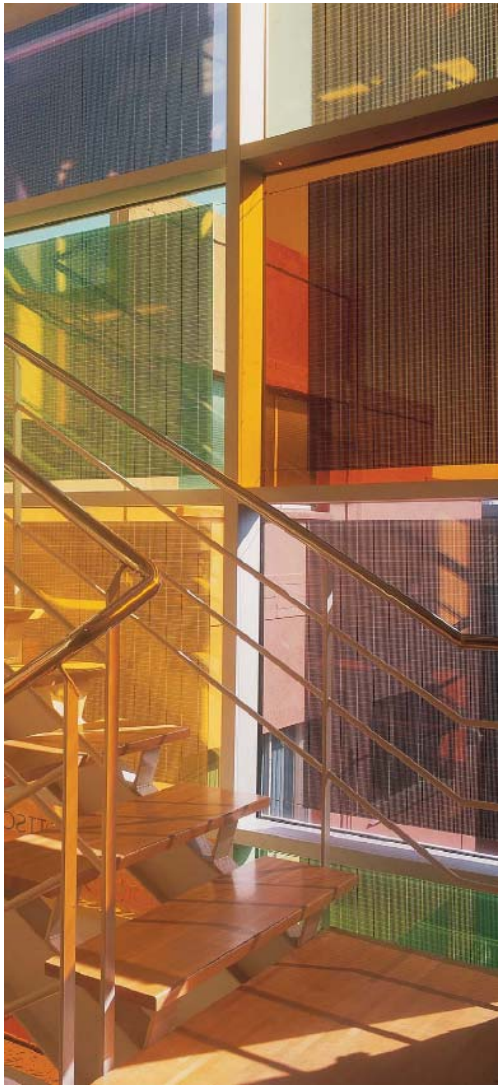
Building Integrated PV (BIPV) 2

- Wide range of possible applications
- Increasing aesthetical options
- Low or no additional costs for support structures
- System solutions required



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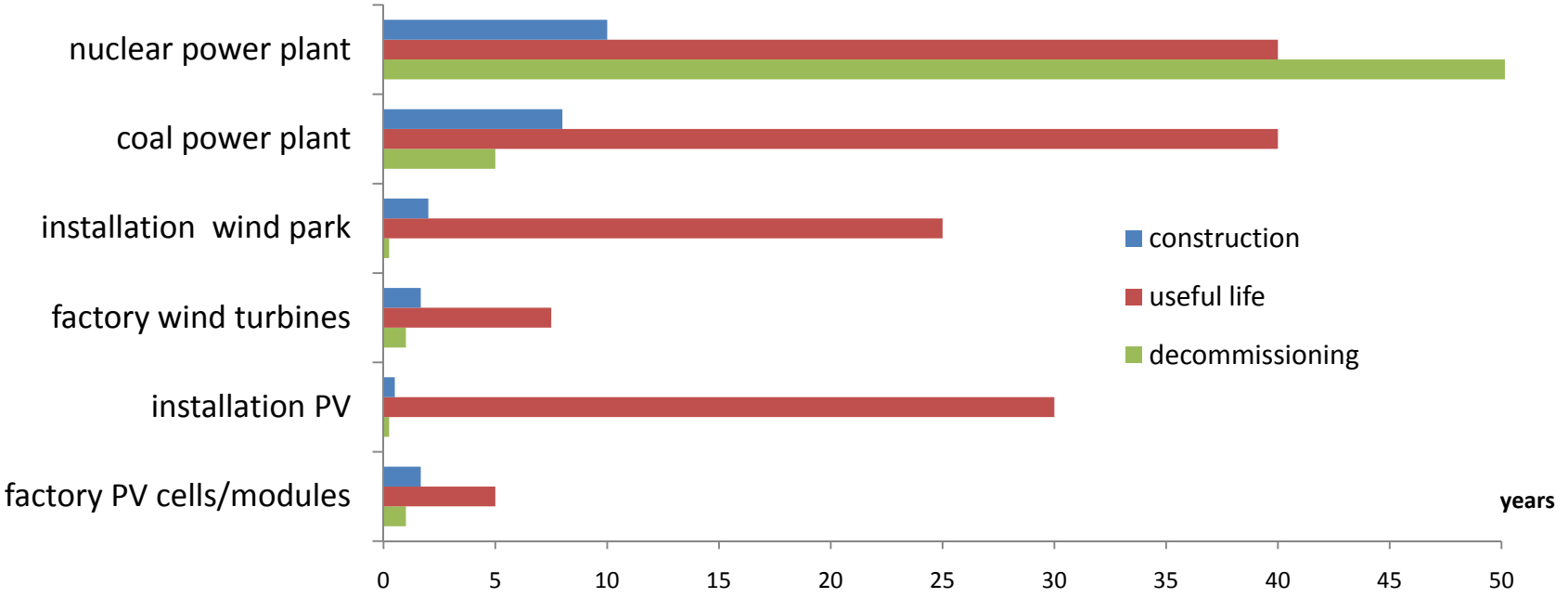
Construction times / Innovation cycles

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



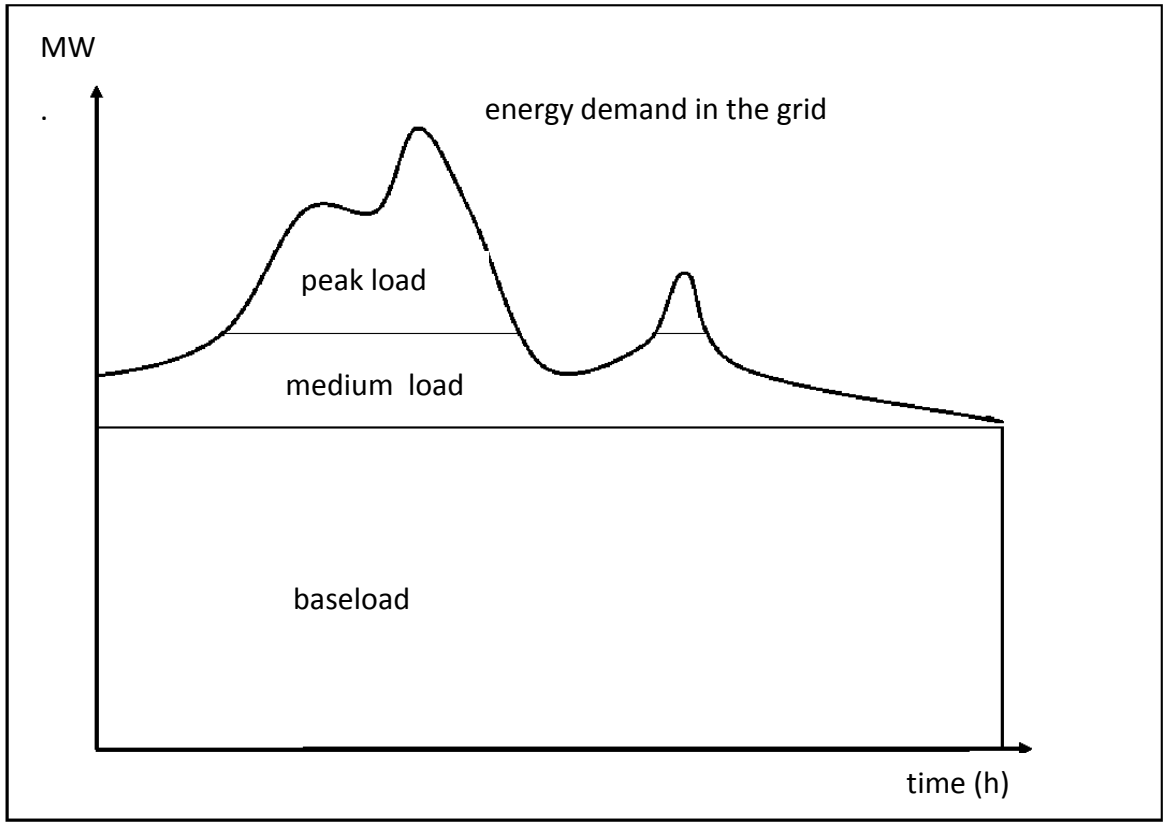
Electricity from renewable energy sources: Scaling-up times

- 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

INTEGRATING FLUCTUATING ELECTRICITY PRODUCTION

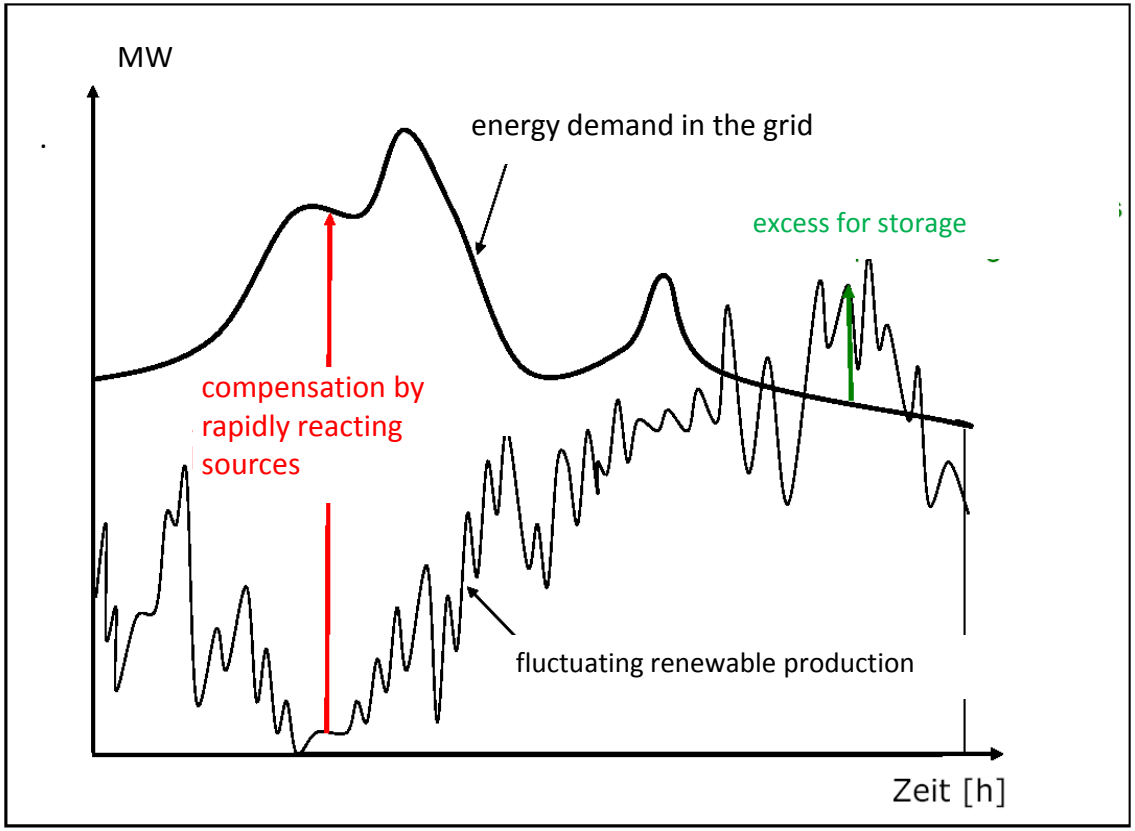
The old baseload concept

- 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 (e.g. hydro, gas turbines)
- Storage becomes important
- Load management becomes important (smart grid)
- No need for baseload plants



PV and hydroelectricity: ideal partners

- Hydroelectricity is an ideal complement to photovoltaics in the public grid:
  - can react very rapidly to demand
  - can store electricity
- 1/3 of the power production capacity in Macedonia is hydroelectricity

➢ Macedonia can easily add considerable volumes of photovoltaics (and wind)

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
- Objectives for 2020 are not sufficient for defining strategies, today's decisions condition the structure in 2050
- New business models and adapted regulatory frameworks are urgently needed – resistance by traditional structures risks to end in losses or decline

IMMEDIATE CHALLENGES for European industries and governments

- Ensure strong and **steady market growth** – low entrance barriers, decreasing subsidies
- Integration of a large share of **fluctuating electricity production** in the public grid
- Maintain **technological lead of European industries** – strengthen research, equipment providers, European cooperation
- Foster **integration of PV** in buildings, vehicles, appliances, smart grids ..
- Build up in time **competent capacities** along the whole value chain – ensuring strong market presence, high quality, optimal integration
- Urgently develop a European **multi-level governance framework**
- Develop **new business models**
  - for utilities
  - for industries combining production and consumption of electricity
  - for new service providers
  - for international PV companies

A collective international learning process

Rapid learning requires co-operation:

- Co-operation along the value creation chain
- Co-operation between research and industry
- Co-operation between national industry associations
- Co-operation between governments in order to ensure a balanced market growth
- Cooperation between local governments

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