Federal Ministry
of Economics
and Technology

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Energy

Photovoltaics: technology and market developments – the role of Germany

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renewables
Made in Germany

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

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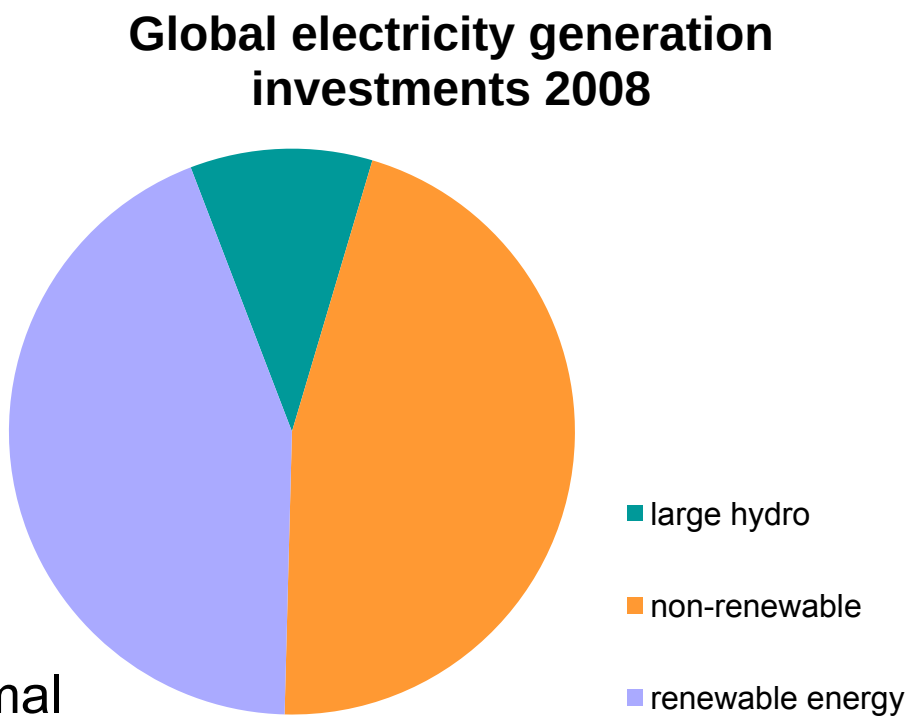
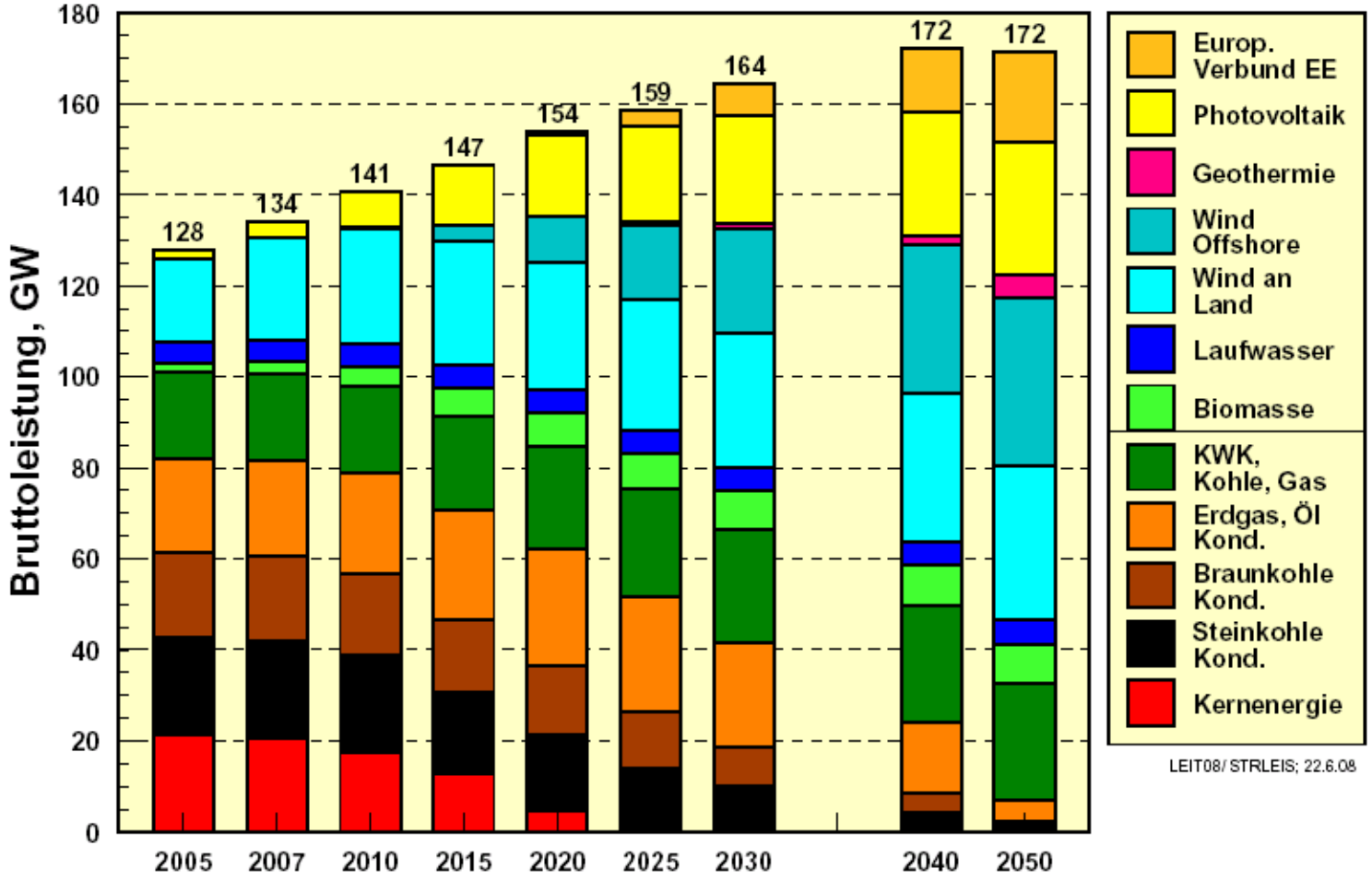
Dramatic shift in perceptions: Renewable energy – the only way out

- Huge investments in renewable electricity generation
  - 2008: US$ 155 bn
  - Four-fold increase since 2004
  - Solar 49% growth
  - Europe 49,7%
- High priority in economic recovery programmes
- New programmes for solar thermal
- 138 countries joined the new International Renewable Energy Agency IRENA



Lead scenario of the German Ministry for Environment and Renewable Energies



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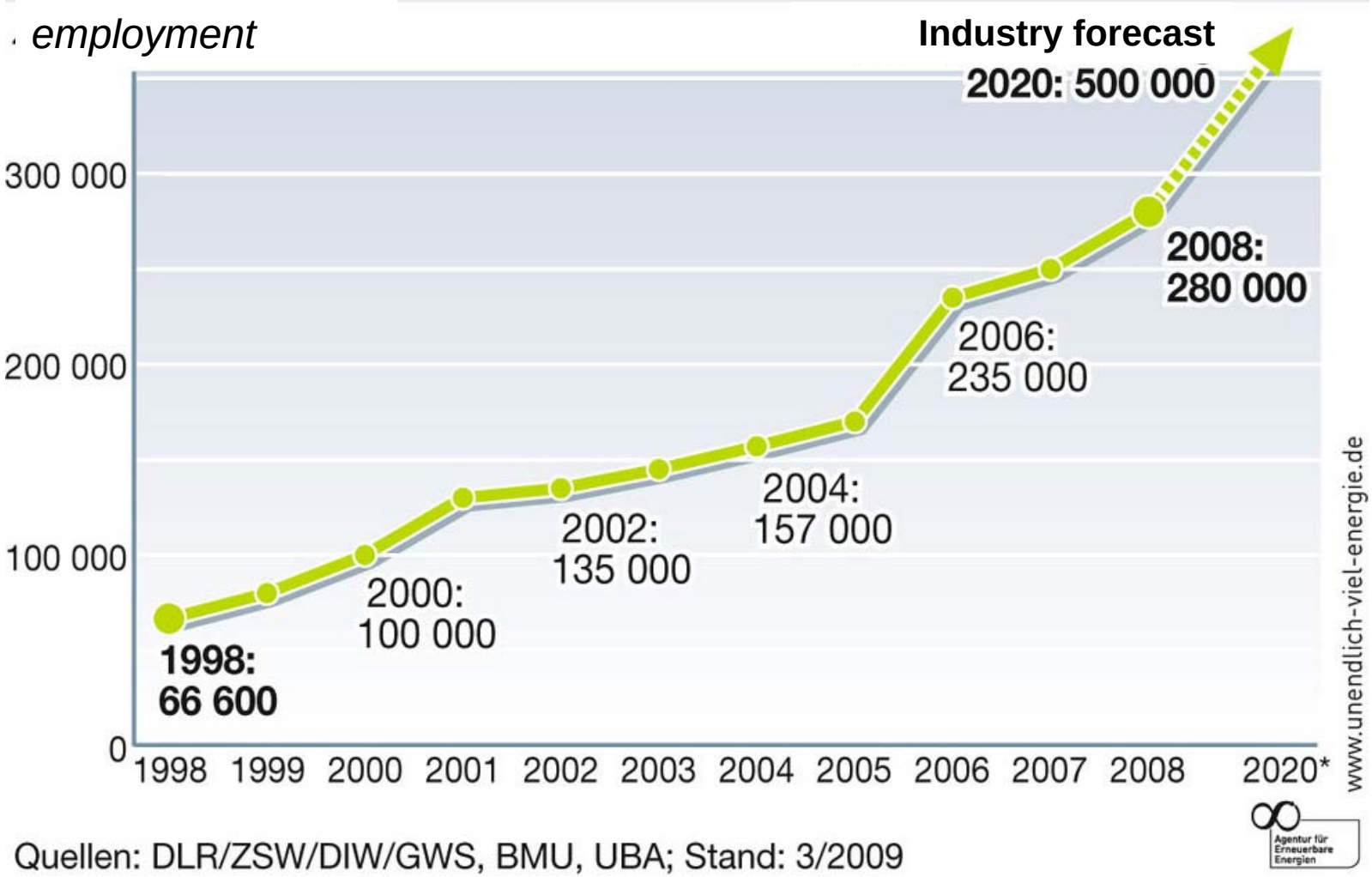
Employment in renewable energies in Germany



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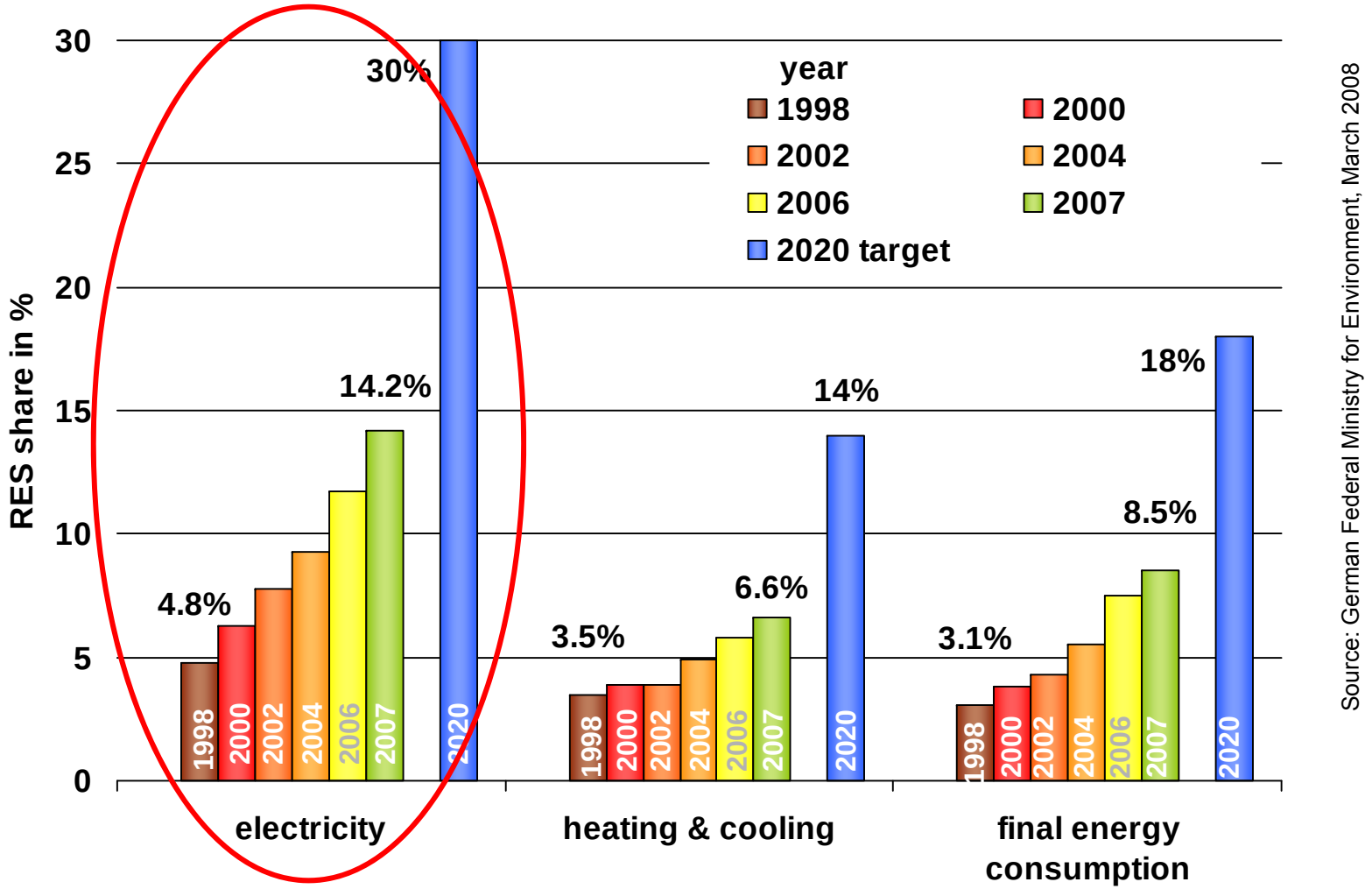
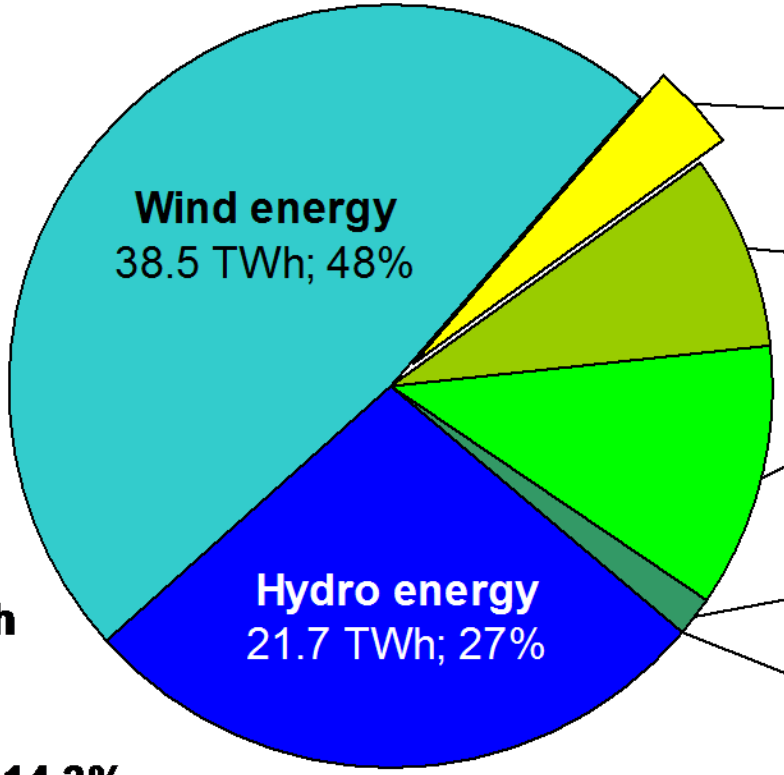
Renewable share in final energy consumption in Germany



Share of Solar Electricity in Germany

Distribution of Renewable Energy Electricity Production in Germany 2007



Photovoltaics
3.0 TWh; 4%

Bio energy solid
6.6 TWh; 8%

Bio gas
8.9 TWh; 11%

Bio energy liquid
1.2 TWh; 2%

Geothermal
0.1 TWh; 0.1%

Total RES electricity production 2007: 86.7 TWh
RES share of electricity consumption: 14.3%

Source: BEE, Jan 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

Development of the German PV market

PV Market Data 2008	
Newly installed power	1 500 MWp
Total installed power	5 334 MWp
No. of total systems installed	ca. 500 000
Turnover 2008	6 Bln € / 8.1 Bln $
Employees	45 000

Milestones

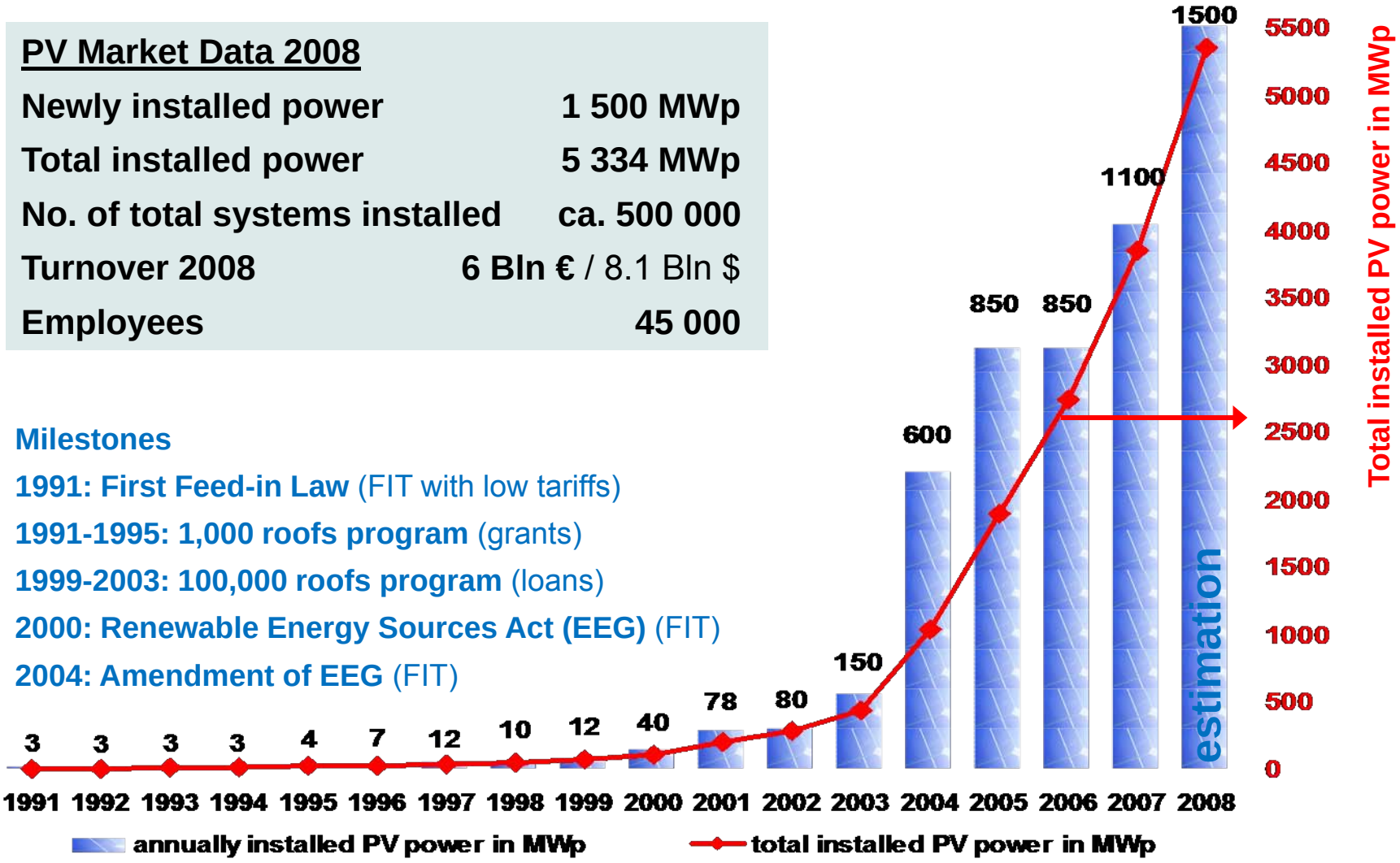
1991: First Feed-in Law (FIT with low tariffs)

1991-1995: 1,000 roofs program (grants)

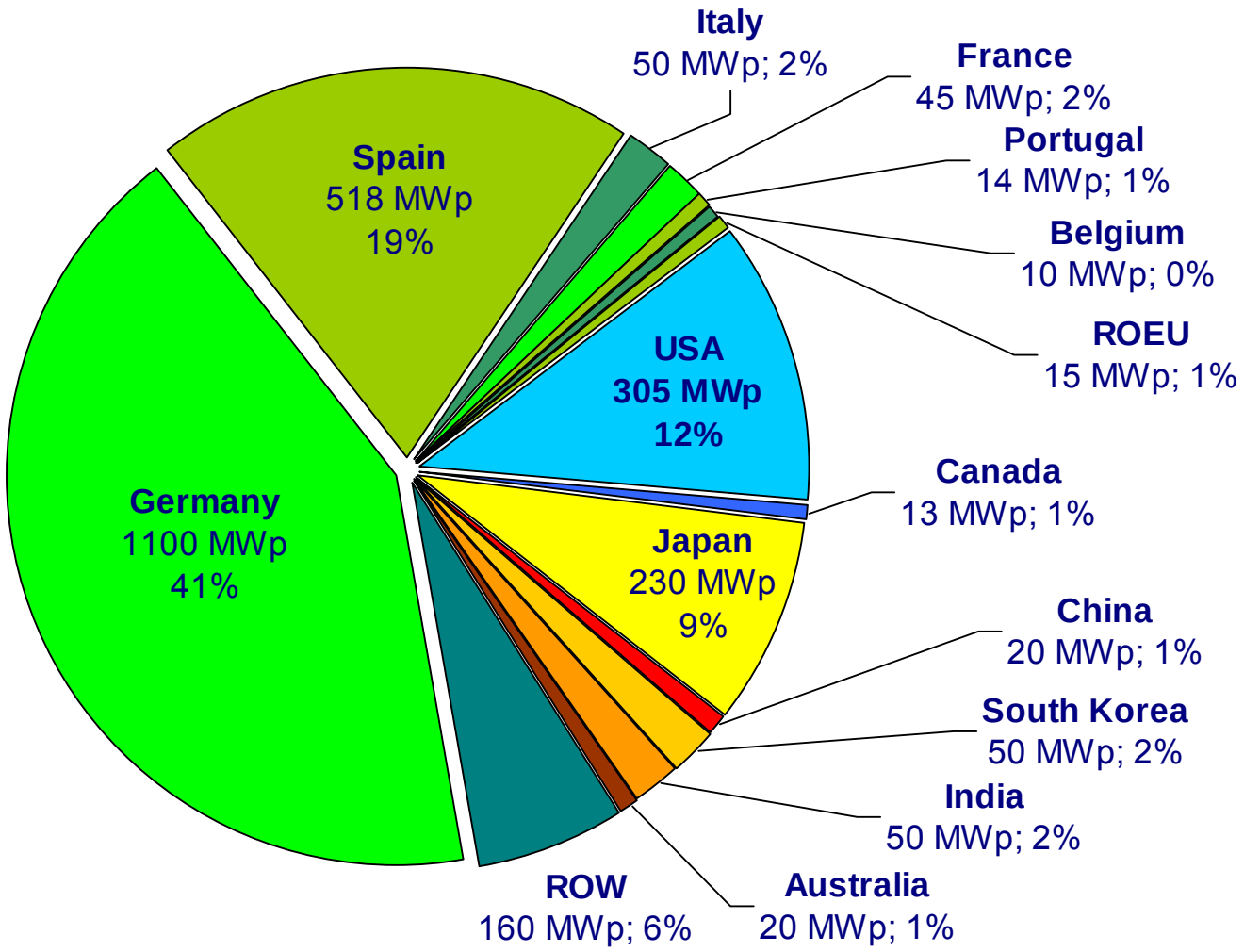
1999-2003: 100,000 roofs program (loans)

2000: Renewable Energy Sources Act (EEG) (FIT)

2004: Amendment of EEG (FIT)



Photovoltaic World Market 2007



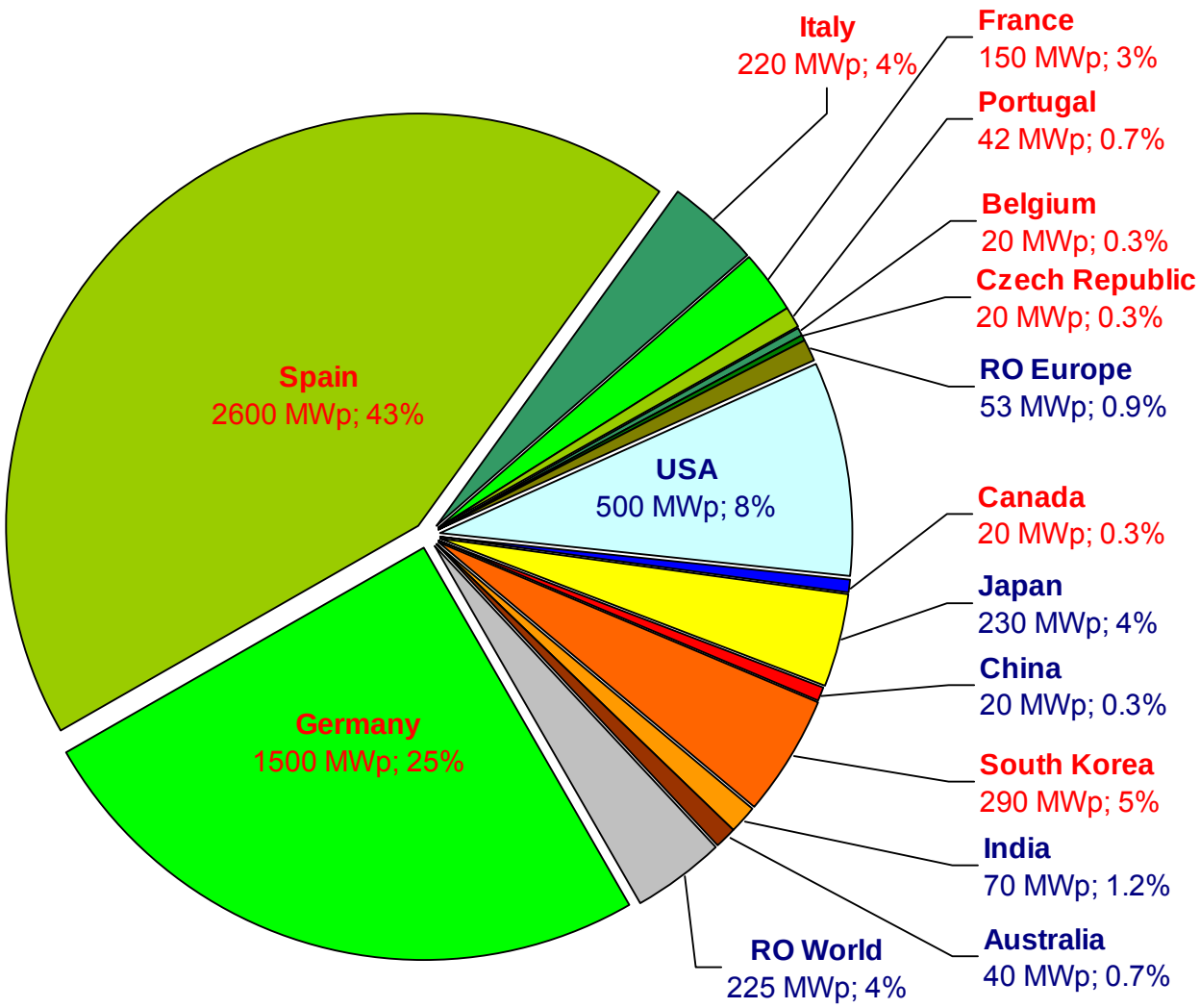
New installed PV Power

2006: 1600 MWp

2007: 2650 MWp
(+66%)

Source: BSW-Solar, EPIA, NNPVA
Updated 5 September 2008

Photovoltaic World Market 2008



New installed PV Power

2006: 1600 MWp

2007: 2650 MWp (+66%)

2008: 6000 MWp (+126%)

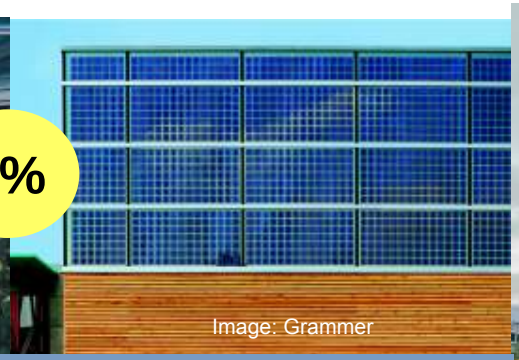
Red Letters: Countries with Feed-in tariff schemes

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

Image: Sunenergy

Germany: Market Segments of on-grid PV Systems

1%



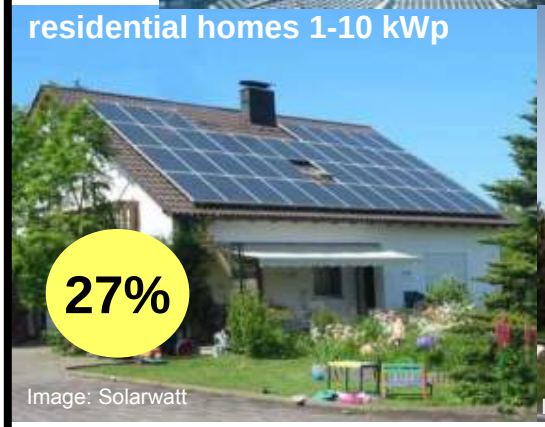
BIPV

Effort of mounting

Roof top

residential homes 1-10 kWp

27%



multi family houses, public + social buildings, farms, commercial plants 10-100 kWp

49%

Large and very large commercial > 100 kWp

13%

Ground mounted

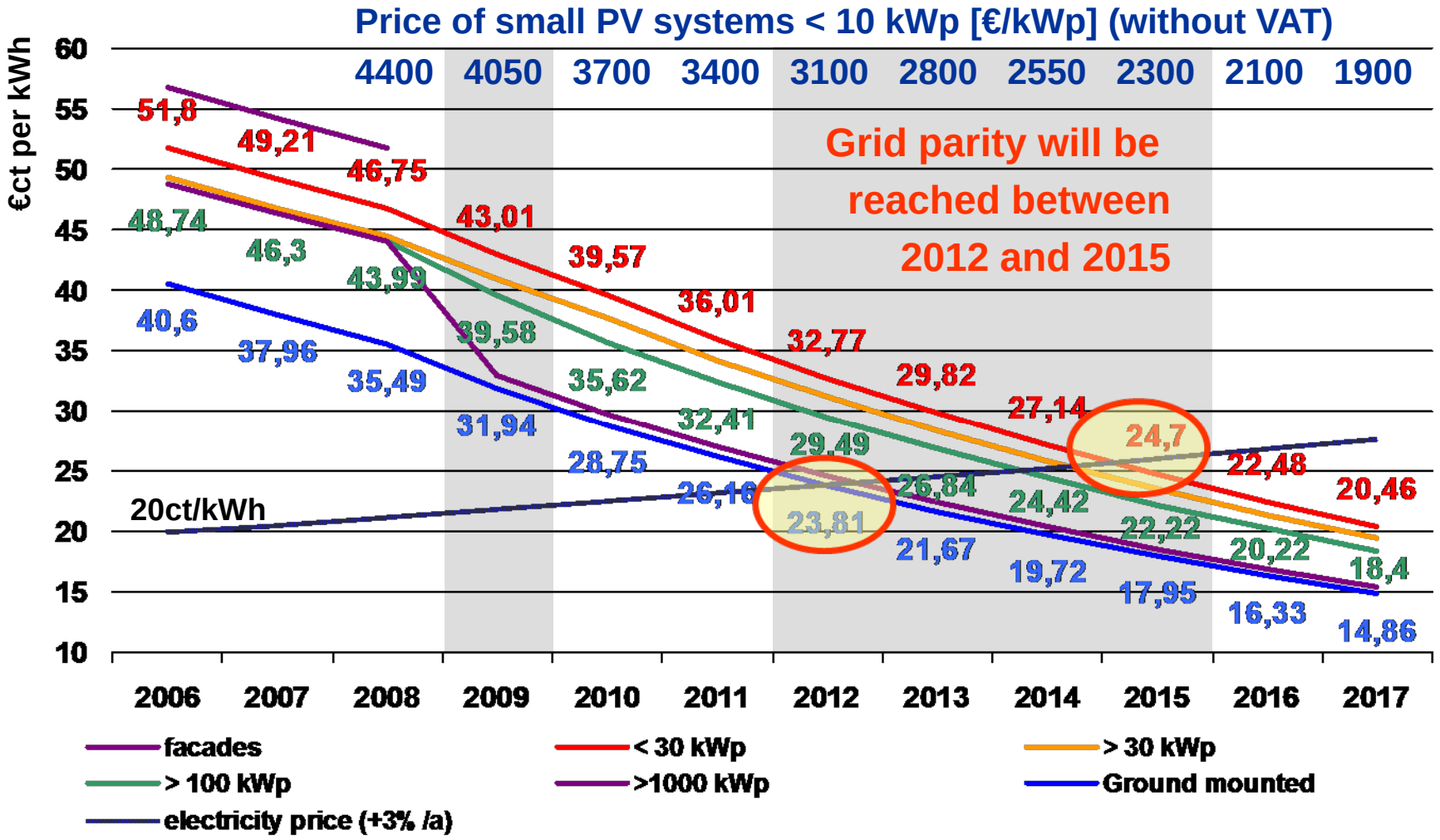
Market share in 2006

10%

Size of the system

Feed-in Tariffs for PV within the German EEG

Based on degression rates decided on June 6th, 2008



Profitability of PV plants: influencing factors

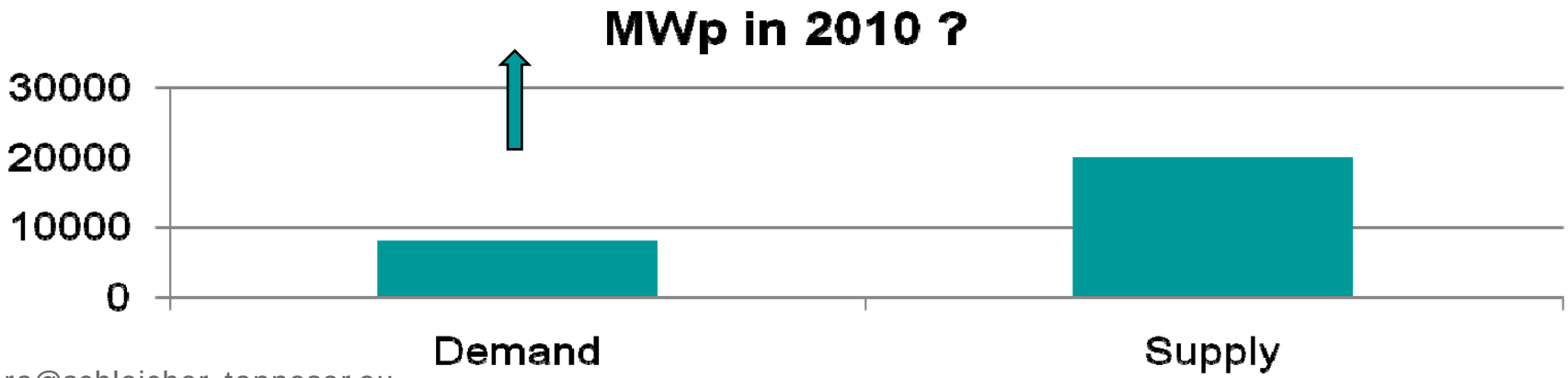
- Costs of the system (modules [ca. 50%], rest of the system, installation)
- Running costs (ca. 1% p.a.: maintenance, insurance; taxes)
- Electricity yield of the system (location, orientation, quality of the installation)
- Duration of the installation, of the warranty (20-25a)
- Feed-in-tariff: amount / duration
- Financial support for investment (taxes, other subsidies)
- Bank credit: amount / structure / interests

Independent from the economic crisis: worldwide PV overcapacity

- Announcements for production capacity in 2010: 20 GWp
- Demand estimates range between 5 and 10 GWp
  - Crash of the Spanish market
  - Economic downturn
  - End of silicon bottleneck
  - Overinvestment

→ Big efforts in market development are necessary

→ Only strong and high quality producers will survive

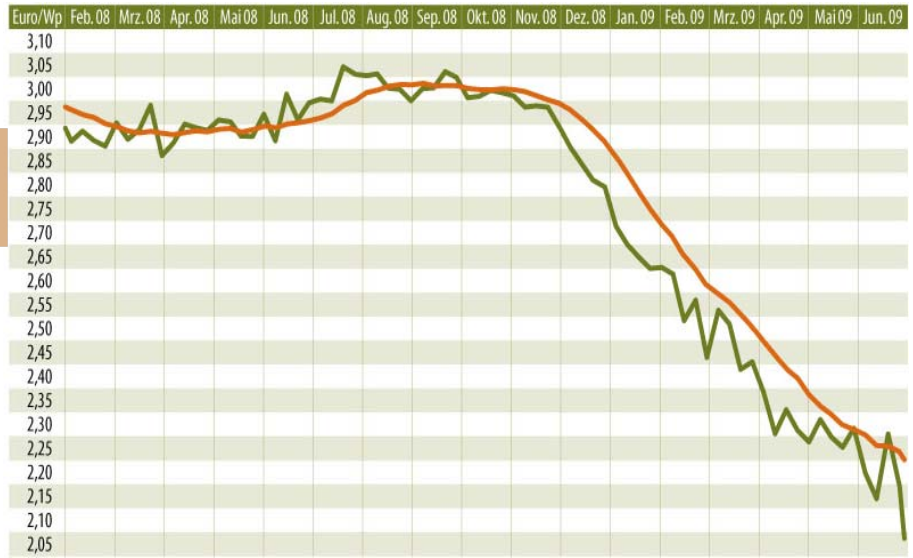


Costs and now also prices fall more rapidly

- Prices fell 30% Jan-Aug 2009:
  - Sufficient Si supply after completion of new facilities
  - Massive capacity build-up mainly in China, key-turn factories
  - Breakdown of the Spanish market, credit crunch
- Prices do not correspond to lowest available production costs
- Lowest module production costs today: around 1€/Wp
- Announced module production costs end 2010: <0,60 €/Wp

Chinese crystalline modules

3,00 → 2,10 €/Ws



The crisis: impact on business

- Medium term growth prospects for renewables: better than ever
- Credit crunch brings problems to project financing
- Government aid programs support growth of renewables – safe haven for investments
- Low oil price: temporary problems
- PV - a special case:
  - overcapacity brings consolidation of the sector
  - emphasis on quality
  - sinking prices, increased competitiveness
  - new markets needed

EU sets ambitious targets for 2020

- In December 2008 the EU decided compulsory targets for 2020
  - Decrease of CO2 emissions: -20%
  - Reduction of energy consumption: -20%
  - Share of renewables in final energy consumption 20%
- National targets agreed, national action plans required, regular reporting
- Romania: 17% → 24%
- Detailed policies for electricity, heat
- →Electricity needs 35-40% renewables by 2020

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EPIA is more ambitious: Towards PV competitiveness in Europe

European Photovoltaic Industry Association EPIA:

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

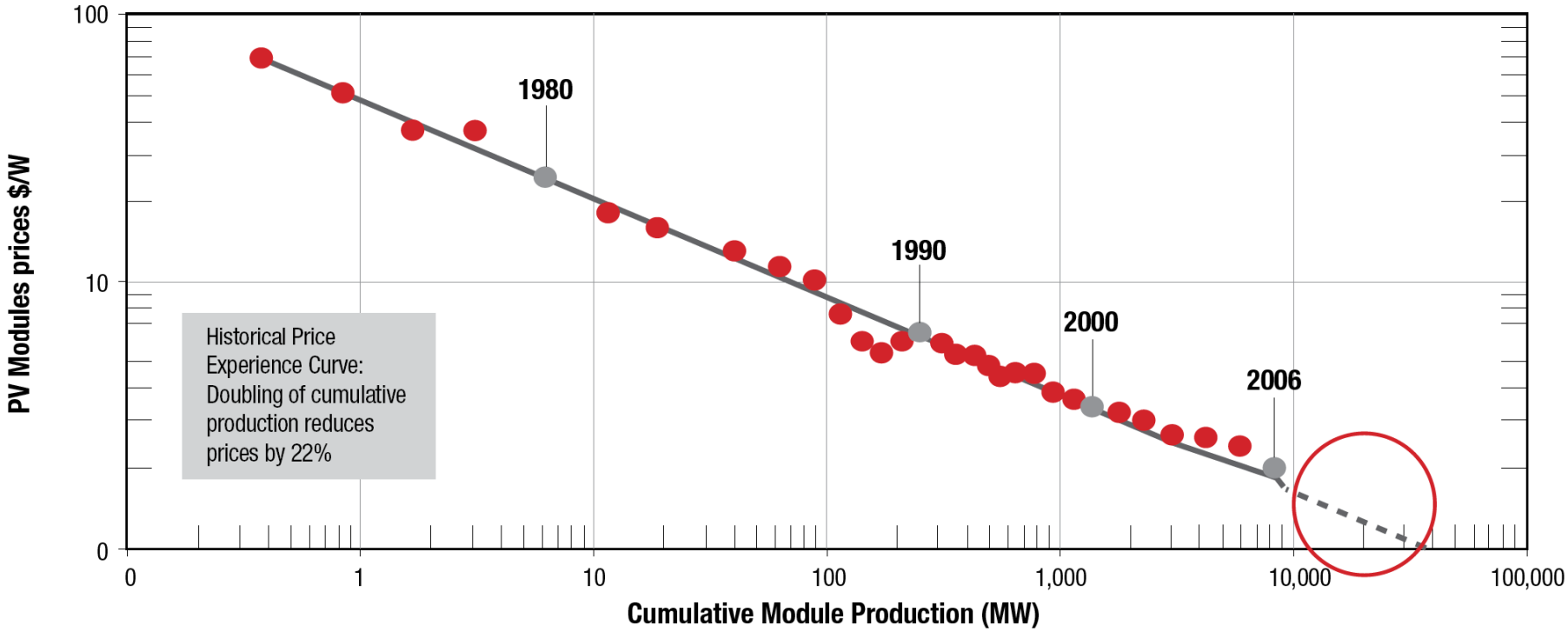
→ Step by step grid parity will be reached in all important markets in the coming years

	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%

The PV learning curve



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

Boosting innovation in photovoltaics

The new PV markets opened since 2003 by the German feed-in-tariff, enlarged by Spain and later followers have boosted innovation activities in the PV sector:

- Increased and lower cost silicon production
- Lower costs and efficiency gains in c-Si cells
- Thin film technologies: aSi, µc-Si, micromorph Si, CIGS, CdTe …
- Concentrating photovoltaic systems CPV
- New PV concepts – dye (DSC); organic (OPV); fluorescent concentrators etc.
- Building integration of PV (BIPV)
- Tracking and support systems
- Grid integration concepts / off-grid systems

→Innovation and cost reduction are accelerating

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

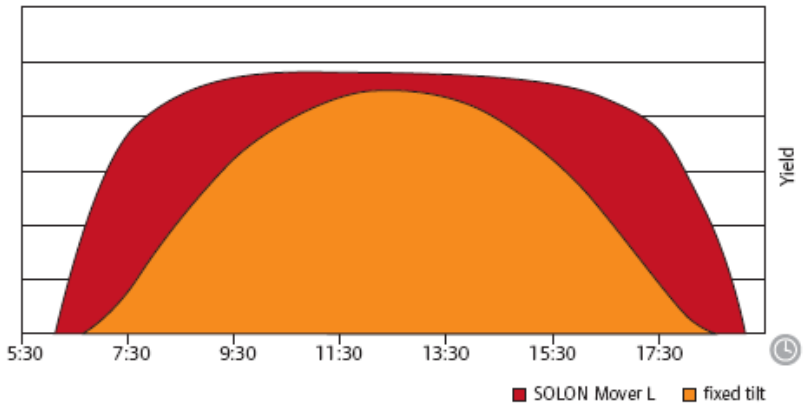
© Archimedes

- 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

© Concentrix

Two axis tracker systems

- Higher yield
- Higher costs
- More surface required (5ha/MWp)



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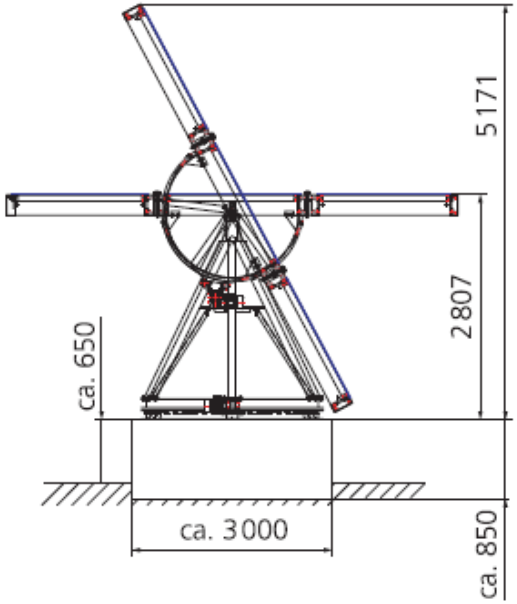
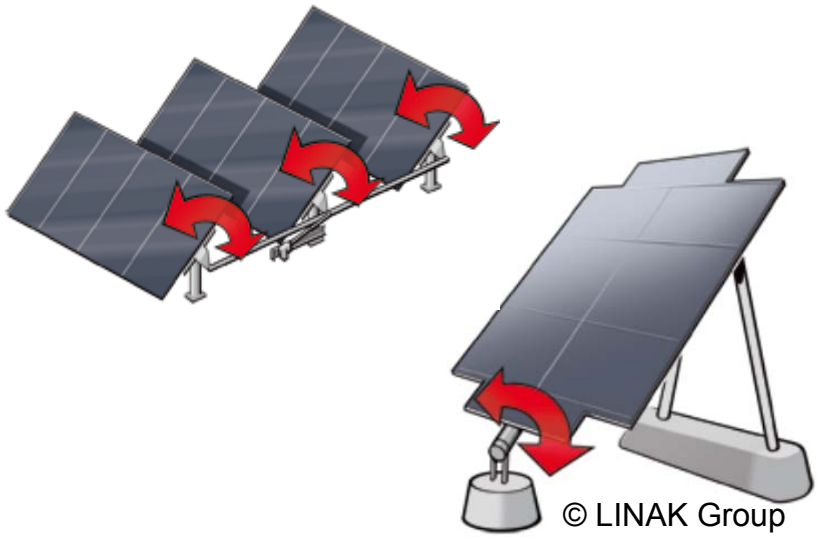


Single axis tracker systems

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



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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


© Sufurcell

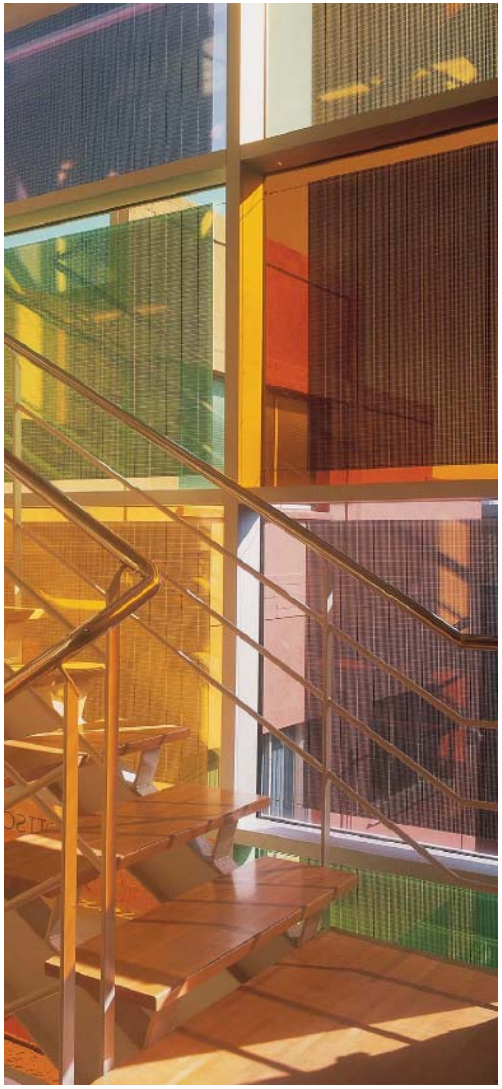
- Very high potential but little commercial progress in the last years
- Research in Germany: Fraunhofer ISE etc.
- Innovative Systems and Components:
  - Schott
  - Schüco
  - Systaic
  - Solon
- New opportunities with thin film products


© Solarsiedlungs-GmbH

Building Integrated PV (BIPV) 2

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

© Schott



Building Integrated PV (BIPV) 3

© Saint Gobain

© bsw-solar

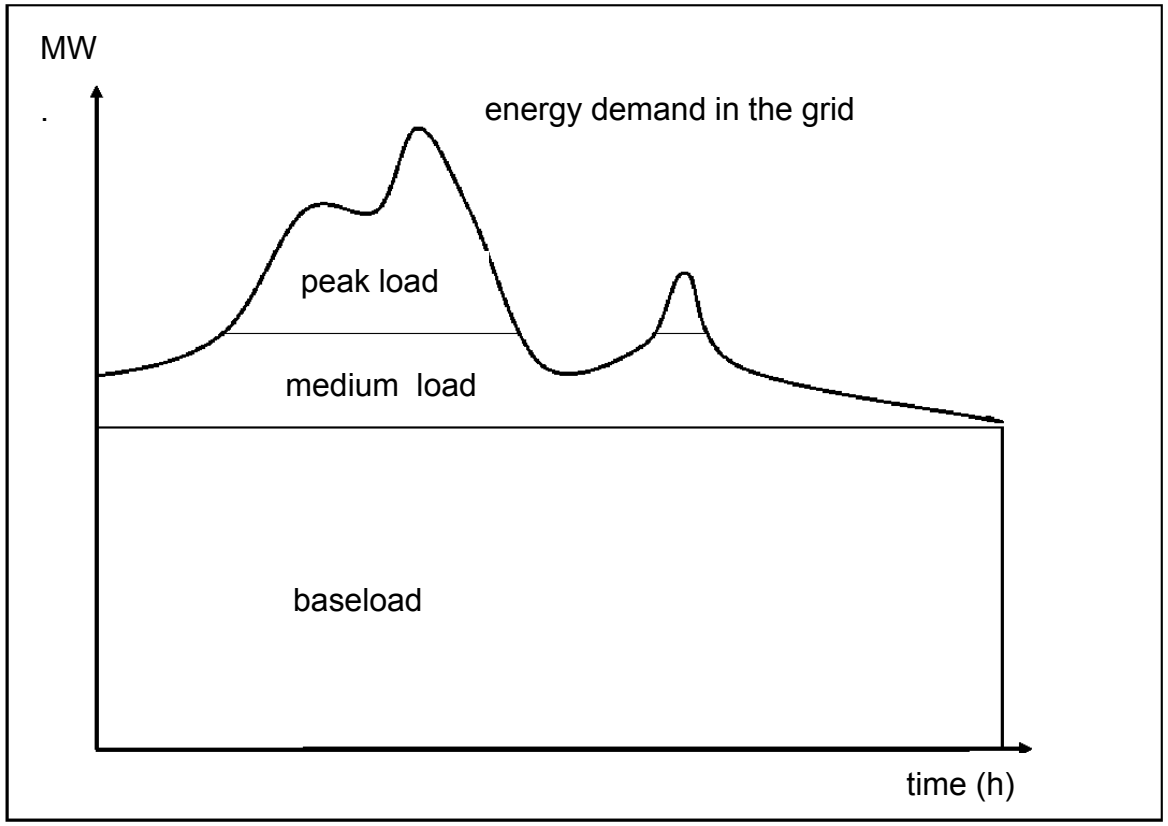
© www.solarnova.de

Grid integration / mini-grids / off-grid systems

- Reduced scepticism concerning grid management:
  Inverter industry : no problem with up to 50% solar electricity in German grid
- Inverters have to take over tasks in grid stabilisation
- Hybrid power stations combining wind, solar, biogas or hydro show success in matching demand
- Smart grids and net metering allow to adapt demand to the offer
- Rapid progress: batteries and other storage technologies

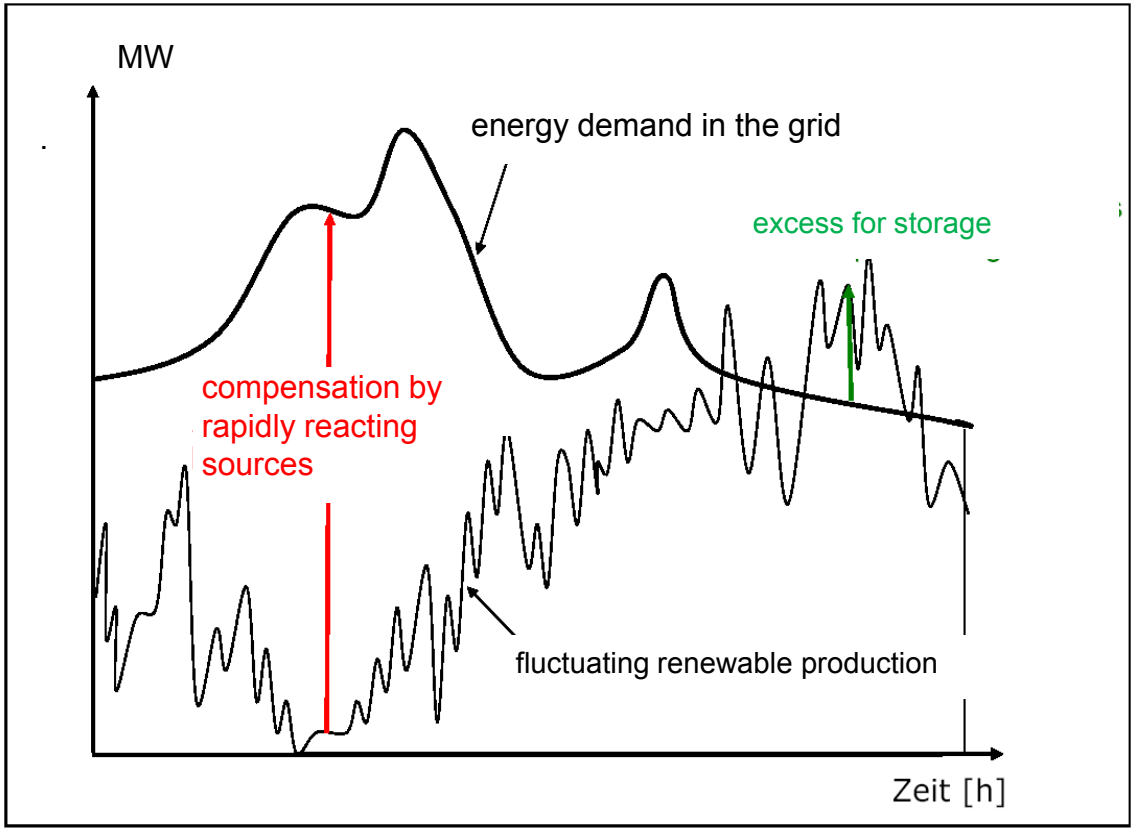
The old baseload concept

- cheap baseload electricity from large plants
- expensive peakload from more variable sources



The new paradigm

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



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

Thank you

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