Federal Ministry
of Economics
and Technology

Ruggero Schleicher-Tappeser
consultant sustainable strategies

Energy

Solar Thermal &Photovoltaics: technology and market developments – the role of Germany

Ruggero Schleicher-Tappeser, consultant, Berlin

AHK, Cairo, June 22, 2009

ruggero@schleicher-tappeser.eu

Outline

I am a free-lance consultant working closely with the German Solar Industry Association BSW-solar. Therefore I partly use BSW-solar documentation.

1. A rapid paradigm change
2. Germany – growth dynamics of the solar thermal market
3. Germany – growth dynamics of the world's largest PV market
4. PV Market challenges ahead
5. Innovation & emerging technologies
6. Fostering an international learning process

German Solar Industry Association
Bundesverband Solarwirtschaft – BSW-Solar

TASK	Represent the German solar industry in the solar thermal energy and photovoltaics sectors
VISION	A worldwide sustainable energy supply provided by solar energy
ACTIVITIES	Lobbying, political advice, public relations, market observation, standardization
TIME	Over 25 years of activity in the solar energy sector
MEMBERS	More than 600 solar producers, suppliers, wholesalers, installers and other companies active in the solar business
HEADQUARTERS	Berlin

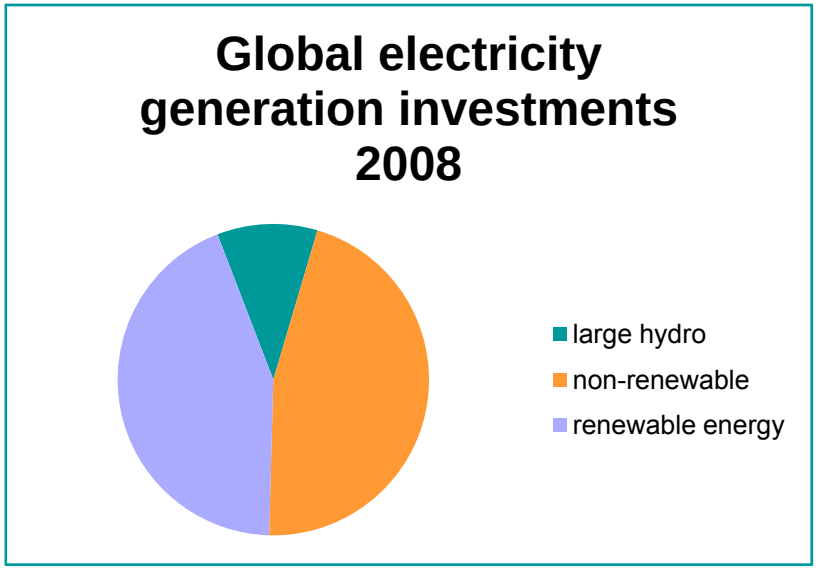
A RAPID PARADIGM CHANGE

Urging problems

- Accelerating climate change
  - Only strong measures will contain warming below 2°C
  - Very rapid transformation of the energy system needed
- Depleting oil and gas resources
  - Raising prices
  - Increasing conflicts
- Increasing energy demand in emerging and developing economies
  - Two billion people without adequate energy supply
  - Growing population

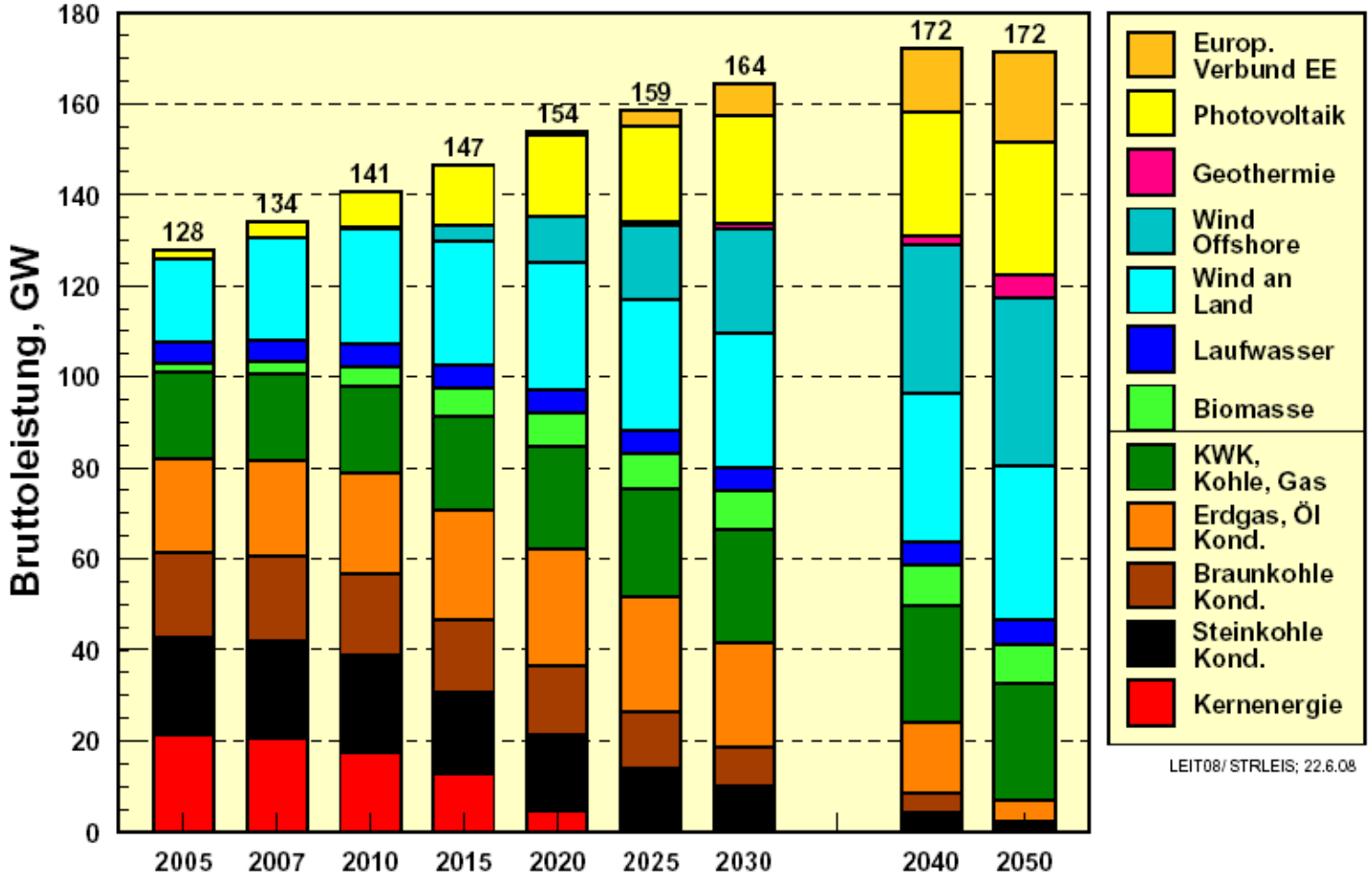
Dramatic shift in perceptions: Renewable energy – the only way out

- Huge investments in renewable electricity generation
  - 2008: US$ 155
  - Four-fold increase since 2004
  - 07/08 only 5% growth
  - Solar 49% growth
  - Europe 49,7%



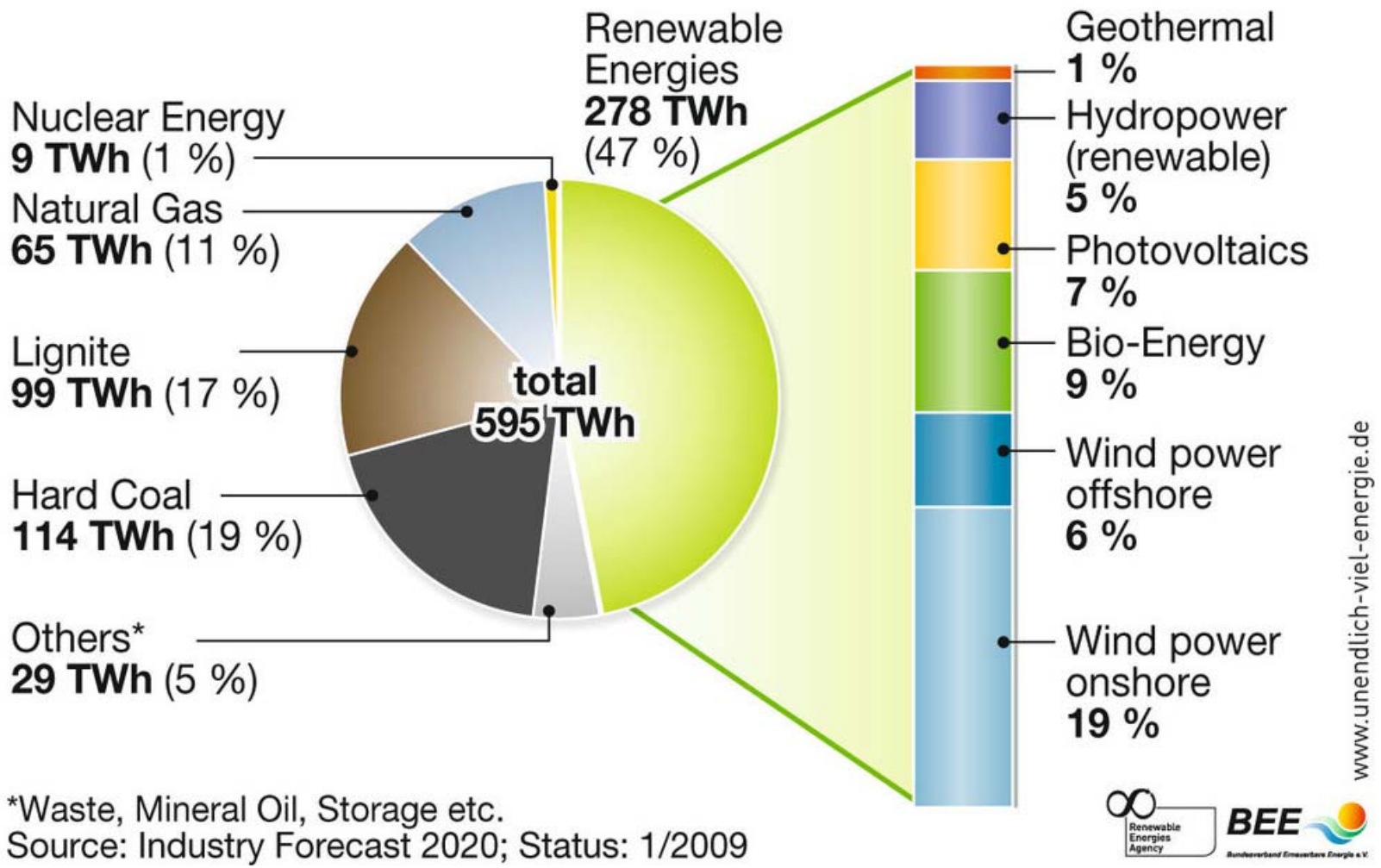
- High priority in economic recovery programmes
- New programmes for solar thermal
- Over 100 countries joined the new International Renewable Energy Agency IRENA

Lead scenario of the German Ministry for Environment and Renewable Energies



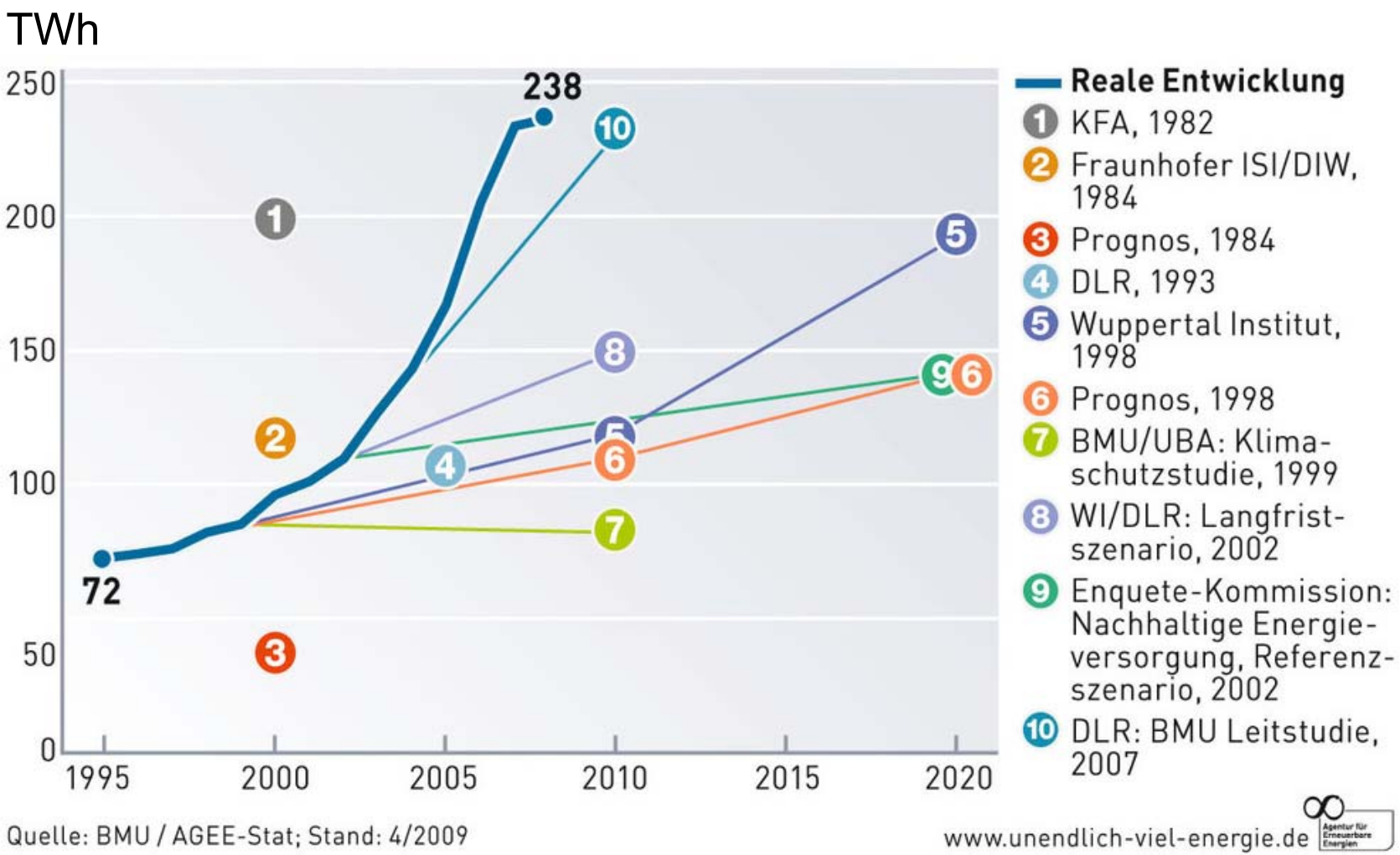
ruggero@schleicher-tappeser.eu

Renewable industry forecast Germany: 47% renewable electricity in 2020



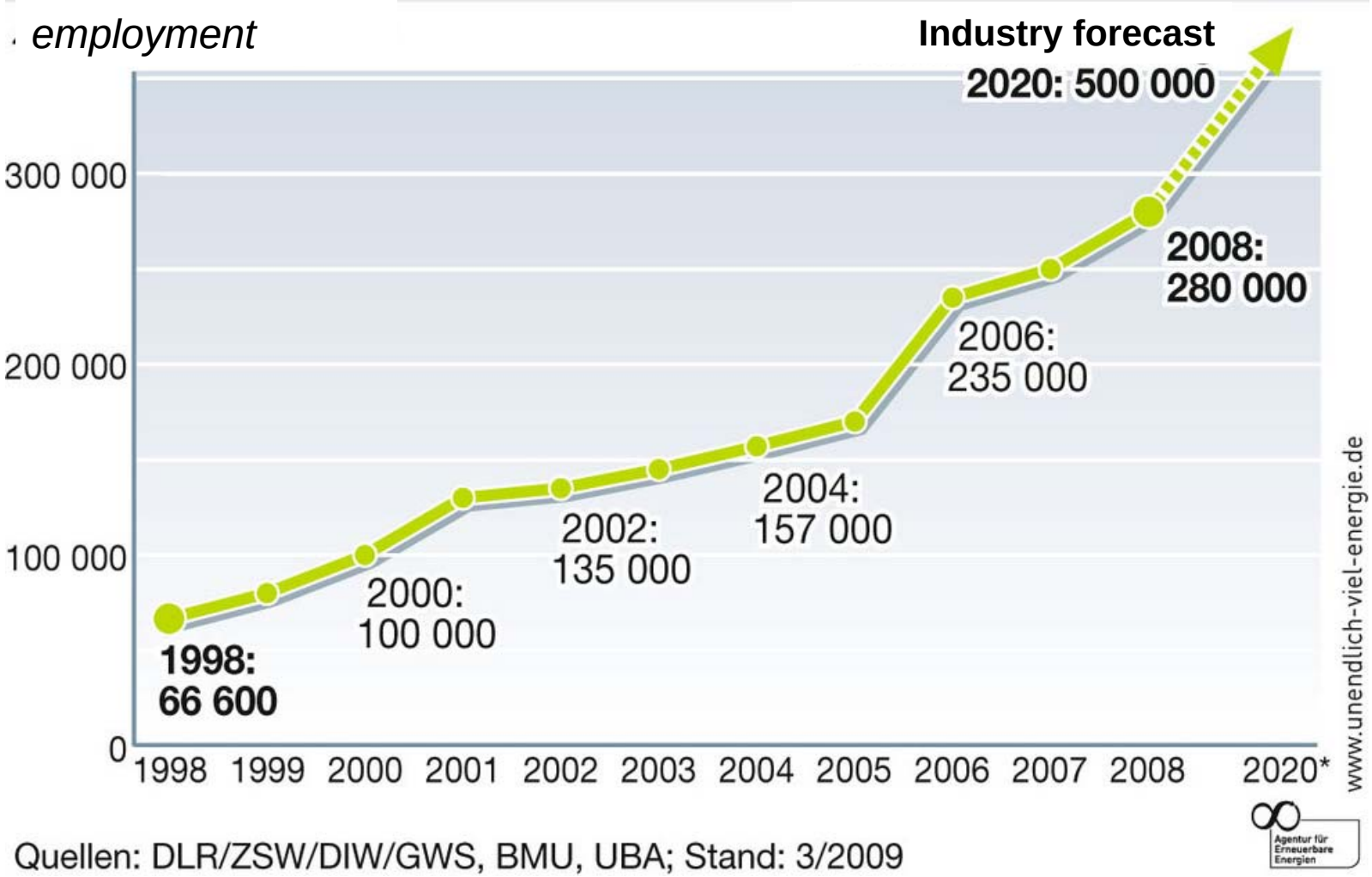
ruggero@schleicher-tappeser.eu

Forecasts and reality: share of renewables in German final energy consumption



ruggero@schleicher-tappeser.eu

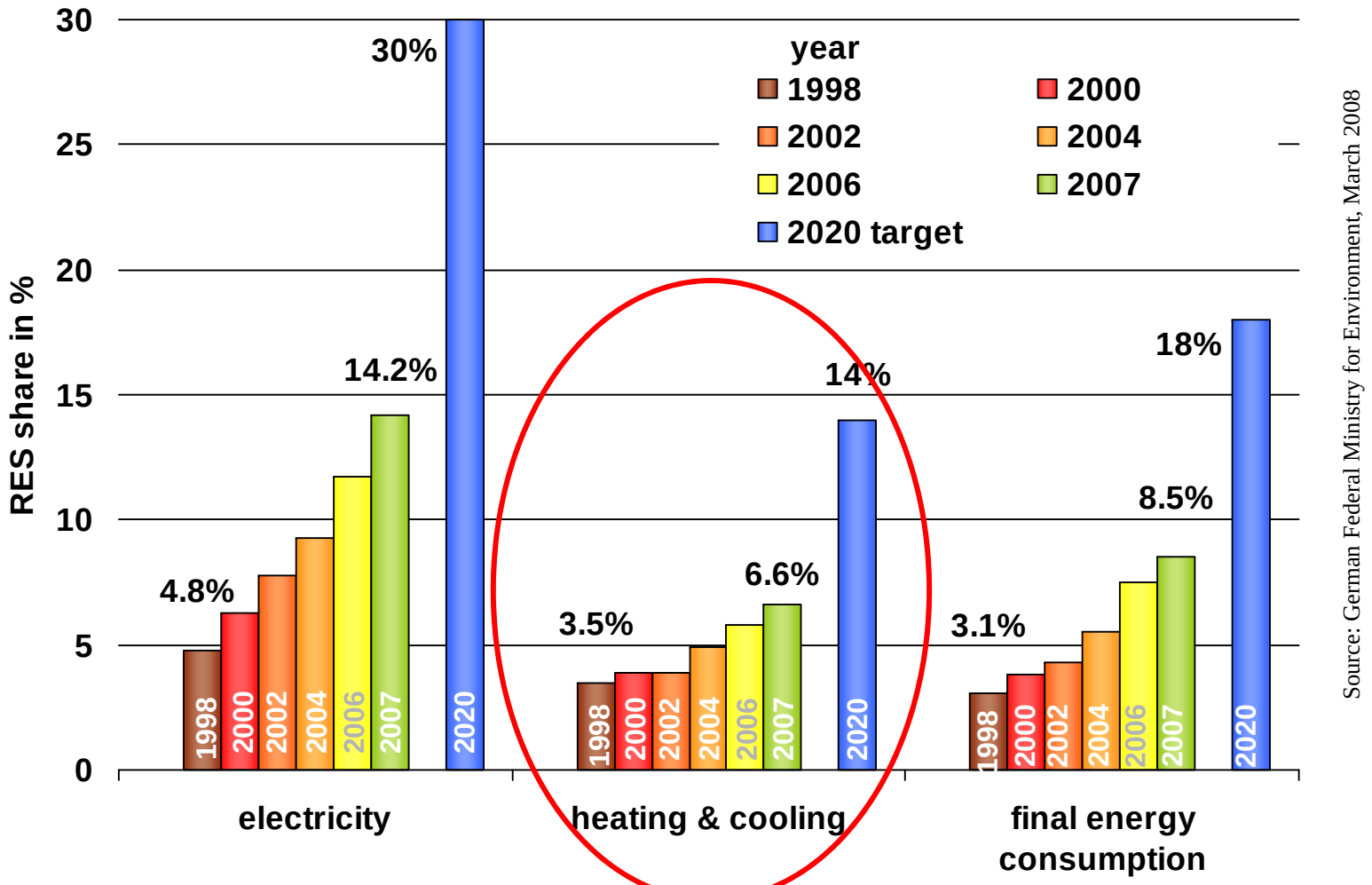
Employment in renewable energies in Germany



ruggero@schleicher-tappeser.eu

GERMANY – GROWTH DYNAMICS OF THE SOLAR THERMAL MARKET

Development of the renewable share in final energy consumption

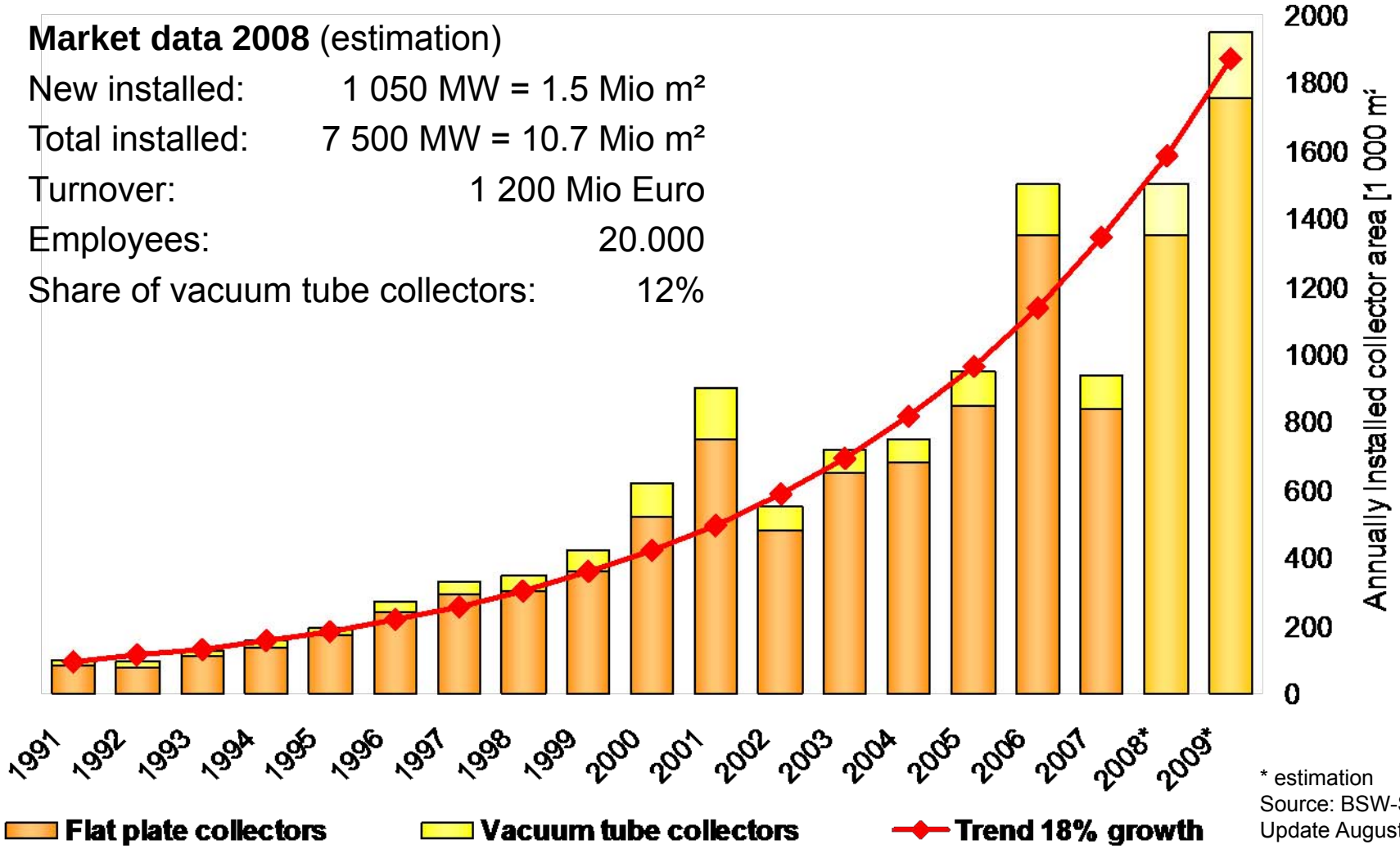


Source: German Federal Ministry for Environment, March 2008

Development of the German Solar Thermal Market

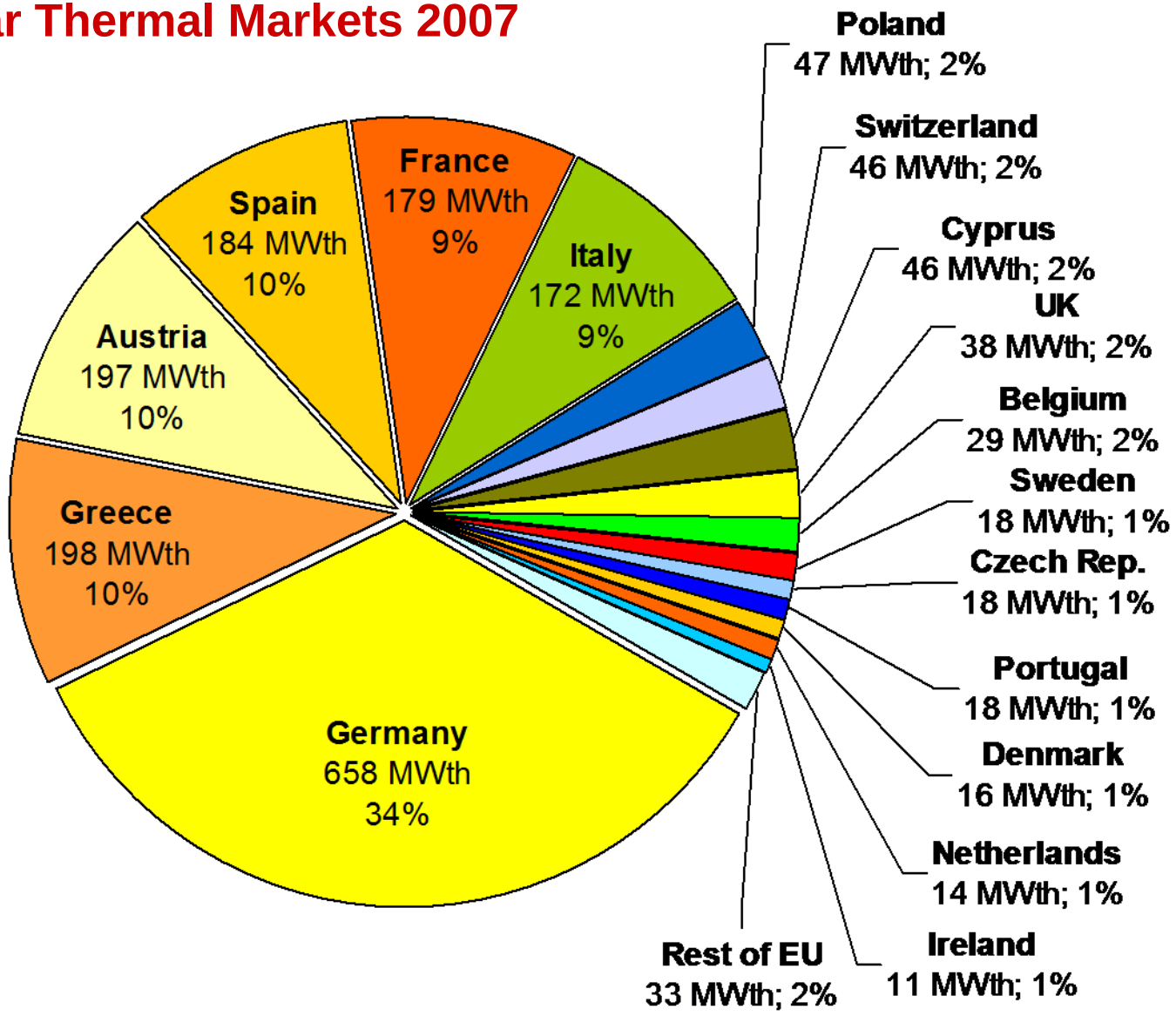
Market data 2008 (estimation)

New installed:	1 050 MW = 1.5 Mio m²
Total installed:	7 500 MW = 10.7 Mio m²
Turnover:	1 200 Mio Euro
Employees:	20.000
Share of vacuum tube collectors:	12%



* estimation
Source: BSW-Solar
Update August 2008

European Solar Thermal Markets 2007



European Market 2007:
2.7 Mio m²
1.9 GWth

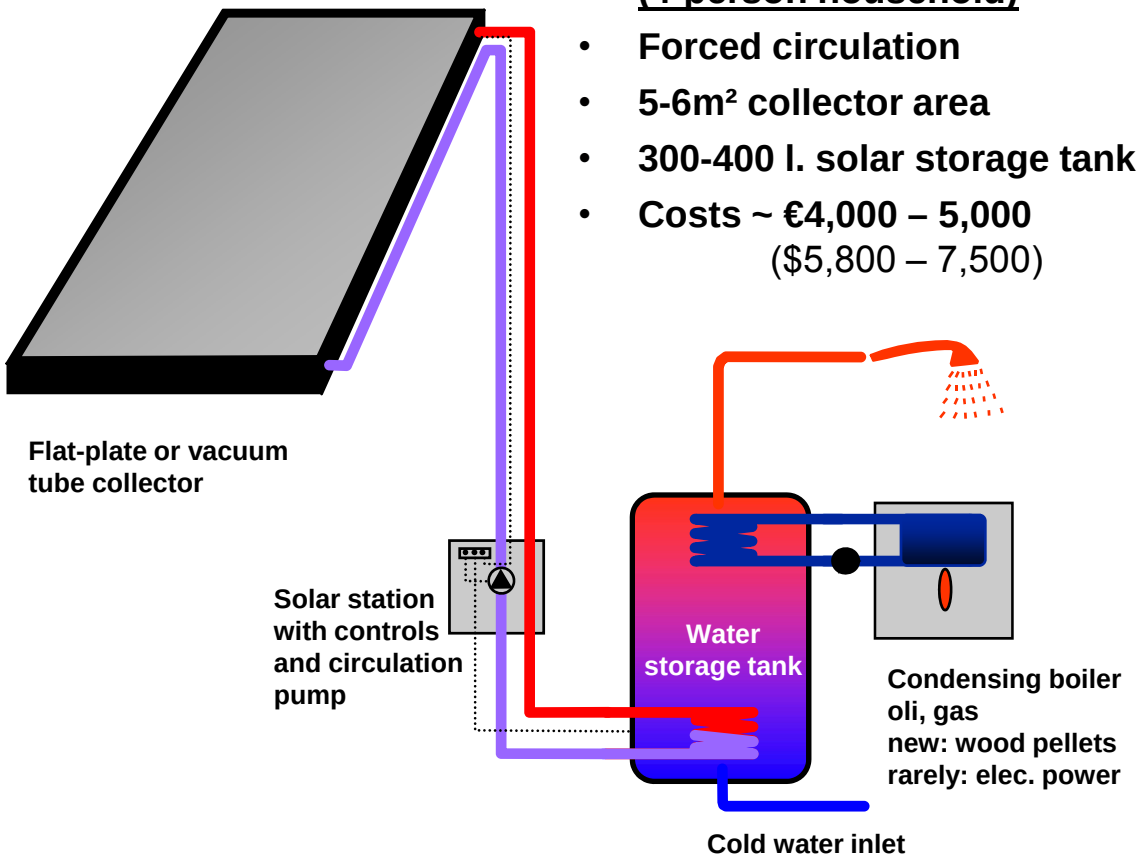
Source: ESTIF/BSW

Domestic Hot Water Production

Market share in Germany: 55 %

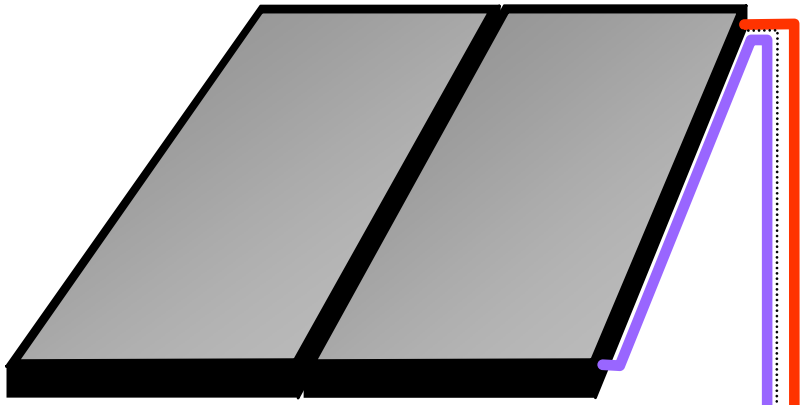
Typical data for Germany (4-person household)

- Forced circulation
- 5-6m² collector area
- 300-400 l. solar storage tank
- Costs ~ €4,000 – 5,000 ($5,800 – 7,500)

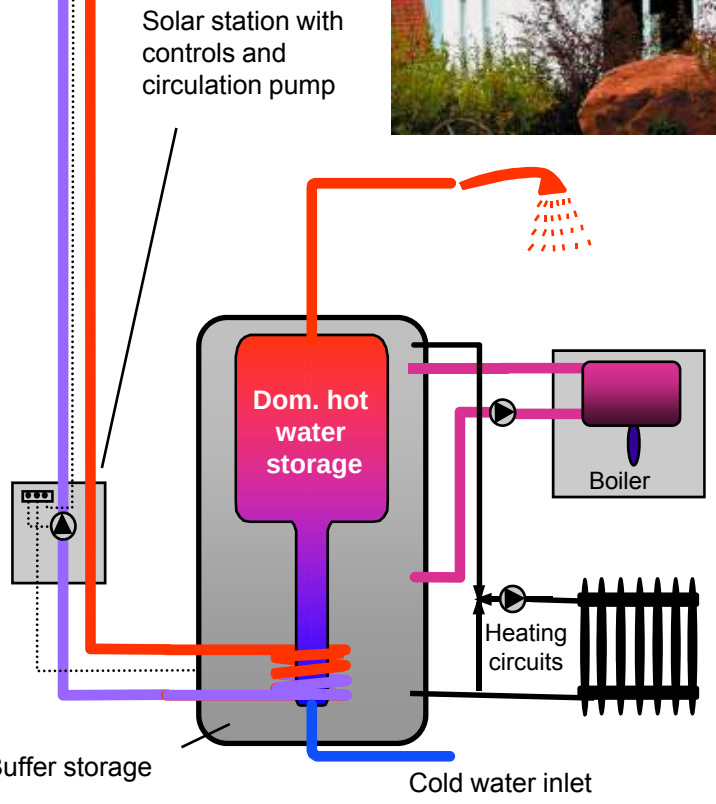


Solar Thermal Combined System

Market share in Germany: 45 %



Flat-plate or vacuum tube collector



Combined solar thermal system for DHW and auxiliary room heating

- **8-15 m² collector area**
- **500-1,000 litres combined storage**
- **Costs ~ €10,000 – €15,000**
  ($14,500 – $22,000)
- **Forced circulation system**

Combi storage

Image: Paradigma

Special Know-how in Large Scale Solar Thermal Systems

Large solar thermal systems for multi family houses, hotels, hospitals, nursing homes etc. must to be designed well

German companies have a lot of experience and offer matured systems

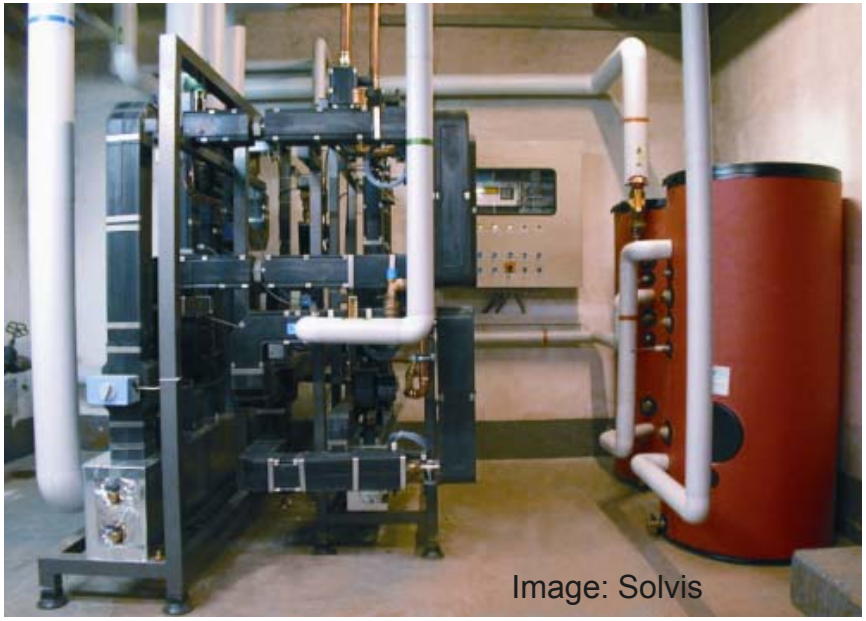
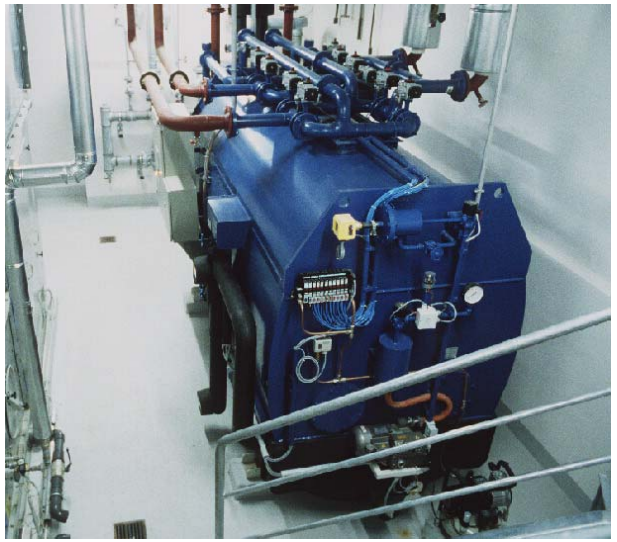


Image: Solvis

Image: Wagner & Co

Promising Technology: Solar Assisted Cooling

- Solar thermal driven cooling machines
- Cooling demand and solar supply are fitting well
- There are more than 100 systems installed in Europe and they are working well
- Small systems for office buildings and one/two-family houses are under development



Adsorption cooling machine

Source: Viessmann

Source: Fraunhofer ISE

Solar District Heating will play a big role in the future

Solar disctrict heating in Marstal, Denmark
17,000 m² collector area

© Arcon

© Solites

Semi-detached houses in Neckarsulm, Germany

© Solites

12,000 m² seasonal storage
Friedrichshafen, Germany

Solar Thermal Vision 2030
of the European Solar Thermal Technology Platform ESTTP

New buildings

100% solar heated buildings will be the building standard

Existing building stock

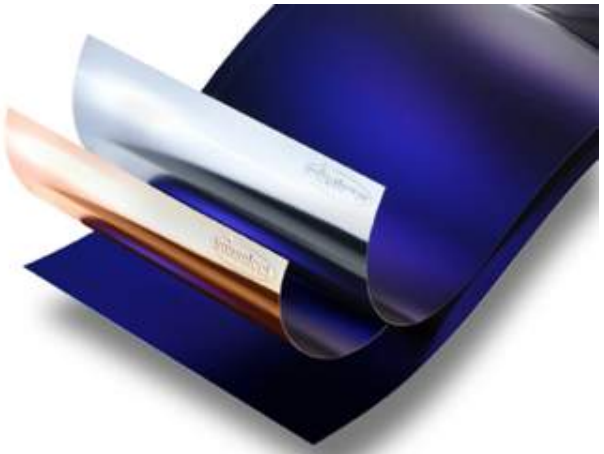
Solar refurbished buildings, > 50% solar heated, will be the most cost effective way to refurbish the building stock

Industrial and agricultural applications

solar thermal systems will cover process heating and cooling demands

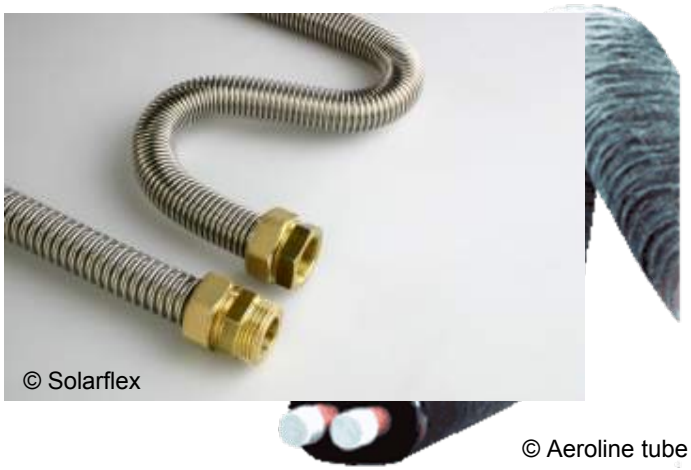
Overall goal:
Cover 50% of the low temperature need up to 250°C with solar thermal

Continuous improvements in the Solar Thermal Technology



© alanod, sunselect

Selective absorber coating



© Aeroline tube systems

Improved piping

© KBB Kollektorbau

New collector design

© Wilo

High efficient solar pumps

Solar Thermal Innovations in Germany

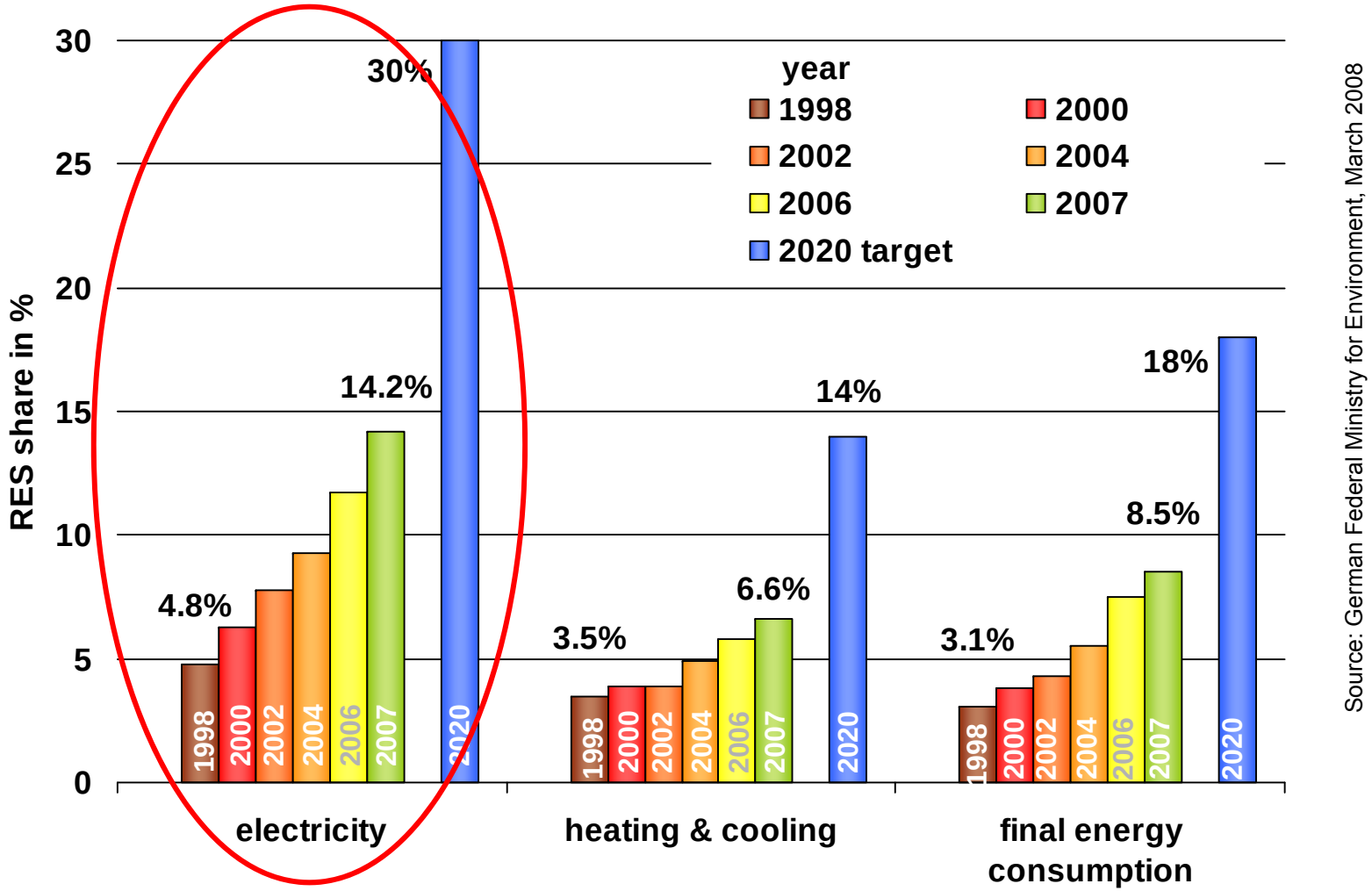
- Stratified, seasonal, and latent heat stora
- Anti-reflective glass
- Sputter process for absorber coating
- New collector types (improved functionali
- Improved piping connecting collectors an
- Control system technology, heat transfer pumping
- Solar cooling, high-temperature collectors
- …

Targets

- Higher solar fraction of heat supply in buil
- Higher efficiency at lower costs
- Improved integration into the heating syst building envelope

GERMANY – GROWTH DYNAMICS OF THE WORLD'S LARGEST PV MARKET

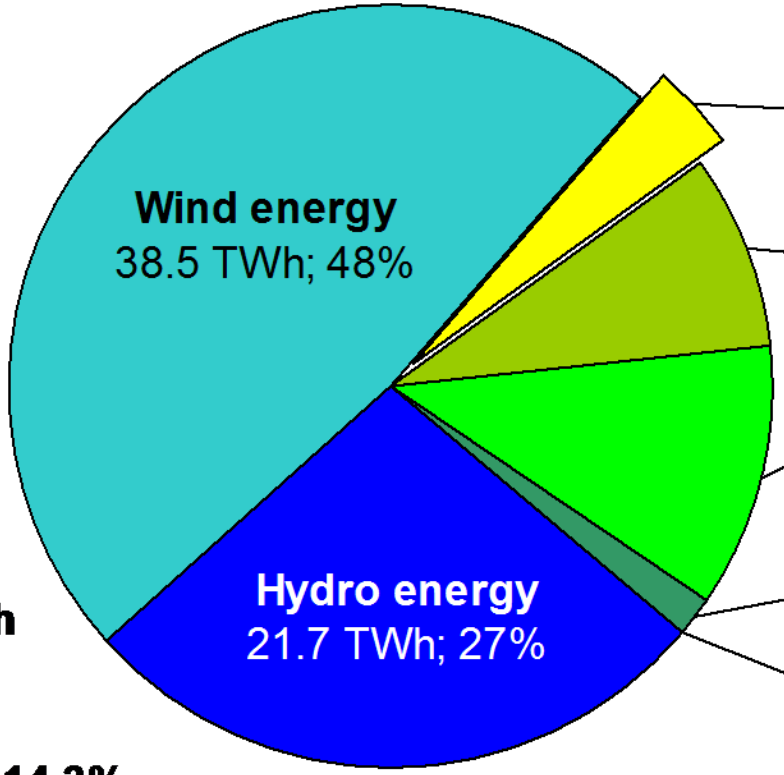
Renewable share in final energy consumption



Source: German Federal Ministry for Environment, March 2008

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

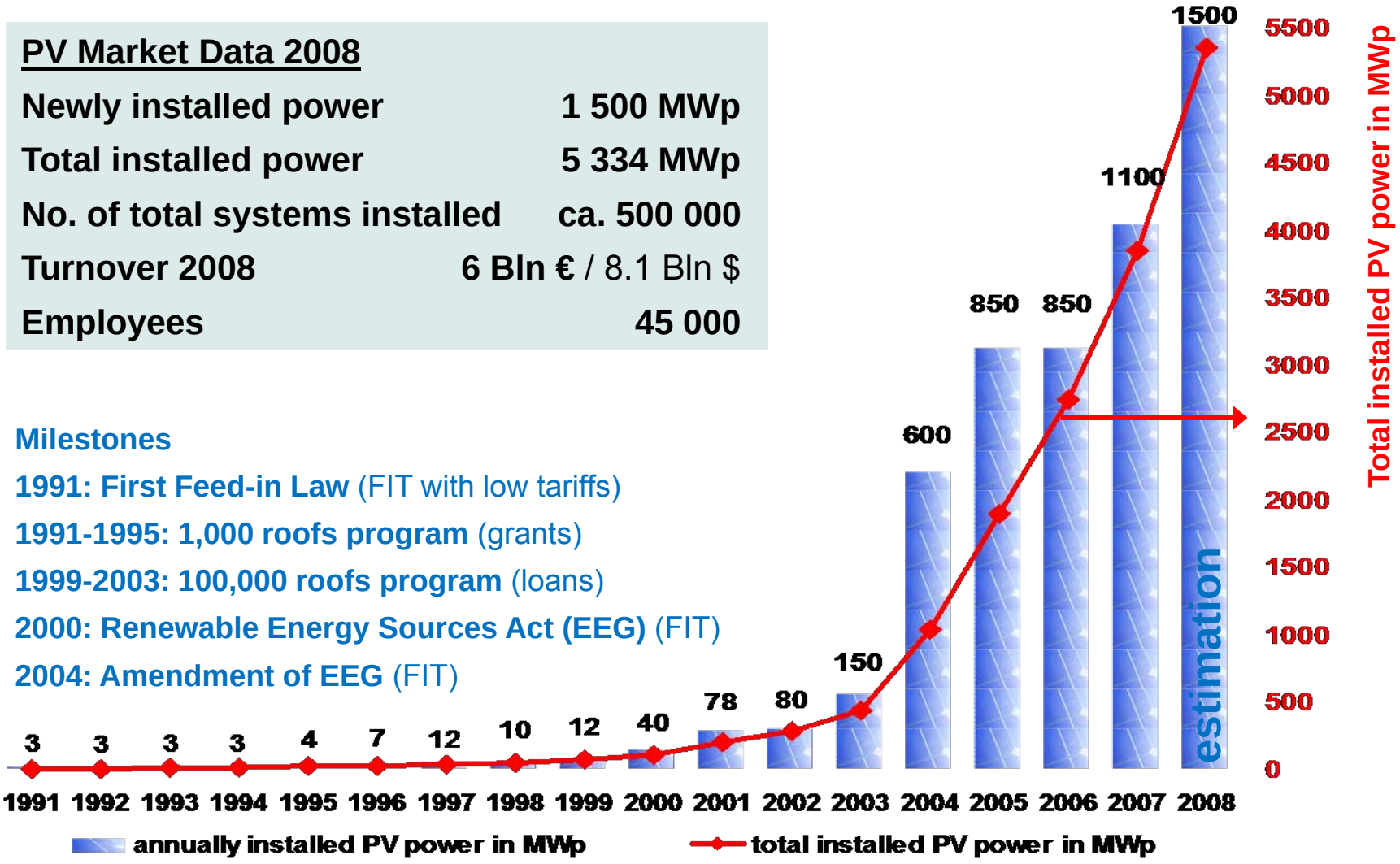
1991: First Feed-in Law (FIT with low tariffs)

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

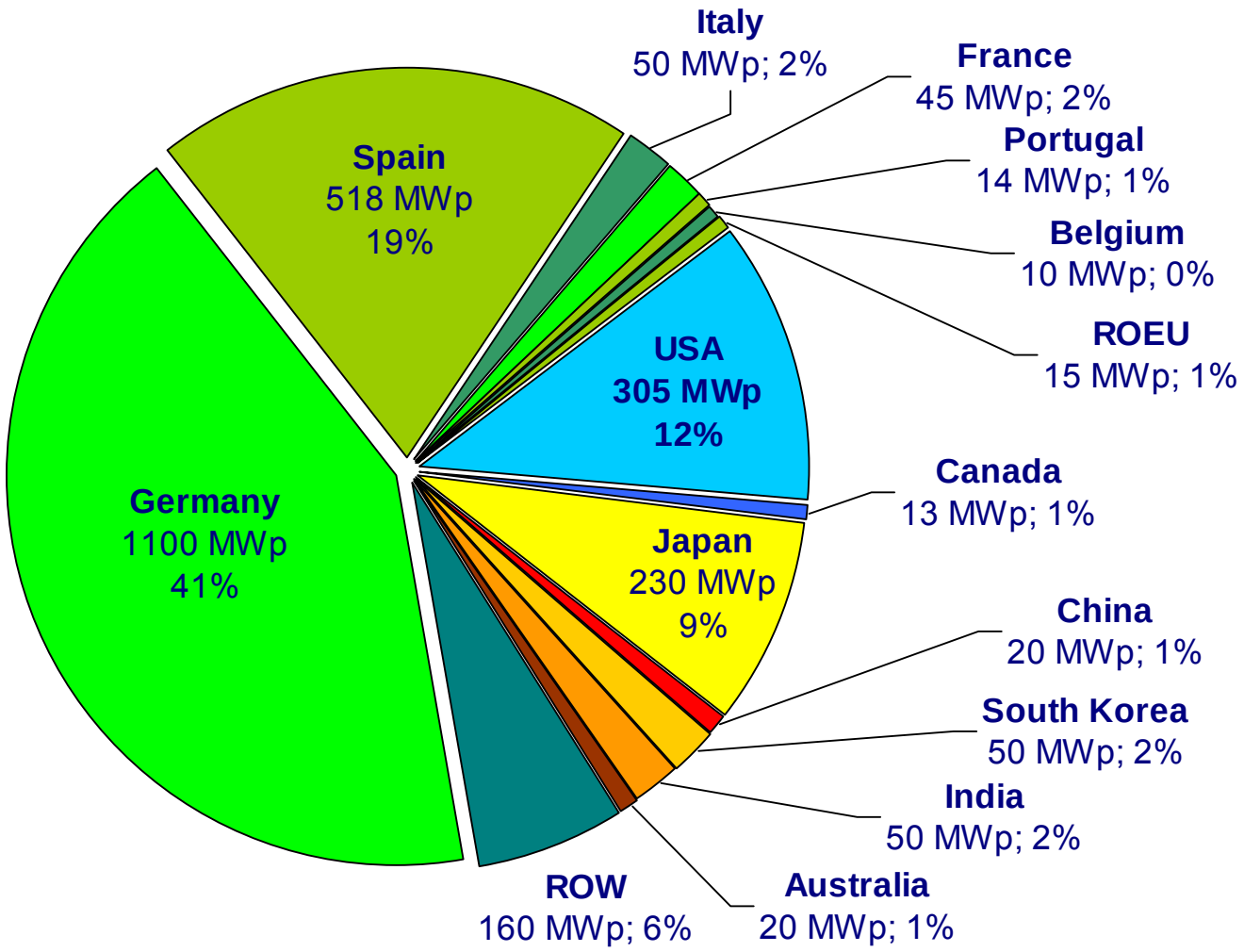
1999-2003: 100,000 roofs program (loans)

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

2004: Amendment of EEG (FIT)



Photovoltaic World Market 2007



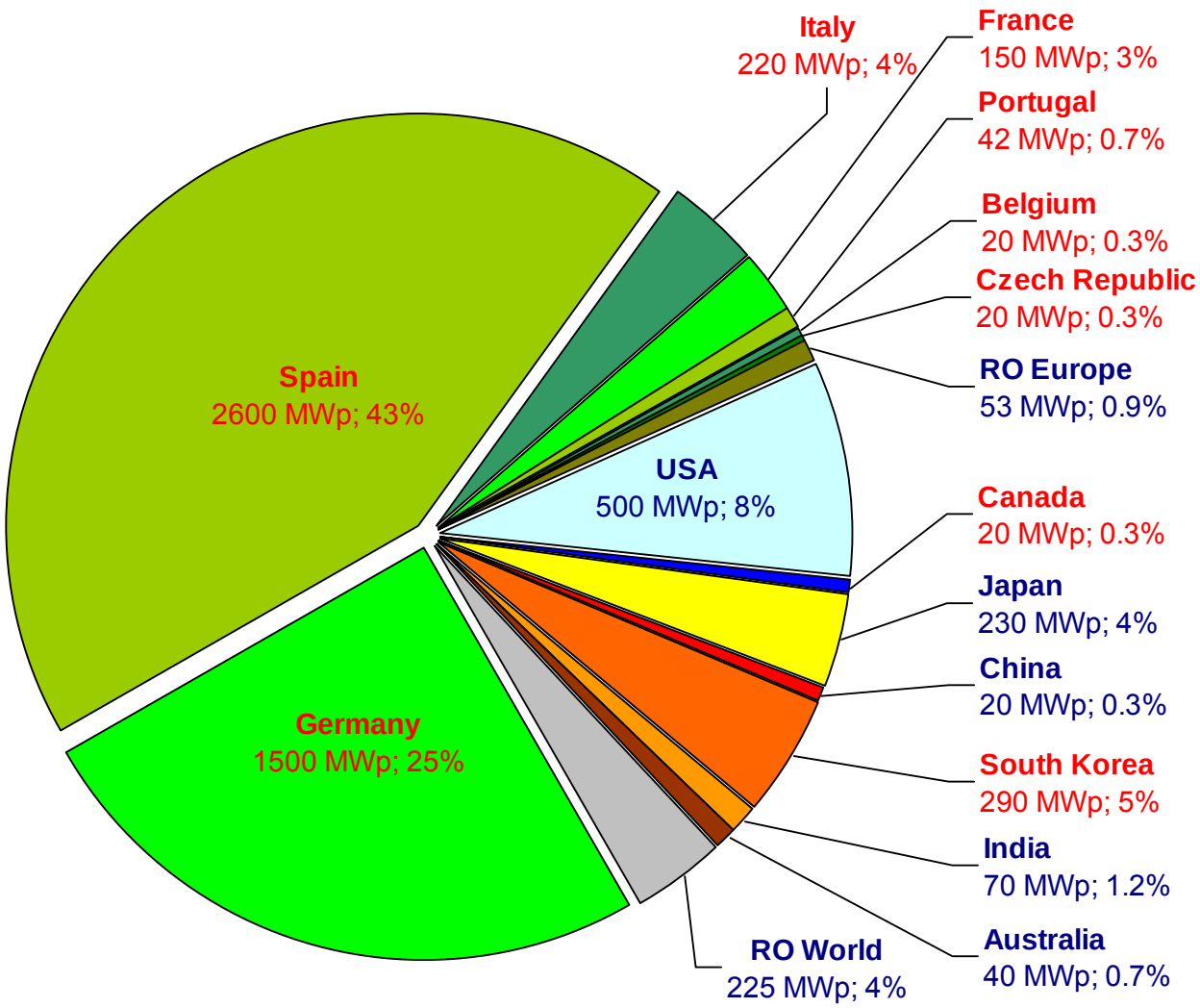
New installed PV Power

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%)

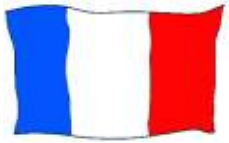
2008: 6000 MWp (+126%)

Red Letters: Countries with Feed-in tariff schemes

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

Image: Sunenergy

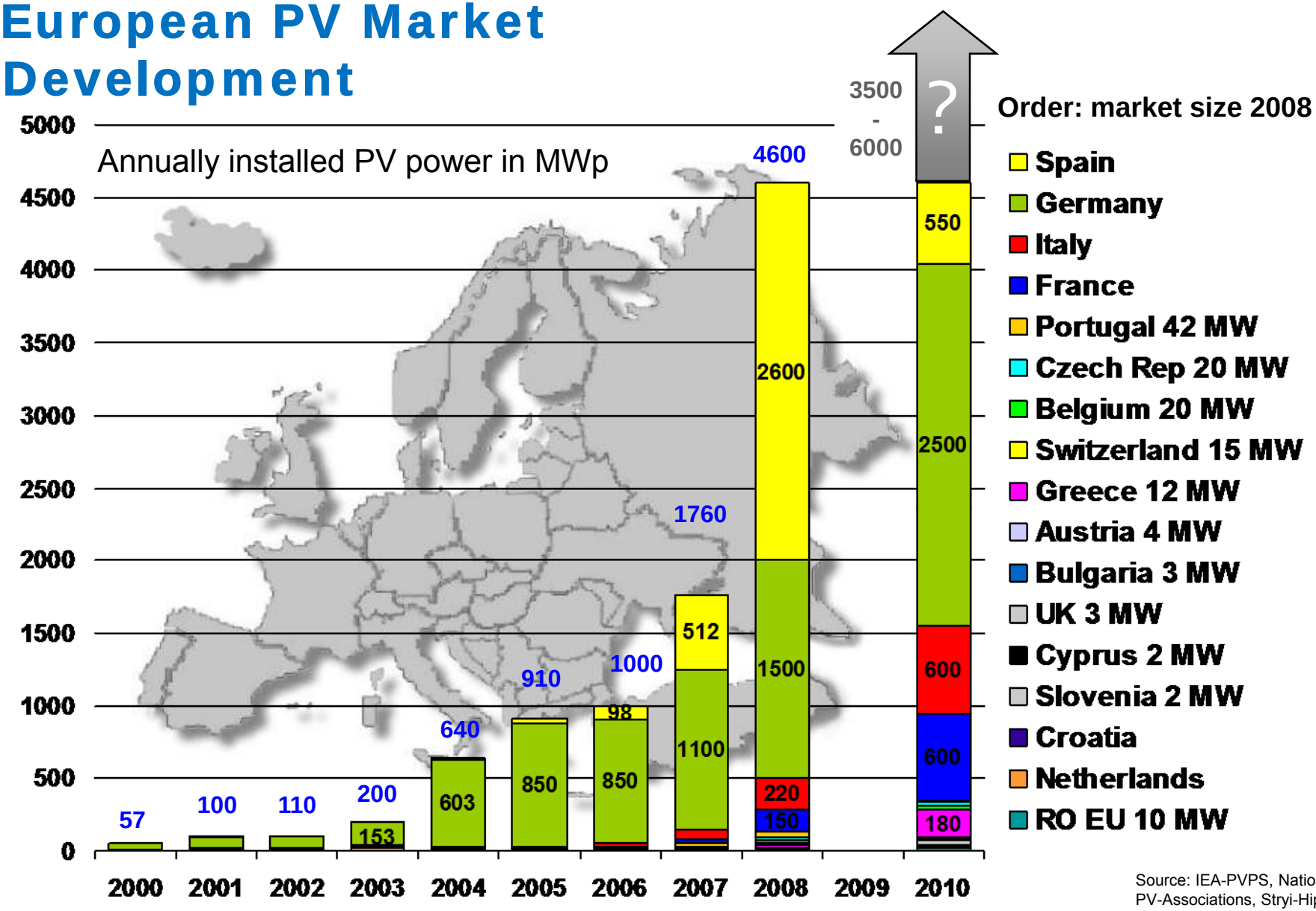
Feed-in tariffs in European PV Markets



	Feed-in tariffs [€ct/kWh]			Market size [MWp]		
Year	2008	2009	Growth	2008	2010	Growth
Germany	37.96 54.21	31.94 43.01	-8% -10%	1500	2500	x1.7
Spain	23 44	32 34	-25%	2600	550	x0.2
Italy	36 49	35.28 48.02	-2%	150	600	x4
France*	31.19 57.16	32.82 60.17	+5%	150	600	X4
Greece**	40 50	40 50	0%	10	200	x20

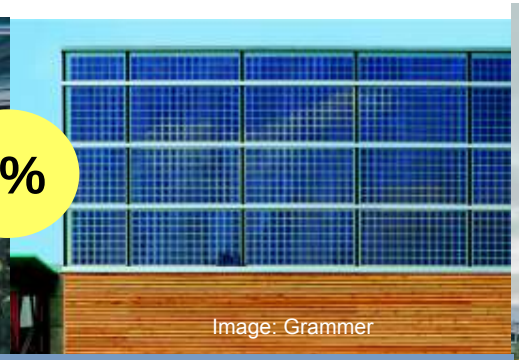
* plus tax reduction ** plus subsidies Source: National PV associations

European PV Market Development



Source: IEA-PVPS, Natioal PV-Associations, Stryi-Hipp

Germany: Market Segments of on-grid PV Systems



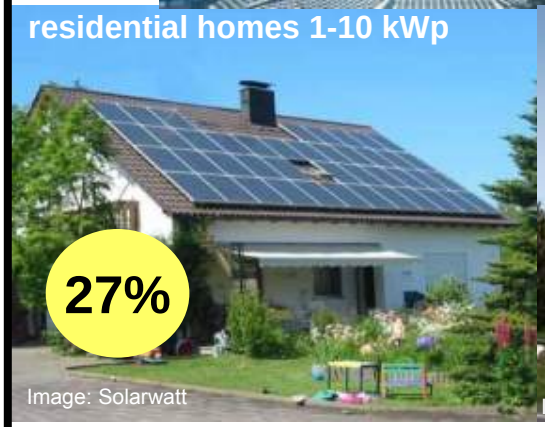
1%

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%

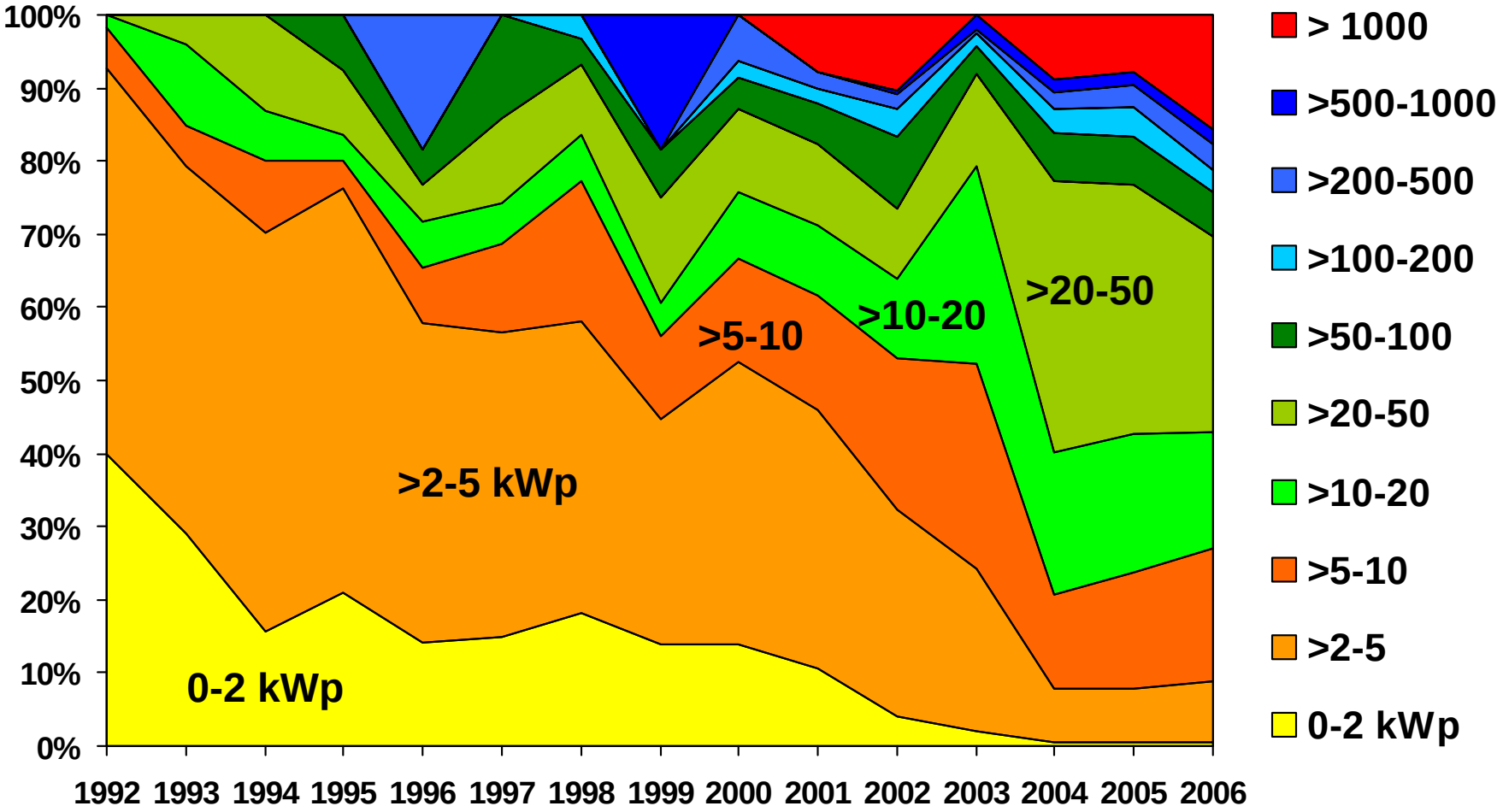
Ground mounted

Market share in 2006

10%

Size of the system

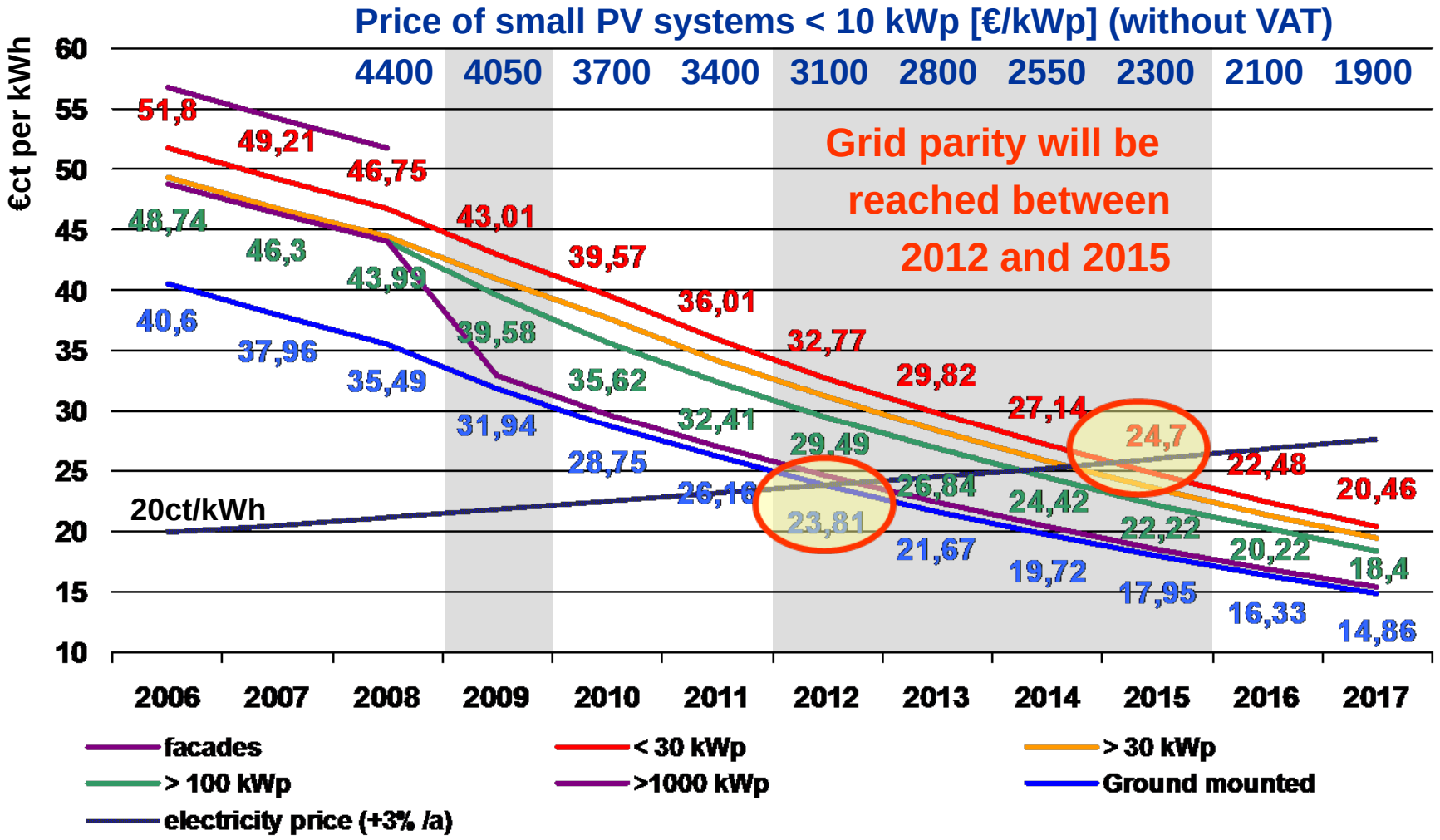
Market share of PV systems according to size



Source: BSW-Solar, calculated from data of 2.2 GWp PV systems from EnBW, EON, RWE, Vattenfall

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

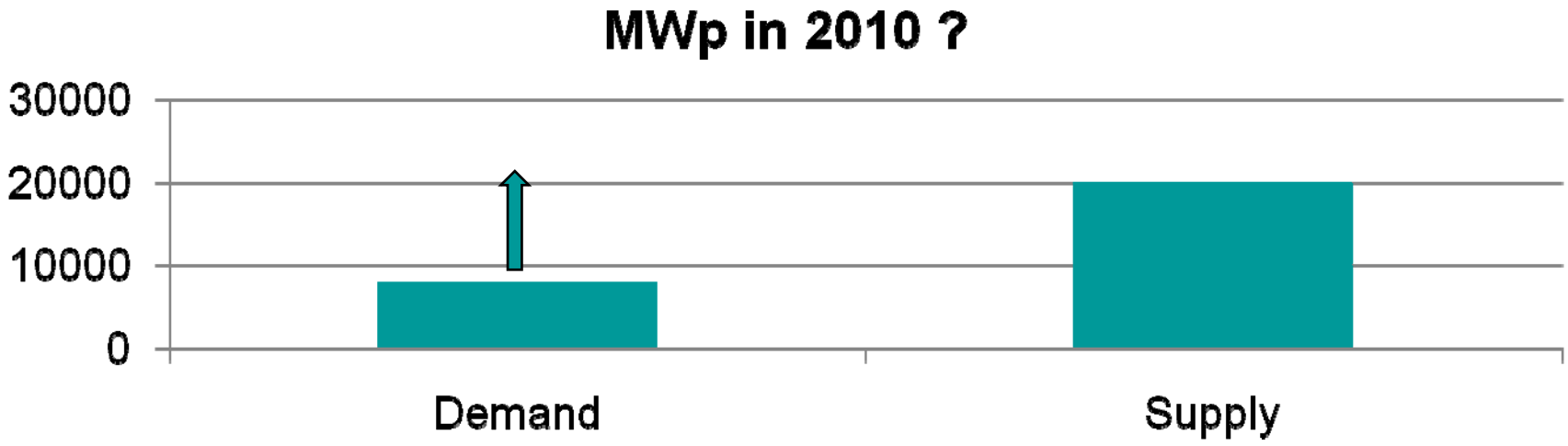
PV: CHALLENGES AHEAD

Independent from the economic crisis: worldwide PV overcapacity

- Announcements for production in 2010 amount to 20 GWp
- Demand estimates range between 4 and 14 GWp

→ Big efforts in market development are necessary

→ Only strong and high quality producers will survive



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
- Detailed policies for electricity, heat
- →Electricity needs 35-40% renewables by 2020

ruggero@schleicher-tappeser.eu

German Renewable Energy Association: Prognosis exceeds EU targets

Share of total electricity production in Germany

	share 2020	growth 2007-2020
• Biomass	9%	+119%
• Geothermie	1%	
• PV	7%	+1217%
• Hydro	5%	+54%
• Wind onshore	19%	+182%
• Wind offshore	6%	
• **TOTAL**	**47%**	

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 crisis: impact on business

- Medium term growth prospects for renewables better than ever
- Credit crunch brings problems to project financing – utilities and private investors not touched
- 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

INNOVATION AND EMERGING TECHNOLOGIES

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

The importance of system costs

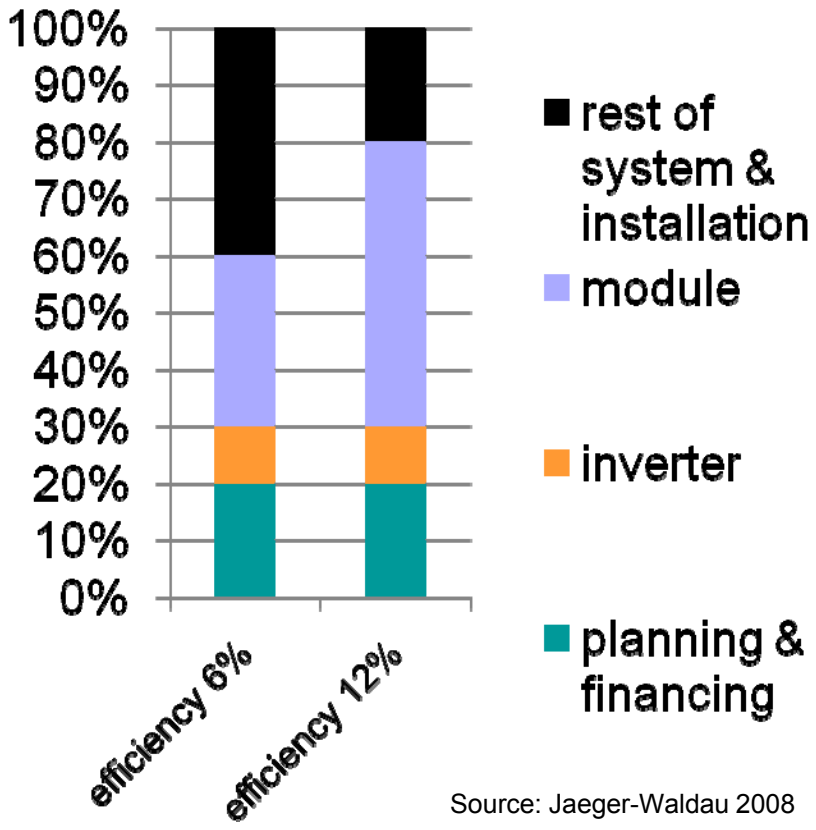
- Lower efficiency requires larger surfaces
- At low efficiency module costs may make up for only 1/3 of system costs

→ Efficiency matters

→ Costs of the rest of the system matter

→ Interesting prospects for innovative BIPV with low cost cells

Cost components at overall system costs of 2 € / Wp



Source: Jaeger-Waldau 2008

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

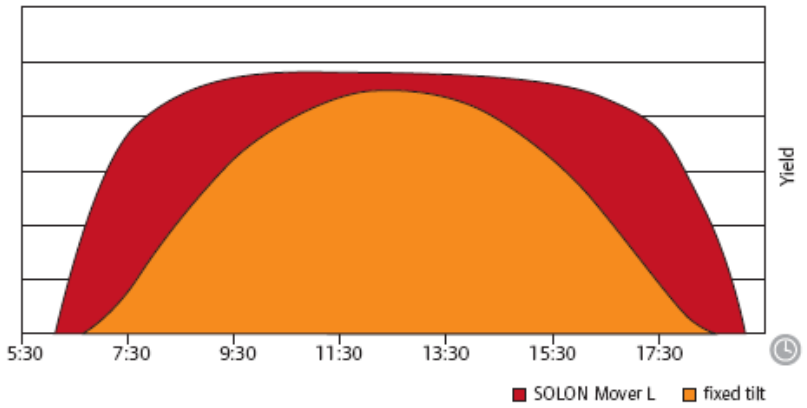
© Archimedes

- 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

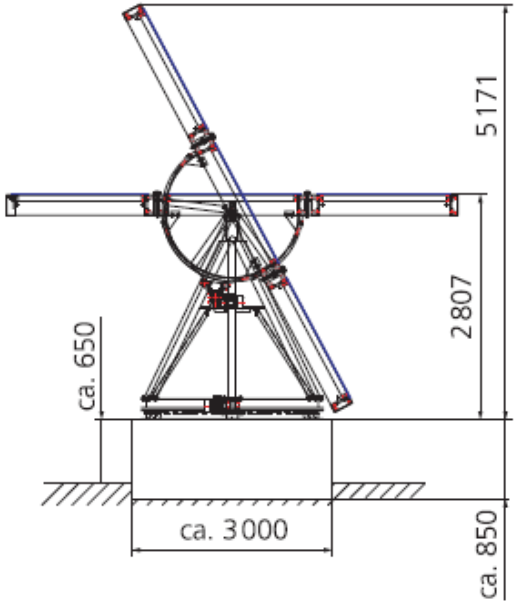
© Concentrix

Two axis tracker systems

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

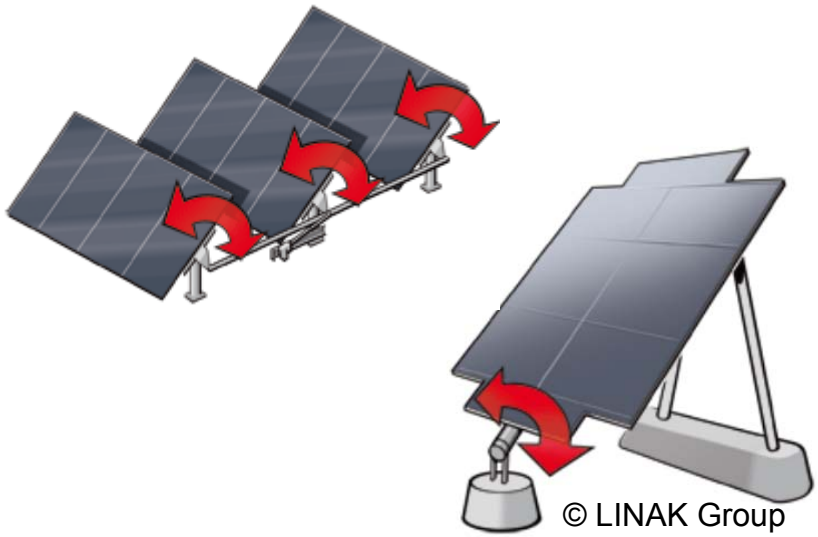


© LINAK Group



Single axis tracker systems

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



© LINAK Group

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

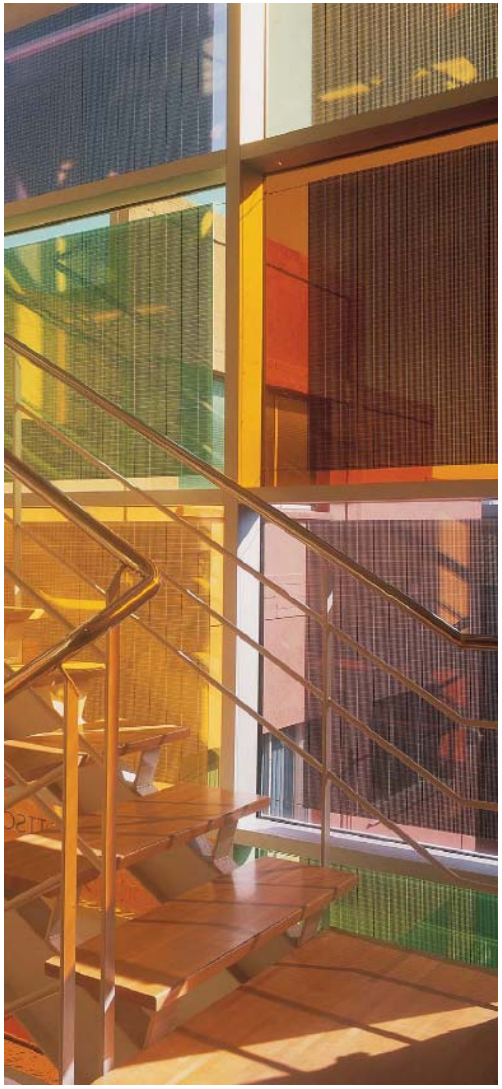
- Very high potential but little commercial progress in the last years
- Research in Germany: Fraunhofer ISE etc.
- Innovative Systems and Components:
  - Schott
  - Schüco
  - Systaic
  - Solon
- New opportunities with thin film products


© 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

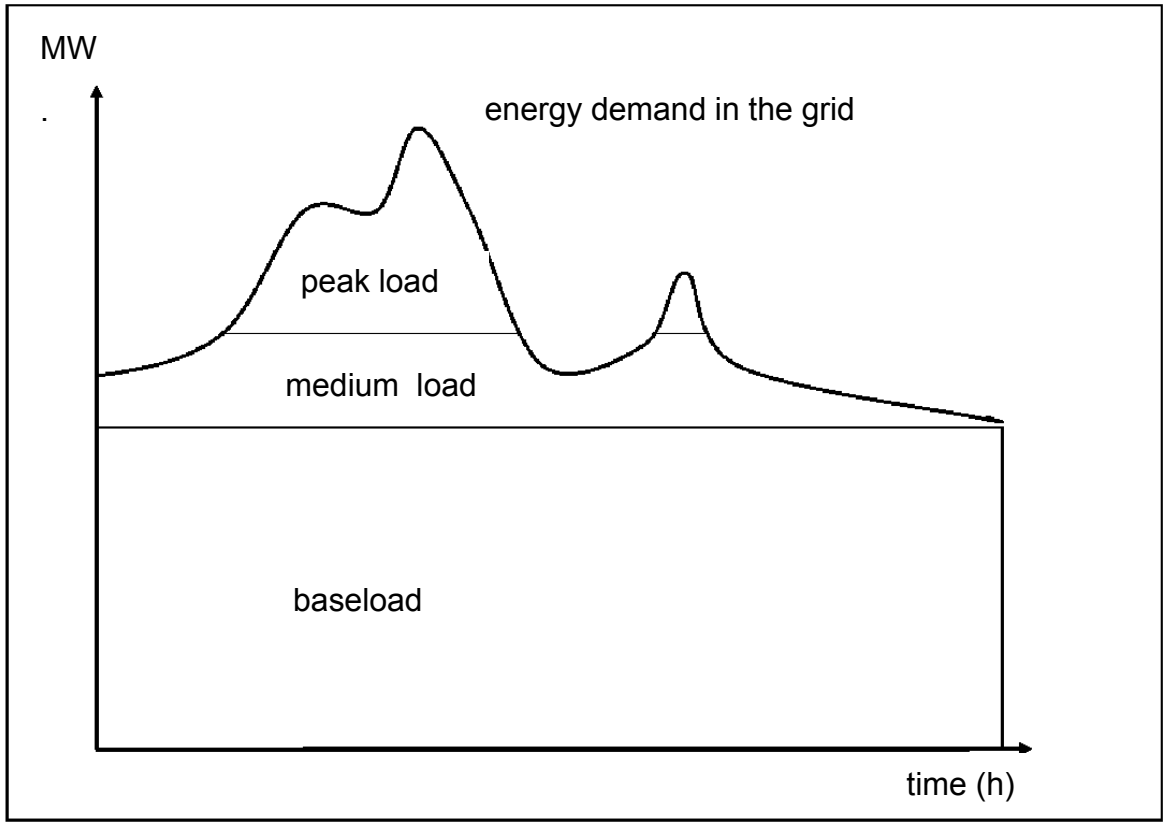
© www.solarnova.de

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

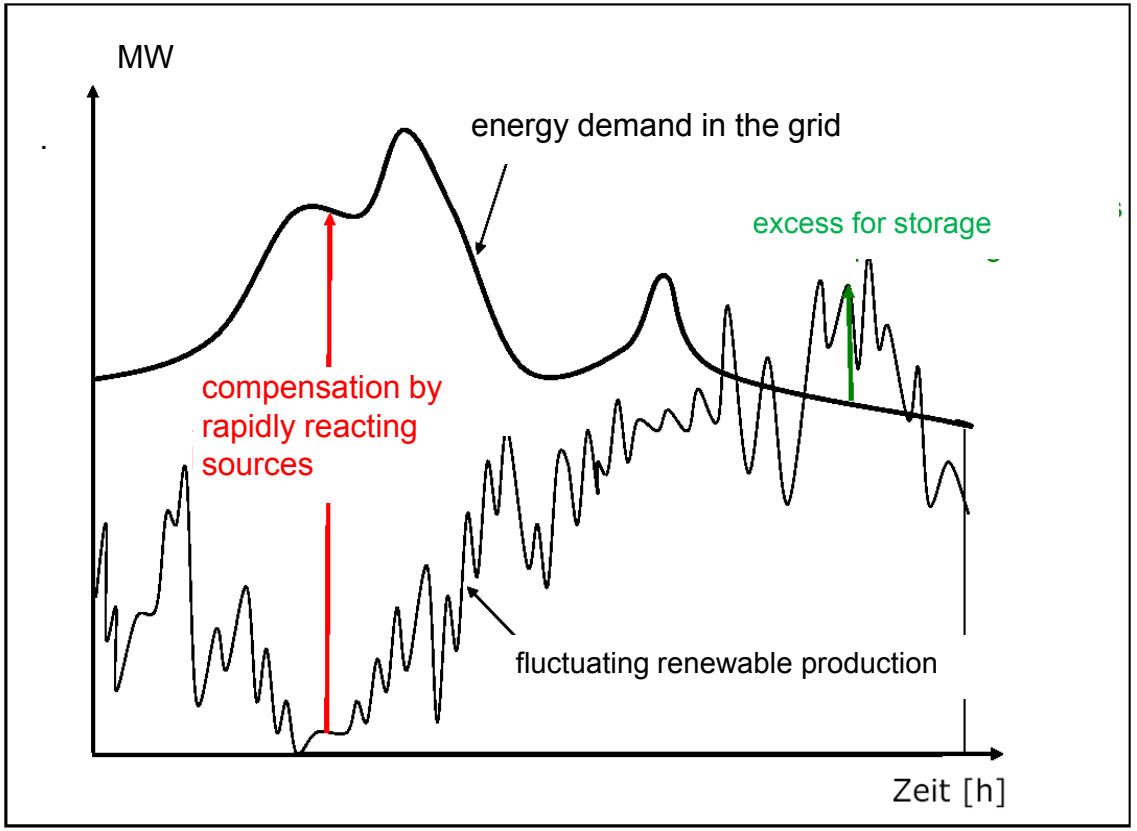
The old baseload concept

- 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



Mini-grids & hybrid systems

- Mini-grids:
  - improved inverters & controls → bottom-up construction of grids increasingly attractive: scalable mini-grids with usual 230V appliances
  - hybrid systems combining PV, wind and biofuels increasingly standardised
  - Improving storage technologies
- PV markets off centralised grids with huge potential
  - high diesel costs call for new approaches
  - declining costs of PV-focused mini-grids offer new solutions
  - rural population needs electricity
- Important contributions from research institutes and industry (ISET Kassel, Fraunhofer ISE, SMA, Kaco, Steca, Fronius, Energiebau ..)

A COLLECTIVE INTERNATIONAL LEARNING PROCESS

Fascinating challenges asking for joint efforts

- PV will be able to deliver large parts of worldwide electricity at competitive costs
- New opportunities for areas with no or weak grids
- Huge growth opportunities for the PV industry

Challenges

→ Bridging of the cost gap until grid parity, ensuring continuous market growth (► politics)

→ Reducing administrative barriers for PV (► administration,politics)

→ Bringing down the costs through continuous innovation (► industry, research)

→ Ensuring high quality with qualified personnel (► industry, training institutions)

→ Creating new markets with new applications, BIPV (► industry)

→ Supporting the growth of PV markets worldwide (► industry, politics)

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

International cooperation needed
A new important player: IRENA

We are in a rapid global learning process, facilitators are needed, an important one could be:

- The International Renewable Energy Agency (IRENA): a dedicated International Organisation for renewables
- Founded in Bonn on January 26, 2009
- More than 100 countries signed
- Headquarters and Director General to be decided next weekend in Sharm el Sheikh
- An important signal, far beyond the organisation itself: Renewables are being taken serious

Thank you

www.bsw-solar.de

www.irena.org

www.schleicher-tappeser.eu