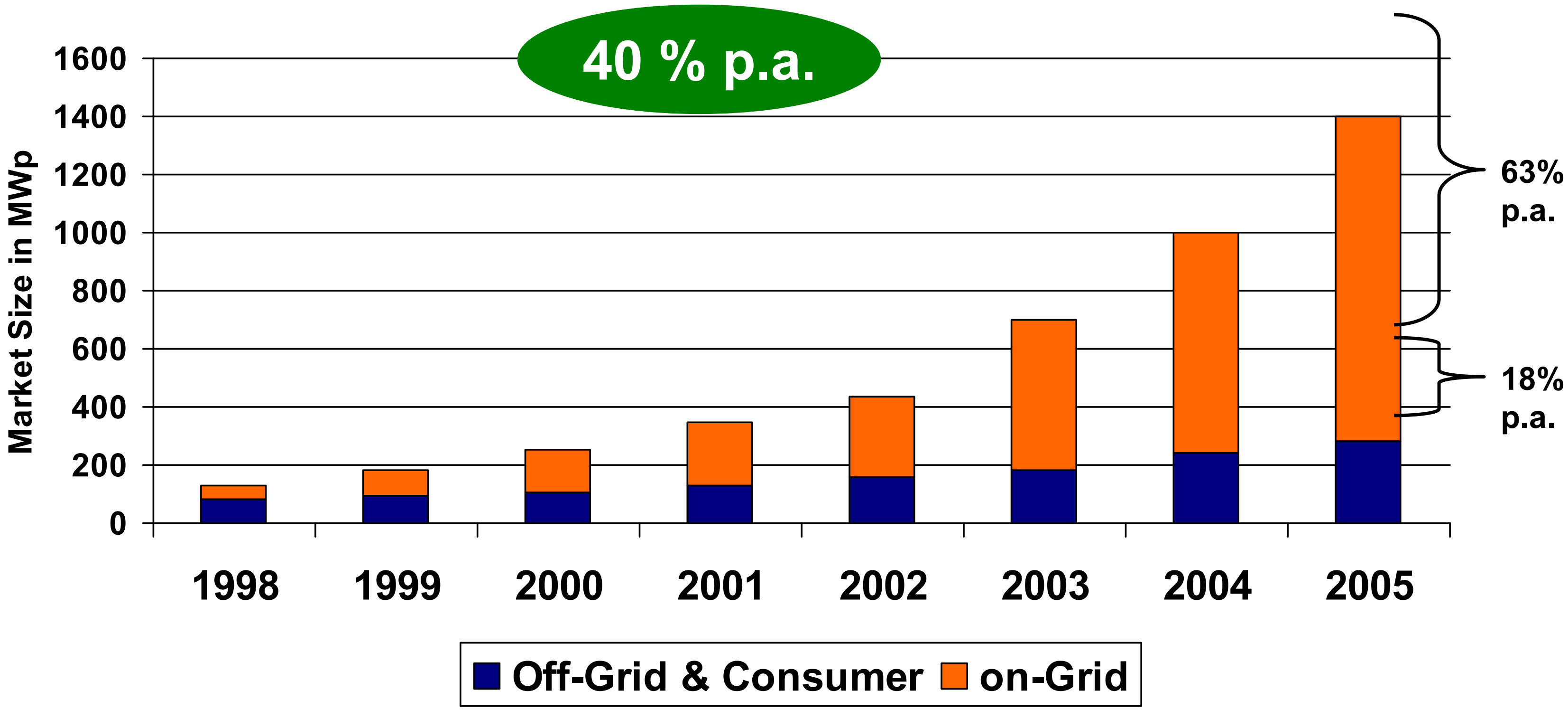
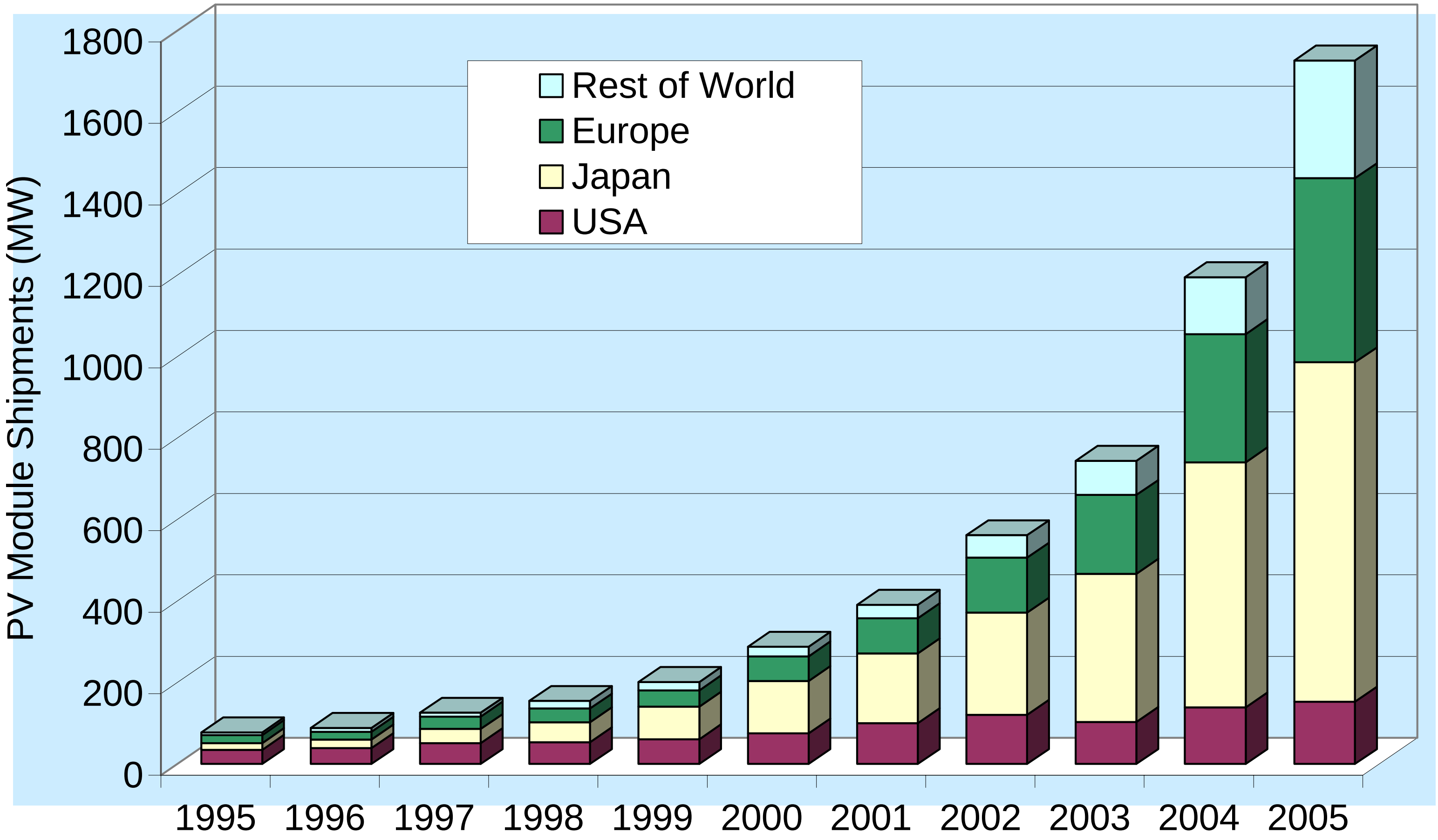
Solar Photovoltaic market, cost and trends in EU

World PV Market Size and Application Segmentation



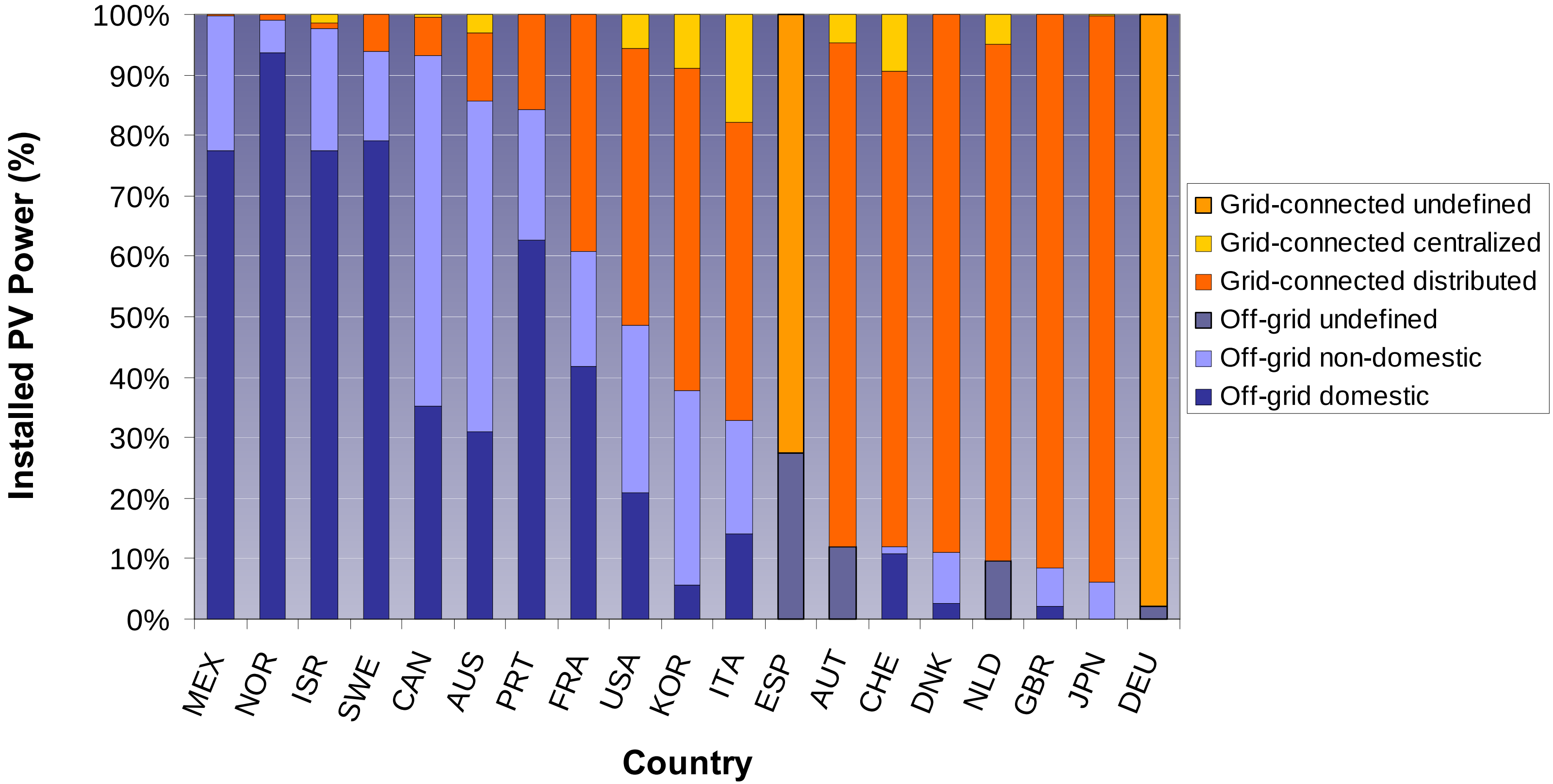
Growth in module production

(source: PV News)



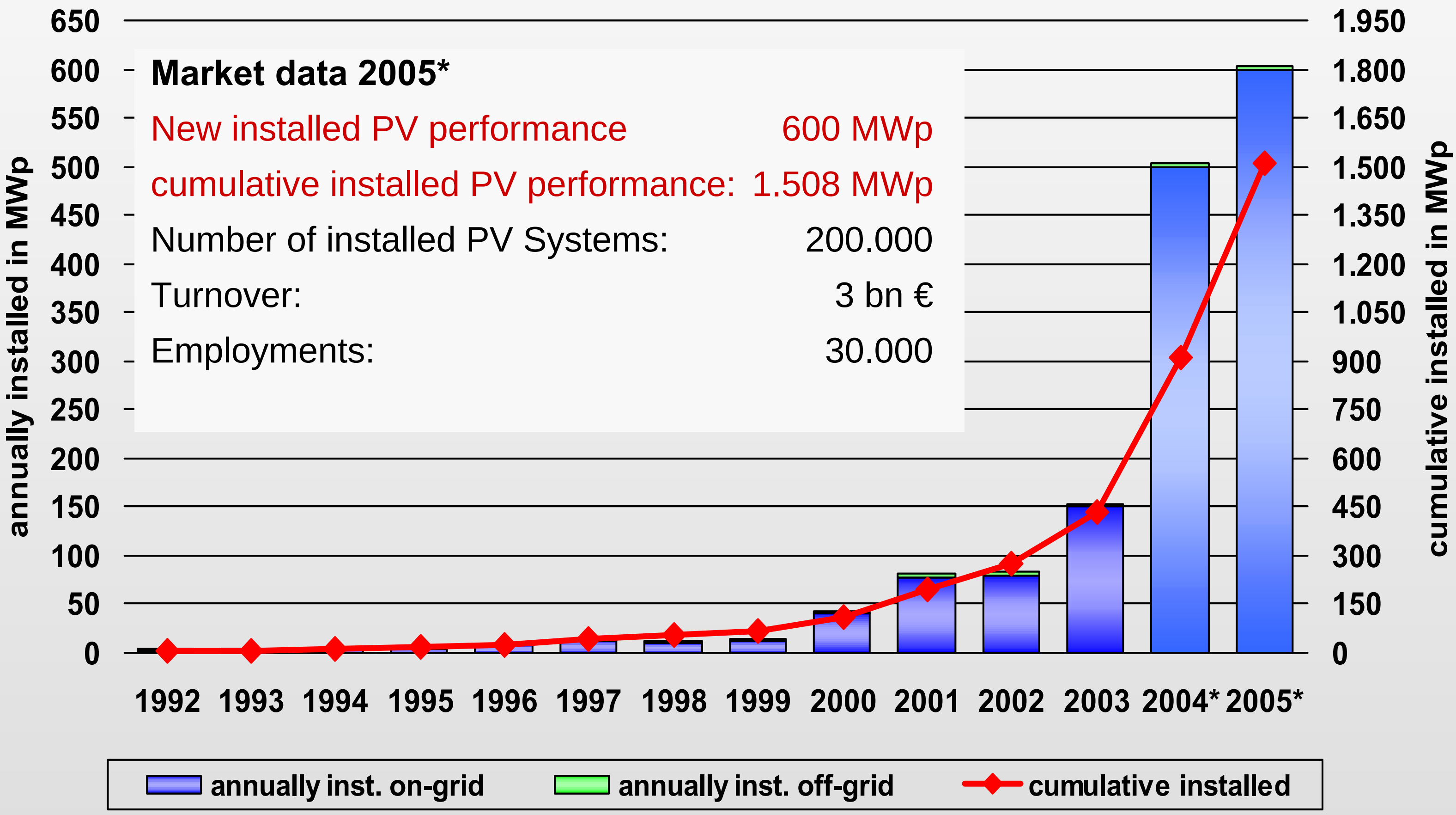
Country diversity

Installed PV power in the reporting countries by application (%) in 2005

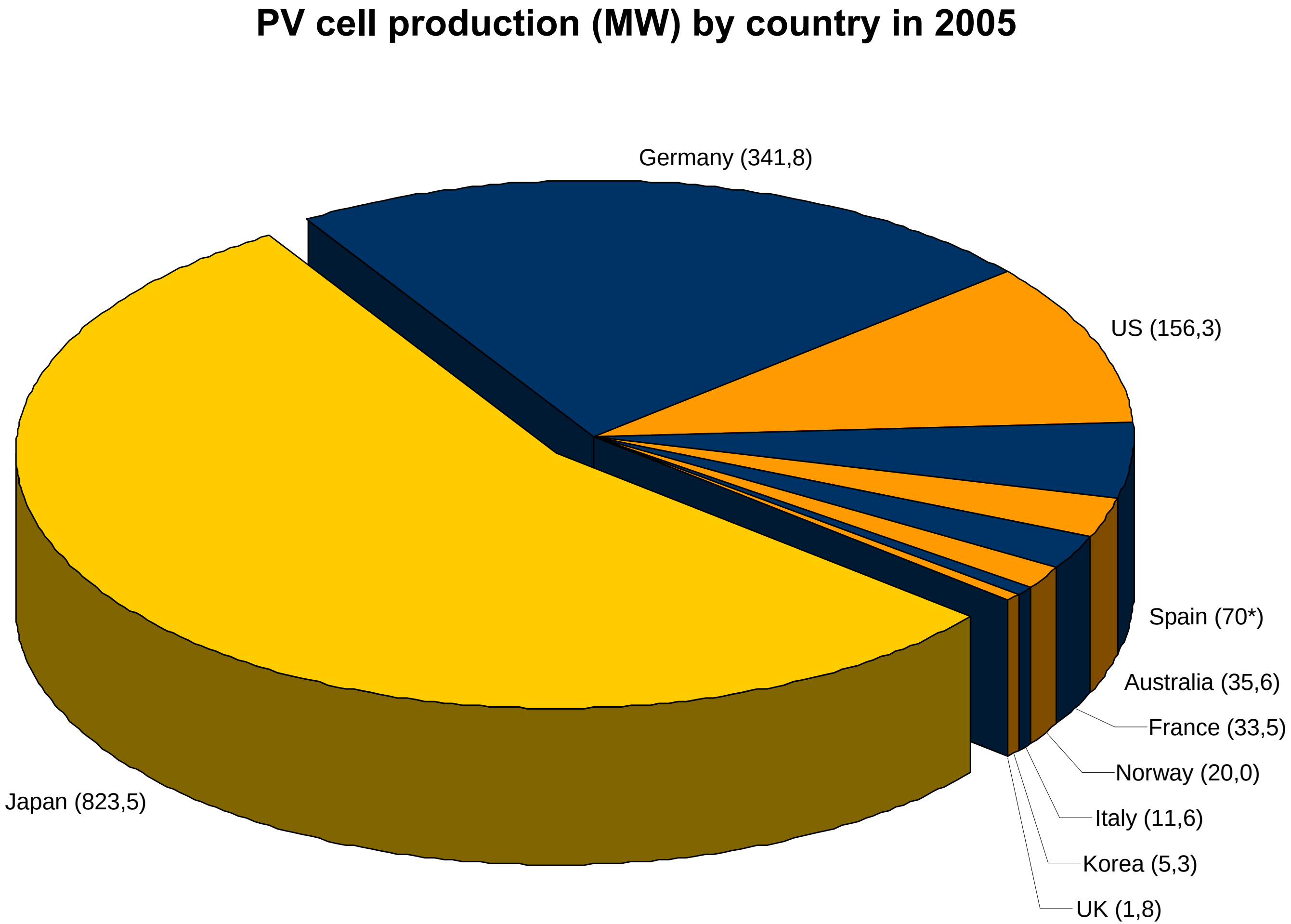


PV Market development in Germany

Annually and cumulative installed PV performance in Germany

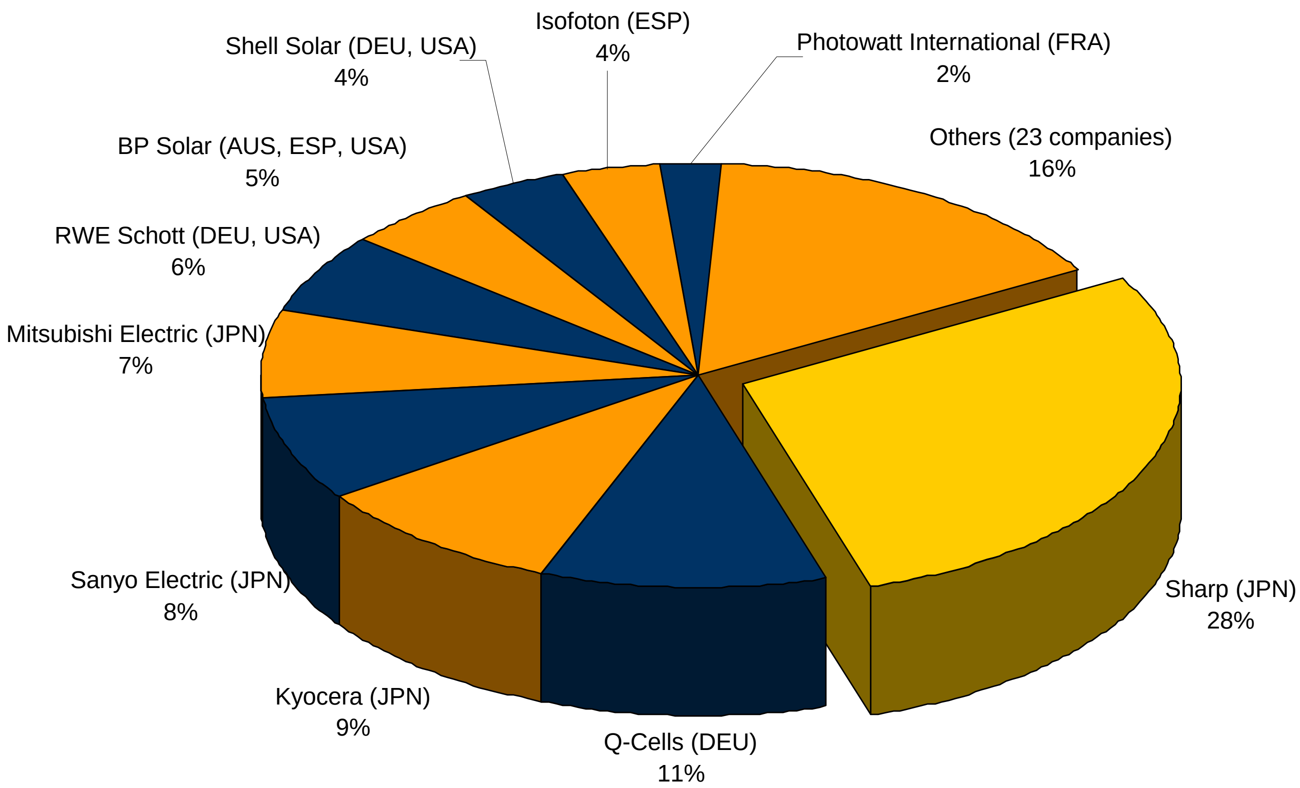


The key players



The key players (2) ..

Share of PV cell production in the reporting countries by company in 2005 (%)



European Market Support Programmes

Country	Feed-in law			other support programs
	Tariff [€ct/kWh]	Duration [a]	Cap [MW]	
Germany	41 – 52 BIPV + 5ct	20	-	
Italy	44 – 49	20	1,000	
Portugal	22 – 41	lifetime		I, T
Spain	22 – 44	25	400	I, T
France	30 - 40 BIPV + 15- 25	20	-	
Greece	40 – 50	20		
other countries	Feed in Laws: Switzerland (1991); Denmark (1993); Sweden (1997); Norway, Slovenia (1999); Latvia (2001); Austria, Czech Republic, Lithuania (2002); Cyprus, Estonia, Hungary, Slovak Republic (2003); Turkey, Ireland (2005)			

I: Investment subsidy
T: Tax reduction

Tariffs most effective program worldwide to stimulate the renewable energy market

- **Equal market opportunities for all the renewable energies based on** specific feed-in-tariffs

- Financial support is given to customers **(he has free choice → competitive market)**

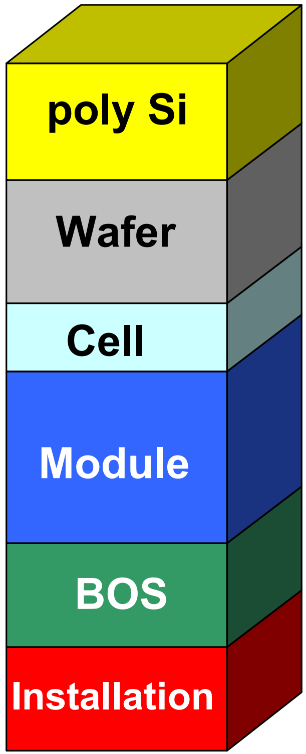
- Customer focus is on product quality and performance **as a result of high competition in the market**

- **The** long reliable availability (>20 years) **of the system performance is the key requirement for the end user of renewable power technologies**

- **Financial support is spread on** special fee to all electricity users **(with the exception of electricity intensive industry)** → not dependent on yearly state budgets

Value Added Chain for grid-connected PV

17%	poly Si	24% (15)
18 %	Wafer	26% (25)
10 %	Cell	14 % (20)
25 %	Module	36% (40)
15 %	BOS	
15 %	Installation	
100 %		100 % (100)



Increasingly important is the industry to produce manufacturing equipment and materials for the whole value chain.

Value 2005 -2004 in brackets

Raw silicon	Wafer	Solar cells	Solar modules	Special modules	Inverters / Bat. chargers
Wacker Chemie	ASI Intertech	Deutsche Cell	GSS	ASS	Aixcon
Degussa / SolarWorld	Deutsche Solar	Ersol	Heckert-B.X.T.	Glaswerke Arnold	Dorfmüller
	PV Silicon	SCHOTT Solar	SCHOTT Solar	Saint Gobain	Kaco
Silicon ingots	SCHOTT Solar	Sunways	Scheuten	Sunovations	Siemens
ASI Intertech		Q-Cells	SMD	Sunware	SMA
Deutsche Solar			Solar-Fabrik	Webasto	Solar Konzept
PV Silicon			Solar Factory	Solarc	Sunways
			Solara	Solarnova	Steca
			Solarwatt		Würth Solergy
			Solon	**Thin film Modules**	
			Sunset		
				Antec	
				Sulfurcell	
				Würth Solar	
				SCHOTT Solar	

Companies in Germany within the Solar Supply Chain

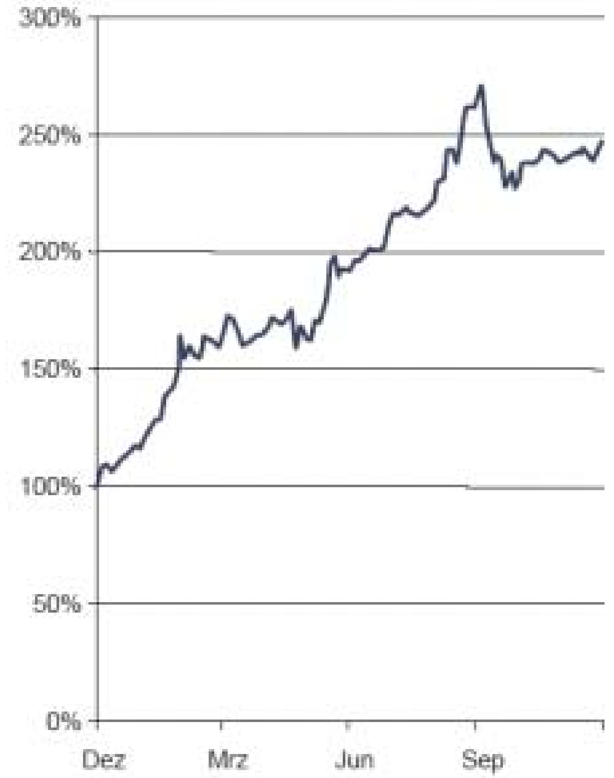
PV TRAC: Statements

- System price today 5 € / Wp
- Generation cost 0.25 – 0.65 € / kWh

- PV in 2030: 200 GW (EU)
- Target 2030: 1 € / Wp
- Target 2030: 0.05 – 0.12 € / kWh

Solar shares with huge increases in 2005 …

- Since beginning of 2005 solar stocks have soared
- PPVX-Index increased by 250% between 1.1.2005 and 31.12.2005
- Many (smaller) companies took advantage of the positive market environment for capital increase or an IPO (20 new listed companies over the last 18 months)
- Investors seemed to make no differentiation and were willing to pay any price for solar shares



Source: Solar-Verlag, Öko-Invest

SARASIN

Remarkable growth in 2005 despite solar silicon bottleneck

Worldwide solar cell production grew from 1'200 to >1'600 MW by 33%.

How was this possible?

- Economical usage of solar-grade silicon (lesser cutting and sawing waste; thinner wafers, lesser breakage, etc.)
  ➡ average use of 11.5 t solar silicon per MWp
- Development of new production technologies such as string-ribbon and 'edge-defined film growth'
- Improved efficiency of solar cells not only in yield (average 14.5% at the moment to >20%)
- High poly silicon prices shifted further material from the semi-conductor industry to PV applications
- All inventories of solar silicon and intermediary products are use up

SARASIN

Key Issues & Risks of the PV market

ISSUE	RISK
Solar grade silicon production is THE dominant factor that defines growth	Certain delays in capacity expansion could prolong bottleneck
Broadening policy support provides the basis for new growing PV markets	Feed-in tariff in the important market Germany faces growing 'political' opposition because of 'out-of-balance' cost reduction
2006 will be the year of the price peak for PV systems. 2-4% decline is expected in 2007	On-going high prices of PV systems could reduce demand
Solar energy will be competitive with conventional peak load power prices by 2012 for Southern Europe and 2020 for Middle Europe	Reduction of conventional energy prices. Global rise in interest rates. In Germany linked with +3% VAT and 5% reduction of the feed-in tariff
World-wide growing customer acceptance of PV systems	Sales could suffer because of neglected marketing efforts

What factors determine the future success of PV-companies?

- **Critical size of the company:** to fully profit from economy of scale. Suppliers of input materials may focus on long-term partnerships with larger customers with financial power to minimise risk.
- **Establish a clear business model and USP:** to outstand the mass. Examples are *Sunpower* (highly efficient solar cells), *Evergreen* (efficient production method).
- **International customer basis:** home market (especially for German companies) is not enough. Growth markets of the future are Southern Europe, Asia and North America.
- **Growth despite solar silicon bottleneck:** Successful procurement strategy (e.g. *Q-Cells*); opening up joint ventures (e.g. *SolarWorld*), participations or own silicon production sites; Technological progress to improve MW yield per ton solar silicon; Expand thin-film activities.

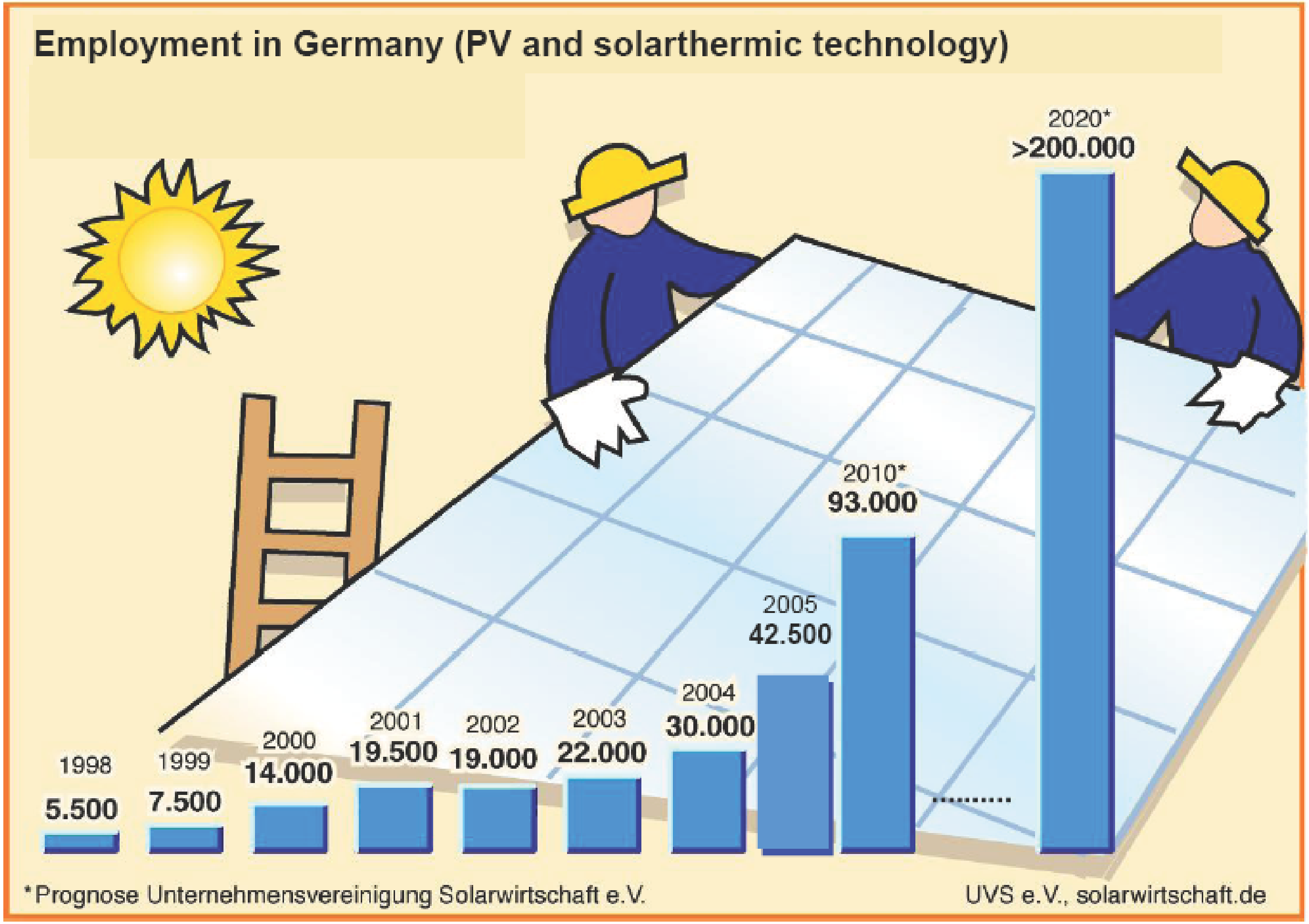
The Challenges of the Future

- Growth is still somewhat dependent on fragile basic framework of political support programmes and development of oil & gas prices
- Further process improvements and cost cutting are necessary
- Additional countries (China, India, Thailand, Spain, Italy…) will feed the world-wide growth of the PV industry
- Silicon bottleneck accelerates the efficient usage of this raw material and may pave the way for new technologies and other cell types
- With raw material constraints one should not forget the quality of the products. Do not spoil the trust that lies in the sector
- Investors have high expectations in the solar companies. They can fulfill them in the long-run. Not all companies will survive

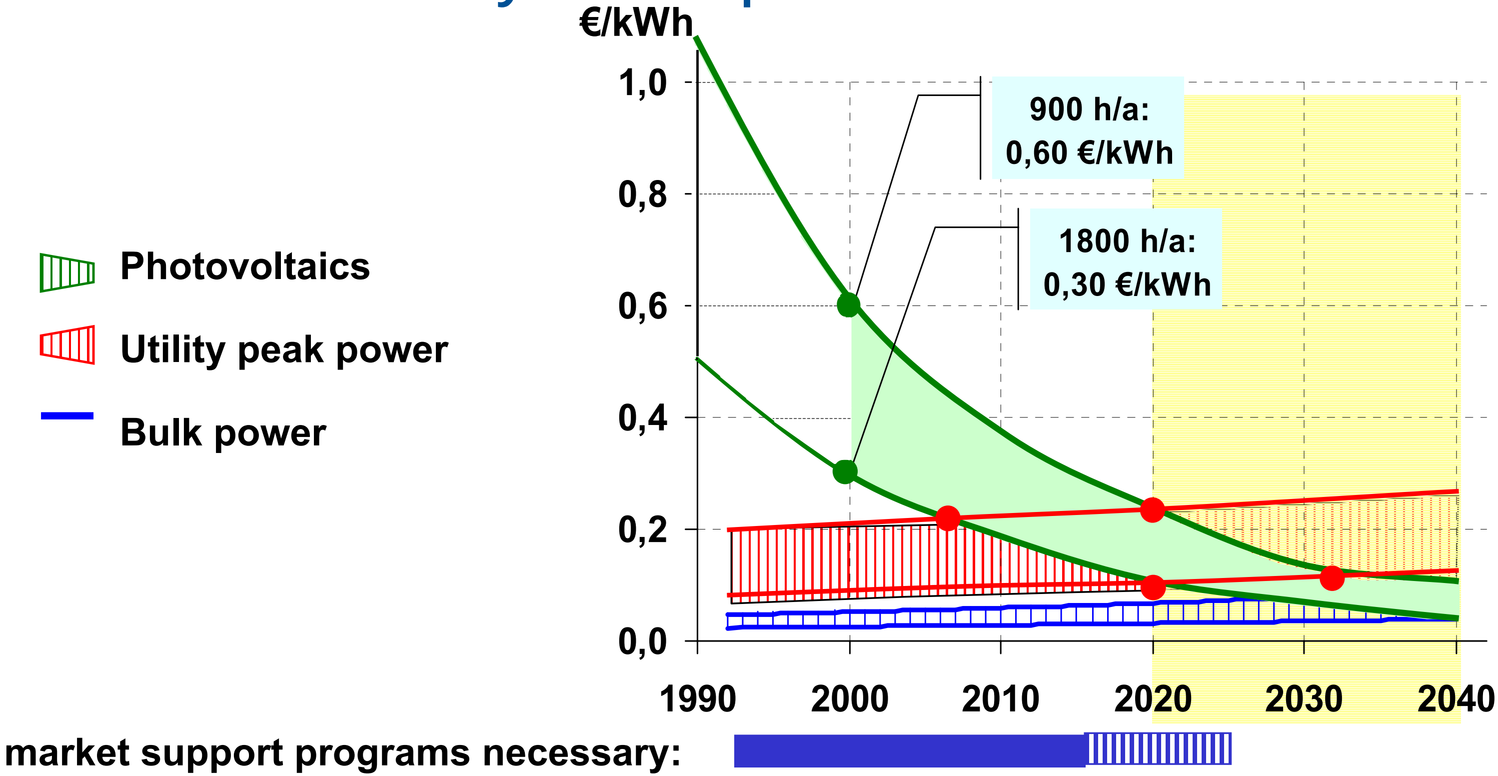
**Aim for a continuous growth
to reach the ultimate goal:
Being cost competitive !**

SARASIN

PV creating jobs



Competitiveness between Cost for PV kWh and utility kWh prices



Source: RWE Energie AG and RSS GmbH

Time for Competitiveness of Grid-Connected PV Solar Electricity without Support

- **Cost and price decrease for technology driven PV solar electricity systems**
  - experience curves
  - technology roadmap

- **Cost and price increase for conventional electricity**
  - fuel price increase
  - internalization of external cost (CO2, …)
  - price differentiation of peak and bulk electricity in truly liberalized markets

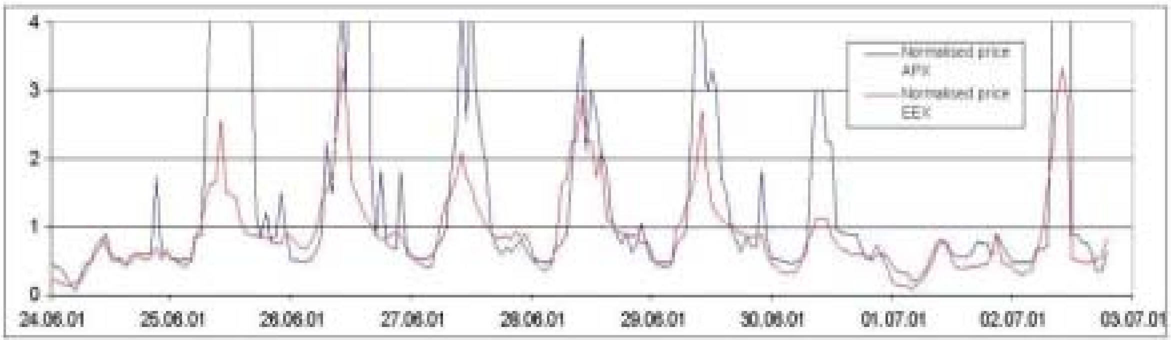
- **Degree of correlation between times of peak power demand (high price) and delivery of PV produced electricity**

Value of PV kWhs

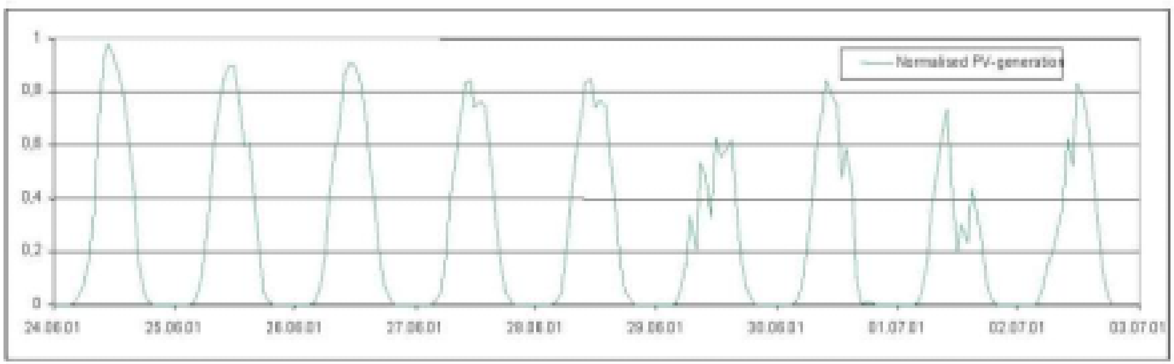
- **PV solar electricity systems provide**
  - decentralized kWh at point of use
  - good integration in future Smart Electricity Networks
  - excellent correlation with high prices at peak hours in summer and afternoons
- **Value of PV kWh is not correlated with**
  - avoided fuel costs for power stations!
  - cost and price of bulk power electricity!
- **… but well correlated with**
  - peak hour prices in liberalized markets (higher cost for peak electricity results in higher prices)
  - today 20 … 30 €ct/kWh
  - future 25 … 40 €ct/kWh

Spot Market Prices in Correlation with PV Electricity Generation in Germany

Spot market price

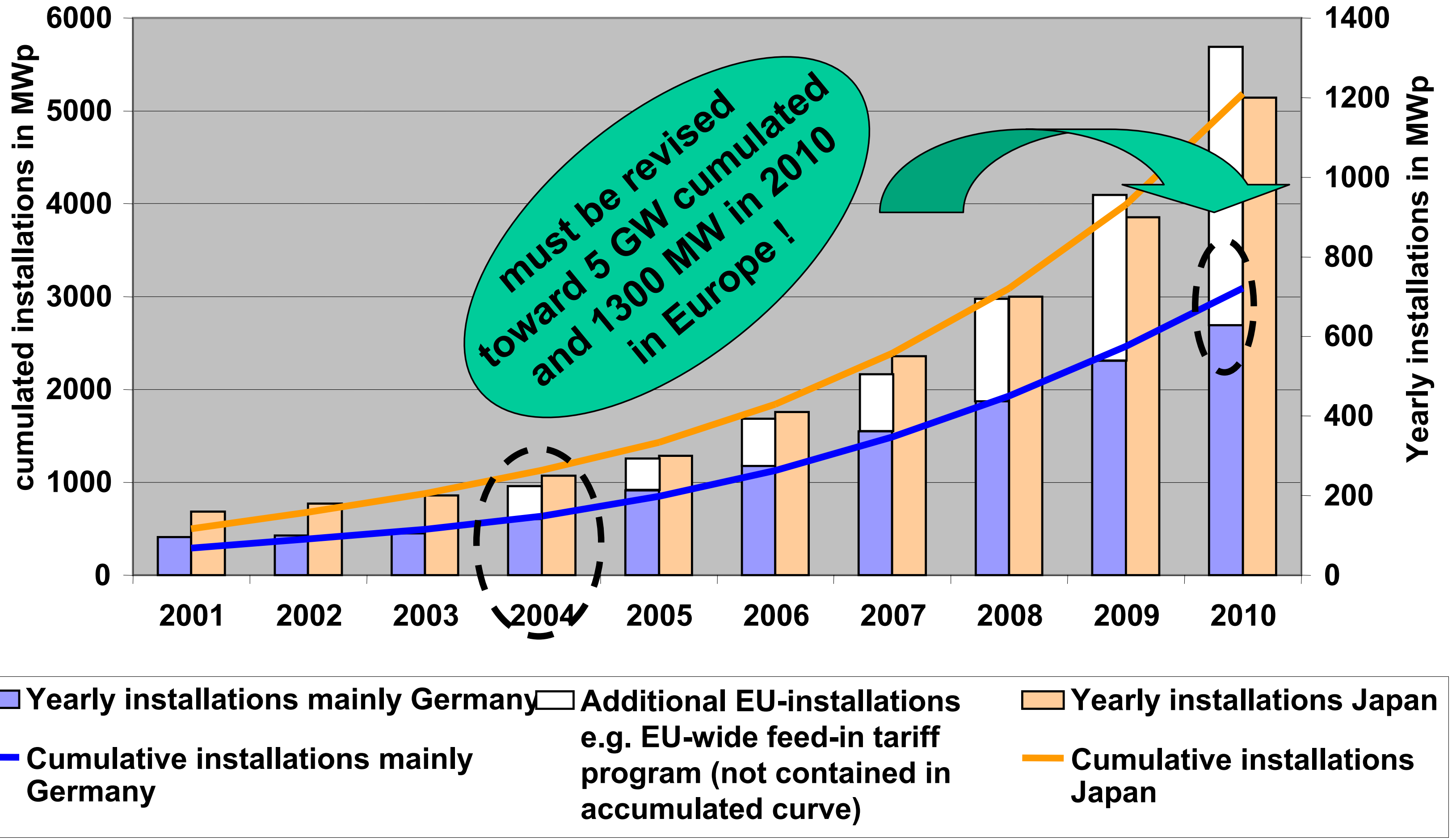


PV power output



Source: Fraunhofer Institut Solare Energiesysteme

Comparison of the future market development in Europe and Japan



The European Photovoltaic Technology Platform and the Vision to 2030

- The PV Technology Platform was set up in Spring 2005
- It brings together all stakeholders to promote PV technology
- A Vision Report was published in 2004 with targets for system cost reduction
- Working Group 3 of the Platform is currently defining the Strategic Research Agenda required to meet those targets

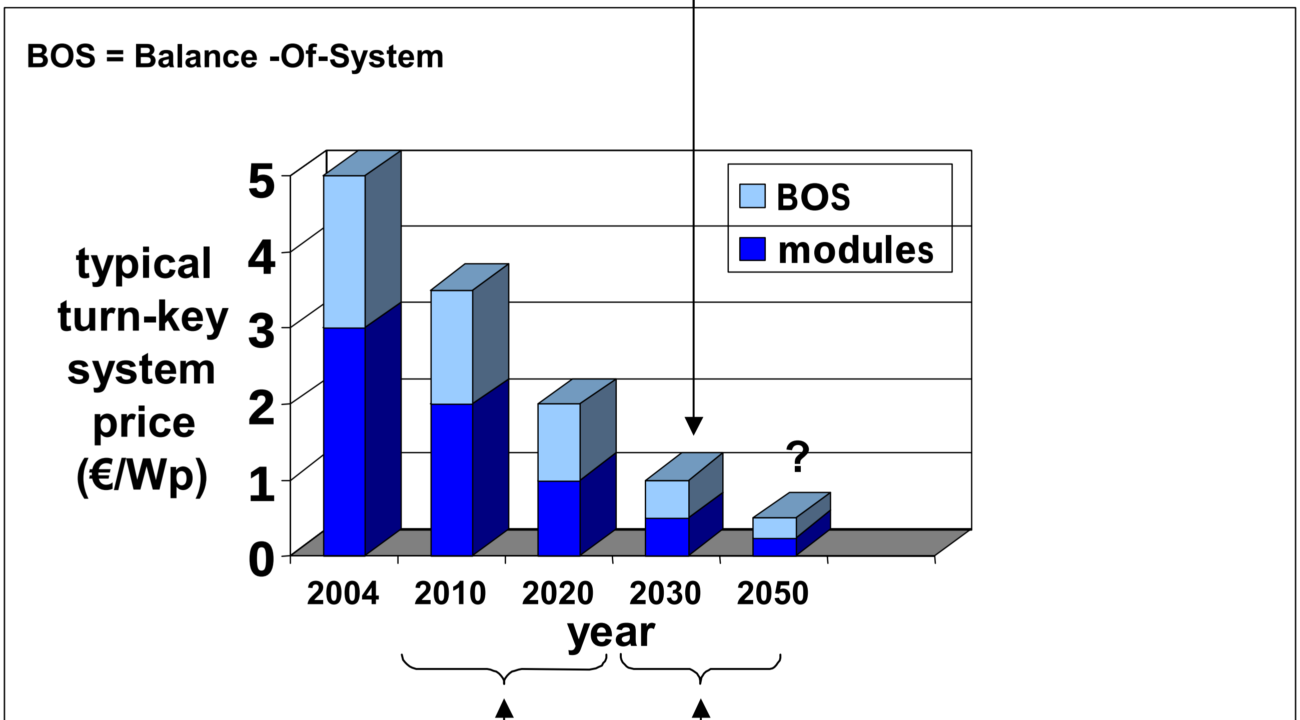
http://www.eupvplatform.org

The PV Vision for 2030

- Electricity costs at **0.05-0.12 Euro/kWh**, flat plate modules up to 25% efficiency, system lifetimes of 40 years, energy payback times <1 year for all technologies
- Annual production in Europe of **20-40 GW**, between 200,000 and 400,000 jobs created
- **200 GW installed in Europe and 1000 GW worldwide**, representing 4% of the world's electricity supply
- PV will have provided access to electricity for over 100 million families, affecting around half a billion people

1000 GWp globally

200 GWp in EU (200,000 jobs)



competing consumer & peak prices

competing wholesale prices

Adapted by W. Sinke from Vision Report

BOS Costs

- The proportion of the system cost relating to the BOS aspects (components, structures, installation and other costs) varies with system type and application
- Typically they are between 25% and 60% of the total system cost
- Research programmes often focus on cost reduction of the PV module, but significant reductions need to be made at the system level also
- Since some BOS aspects are more mature than the modules and/or are not linearly related to system size, these reductions will be challenging

System Costs

- **We determine the cost of a PV system by considering**
  - The initial capital cost of all components (including installation)
  - The lifetime of the system
  - The lifetime of the each component, including replacement costs where necessary
  - The operation and maintenance costs
  - The financing costs
- **To obtain the unit energy cost, we must then divide this by the overall energy output of the system over its lifetime**
- **Thus, reduction of unit energy cost requires**
  - Reduction of overall system cost
  - Maximisation of output across the system lifetime

Cost Reduction

- Component cost reductions arise from lower material usage, increased efficiencies and lower cost production
- Increases in component lifetime reduce life cycle cost and the need for replacement
- Harmonisation of components can lead to
  - Economies of scale in production
  - Easier maintenance and replacement
  - Standard designs and reduced installation costs

Need of harmonisation

- **Modules of** equivalent power rating **from different manufacturers are** all of different sizes**, sometime by only a few mm**
- Modifications may be needed for support structures **resulting in extra design and fabrication costs**
- **If** replacement **is required, it may be difficult to find both an electrical and physical fit – resulting in additional cost**

Energy Output

- **The test for competitiveness is not cost per Wp but** cost per kWh **and how it compares with the cost of alternative energy services**
- **Energy output estimation comes from**
  - Predicted annual output
  - Assumed system lifetime
  - Assumed degradation factors
- **Clearly this requires operation without significant problems across the lifetime**
- R&D needs to focus on activities targeting improved overall performance

Improved Reliability

- **Minimisation of component faults (linking to increased lifetimes)**
- **Rapid detection of and attention to problems in cost effective manner**
- **Project Performance includes updating of European monitoring guidelines to address a wide range of system types and users and the whole operating period from installation to replacement**
- **Remote monitoring and easy operation solutions for non-technical users**
- Influence user confidence and perception of value

Value of PV Electricity

- Target electricity costs vary according to the application
- System approaches should consider the maximisation of the value of PV generated electricity
- This allows more rapid expansion of the market and improves the perception of PV in the energy mix
- Short term storage options to time shift supply to high demand periods, UPS systems, use of inverter for maintaining grid supply quality

Grid Architectures

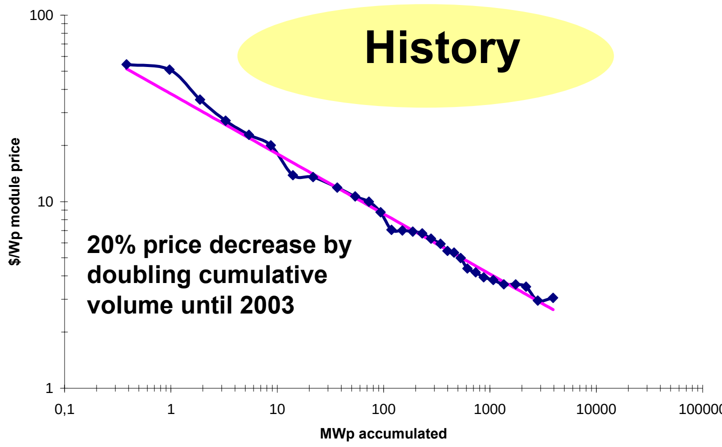
- Europe will need to spend 500 billion Euro up to 2030 on upgrading the electricity network
- Future grids will have local storage and generation
- PV can be an integral part of microgrids, operating mainly connected to the network but also independently when necessary
- Need to consider the optimisation of the overall energy mix and the best role for PV systems

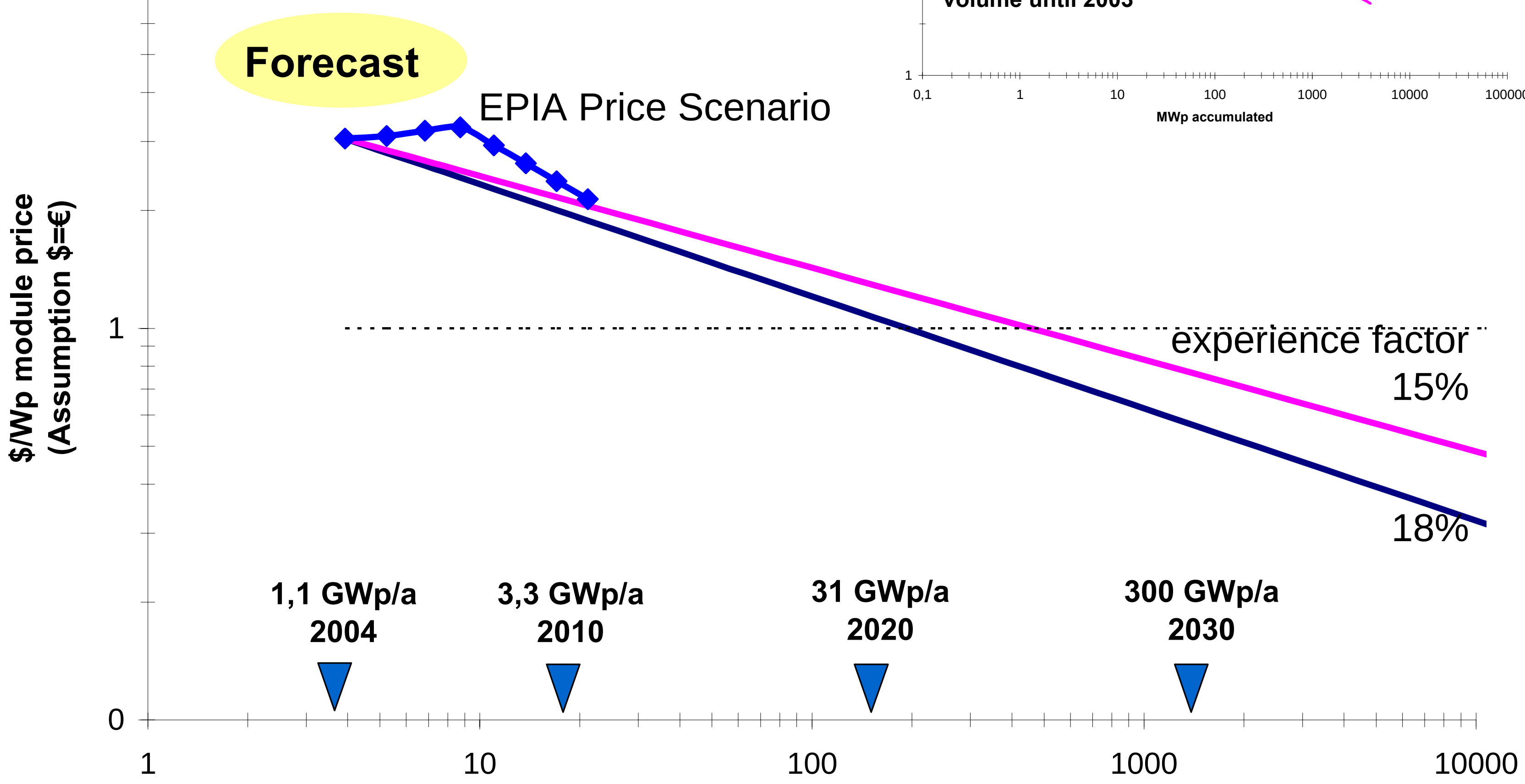
(from European SmartGrids Technology Platform)

Summary

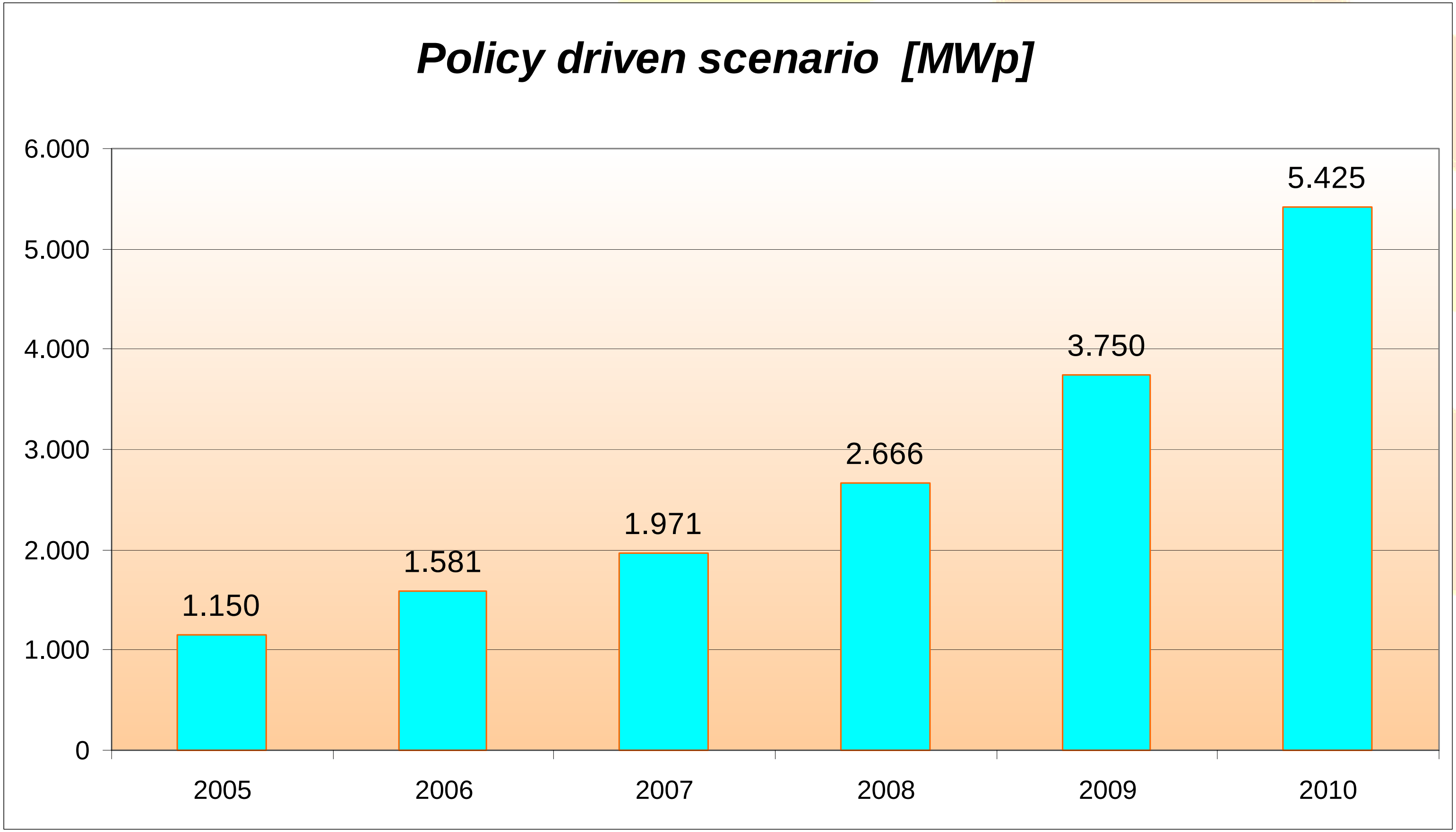
- **PV is expected to provide a significant part of the world's electricity supply by 2030**
- **Cost reductions need to be realised at both module and system level**
- **This requires:**
  - Reduced component costs
  - Increased component lifetimes
  - Harmonisation of component specifications
  - Maintenance of high performance levels throughout operation
- **The use of PV systems in microgrids and applications that maximise the value of PV electricity will be key factors in the development of the technology**

Price Experience Curve for PV Solar Modules

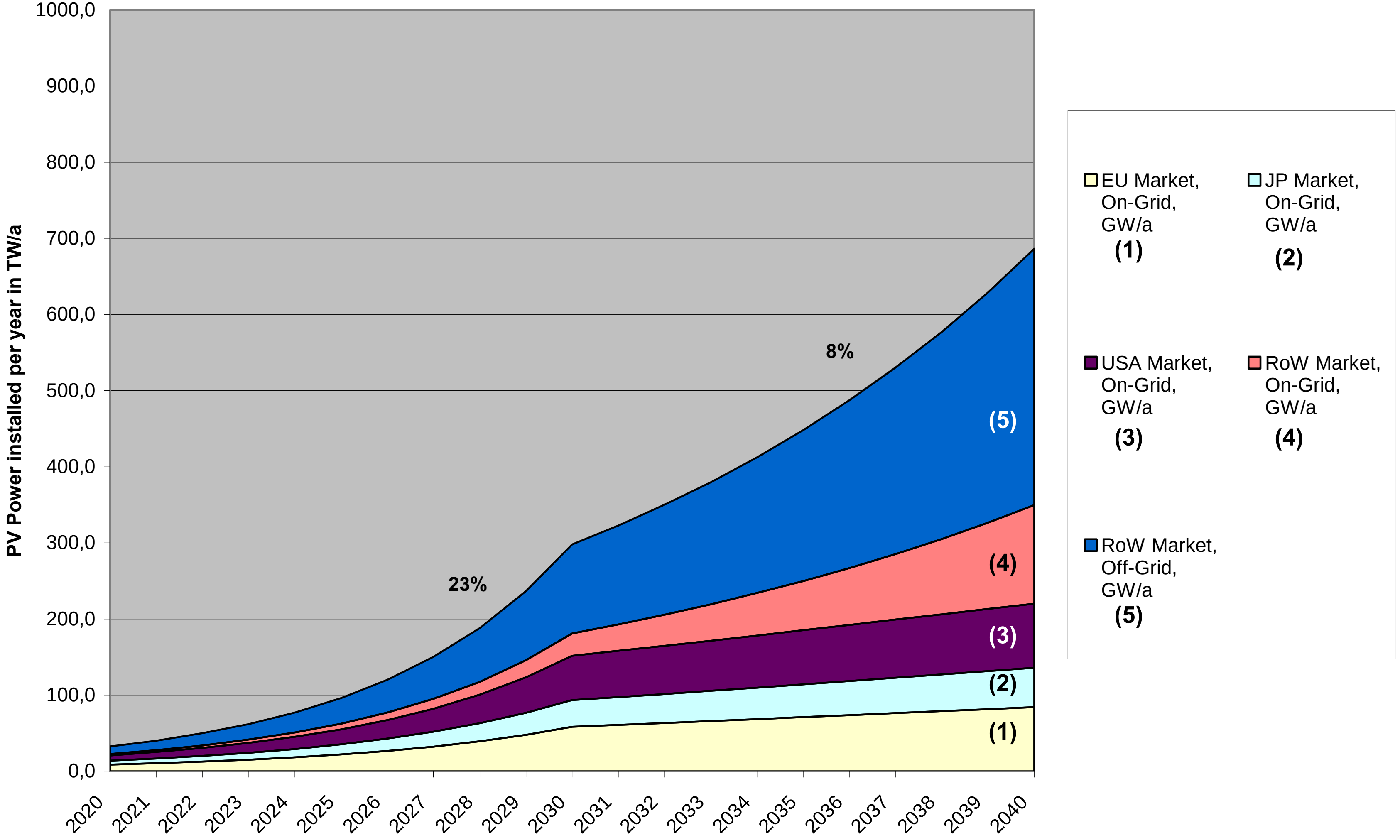




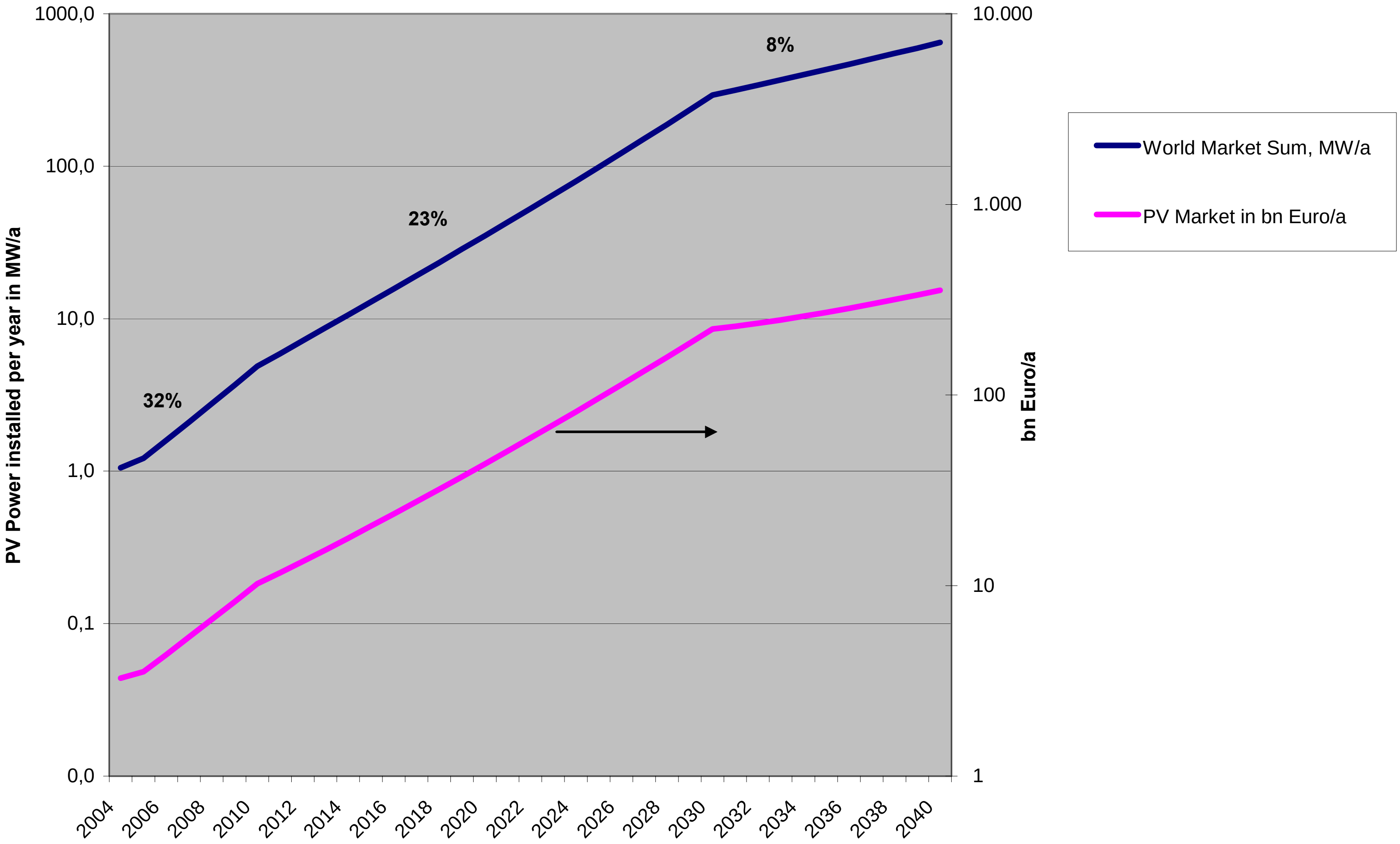
Annual Worldwide Market



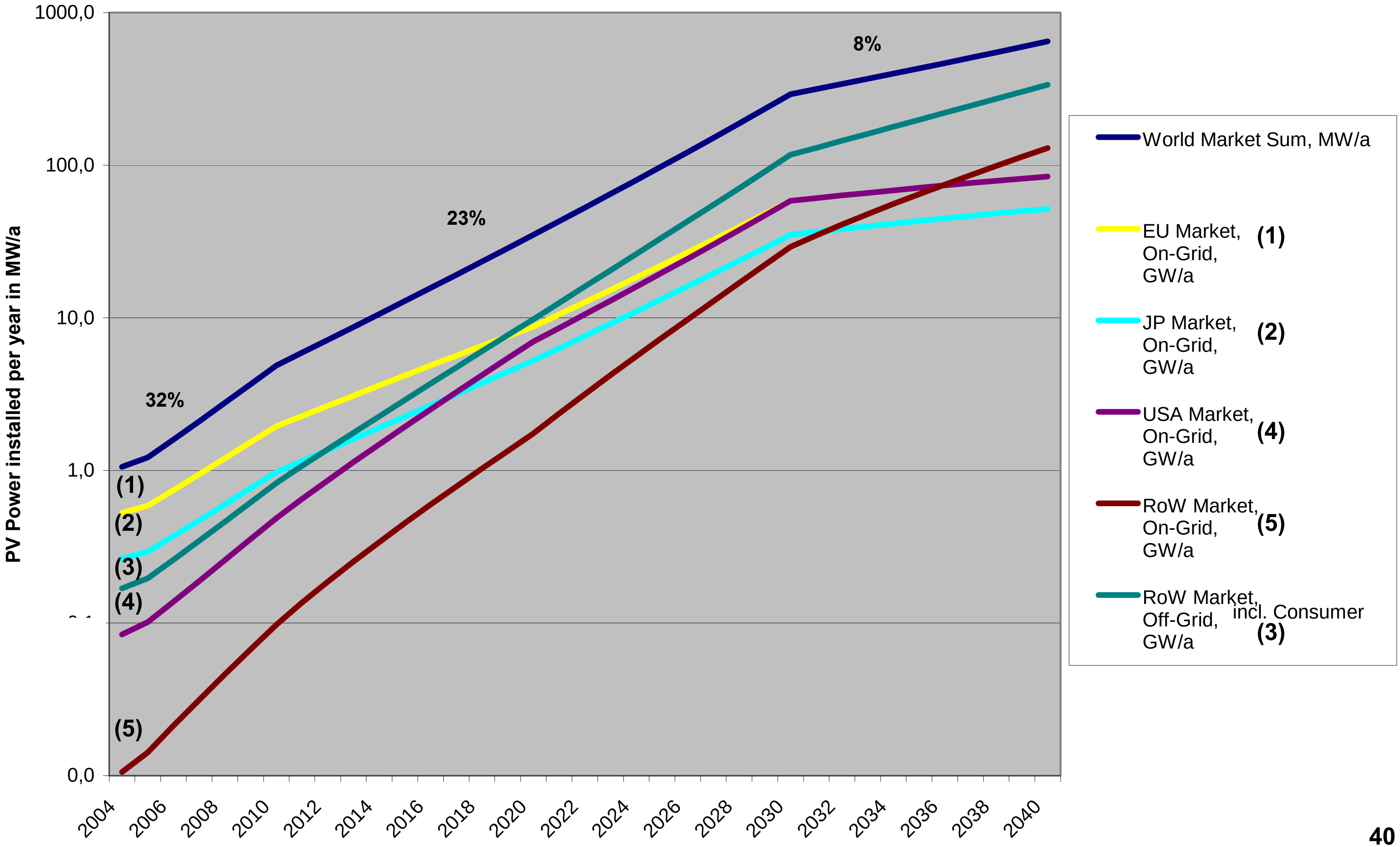
Development of the Various Market Segments (absolute)



Future Growth of the Global PV Solar Electricity Market in GW and bn € turnover

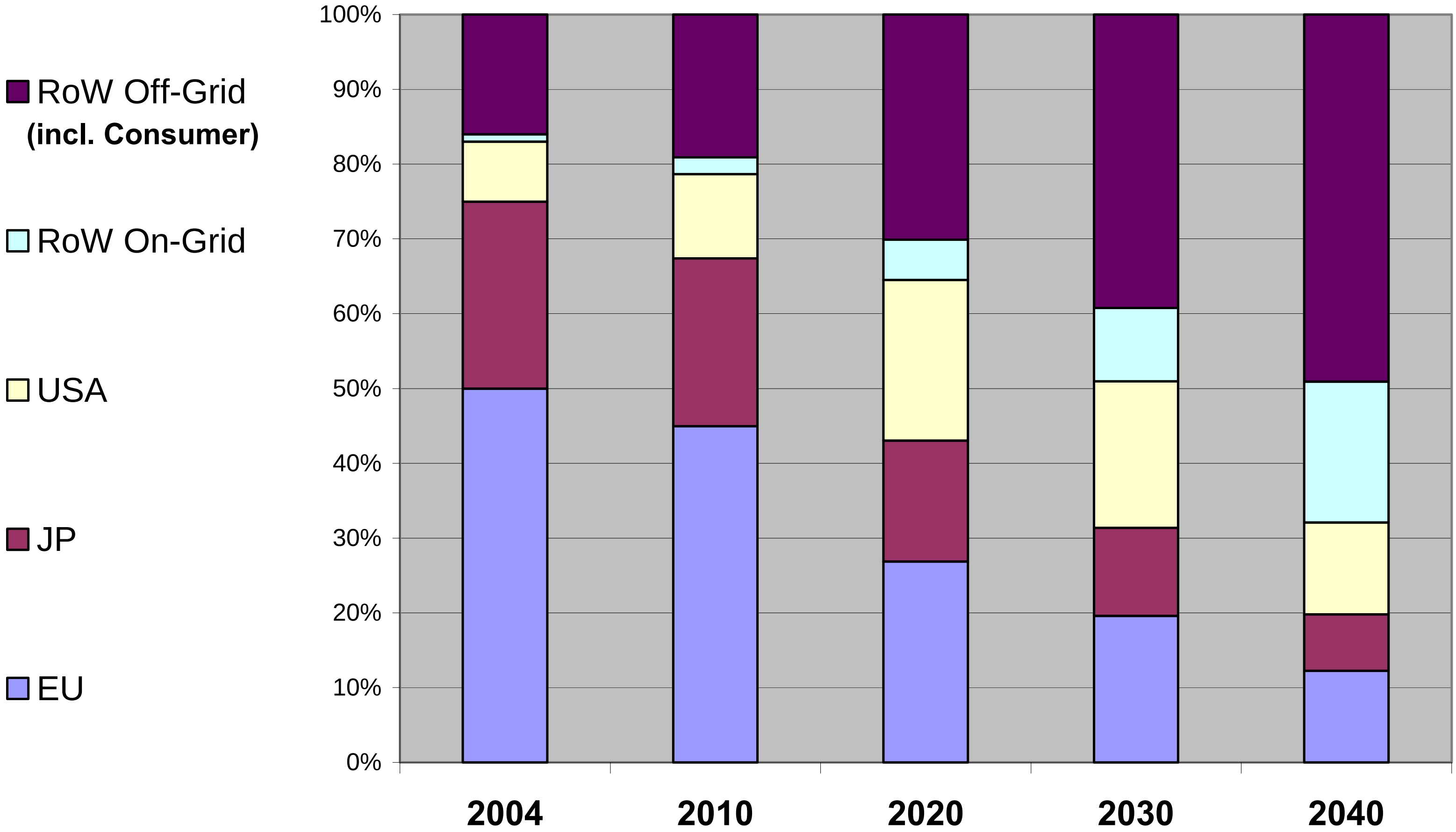


Development of the Various Market Segments

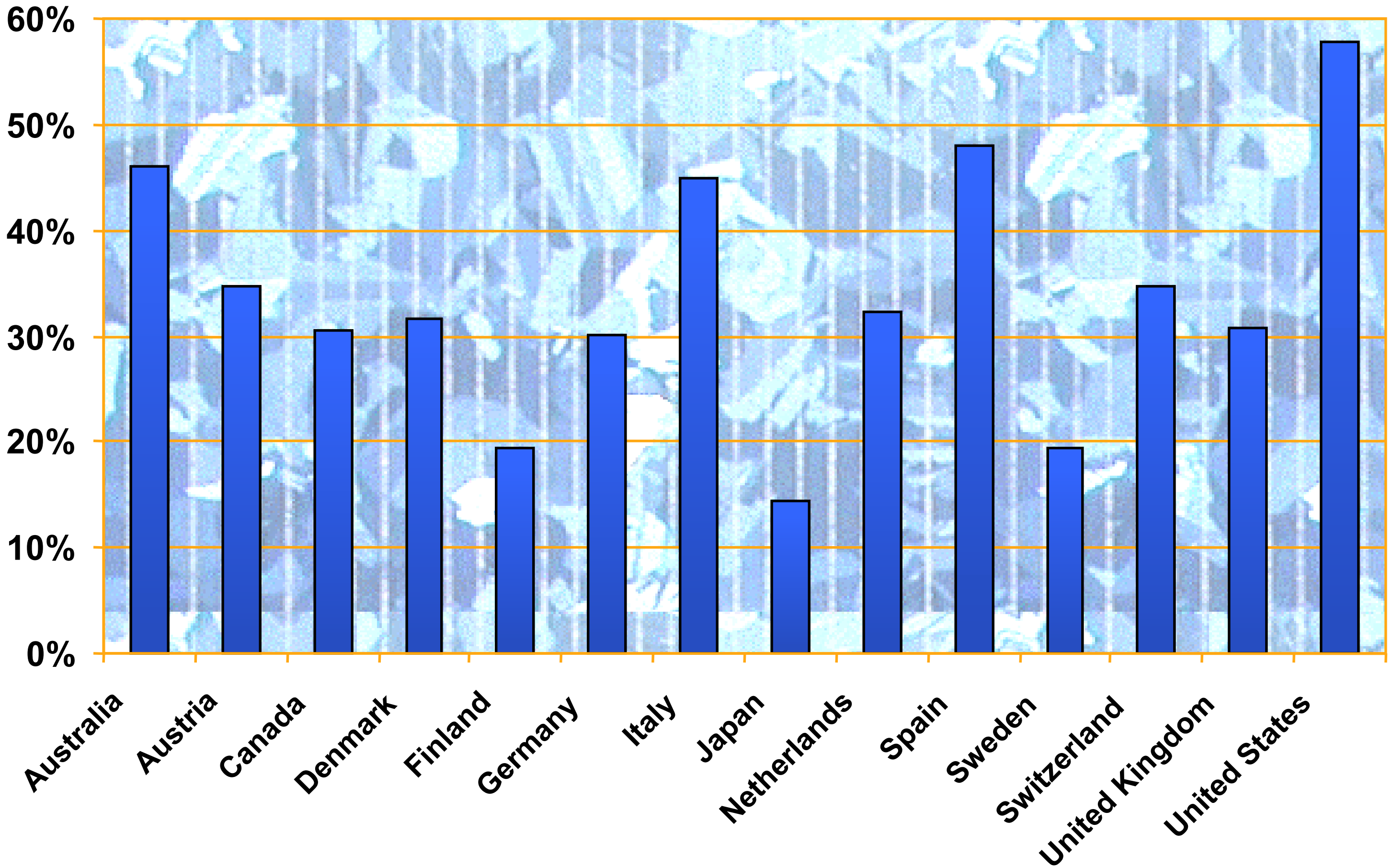


Development of the Various Market Segments

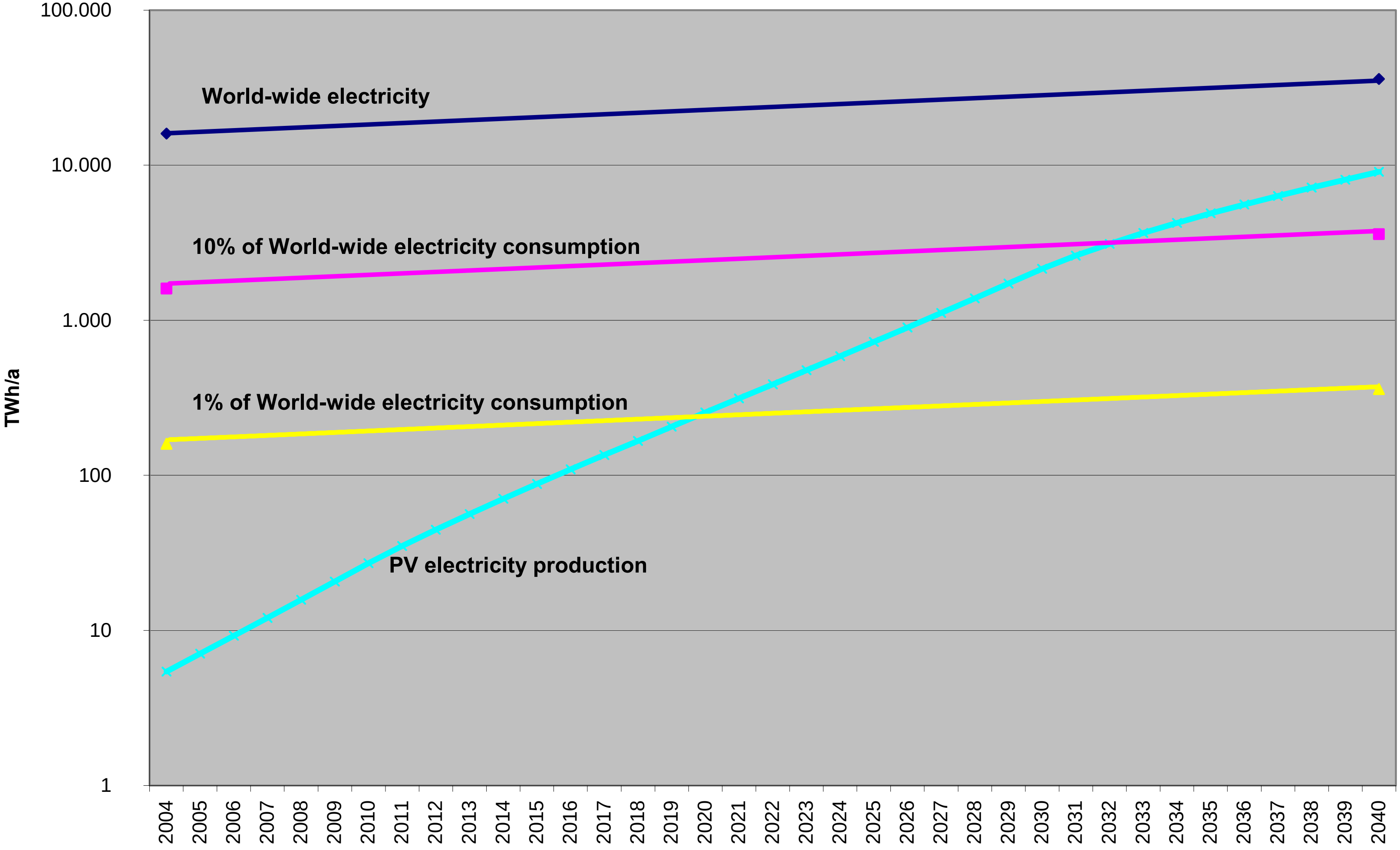
Yearly installed PV Power: **1,2 GW** **5 GW** **30 GW** **300 GW** **650 GW**



Potential of building integrated PV as contribution to electricity supply



Electricity produced by PV compared with Global Electricity Consumption



Lessons learned

- **Success builds on a good balance between technology, industry and market development**
- **Creating sustainable markets is a challenge but a must**
- **Monitoring performance, quality and reliability are important**
- **Benefits of good policy are proven**
- **PV needs a long term vision but strong action and commitment now !**

Recommendations for the Global Economy Regions during the "Transition Phase"

- **The transition phase needs political and public support**
  - Consider the interest of national politicians in their national intention – e.g. build up working places in a high-tech industry
  - Do not unbalance important markets
- **Develop domestic markets for domestic production**
  - Balanced production along the value chain compared to domestic markets
  - Development of local markets needs at least 10 years
- **Strict export policy may severely impact the whole industry**
- **Set the course now to the growth of existing and creation of additional markets**

Final thoughts: Is PV special?

Strengths - High potential - Solar resource availability - Diverse applications - High-tech nature - Image by end-users	**Weaknesses** - High cost - Low energy contribution - Intermittency - Lacking awareness - Image by professional sector
Opportunities - Industrial development - Synergies with other industries / building sector - Combination with other energy technologies - Implementation interfaces	**Threats** - Short term policies - Stop and go effects - Managing growth - Silicon resource - Perceived insignificance

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