IEA INTERNATIONAL ENERGY AGENCY

Promotional Drivers for Grid-Connected PV

PVPS

PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Report IEA-PVPS T10-05:2009

INTERNATIONAL ENERGY AGENCY
PHOTOVOLTAIC POWER SYSTEMS PROGRAMME

Promotional Drivers for Grid-Connected PV

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This report has been prepared under the supervision of

PVPS Task 10 and PV-UP-SCALE

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FOREWORD

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD) which carries out a comprehensive programme of energy co-operation among its member countries. The European Commission also participates in the work of the IEA.

The IEA Photovoltaic Power Systems Programme (PVPS) is one of the collaborative R & D Agreements established within the IEA. Since 1993, the PVPS participants have been conducting a variety of joint projects in the application of photovoltaic conversion of solar energy into electricity.

The mission of the Photovoltaic Power Systems Programme is "to enhance the international collaboration efforts which accelerate the development and deployment of photovoltaic solar energy as a significant and sustainable renewable energy option." The underlying assumption is that the market for PV systems is gradually expanding from the present niche markets of remote applications and consumer products, to the rapidly growing markets for building-integrated and other diffused and centralised PV generation systems.

The overall programme is headed by an Executive Committee composed of one representative from each participating country, while the management of individual research projects (Tasks) is the responsibility of Operating Agents. By the end of 2007, 12 Tasks were established within the PVPS programme.

The objective of Task 10 is to enhance the opportunities for wide-scale, solution-oriented application of photovoltaics (PV) in the urban environment as part of an integrated approach that maximizes building energy efficiency and solar thermal and photovoltaics usage. The Task's long term goal is for urban-scale PV to be a desirable and commonplace feature of the urban environment in IEA PVPS member countries.

This report has been prepared by EEG (Energy Economics Group- Austria) for IEA-PVPS Task 10 under the corresponding supervising within this programme and the European research project PV UP-SCALE which both comprise closely linked activities. Both research activities complement each other by involving partners from differing countries with differing characteristics of and viewpoints on PV. The whole set of involved countries is indicated in the Figure below, which depicts all partners by their country of origin for both research activities. It is especially the aim and duty of those few partners who participate in both activities to strengthen cooperation in order to meet the common objectives of both activities. This report represents a first result of this collective work on Value Analysis and has been prepared based on contribution of both IEA-PVPS-Task 10 and PV UP-SCALE partners.

More information of the activities of Task 10 and PV-Up-Scale can be found on:

- www.iea-pvps-task10.org
- www.pvupscale.org

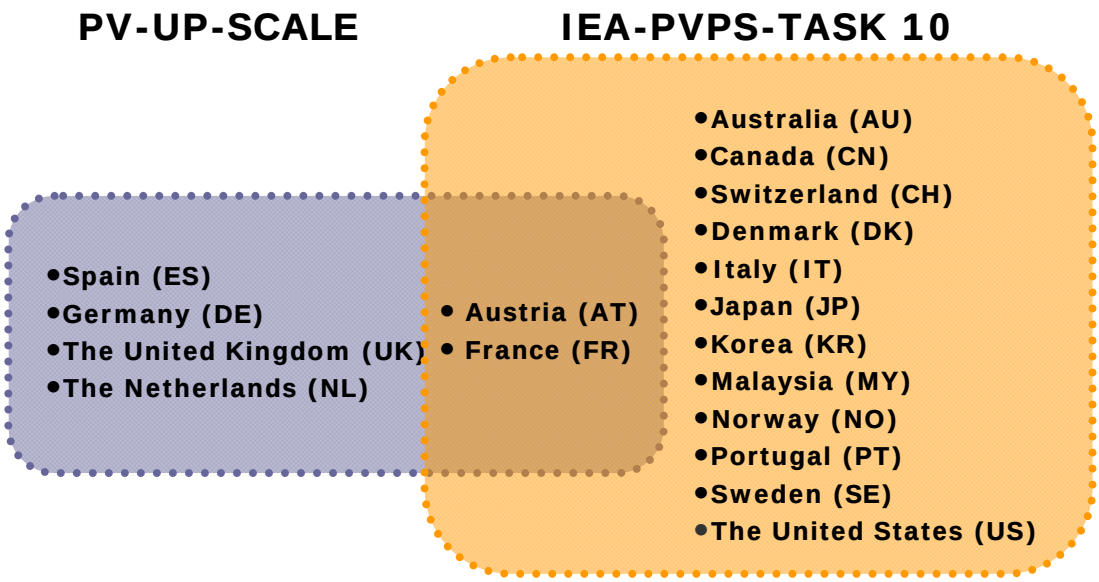

Figure: Overview on countries participating in the European research project PV Up Scale and the activities as set in the frame of IEA-PVPS Task 10.

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CONTENTS

FOREWORD I

ACKNOWLEDGEMENT III

CONTENTS V

FIGURES VIII

TABLES IX

1 INTRODUCTION 1

1.1 CORE OBJECTIVE 1

1.2 CURRENT STATE OF THE ART 1

1.3 STRUCTURE OF THIS REPORT 4

2 WHAT ARE PROMOTIONAL DRIVERS? 5

2.1 THEORETICAL BACKGROUND 5

2.2 TYPES OF PROMOTIONAL DRIVERS 7

3 THE MOST SUCCESSFUL PV DEPLOYMENT PROGRAMS WORLDWIDE ... 10

3.1 INVESTMENT FOCUSED FINANCIAL INCENTIVES 15

3.1.1 Japanese Residential PV System Dissemination Program (RPVDP) 15

3.1.2 Japanese Field Test Projects on PV Power Generation System for Public and Industrial Applications 16

3.1.3 California's Emerging Renewables Program (CA ERP) 16

3.1.4 Australian Photovoltaic Rebate Program (PVRP) 17

3.1.5 Danish SOL 300 and SOL 1000 17

3.1.6 The Californian CPUC's Self Generation Incentive Program (SGIP) 17

3.1.7 Italian PV Roof Program 18

3.1.8 New Jersey's Clean Energy Program's Customer On-Site Renewable Energy (CORE) 18

3.1.9 The Great Britain Major PV Demonstration Programme 18

3.1.10 Australian Solar Cities 19

3.1.11 Swedish PV Program 19

3.1.12 Great Britain Low carbon building program 19

3.1.13 US PV Investment Tax Credit 19

3.2 GENERATION-FOCUSED FINANCIAL INCENTIVES 20
3.2.1 German Renewable Energy Act (EEG)..... 20
3.2.2 Spanish feed-in tariff..... 20
- ROYAL DECREE 661/2007 (RD 661/2007): The Royal Decree 661/2007 built on the Royal Decree 436/2004 und came into force on 1 June 2007. Tariffs are annually reviewed and will be reduced in the following way: 21
- ROYAL DECREE 1575/2008 (RD 1575/2008)..... 21
3.2.3 Italian feed-in tariff – "Conto Energia"..... 22
3.2.4 California Solar Initiative (CSI)..... 22
3.2.5 US Net Metering 24

3.3 MIXED FINANCIAL INCENTIVES 24
3.3.1 Energy Premium Regulation (EPR) and MEP Netherlands 24

3.4 RENEWABLE PORTFOLIO STANDARDS FOR PV..... 24
3.4.1 Japanese Renewable Portfolio Standard..... 24
3.4.2 New Jersey's Renewable Portfolio Standard (NJRPS) 24

3.5 VOLUNTARY GENERATION-FOCUSED FINANCIAL INCENTIVES..... 25
3.5.1 Swiss Solar Stock Exchange Programs 25

3.6 OTHER REGULATORY PROGRAMS 25
3.6.1 Spanish Technical Building Code 25

3.7 OTHER VOLUNTARY PROGRAMS..... 26
3.7.1 Japanese Green Power Fund 26
3.7.2 Japanese Net billing 26

4 SUCCESS CRITERIA FOR PV DEPLOYMENT PROGRAMS..... 27

4.1 DEFINITION OF SUCCESS CRITERIA..... 28

4.2 DISSEMINATION EFFECTIVENESS..... 28

4.3 COSTS FOR THE PUBLIC 29

4.4 DEVELOPMENT OF COSTS OVER TIME 32

4.5 IMPROVEMENT OF TECHNICAL PERFORMANCE 36

4.6 MARKET CONFORMITY 38
4.6.1 Consumer's WTP in the Residential Sector 39
4.6.2 Profitability for the Consumer..... 41
4.6.3 Providing Financing Possibilities..... 43
4.6.4 Investor's Effects on the System Sizes..... 44

4.7 ACCOMPANYING MEASURES..... 46

5 OVERALL PERFORMANCE: MARKET TRANSFORMATION 48

6 CONCLUSIONS 49

REFERENCES 52

APPENDIX 1 54

APPENDIX 2 56

APPENDIX 3 57

FIGURES

Figure 1: Worldwide yearly installed capacity by application until 2007 1
Figure 2: Cumulative installed total PV capacity of leading countries 1992-2007 in MW 2
Figure 4: Installed total PV capacity and capacity of grid-connected systems in 2007 in Watt per capita 3
Figure 5: Yearly installed PV capacity per capita over time (1993-2007) in various countries 3
Figure 6: Supply and demand curves 5
Figure 7: Factors affecting WTP/demand curve and Supply curve 6
Figure 8: Incentives required to increase market penetration 6
Figure 9: Cumulative grid installed capacity with important milestones in the largest grid-connected markets. 11
Figure 10: Yearly grid installed capacity with important milestones in the largest grid connected markets. 11
Figure 11: Cumulative installed capacity with important milestones in emerging grid-connected markets 12
Figure 12: Yearly grid connected installed capacity with important milestones in emerging grid-connected markets 12
Figure 13: Global effectiveness to 2005 29
Figure 14: Costs for the public for a feed-in tariff and for one up-front investment subsidy. 30
Figure 15: Costs for the public 31
Figure 16: Evolution of the costs for the public over time 31
Figure 17: Development of rebates over time and in various countries 32
Figure 18: Cost reductions (USD/kWp) over time in the residential sector 33
Figure 19: Evolution of module costs and non-module costs for Germany, Japan and Spain in the residential sector 35
Figure 21: Strategies to promote PV Performance 37
Figure 22: Money paid by the applicants per plant vs. subsidies granted per plant over time in two large markets (California and Japan) and one emerging market (Australia) 40
Figure 24: PV electricity cost-effectiveness for the consumer including subsidies in 2005 42
Figure 25: PV electricity cost-effectiveness for the consumer without including subsidies in 2005 42
Figure 26: Capacity and number of systems financed by both programs in 2005 44
Figure 27: Average plant sizes approved in the Spanish Financing Line ICO-IDAE. 45
Figure 28: Average plant sizes of on grid centralized systems in Germany 45
Figure 29: Average plant sizes of approved systems >50kW through the Italian “Conto Energia” 46

TABLES

Table 1: Type of promotional drivers 8
Table 2: Evolution of most influential PV policies for the residential sector in selected countries .. 14
Table 3: Evolution of most influential PV policies for the residential sector in selected countries (Continuation) 15
Table 4: Installed capacity within the Japanese Field Test Projects on New PV Power Generation Technology Program (Source: Ikki- Various issues; IEA-PVPS-Annual report, 2004) 16
Table 5: Subsidies in New Jersey's Programs 18
Table 6: Overview of German Feed-in Tariffs in 2004, 2007 and 2009 in EUR-ct/kWh 20
Table 7: Spanish feed-in Tariffs in 2006 21
Table 8: Spanish feed-in Tariffs in 2007 according RD 661/2007 21
Table 9: Spanish feed-in Tariffs in 2009 according RD 1575/2008 21
Table 10: Italian Feed-in Tariffs in 2006 22
Table 11: Italian Feed-in Tariffs in 2009 (after the amendment in February 2007) 22
Table 12: Overview of the California Solar Initiative 23
Table 14: PV requirement in the new Spanish Technical Building code 26
Table 15: Features of analyzed programs 27
Table 18: Examples of financing programs 43
Table 19: barriers related to time from a demand side point of view 47
Table 20: Major PV deployment programs and important milestones in the past 54
Table 21: Major Marketing Programs (2008) 55
Table 22: ISO country and currency codes 57

1 INTRODUCTION

1.1 CORE OBJECTIVE

The core objective of this study is to analyze the success of various regulatory state promotions (i.e. governmental programs) and marketing (governmental and non governmental) programs for grid-connected PV systems worldwide. To meet this objective a review of the most important past and current programs around the world was conducted. The final mission of this study was to analyze the effect of these programs in terms of "market transformation." Market transformation makes reference to the process towards a sustainable market.

Derived from this core objective, related targets of this report are:

- to describe and document the largest and most influential PV promotion programs worldwide;
- to extract crucial success factors to help design new strategies.

1.2 CURRENT STATE OF THE ART

In 2007 grid-connected PV applications were by far the most significant PV market as represented in Figure 1. This was mainly caused by recent progress in Germany, Spain, Japan and California where more than 90% of global grid-connected installations took place, see Figure 2.

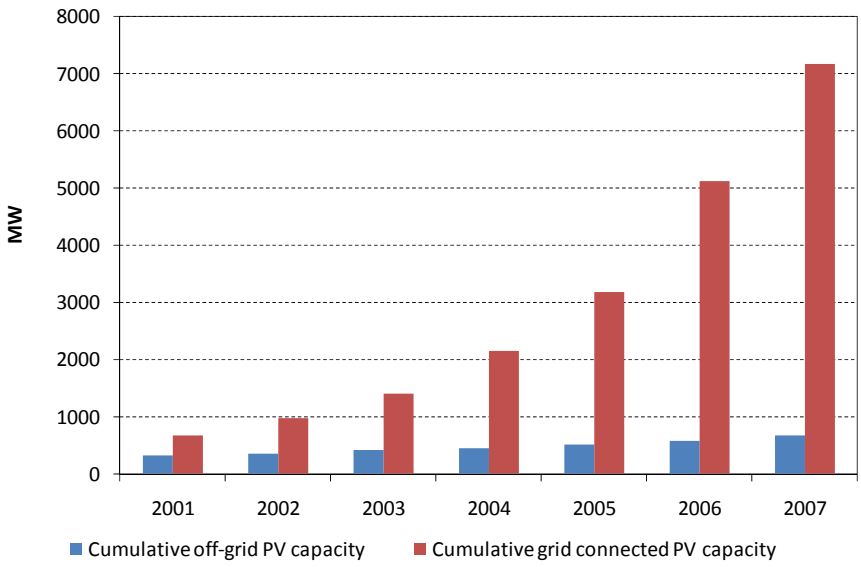

Figure 1: Worldwide yearly installed capacity by application until 2007

(Sources: IEA-PVPS Trend reports in PV Applications, 2001-2007)

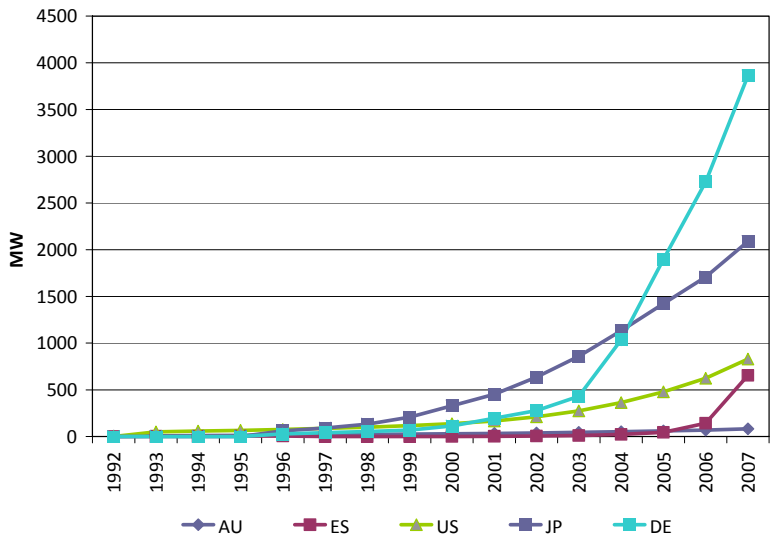

Figure 2: Cumulative installed total PV capacity of leading countries 1992-2007 in MW

(Sources: IEA-PVPS Trend reports in PV Applications, 2001-2007,)

In many other "emerging" markets, like Italy, The Netherlands, and Australia where comprehensive promotion activities took place, significant increases were also achieved, see Figure 3

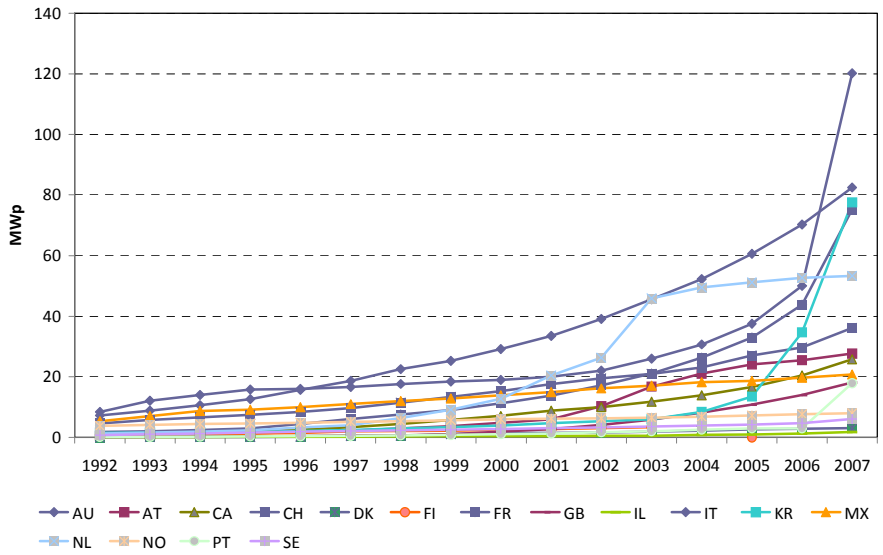

Figure 3: Cumulative installed total PV capacity of emerging countries 1992-2007 in MW

(Sources: IEA-PVPS Trend reports in PV Applications, 2001-2007,)

If installed capacity is related to the population, as can be seen in Figure 4 and Figure 5, emerging smaller countries like The Netherlands, Switzerland, and Austria are coming closer in performance compared to the larger ones.

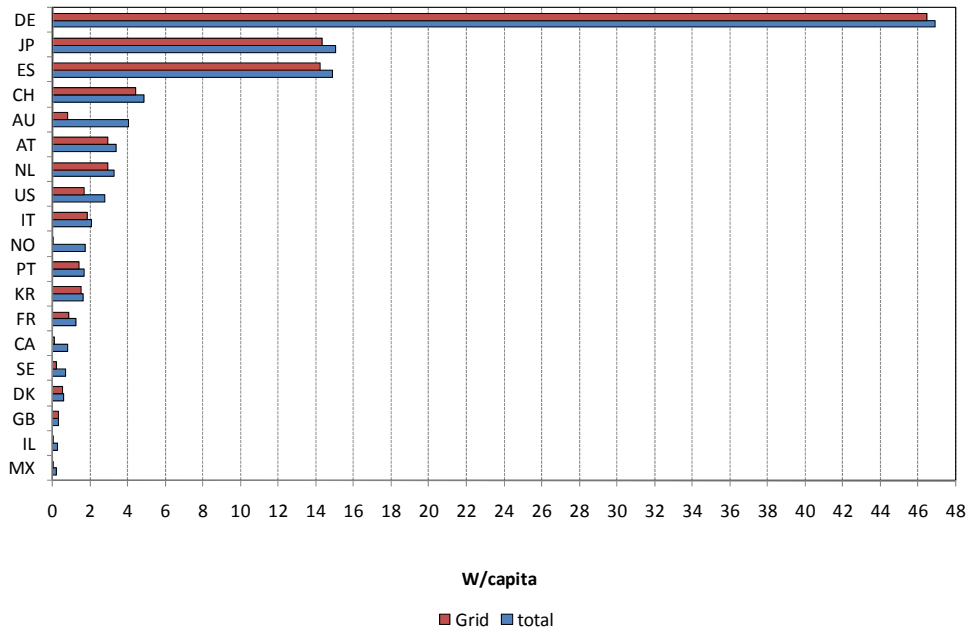

Figure 4: Installed total PV capacity and capacity of grid-connected systems in 2007 in Watt per capita

(Sources: IEA-PVPS Trend reports in PV Applications, 2001-2007,)

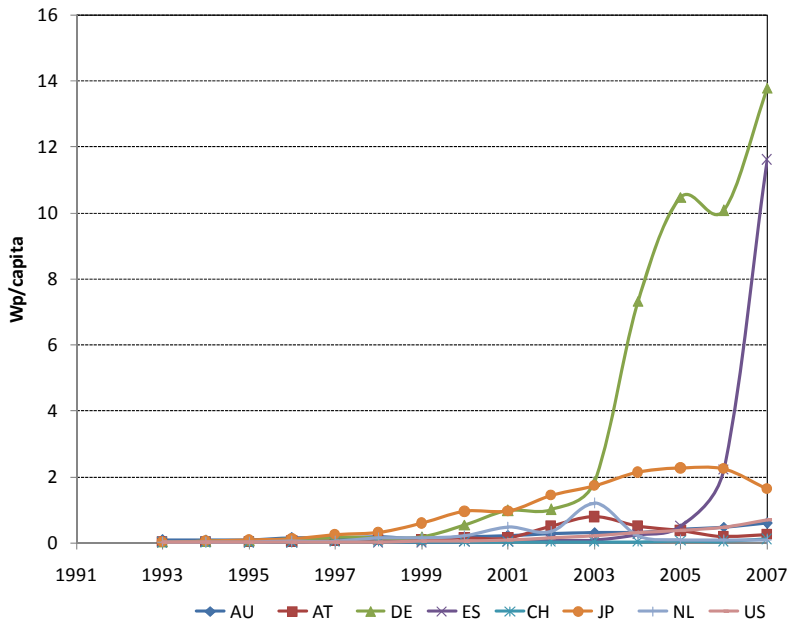

Figure 5: Yearly installed PV capacity per capita over time (1993-2007) in various countries

(Sources: IEA-PVPS Trend reports in PV Applications, 2001-2007,)

1.3 STRUCTURE OF THIS REPORT

This report is structured as follows:

The theoretical bases of supply and demand are explained in the next section. They determine the market behaviour of consumers and producers. The types of existing strategies are documented in Section 2. In Chapter 3, different programs around the world are described. Chapter 4 focuses on defining success criteria which will be used for the analysis of the programs. Finally, the major conclusions complete this analysis.

2 WHAT ARE PROMOTIONAL DRIVERS?

2.1 THEORETICAL BACKGROUND

Some theoretical background (see Haas, 2002) has to be explained in order to understand the importance of policies and the meaning of some terms used. A major issue is to understand the factors of prices, costs, and willingness to pay (WTP) for a product or willingness to invest and how they may vary.

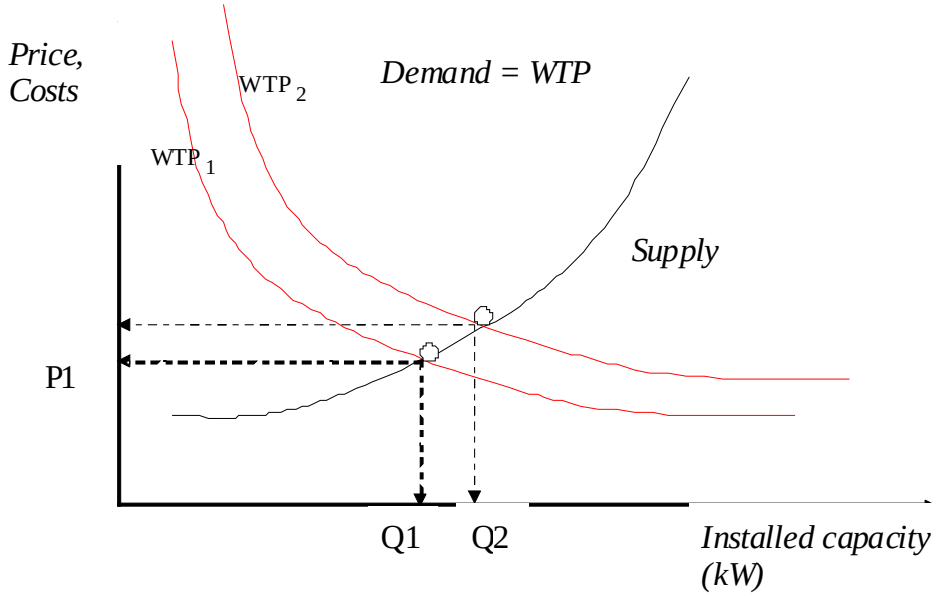

Figure 6: Supply and demand curves

Figure 6 shows the supply and demand curves. The demand curve (WTP_1 in Figure 6) characterizes how much a consumer is ready to pay for a commodity (in our case a kW or kWh of PV). The supply curve is defined by the costs to produce a certain number of units of a product (kWh or kW of PV). The price market P1 is the point where supply curve and demand curve meets. P1 will be the market price if no factor affecting these curves changes. At P1 consumers are ready to buy (to install) the quantity Q1 and producers to produce the quantity Q1. Nevertheless there are factors that can affect the supply curve and demand curve moving them and altering the final installed capacity Q2 (for simplicity only a change of the WTP_1 represented by WTP_2 has been depicted in Figure 6). The most important factors which can affect the supply curve and demand curve are depicted in Figure 7.

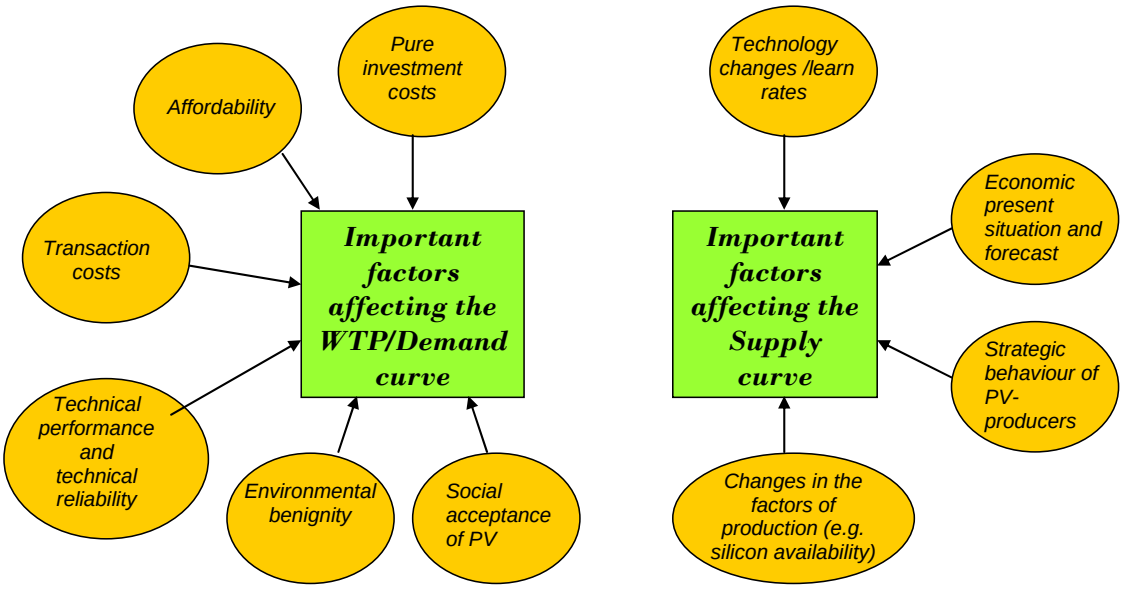

Figure 7: Factors affecting WTP/demand curve and Supply curve

A major objective of this study is to analyze which measures affect consumers' WTP and which rebates are necessary to achieve a favourable change of the supply curve. These effects are shown in Figure 7. An important aspect to consider is that Figure 6 represents the case of a mature market. **In a mature market**, supply curves are increasing because if prices increase, producers will be willing to produce and therefore there will be more product available in the market and price has to follow, i.e. **competition plays**. In the case of an emerging, transitional or imperfect market, as is the case of the PV market, supply curves are decreasing. The reason is that in the long run of an imperfect market, prices decrease if quantity increases (as an effect of a learn rate) (see Haas et al, 2002). Considering this fact, we can focus on the effect of policies on the demand of PV systems. This is depicted in Figure 8.

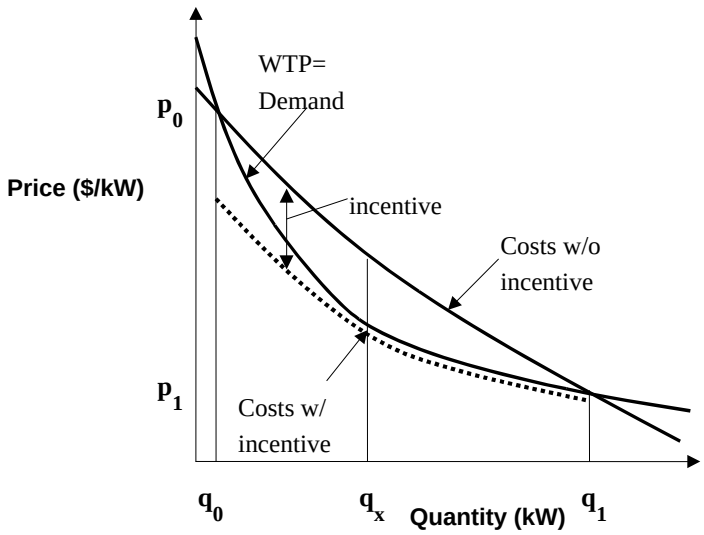

Figure 8: Incentives required to increase market penetration

(Source: Haas, 2002)

Since we assume that we are in an imperfect market, the dynamic supply curve is decreasing. In these circumstances, we can assume that besides the present equilibrium in which the installed capacity is q_o, an equilibrium also exists where the installed capacity is higher and equal to q_1. Promotional drivers are those strategies which lead to a new equilibrium by the following two ways:

- By shifting the WTP[1] (as seen in Figure 7 - for example by increasing the PV acceptance)
- By giving the needed incentives and consequently causing an apparent (but not real!) shift in the supply curve.

If we consider the second point, the most important aspect is to investigate the exact amount of incentives to offer. Since these incentives are considered to be temporary for the purpose of transitioning the emerging market to a sustained or mature market, it is desirable that they have the lowest costs for the public as possible. Economic incentives represent a fictitious price signal for the consumer and in his investment costs thus moving the supply curve from the consumer's point of view. The effect is observed in Figure 8. Subsidies to be at or just higher than the difference between supply curves (costs w/o incentives) and WTP at the desired cumulative capacity q_x Moreover, subsidies have to be reduced over time, otherwise the consequence would be that nothing would be installed – the market would stall - since consumers would wait for the next increase of incentives. Ideally, if subsidies are set to achieve the WTP price, the state of the market improves, both an increase of the WTP and costs reductions are expected. Therefore a reduction of subsidies from the first moment is required. Thus prices are forced to be reduced at the same time as production costs become lower. To put in more direct terms, subsidies targeting a mature market must be initially set at a value that provides a fair investment for the consumer without driving the market demand to a point that causes prices to increase. The subsidy can then be adjusted according to market demand and costs or supply adjustments.

2.2 TYPES OF PROMOTIONAL DRIVERS

Promotional drivers also called market strategies, marketing programs or deployment programs can be classified according to different criteria as it is observed in Table 1. This table is based on the works of Haas, 2002; Haas et al., 2001 and Hoff, 2006. The terms are very common and only a short description of some of them will be given[2].

[1] Considerations about movements in the supply curve go beyond the scope of this study.

[2] More detailed information about the meaning of each program can be found in Haas, 2002; Haas et al., 2001; and Hoff, 2006.

Table 1: Type of promotional drivers
(Source: Haas et al., 2001; Haas, 2002; Hoff, 2006)

				REGULATORY	VOLUNTARY	
TARGET PROGRAMMES				Renewable Portfolio Standards or Quotas	National instalment or capacity targets	QUANTITY DRIVEN
				Tenderings	-	PRICE DRIVEN
FINANCIAL INCENTIVES	GENERATION-BASED	ONE UP FRONT PAYMENT	EXPECTED PERFORMANCE	Expected performance buydown	▪ Green Power Marketing ▪ Green tariffs	
			ACTUAL PERFORMANCE	Performance based buydown		
		MULTIPLE PAYMENTS	EXPECTED PERFORMANCE	–		
			ACTUAL PERFORMANCE	▪ Feed-in tariffs ▪ Net metering ▪ Rate-based incentives	▪ Green Power Marketing ▪ Green tariffs ▪ Solar stock exchange	
	INVESTMENT FOCUSED	ONE UP FRONT PAYMENT		▪ Soft loans ▪ Capacity based buydown[1] ▪ Tax deductions ▪ Tax exemptions ▪ Tax credits	▪ Contracting ▪ Shareholder program. ▪ Contribution ▪ Bidding	
		MULTIPLE PAYMENTS		▪ Capacity based incentive ▪ Tax credits		
OTHERS				▪ Buildings codes	▪ NGO-marketing ▪ Selling green buildings ▪ Retailer program. ▪ Public building programmes.	

Notes:
[1] Commonly known as investment subsidies.

From the consumer's point of view, the strategies that most directly affect him are those that provide financial incentives. Financial incentives can be received as a payment for every kWh produced or as a payment for the system capacity (money for every kW). In Europe recent trends have been towards kWh payments or feed-in tariffs, though there are still capacity

payments. However, in the United States, due to state run programs, there are many differing hybrid concepts that correspond to this main subdivision (see Hoff, 2006).

As explained in further chapters, these concepts are very important because they represent an intermediate step between the Feed-in tariffs, with the advantage of promoting technical performance and capital investment subsidies which reduces the upfront investment cost. Except for some innovative cases, the emphasis of this study focuses on regulatory financial incentives. The Renewable Portfolio Standards will not be discussed in detail due to the low impact for PV thus far.

3 THE MOST SUCCESSFUL PV DEPLOYMENT PROGRAMS WORLDWIDE

The four large current PV markets (Germany, Japan, Spain and California) can be observed in Figure 9 and Figure 10 which represent the cumulative and yearly installed capacity over time respectively. The effect of the new Renewable Energy Law, which came into force in January 2004 in Germany and the effect of the Japanese Residential PV Dissemination program, stands out. The effects of the policies in California are also observed but with a lesser impact. The start of the Spanish feed-in tariff in 2004 corresponds with the increase of installed capacity after 2006[3].

Figure 11 and Figure 12 show the cumulative and yearly installed capacity in some emerging markets respectively. In The Netherlands, the effect of an overly subsidized market is observed in the Figure 12 after 2003 when the yearly installed capacity decreased drastically due to a massive reduction of the subsidies compared with the excessive incentives in the previous years. In fact the market collapsed when the generous EPR and the utilities subsidies (which accounted together for much more than the difference between demand and supply) disappeared in 2003 and the moderate MEP (which accounted for much less than the difference between demand and supply) started.

[3]It takes a long period of time until plants are really installed due to several bureaucratic problems in the approval process.

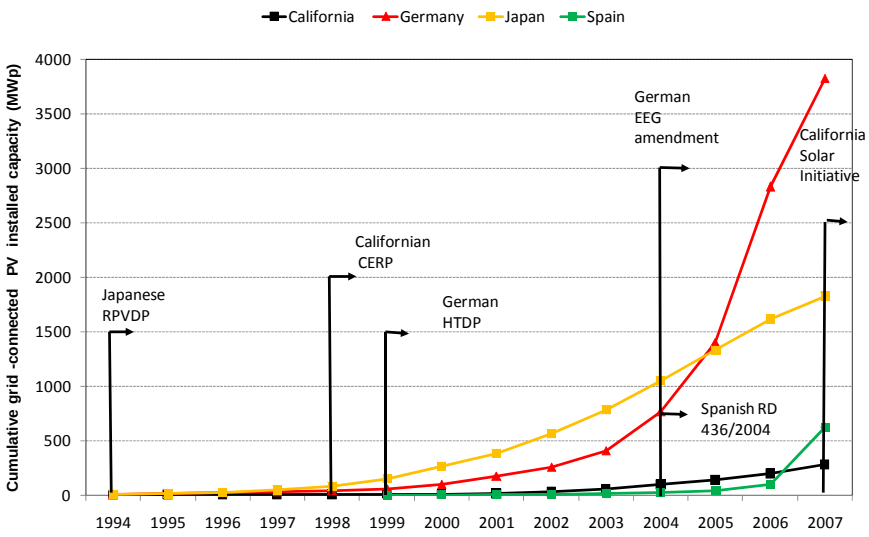

Figure 9: Cumulative grid installed capacity with important milestones in the largest grid-connected markets.
(Source: IEA-PVPS, 2008 and California Energy Commission (CEC) -Homepage)

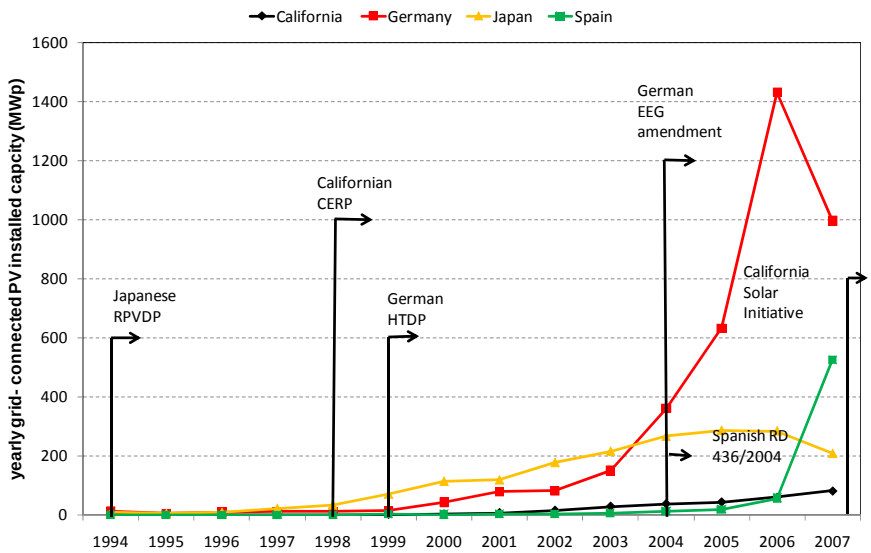

Figure 10: Yearly grid installed capacity with important milestones in the largest grid connected markets.
(Source: IEA-PVPS, 2008 and California Energy Commission (CEC) -Homepage

Notes for Figure 9 and Figure 10:

German data depends strongly on the source. In 2005, both the International Energy Agency (IEA) and the official European data from the PV Eurobarometer accounts for less installed capacity than other sources like the magazine Photon. According to the IEA the cumulated grid installed capacity end 2005 in Germany was 1 429 MWp. According to the Eurobarometer the cumulated grid installed capacity end 2005 in Germany was 1 508 MWp. According to Photon the cumulated grid installed capacity end 2005 in Germany was more than 1 970 MWp. In this study the IEA data is considered.

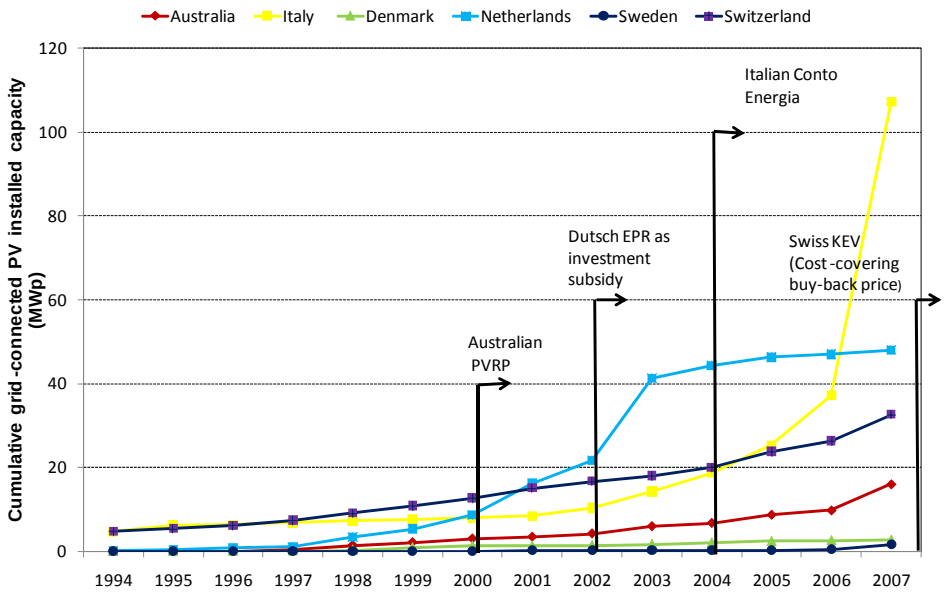

Figure 11: Cumulative installed capacity with important milestones in emerging grid-connected markets
(Source IEA-PVPS, 2008)

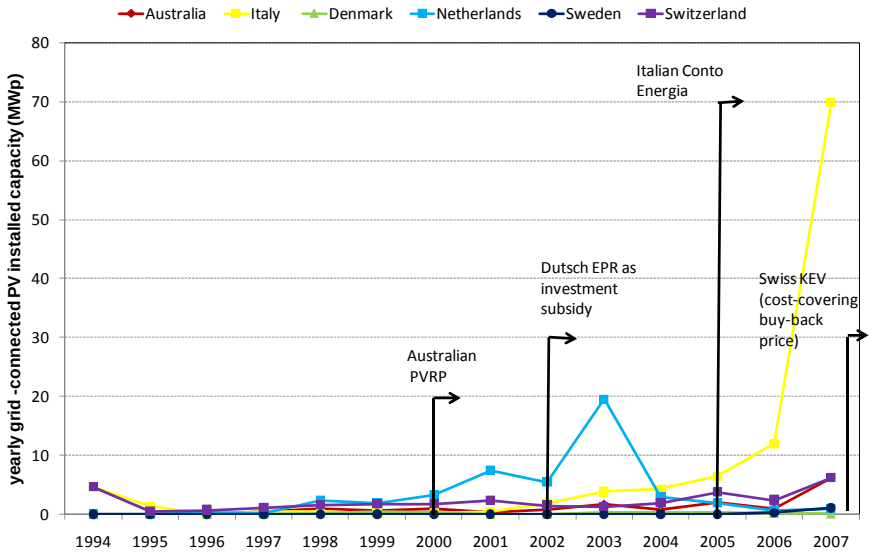

Figure 12: Yearly grid connected installed capacity with important milestones in emerging grid-connected markets
(Source IEA-PVPS, 2008**)**

The comparison of the Evolution of most influential PV policies (see Table 2 and Table 3) and the PV capacity installed over time (see Figure 10 and Figure 12) provides evidence that continuity and evolution of promotion schemes are necessary to assure stable and sustainable markets. Switzerland is a good example. In the mid 90s, Switzerland had the largest installed capacity per capita of the world after the introduction of the first voluntary full cost rate (a type of voluntary feed-in tariff paid by the utilities). Nevertheless and despite a long lack of political will, the Swiss PV market survived thanks to voluntary initiatives promoted by utilities, but lost its place among the big PV power markets. An evolution of the once successful financing strategies in line with the development of the PV world market had

been necessary. In 2008 Switzerland launched a nationwide feed-in tariff, KEV (Cost covering buy-back price).

In this Section, different programs are described. Most of them are still in operation or they have ended recently. The programs with enough data available are used for a later analysis applying the success criteria explained in the following chapter.

Programs which are not included in the later analysis are described in more detail in this chapter. In order to put these programs in context, the evolution of the different policies over time is observed in Table 2 and Table 3. The described programs follow the classification given in Table 1.

Table 2: Evolution of most influential PV policies for the residential sector in selected countries

			1989	1992	1994	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
LARGE MARKETS	DE	Rebates	■	■	■											
		FIT											■	■	■	■
		RPS														
		Voluntary				■	■									
		Soft loans						■	■	■	■	■				
	JP	Rebates			■	■	■	■	■	■	■	■	■	■		
		FIT														
		RPS													■	■
		Voluntary (Net billing to buy-back)			■	■	■	■	■	■	■	■	■	■	■	■
	CA (US)	Rebates						■	■	■	■	■	■	■	■	
		FIT														
		RPS														
		Voluntary	■	■	■	■	■									
		Expected performance Buydown														■
EMERGING MARKETS	ES	Rebates														
		FIT						■	■	■	■	■	■	■	■	■
		RPS														
		Voluntary														
	IT	Rebates								■	■	■	■	■		
		FIT												■	■	■
		RPS														
		Voluntary														
	NL	Rebates									■	■				
		FIT											■	■	■	
		RPS				■	■	■	■							
		Tax exemptions				■	■	■	■	■						
		Voluntary														
	CH	Rebates														
		FIT														
		RPS														
		Voluntary	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Table 3: Evolution of most influential PV policies for the residential sector in selected countries (Continuation)

			1989	1992	1994	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
EMERGING MARKETS	SE	Rebates														
		Tax exceptions														
		RPS														
	DK	Rebates														
		FIT														
		RPS														
		Voluntary														
	AU	Rebates														
		FIT														
		RPS														
		Voluntary (Greenpower)														
	AT	Rebates														
		FIT														
		RPS														
		Voluntary														

3.1 INVESTMENT FOCUSED FINANCIAL INCENTIVES

3.1.1 Japanese Residential PV System Dissemination Program (RPVDP)

The Japanese Residential PV System Dissemination Program was launched in 1994. The program was combined with low-interest consumer loans and comprehensive education and awareness activities for PV. The subsidy was given in three categories: a) individuals installing PV systems to their own house, b) suppliers of housing development complexes or suppliers of houses built for sale, and c) local public organizations that introduce PV systems to public buildings. Subsidies in FY 2005 were 20 000 JPY/ kW_p[4] with a maximum output capacity of the PV system of 10 kW_p. Rebates have been decreasing continuously over time. While in the first years of the program (1994-1999), the subsidies were a fixed percentage of the costs (decreasing from 50% to 33%) this concept changed into fixed amounts per kW_p.

[4] 20 000 JPY are approx: 150 EUR in 2005

3.1.2 Japanese Field Test Projects on PV Power Generation System for Public and Industrial Applications

The Japanese Field Test Projects on New PV Power Generation Technology Program started in 1992 and it was offered to public buildings until FY1997 and to industrial facilities until FY2002. At present the program includes public buildings, industrial facilities and "advanced technology" and is formally named "Field Test Project on New Photovoltaic Power Generation Technology".

Four technologies are included:

- Systems employing new modules
- Systems integrated with construction materials
- Systems using new control methods
- Systems seeking better efficiency

After the finalization of the Japanese Residential PV System Dissemination Program, METI (Ministry of Economy, Trade and Industry) enhanced the program and considered it to be of high importance for PV power dissemination. The long-term strategy is comparable to the strategy followed by the Residential PV System Dissemination Program. It is intended to create a sustainable PV market in the non-residential market.

Table 4 shows the installed capacity and the yearly budget.

Table 4: Installed capacity within the Japanese Field Test Projects on New PV Power Generation Technology Program

(Source: Ikki- Various issues; IEA-PVPS-Annual report, 2004)

	Installed capacity (kW)					
	Systems employing new modules	***Systems integrated with construction materials***	***Systems using new control methods***	***Systems seeking better efficiency***	***Total***	***Total Budget (Billion JPY)***
FY 2003	10	370	60	4 040	4 480	3,50
FY 2004	10	760	30	6 361	7 161	5,03
FY 2005	130	393	281	16 868	17 672	9,23
FY 2006	20	710	351	18 491	19571	11,8

Notes:
FY= Fiscal year

3.1.3 California's Emerging Renewables Program (CA ERP)[5]

California's Emerging Renewables Program was managed by the California Energy Commission (CEC) and started accepting applications in March 1998. At the beginning, five tiers were planned. The maximum buydown was set for the first tier in 3 000 USD per kW_p declining 500 USD per tier to 1 000 USD per kW_p in the final tier. The tiers were not subject to calendar years or specific time frames but each block would be available until exhausted.

[5] From 1 January 2007, rebates for PV under the CA ERP are replaced by the state's California Solar Initiative.

Due to the disappointing number of applications, the program concept was changed in 2001. Since 2003, the program has focused on small and residential systems under 30 kW_p, with a parallel program administered by the utilities for larger scale systems. In July 2006, rebates were set at 2 600 USD per kW_p declining about 200 USD per kW_p every 6 months.

3.1.4 Australian Photovoltaic Rebate Program (PVRP)

The Australian PVRP (now called the Solar Homes and Communities Program) was launched in January 2000 by the Australian Greenhouse Office (AGO) and is available for grid and off-grid buildings. A minimum size of 450 W_p was required. The rebate for the residential sector, community buildings and schools changed between 2000 and 2007 from 5 500, then 5 000 then 4 000 AUD per kWp capped at 1 kW_p, although there was no maximum size limit. Extensions to existing PV systems could receive rebates of 2 500 AUD per kWp capped at 2 500 AUD. Furthermore, housing estate developers and builders could also apply for rebates which amount to 3 500 AUD. A new amendment of the program was announced in May 2007. An increase of subsidies for the residential sector from 4 000 AUD per kWp to 8 000 AUD per kWp and capped at 8 000 AUD was introduced (Australian Greenhouse Office-Homepage) and uptake increased significantly. In 2008, a household means test of AUD 100,000 was introduced. The program will end in 2009 and be replaced by a renewable energy target mechanism.

3.1.5 Danish SOL 300 and SOL 1000

SOL 1000 built on the previous SOL 300 which operated from 2000 to 2001. It targeted a total capacity installed of 750 kW_p. SOL 1000 expired at the end of 2006. The goal was set at 1 000 kW_p at the start of the program but a reduction in budget by the government also caused a reduction of the goal which was finally set at 700 kW_p. Exceptionally low prices occurred due to tenderings for supplying fully installed systems. Investment subsidies amounted to 40%.

3.1.6 The Californian CPUC's Self Generation Incentive Program (SGIP)[6]

The California Public Utilities Commission (CPUC) managed the Self Generation Incentive Program and started accepting applications in July 2001. Rebates were available for PV systems of 30 kW and larger in size. Although systems could exceed 1 MW_p only 1 MW_p of capacity was eligible for the rebate. In 2006, rebates were set at three levels depending on the requested capacity. For the first 50 MW, rebates were set a 2 800 USD per kW_p. After that, rebates were set at 2 500 USD per kW_p. If requested capacity surpassed 120 MW, rebates were set at 2 250 USD per kW_p.

[6] From 1 January 2007, rebates for PV under the SGIP are replaced by the state's California Solar Initiative.

3.1.7 Italian PV Roof Program

The Italian PV Roof Program "Tetti fotovoltaici" was launched in March 2001. The second phase of the program was managed by the 19 Italian regions and announced locally. As a consequence each region was adopting its own amount of incentives. Some regions adopted a 70% incentive, while others adopted 65% with a maximum investment cost ranging from 7 to 7,5 EUR/W_p, depending on plant size. The maximum investment subsidy permitted was 70% of the total costs.

3.1.8 New Jersey's Clean Energy Program's Customer On-Site Renewable Energy (CORE)

The CORE was part of the New Jersey Clean Energy Program which started in 2001. Applicants purchasing systems which include modules manufactured in New Jersey received an additional rebate of 250 USD/kW. The CORE was finished in 2008 with about 63 MW installed. The Renewable Energy Incentive Program (REIPI) started in 2009. The rebate levels for the CORE in 2007 and REIPI in 2009 are shown in Table 5.

Table 5: Subsidies in New Jersey's Programs

(Source: New Jersey's Clean Energy Program- Homepage)

Subsidies in the New Jersey's Clean Energy Program's Customer On-Site in 2007		
Size of the system (kW) (S= Size of the system)	**Private Sector (USD/kW)**	**Public and Non–Profit Sector (USD/kW)**
<10	3 800	4 400
10,001<S<40	2 750	3 450
40,001<S<100	2 500	2 800
100,001<S<500	2 250	2 600
500,001<S<700	2 000	2 050
Renewable Energy Incentive Program		
Size of the system	**Residential solar applications**	**Non residential solar applications**
0 to 10000 Watts with an energy audit	$1,75/Watt	
0 to 10000 Watts without an energy audit	$1,55/Watt	
0 to 50000 Watts	-	$1/Watt
>50000 Watts	-	-

3.1.9 The Great Britain Major PV Demonstration Programme

The Major PV Demonstration Programme in GB was officially launched by the Department of Trade & Industry (DTI) in March 2002 and ended in March 2006. An investment subsidy of up to 50% was granted and both on-grid and off-grid systems were eligible in two different categories: small scale applications from 500 W to 5 kW and medium to large scale from 5 kW to 100 kW. The Programme disposed of a budget of 31,75 MGBP. 1 920 plants with less than 5 kW and a total capacity of 4 740 kW were installed. 202 plants larger than 5 kW_p with a total capacity of 5 950 kW were installed.

3.1.10 Australian Solar Cities

"Solar Cities" was announced in June 2004 and is being implemented by the Department of the Environment,Water, Hertiage and the Arts. Four cities (Adelaide, Townsville, Blacktown and Alice Springs) were initially chosen. The total budget was 75 MAUD and duration of the program until 2013 is foreseen. Energy efficiency, energy saving measures, and the installation of thermal and PV systems are included. In particular, the installation of 3 262 PV systems in the residential, commercial and public sector buildings with a total capacity of more than 5 MW is foreseen. The idea is to extend the lessons learned to other cities in Australia. In 2007, three additional cities were added, Central Victoria, Perth, and Melbourne (Coburg), with an additional budget allocation of MAUD 18.8.

3.1.11 Swedish PV Program

100 MSEK were foreseen for the installation of PV in public buildings in the Swedish PV program which started mid 2005 and should be in force until the end of 2007. In 2006, the financing was increased to 150 MSEK and the program was extended to the end of 2008. Subsidies amount up to 70%.

3.1.12 Great Britain Low carbon building program

The Low carbon building program was launched in April 2006 by the Department of Trade & Industry (DTI), replacing all previous PV Programs in the GB and will run over three years (LCBP-Homepage). Besides PV, eight other technologies for energy efficiency and renewable energy production in buildings are granted. Households, building developers, business, local authorities and public bodies, energy service companies, NGO´s and government offices are eligible. Eighteen MGBP are available for households (for all technologies and not only PV). Up to 3 000 GBP/kW (not exceeding 15 000 GBP and 50 % of total costs) grants are offered for private households.

3.1.13 US PV Investment Tax Credit

The Federal Energy Policy Act of 2005 includes a federal tax credit of 30 percent of total system cost of a solar system. The credit is available to homeowners and commercial owners for solar systems installed from 1 January 2006 through 31 December 2008. The tax credit directly reduces the amount of income tax paid unlike a deduction which reduces the amount of income subject to tax. For homeowners the tax credits are limited up to 2 000 USD per system. In October of 2008 the ITC was extended for 8 years with the residential limit lifted and utilities are now also able to receive the ITC.

3.2 GENERATION-FOCUSED FINANCIAL INCENTIVES

3.2.1 German Renewable Energy Act (EEG)

The German Renewable Energy Act is the main market driver in Germany. The present EEG came into effect in April 2000 and was amended in 2004. It builds on the previous Electricity Feed Law from 1991. The 20 year fixed tariffs, which are granted for new projects each year, decrease by 5% each year. In 2008, a new law was passed which provides for adjustments to the FIT amount depending on the market response. Table 6 shows the guaranteed rates in 2004, 2007 and 2009.

Table 6: Overview of German Feed-in Tariffs in 2004, 2007 and 2009 in EUR-ct/kWh
(Source: BMU, 2009)

Share of capacity	*2009 EEG*	*EEG Progress Report (7.11.2007)*	*2004 EEG*
Roof mounted facilities			
Up to 30 kW	43,01	42,48	44,41
30 kW – 100kW	40,91	40,37	42,26
Over 100 kW	39,58	39,91	41,79
Over 1000 kW	33.00	34,48	41,79
Electricity produced is used within building/facility			
Up to 30 kW	25,01	-	-
Freestanding facilities			
All	31,94	32,01	33,18
Bonuses for facades facilities			
All	-	+ 5	+5
Degression for freestanding facilities			
	Basic fee and bonuses: 2010: 10% from 2011: 9%	Basic fee From 2009: 7% From 2011: 8%	Basic fee 5% Freestanding facilities 6,5%
Degression for Roof systems			
	Basic fee and bonuses: Up to 100 kW 2010: 8% From 2011: 9% Over 100 kW 2010: 10% From 2011: 9.0 %	Basic fee: From 2009: 7% From 2011: 8%	Basic fee 5% Freestanding facilities 6,5%

3.2.2 Spanish feed-in tariff

The Spanish feed-in tariff was often changed in the last years. In the following the last three regulations are described.

-ROYAL DECREE 436/2004 (RD 436/2004): The Spanish feed-in tariff built on the Royal Decree 2818/1998. Grid-connected PV systems had the option to deliver the PV electricity for a price related to the "average electricity tariff" or to participate in the regular electricity market whereby PV rates vary monthly. Nevertheless, the Royal Decree Law 7/2006 from 23 June 2006 separated the feed-in tariff from the average electricity tariff. Rates were guaranteed for as long as the system is running. Table 7 shows the guaranteed rates for 2006 as fixed under the RD 436/2004.

Table 7: Spanish feed-in Tariffs in 2006
(Source: ASIF, 2006)

SPANISH REMUNERATION PV ELECTRICITY (EUR-Ct/kWh)			
<100 kW		>100 kW(2)	
Year 1-25	44,04 (5,75 x AET(1))	Year 1-25	22,98 (3 x AET(1))
Year 26 on	(4,6 x AET(1))	Year 26 on	18,38 (2,4 x AET(1))

Notes:
(1) AET="Average Electricity Tariff" estimated at the beginning of the year considering the generation costs of 1 kWh.
(2) Systems over 100 kW also have the option to participate in the regular market. In this case, PV electricity is paid by summing up market price + an incentive depending on AET. In practical terms this option is not used.

- **ROYAL DECREE 661/2007 (RD 661/2007):** The Royal Decree 661/2007 built on the Royal Decree 436/2004 und came into force on 1 June 2007. Tariffs are annually reviewed and will be reduced in the following way:

Consumer Price Index – 0,25% until 2012

Consumer Price Index – 0,50% after 2012

Tariffs were guaranteed until 371 MW have been installed.

Table 8: Spanish feed-in Tariffs in 2007 according RD 661/2007
(Source: ASIF, 2007)

SPANISH REMUNERATION PV ELECTRICITY (EUR-Ct/kWh)					
<100 kW		>100 kW and ≤ 10MW		>10MW and ≤ 50MW	
Year 1-25	44,038	Year 1-25	41,75	Year 1-25	22,9764
Year 26 on	35,23	Year 26 on	33,4	Year 26 on	18,3811

- **ROYAL DECREE 1575/2008 (RD 1575/2008)**

The present feed-in tariff considers two important points:

1. A yearly capacity cap is set. Plants are granted until the yearly capacity cap is reached. Every year capacity cap is updated according to algorithm
2. Tariffs are calculated according the installed capacity in the previous year.

Table 9 shows the guaranteed fees for 2009

Table 9: Spanish feed-in Tariffs in 2009 according RD 1575/2008
(Source: Appa, 2008)

Type of installation	**Tariff**	**Capacity cap in the first year**
Installations on roof or facades (for commercial, residential or industrial uses) and installations on parking structures		
<20 kW	34	267 MW
>20 kW	32	
All other installations	32	133 MW

3.2.3 Italian feed-in tariff – "Conto Energia"

The present main driver in Italy came into effect in September 2005. A yearly cap of 85 MW was set. Systems were accepted in rigorous order of submission. Accepted systems received guaranteed rates for 20 years. The tariffs were fixed for 20 years, but each year the fixed tariff decreased by 5% for the new projects in that year. Systems larger than 50 kW were subject to a tender mechanism. Table 10 shows the guaranteed rates for systems accepted in 2006. A new law with amendments to the described "Conto Energia" came into effect in February 2007 and the yearly cap of 85 MW was eliminated. The new tariffs are guaranteed for accepted systems 20 years and they decrease 2% every year. They are described in Table 11.

Table 10: Italian Feed-in Tariffs in 2006

ITALIAN REMUNERATION PV ELECTRICITY IN 2006 (EUR-Cent/kWh)	
1≤ kWp ≤20	44,5(1),(3)
20≤ kWp ≤50	46(1),(4)
50≤ kWp ≤1 000(2)	49(1),(4)

Notes:
(1) Additional 10% for build integrated systems;
(2) Tender mechanism;
(3) Rate for PV electricity if it is self-consumed. For the surplus energy, net metering is applied. PV electricity can also be totally sold at 46 EUR-Cent/kWh;
(4) Self-consumed electricity is paid as bonus for the next year.

Table 11: Italian Feed-in Tariffs in 2009 (after the amendment in February 2007)

	ITALIAN REMUNERATION PV ELECTRICITY IN 2007 (EUR-Cent/kWh)		
	Ground mounted systems	Buildings (part integrated(1))	Buildings (integrated)
1-3 kW_p	39,2	43,1	48
3-20 kW_p	37,2	41,2	45,1
>20 kW_p	35,3	39,2	43,1

Notes:
(1) PV modules are coplanar to the surface without substitution of building materials

3.2.4 California Solar Initiative (CSI)

In January 2006, the CEC and the CPUC established the California Solar Initiative which started in January 2007. The goal of the program is to install 3 000 MW by the end of 2017. The CSI offers incentives of up to 2 500 USD per kW_p. These incentives, combined with federal tax incentives, can cover up to 50% of the total cost of a solar system. The CEC manages incentives for all new residential construction while the CPUC manages incentives for existing homes and all other properties. Systems up to 5 MW are eligible although incentives are only paid for up to 1 MW. Table 12 offers a more detailed description of the program.

Table 12: Overview of the California Solar Initiative
(Source: IKKI-Various Issues, November 2006; CSI-Homepage, 2009)

CEC	CPUC
Budget	
400 MUSD	2 165 MUSD
Installed capacity	
360 MW	1 940 MW
Target	
New home constructions	All except new home constructions (existing residential homes and existing and new commercial, industrial, and agricultural properties)
Program description and incentive structure	
New Solar Homes Partnership - Systems >1kW$_{AC}$ - Expected Performance Based Incentive(1) Incentives will decline over the life of the program. The decline will be given as a specific volume in capacity (MW) has occurred. The initial base incentive for a reference system (variations depends on the calculated expected performance) is set at 2 500 USD/kW (custom homes and small developments) or 2 600 USD/kW (Production housing with solar as a standard feature(2))	The program offers two types of incentives: - Expected Performance Based Buydown[1] for systems <100kW (. (Systems <50kW after 2008 and Systems <30 kW$_p$ after 2010).: Applicants receive an initial incentive of 2 500 USD/kW (residential and commercial) or 3 250 USD /kW (non-profit and gov´tl). Incentives will decline over the life of the program. The decline will be given as a specific volume in capacity (MW) has occurred(3) - Performance based incentive for systems >100 kW. (Systems >50kW after 2008 and Systems >30 kW$_p$ after 2010). Applicants receive an initial incentive of 0,39 USD/kWh (residential and commercial) or 0,50 USD/kWh (non profit and gov´tl). Incentives will decline over the life of the program. The decline will be given as a specific volume in capacity (MW) has occurred(4). Payments will be received during 5 years. Systems <100 kW may choose between both incentive types.
Start date	
January 2007	January 2007

Notes:

(1) Expected performance based incentive: Applicants have to use the California Energy Commission PV calculator to determine the expected performance.

(2) The incentives decline in 10 steps. The $2 500/kW Is offered for the first 70MW statewide and reduced to $200/kW for the last 350 MW installed statewide.

(3) Residential and commercial incentives are reduced in 10 steps down to 200 USD/kW, and governmental are reduced to 700 USD/kW respectively for the last 350 MW installed statewide under the CSI.

(4) Residential and commercial incentives are reduced in 10 steps down to 0,03 USD/kWh, and governmental are reduced to 0,10 USD/kWh respectively for the last 350 MW installed statewide by the under the CSI.

3.2.5 US Net Metering

A Major focus for the individual states in the US is net metering which allows a PV system owner to receive full retail value for the full output of the PV system regardless of whether or not all the energy is directly consumed at the time it is produced. By October 2008, 40 states had statewide net metering rules. This incentive is highly variable due to the varying costs for retail electricity in the states.

3.3 MIXED FINANCIAL INCENTIVES

3.3.1 Energy Premium Regulation (EPR) and MEP Netherlands

The EPR was in operation between 2001 and 2003 and during this period was the most important market tool for private consumers. Although it was a fiscal measure at the beginning, the EPR was converted into a direct investment subsidy in 2002. Investment subsidies between 3,5 EUR/W_p and 4,375 EUR/W_p were granted. Many utilities also granted investment subsidies (approx. 1 EUR/W_p) to PV systems with feed-in tariffs (0,18-0,25 EUR/W_p). After the finish of the EPR the MEP (Milieukwaliteit van de Elektriciteitsproductie) came into force in July 2003 and finished in 2006. 9,7 EUR-Cent/kWh were guaranteed for 10 years in the framework of the MEP. At present (June 2007) net metering is applied.

3.4 RENEWABLE PORTFOLIO STANDARDS FOR PV

3.4.1 Japanese Renewable Portfolio Standard

The Japanese Renewable Portfolio Standard (Law on Special Measures Concerning New Energy Use by Electric Utilities) was enforced from Fiscal Year 2003. In 2007 the new quota for new energy by FY 2014 was set at 16 billion kWh (1,63% of the total electricity sales). From FY 2011, PV generation is directly affected by this measure as 1 kWh PV power generated counts as 2 kWh in order to equate PV to other less expensive renewable energy electricity generators.

3.4.2 New Jersey's Renewable Portfolio Standard (NJRPS)

In 2006, The New Jersey Board of Public Utilities (NJBPU) approved a requirement that each supplier/provider must include 22,5% of renewable electricity in the electricity it sells to retail customers by 2021. This mandate also includes 2% of solar electricity or approximately 1500 MW. That is the largest US solar goal on a per capita basis. New Jersey also set up a market trading platform for Renewable Energy Credits[7] or RECs and to assure that Solar RECs (SRECs) met the RPS goal, specific floor prices were set for SRECs Table 13 shows the prices for SRECs, 1 SREC = 1 MWh) and the quantity traded until August 2008.

[7] A renewable energy credit is the non-energy green attribute of a MWh.

Table 13: Solar Renewable Energy Certificates in New Jersey
(Source: New Jersey's Clean Energy Program - Homepage)

Period of time	*Number of SRECs traded*	*Weighted Avg Price ($/MWh)*
Jul 2004-Aug 2005	5773	200,59
Jul 2005-Aug 2006	19335	215,09
Jul 2006-Aug 2007	53932	220,28
Jul 2007-Aug 2008	84728	246,15

Since 2001, New Jersey, the second largest solar market in the US, also has a solar rebate -- New Jersey´s Clean Energy Program which provides investment subsidies for residential, commercial and public sector markets (see description in 3.1.8). After the introduction of the NJRPS the NJ Board of Public Utilities designed a transition which gradually reduces the investment subsidies in order to finance PV systems solely by means of solar certificates8.

3.5 VOLUNTARY GENERATION-FOCUSED FINANCIAL INCENTIVES

3.5.1 Swiss Solar Stock Exchange Programs

Until March 2007[9], the Swiss market was substantially sustained by solar stock exchange programs (Solarstromboersen) offered by utilities. The market volume created amounts to approx. 2 MW_p annually. Electricity is generated by privately-owned PV systems and fed into the public grid. Other customers may buy this electricity and pay rates corresponding to the PV production costs. On the supply-side, only the most cost-effective projects are selected by a bidding process. One of the most well known programs is the Solar Stock Exchange of the EWZ (Elektrizitätswerk der Stadt Zürich) in Zurich. In April 2007, green electricity consumers of the EWZ paid 0,85[10] CHF/kWh (0,9146 CHF/kWh incl. VAT) for their solar electricity. About 8 500 consumers participated in the program (until July 2006). Bidding processes are open every 1,5 years whereby the best offers receive a contract for selling their PV electricity for a period of 20 years.

3.6 OTHER REGULATORY PROGRAMS

3.6.1 Spanish Technical Building Code

The new Spanish technical building code came into force in March 2006. Concerning PV, its use is compulsory in certain buildings depending on their use and minimum size. It is applicable to new as well as retrofitted buildings if their surface is bigger than 1 000 m² with more than 25% of the enclosure modified by retrofit. Table 14 shows the characteristics of buildings in which installation of PV is compulsory. In these buildings, a minimum PV power is to be installed depending on the local climatic conditions.

[8] Moreover, solar system owners receive the US PV Investment Tax Credit and also can save money in the electricity bill by means of net metering.

[9] Swiss Parliament decided in March 2007 to introduce feed-in tariffs for plants built after 1 January 2006.

[10] Approx. 0,52 EUR and 0,70 USD in 2007

Table 14: PV requirement in the new Spanish Technical Building code

TYPE OF BUILDING AND USE	MINIMUM SIZE
Commercial, large supermarkets	5 000 m² surface
Commercial, multi-stores	3 000 m² surface
Commercial big stores	10 000 m² surface
Showgrounds (for trade fairs)	10 000 m² surface
Office and public buildings	4 000 m² surface
Hotels and guesthouses	100 beds
Hospitals and clinics	100 beds

3.7 OTHER VOLUNTARY PROGRAMS

3.7.1 Japanese Green Power Fund

The Japanese Green Power Fund was established in 2000. The Fund is maintained from donations from customers and aims to promote PV and windmills. Donors are charged 500 JPY/share/month. The utility matches donor contributions. By the end of FY 2007, 16828 kW and 874 projects have been installed.

3.7.2 Japanese Net billing

Electric utility companies in Japan are continuing a net billing to buy-back surplus PV electricity at the same rate as the retail price of electricity since 1994.

4 SUCCESS CRITERIA FOR PV DEPLOYMENT PROGRAMS

Success has to be defined to enable an analysis of the success of the deployment programs. In this study, diverse success parameters have been extracted and analyzed for selected programs until 2005. Table 15 shows the most important features of the programs.

Table 15: Features of analyzed programs

PROGRAM	*ABBREVIATION*	*COUNTRY*	*TYPE OF PROGRAM*	*YEAR*
German 100 000 Roof Program	DE HTDP	Germany	Investment-focused financial incentives with one up-front payment	1999-2003
Solarstromerzeugen		Germany		Since 2005
Japanese Residential PV System Dissemination Program	JP RPVDP	Japan		1994-2005
California's Emerging Renewables Program	CA ERP	US (California)		1998-2006
Spanish Financing Line ICO-IDAE	ES ICO-IDAE	Spain		2000-2005
Italian PV Roof Program "Tetti fotovoltaici"	IT "Tetti PV"	Italy		2001-2005
Energy Premium Regulation	NL EPR	Netherlands		2001-2003
"Milieukwaliteit van de Elektriciteitsproductie"	NL MEP	Netherlands		2003-2006
Danish SOL 300 and SOL 1000	DK SOL 300 + SOL 1000	Denmark		2000-2006
Australian Photovoltaic Rebate Program	AU PVRP	Australia		Since 2000
German Renewable Energy Act	DE EEG	Germany	Generation-focused financial incentives with multiple payments	Since 2000
Spanish Feed-in Tariff-ROYAL DECREE 436/2004 and ROYAL DECREE 2818/1998	ES RD 436/2004	Spain		Since 1999
Italian Feed-in Tariff – "Conto Energia"	IT "Conto Energia"	Italy		Since 2005
EWZ Swiss Solar Stock Exchange Program	CH EWZ	Switzerland	Voluntary generation-focused financial incentives with multiple payments	Since 1996

4.1 DEFINITION OF SUCCESS CRITERIA

The success criteria studied are defined in Table 16.

Table 16: Definition of success criteria

Success criteria	Definition	Quantitative parameters
Dissemination effectiveness	Degree to which a measure maximizes the installed power and reaches maximum participants that play decisive roles as multiplier agents	Global effectiveness: Total installed capacity Local effectiveness: installed capacity per inhabitant
Costs for the public	Measurement of the efficiency of a program. Amount of money spent for subsidies and other financial incentives compared with the output of the policy (e.g. installed capacity)	Monetary unit/ installed capacity
Cost reductions	Policies can contribute to system cost reductions over time	Monetary unit/ kW or kWh
Improvement of technical performance	Measure of how policies can contribute to improve and secure the technical performance of the installed systems over time	Standards and codes
Market conformity	Contribution of a policy to a sustainable PV market by satisfying the needs of the market	-Willingness to Pay (WTP) for PV electricity -Cost effectiveness -Willingness to Invest (WTI)

4.2 DISSEMINATION EFFECTIVENESS

One of the objectives of any program must be to maximize the installed power and to reach a maximum of participants that play a decisive role as multiplier agents. For this reason dissemination effectiveness will be quantified in the following way:

- Global effectiveness: Total installed capacity
- Local effectiveness: Installed capacity per inhabitant

Figure 13 shows the installed capacity both in absolute values and in relative values in different countries and programs. The existing difference between Germany and the rest of programs stands out. The difference between capacity installed during the program Tetti fotovoltaici and the approved capacity of the Conto Energia in only 3 months of operation is also remarkable. Although the installed capacity by the Swiss solar stock exchange of EWZ is unspectacular compared with the big markets, it is practically twice as much as the installed capacity in the national program in Denmark with SOL 300 and SOL 1000.

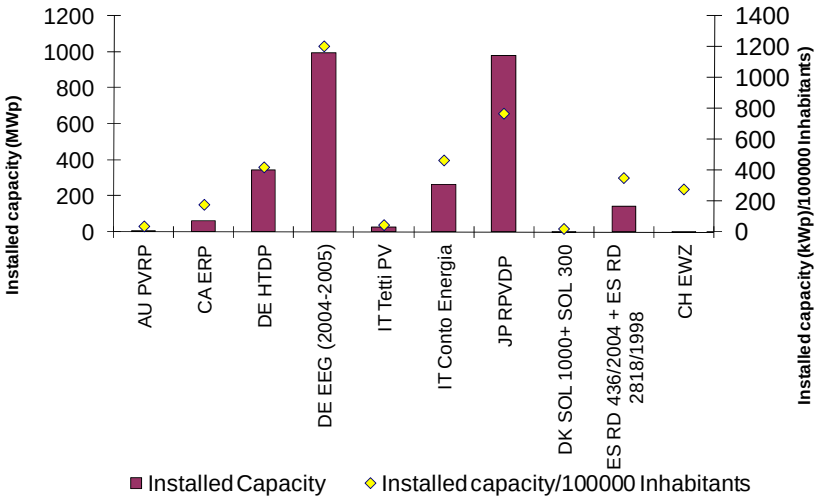

Figure 13: Global effectiveness to 2005
(Own calculations)

Notes:
(1) The data corresponding to Spain comes from program ICO-IDAE and represents accepted power rather than installed capacity. It also includes a small percentage of off grid plants.
(2) For the Swiss program of EWZ, the inhabitants of Zurich have been considered.
(3) For the Italian FIT capacity, accepted capacity and not installed capacity has been considered in order to give a better idea of the market.

It is important to highlight those measures in this context in which the "mass public" is affected and not only the "green" buyer or "the typical innovator" of emergent markets. We refer to measures which imply a process of socialization of the energy. For example, the "builder mandates" like the Spanish technical building code that came into force in March 2006 and which makes the use of PV mandatory for certain types of public and commercial buildings.

4.3 COSTS FOR THE PUBLIC

The costs for the public are a measure of the efficiency of a program.[11,12] This means that at the end of the program it must have obtained a maximum of capacity installed with a minimum societal monetary cost. Usually this is one criterion to be fulfilled by the organizer of the program; i.e. the government or local agency designing the program. Theoretically, different concepts entail different societal costs. For example, Figure 14 depicts the public costs (hatched surface) for a feed-in tariff with a fixed duration and tariff for each PV owner which changes over time for new applicants and for one up-front investment subsidy which also changes over time.

[11] A comprehensive explanation of the theoretical background of costs of the public for different deployment strategies can be found on Hoff et al, 2006.
[12] The source of fund for the PV deployment program is not discussed in this study (e.g. about 5% added costs to retail electricity prices to pay for FIT costs Germany and about 7,8% in Italy)

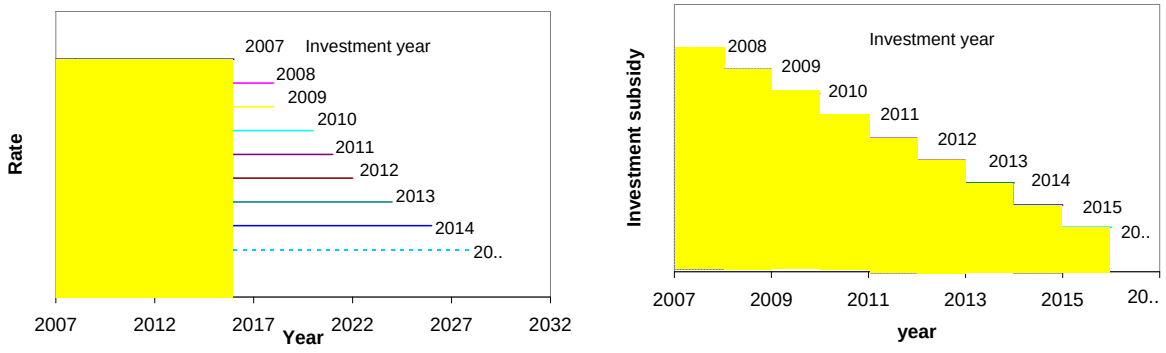

Figure 14: Costs for the public for a feed-in tariff and for one up-front investment subsidy.

(Source: Hoff, 2006; Own researches)

Figure 15 and Figure 16 show economic efficiency. The costs for the public are calculated in the following ways:

A) Total money spent:

- In the case of investment subsidies: Cost for the public are calculated by multiplying the investment subsidy per installed capacity unit (e.g. kW_p) times installed capacity.
- In the case of feed-in tariffs: Costs are taken from the literature; i.e. official sources13

B) Spent money per kWp:

- In the case of investment subsidies: Costs are taken from the literature;
- In the case of feed in tariffs: Costs are calculated by multiplying the total money spent times installed capacity.

The total money spent by kW until 2005 is quite similar in Australia, California and Denmark. Without considering Germany and Spain, Japan demonstrates the greatest economic efficiency by spending the least amount of money per kWp. The subsidy just reached approx. 20 000 JPY/kW[14] in the last year of the program. Germany and Spain represent a special case which is difficult to compare in this context to the other programs since the concept for the financing of the systems is quite different (feed-in tariffs). Taking into consideration the extra money spent by the community for the feed-in tariffs, the German and Spanish concept is more expensive than the concepts of rebates in the other countries - especially if compared to Japan.

[13] CNE in Spain: www.cne.es and VdN in Germany www.vdn-berlin.de

[14] 20 000 JPY ≈ 144 EUR in 2005

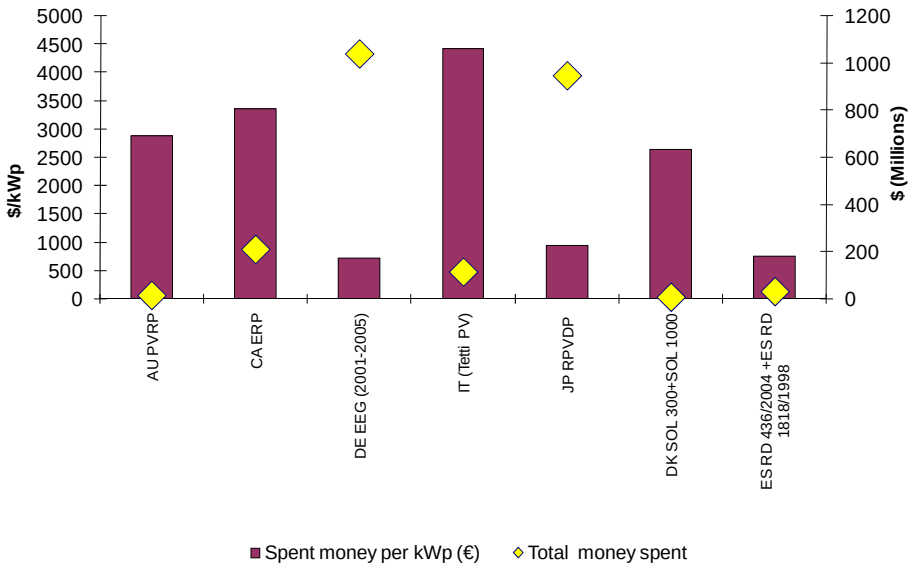

Figure 15: Costs for the public

Notes:

(1) The costs depicted for Spain and Germany are only the costs occurred until 2005. The tariffs in Spain are paid for 25 years and in Germany for 20 years.

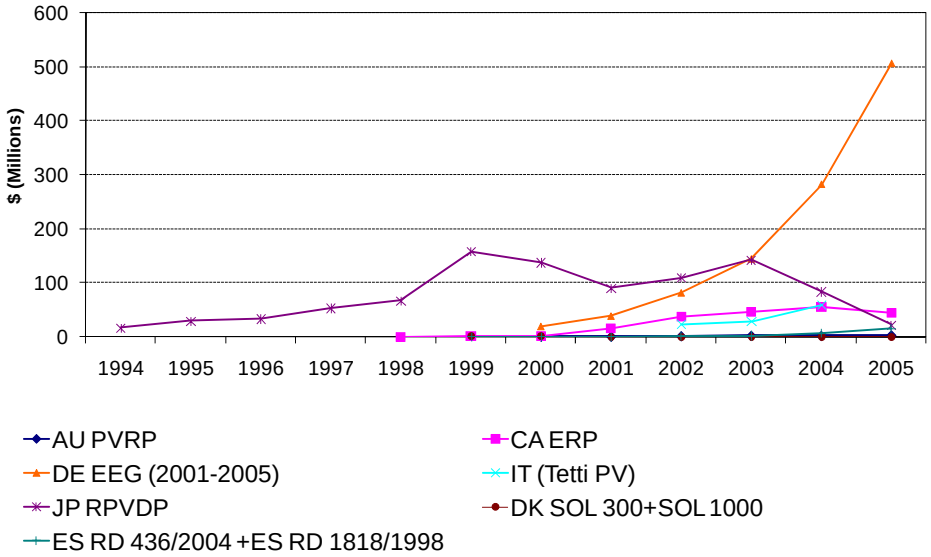

Figure 16: Evolution of the costs for the public over time

Notes:

(1) The costs depicted for Spain and Germany are only the costs occurred until 2005. The tariffs in Spain are paid for 25 years and in Germany for 20 years.

In Figure 16, it stands out that the same amount of money was spent in Japan in 1994 as in 2005 whereas about 1 860 kW_p were installed in 1994 compared to more than 130 MW_p in 2005. This is an example of driving the public costs of the subsidy down and both supply and demand up.

Figure 17 shows the evolution of the investment subsidies in different years for some countries. It can be seen that Italy, The Netherlands and California offered considerably higher rebates than other countries in some years (highlighted in the figure with an

interrogation mark). It could hint at over subsidized markets in Italy between 2002 and 2004 and in California and Netherlands in 2003. Although the increase of Californian Rebates in 2001 and 2002 were caused by the energy crisis, they lead on the one side to a reduction of requests[15] and on the other side to an increase of system prices (see 4.4). The effect of the Dutch excess is seen in Figure 17 where the market collapsed after the investment subsidy was abolished. Nevertheless, the high subsidies received in 2003 in The Netherlands were given by different parties (national government and local energy companies) without proper coordination, and it was certainly not done intentionally. Probably the main problem in The Netherlands was the complexity and the large number of different subsidy schemes, together with a lack of political support for RE within the new government after 2004. The rebates in California and Australia in 2005 reached the same level as Japan offered in 1998. Of course there are variable factors such as electric rates and solar resource that effect WTP, but this is also an indicator of the benefits for the continuity and evolution of the Japanese program.

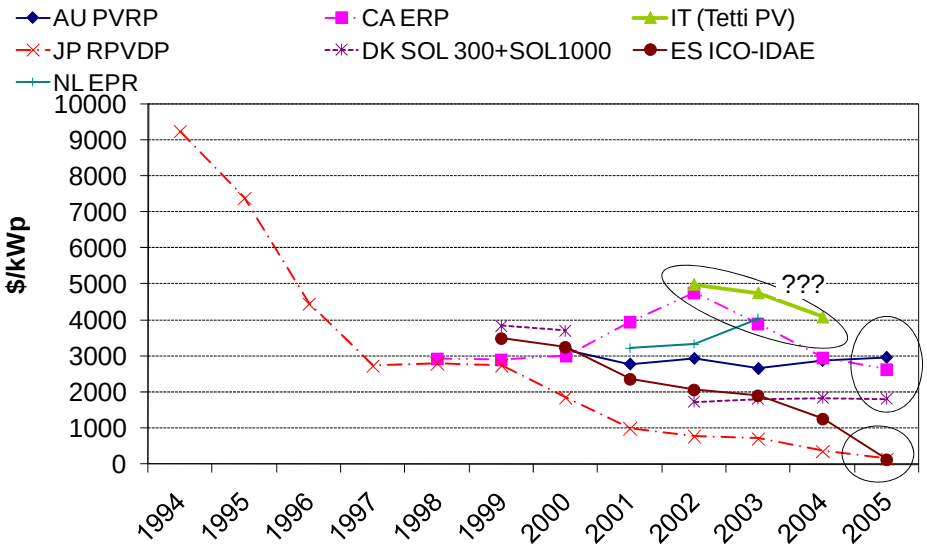

Figure 17: Development of rebates over time and in various countries

4.4 DEVELOPMENT OF COSTS OVER TIME

The cost development of a technology can be used as criteria to see how a policy has contributed to a technical change. For that reason and according to previous studies, different incentives lead to different cost reductions (see Haas, 2002 and Lopez-Polo, 2004). We have to consider two components: a global component and a local component. Whereas the module prices are determined essentially by international and global market laws, installation costs are mostly determined by the local market. Nevertheless, policies have to be designed in a way that they represent an incentive to reduce basic installation costs.

[15] Many applicants that requested a subvention resigned to it when they noticed that in the following year the subvention was going higher…

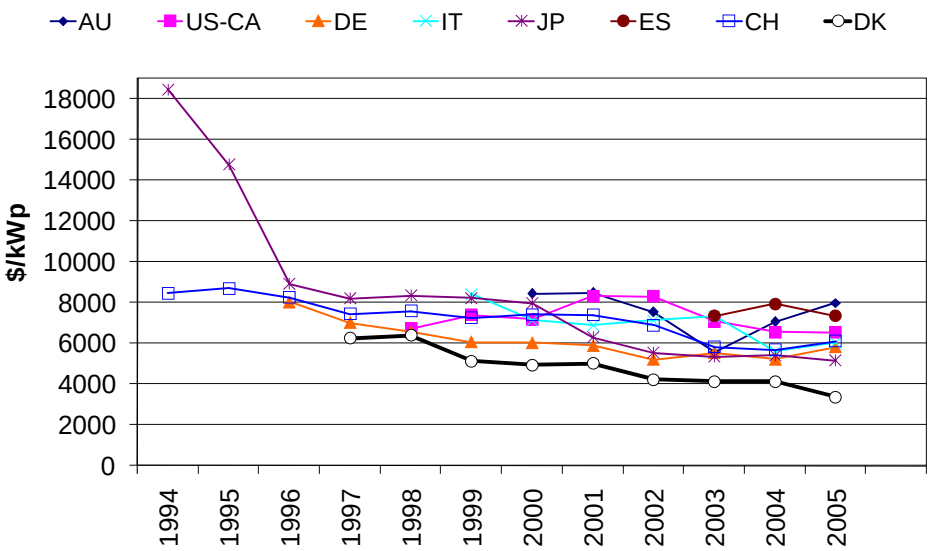

Figure 18: Cost reductions (USD / kWp) over time in the residential sector

(Source: IEA-PVPS, 2006; California Energy Commission - Homepage; IEA-PVPS - National status reports, Different years; IKKI, various issues; IDAE, 2006)

Notes:
(1) System costs do not include VAT and charges after installation.
(2) Costs for California have been extracted from data provided by the California Energy Commission. From this data, an 8% sale tax has been subtracted.
(3) In the case of data provided in a range of values, no average value has been taken but the minimum value was used since the author assumed minimum system costs are a better representation of cost reductions.
(4) Low costs in Denmark are due to bulk purchases in SOL 300 and SOL 1000.

Figure 18[16] shows the cost evolution in different countries for the residential sector. Taking into account that data represent real costs (inflation is included and each country experiences different exchange rate impacts), most represented countries have experienced an increase of costs in the last years or only a slight decrease. The high demand by the beginning of the amended EEG in Germany in 2004 has caused an increase of prices both in modules worldwide and in installation in Germany[17]. Although the global dynamic component of global costs[18] needs more investigation, it can be stated that facts follow classic economic theory: "The short term development in an imperfect market – as it usually exists for an emerging new technology – is that costs increase if demand increases. Yet, this leads to the emergence of new companies, competition increases and costs drop. In the long run prices will decrease till a perfect competitive market is reached" (see Haas, 2002). This explains the global cost increase tendency in the last years argued in most cases as the increase of module costs due

[16] Most programs outside of the US use a DC-STC rating (basically, the standard test condition rating on the back of the modules, in DC). This is a rather poor rating system, and CA has made two adjustments: applying inverter efficiency ratings and adjusting module ratings to PTC (not STC). The combination of these two "fixes" results in ratings that are, on average 0,84 as much as DC-STC. Therefore the author considered that cost data is given according to a DC-STC rating in all countries except for California where costs are given according to a PTC rating with inverter efficiency adjusting.

[17] In this analysis, factors affecting the production chain such as the increase of silicon prices due to shortage, have not been extracted.

[18] E.g. how developments in Germany have influenced the development of costs in other parts of the world

to a silicon shortage. In fact markets could also have experienced an increase of installation costs.

In the case of Germany, a cost increase between 1% and 4% occurred in 2005. Although this does not represent a big increase given the volume of annual installation (see Figure 9), it shows the existence of an imperfect market in which a certain sector is increasing its margins of benefit while the final pricing does not reflect the learn rates that the sector experiences. That is clearly seen in Figure 19 for 2003 in Germany. In that year, total system cost increased although module costs dropped. Module cost reductions were coupled with an increase of installation costs. This confirms the importance of the reduction over time of financial incentives so that cost reductions and prices occur parallel and not independently of each other, thus causing a distorted market. If financial incentives are not reduced over time, the market prices are not forced to be lower in order to meet the demand. A continuous reduction of financial incentives also entails less cost for the public. In fact, all analysed programs except the Spanish feed-in tariff have a dynamic concept and incentives are reduced over time. Until recently[19] the Spanish feed-in tariff was tied in with the electricity tariffs and, therefore, they were expected to get higher. Nevertheless, the financing line ICO-IDAE established eligible maximum costs of reference. This contributes to improved market transparency since it is a very useful tool to compare budgets, but it is also an obvious incentive to maintain the costs of the facilities within margins. In fact, the final costs of the supported plants only differ 1% from the reference costs established by the program. Although it is a good concept, the presented reference costs diminished little in the three years of the program duration and, therefore, they did not lead to significant reductions as depicted in Figure 18. Figure 19 shows the evolution of module costs and non-module costs for Spain[20], Germany and Japan. The part corresponding to the non-module costs is higher in Spain than in Japan and Germany. Nevertheless, a fast reduction of the part which includes labor costs is observed in Spain.

[19] Until the introduction of the Royal Decree Law 7/2006 from 23 June 2006

[20] In 2005 Spain was considered an emerging market

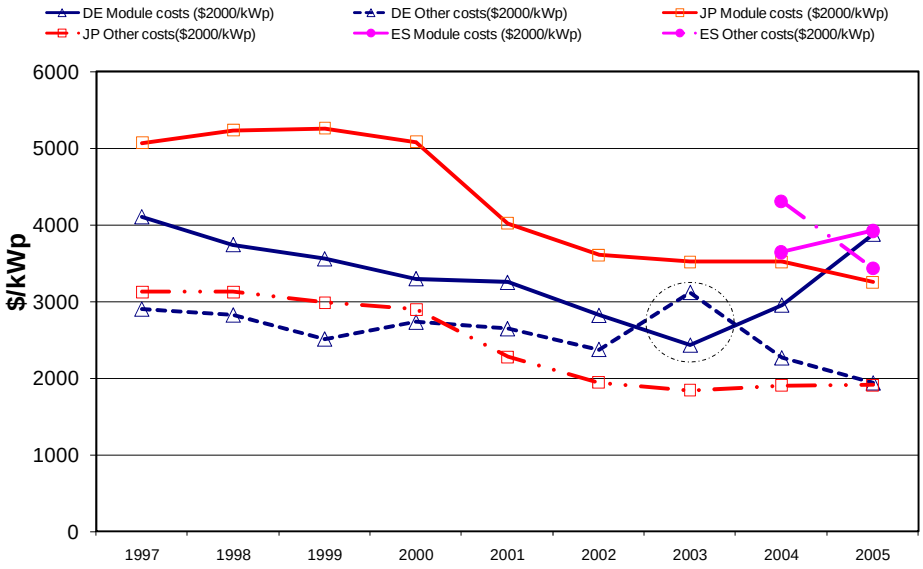

Figure 19: Evolution of module costs and non-module costs for Germany, Japan and Spain in the residential sector

(Source: IEA-PVPS, 2006; IDAE, 2006)

California is a particular case. System costs have been reduced in all ranges of power except for plants between 2 kW and 5 kW_p (depicted in Figure 18[21]). This can be an effect of the STOP and GO policy observed in Figure 17 to which the residential sector could be more sensitive than other markets. Moreover there were two differentiated phases to the program. The first phase includes the period from the beginning of the program to 2002. In this first period, system prices were increasing. From the year 2002, they were diminishing. This coincides with the subsidies shown in Figure 17. In spite of these changes the buyers of a system paid almost the same amount for a system[22]. It means subsidy variations often are caught by retailers increasing or diminishing the prices of the systems but leaving the final price invariable to the buyer (see Wiser et al., 2006).

In the Danish SOL 300 and SOL 1000 two tenders were carried out to obtain the best prices for the offered equipment. The resulting prices are depicted in Figure 18. The attainment of these prices offered by big companies of international character can cause two effects: on the one hand they destabilize the local market rendering them incapable of competing with these prices and on the other hand impeding the development of independent know-how.

Some programs take into account the size of the system (economies of scale) and installation type. In general, additional incentives for the integration of PV in buildings have only been considered in the EEG of Germany and the Conto Energia in Italy. The Australian PVPR and the California CSI also offers subsidies distinguishing between housing builders, residential owners, communities and schools.

[21] If we consider the totality of system costs declined from 12 000 USD per kW (2004 USD) in 1998 costs to less than 9 000 USD/kW in the last year.

[22] This point is explained in detail in the next section.

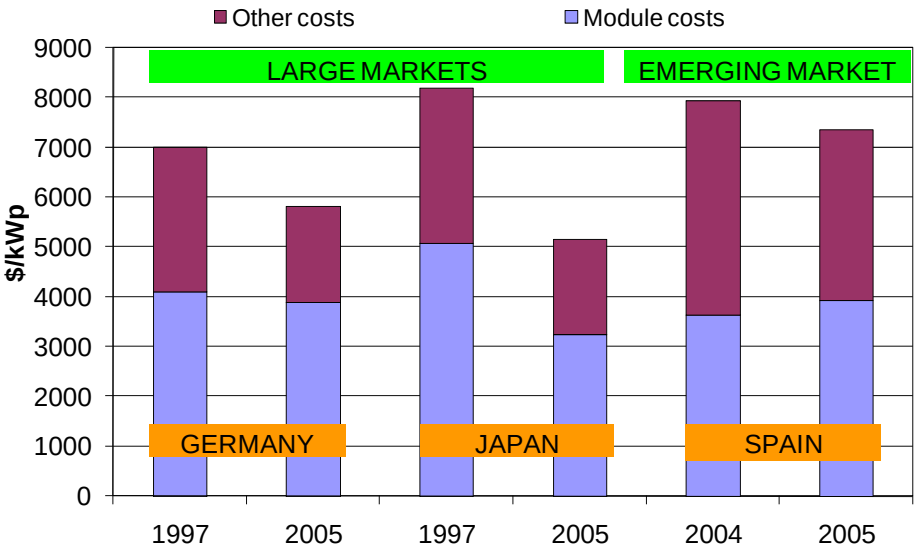

Figure 20: Comparison of module costs and non-module costs for two large markets (Germany, and Japan) and one emerging market (Spain) in the residential sector

(Source: IEA-PVPS, 2006; IDAE, 2006)

4.5 IMPROVEMENT OF TECHNICAL PERFORMANCE

An optimal PV policy must contribute:

- To the necessary technological change that helps to establish a mature market and
- To securing the technical performance of the systems in order to ensure that public funding is really used to the full value (see Wiser et al., 2006; Barbose et al., 2006).

This refers not only to a production point of view, which is not the object of this study, but from the point of view of the user and the distribution chain. It implies that the systems work correctly and there is a minimum level of standardization. Not all programs have focused these questions in the same way. The first obvious difference is that feed-in tariffs (and performance-based programs in general) contribute to the efficient functioning and design of plants and components since the incentives depend directly on the energy output. The question is how other types of programs, beside the classic feed-in tariffs used in Europe until now, could contribute to it. Some examples are documented in the following:

- Japan is carrying out the Field Test on New Photovoltaic Power Generation Technology which focuses on public and industrial sectors in a similar way to the focus on the residential sector. In this program, it stands out that most of the accepted projects from FY 2003 and FY 2006 fall into the category aimed at high efficiency (in FY 2006, 610 systems corresponding to 20 552 kW came from projects seeking better efficiency, the second category accounted for 33 systems and 1 064 kW integrated with construction materials).
- Australia requires certified products and installers in its program.
- California only allows a certified list of PV system components which have to provide a minimal guarantee of 5 years.

- Both New Jersey and Californian systems were randomly checked at a period of time after installation.

These actions not only improve the supply chain but also increase the market transparency thereby reducing transaction costs. A well-working supply chain is fundamental. Italy is a good example. Although the program Tetti Fotovoltaici included various courses for the training of installers, including some free of charge, the present market has to improve its distribution networks by increasing the number of installers in order to meet the demand caused by the "conto energia."

The measures that can be adopted to guarantee or to improve the technical performance in promotion programs have been analyzed in detail by Barbose et al., 2006. In their work, eight forms to improve the technical performance by means of an incentive program and five performance factors affecting the operation of a PV system are defined. They are depicted in Figure 21.

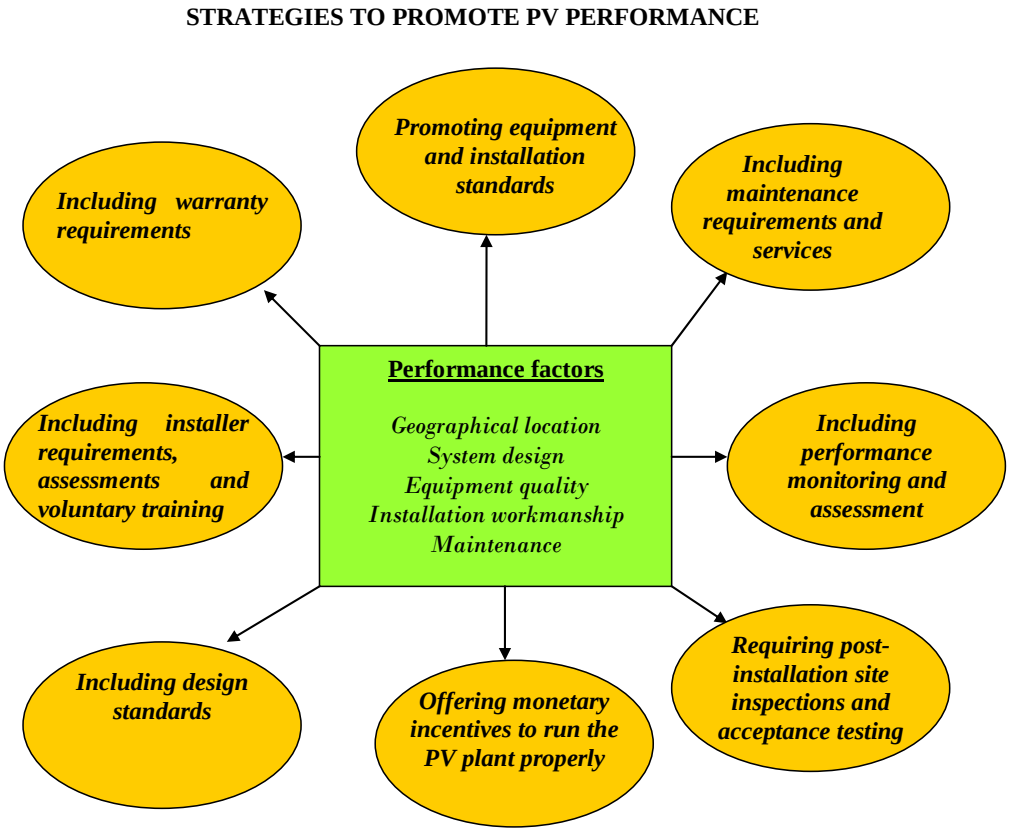

Figure 21: Strategies to promote PV Performance

(Source: Barbose et al., 2006)

Table 17 provides examples of how these strategies have been applied in some programs:

Table 17: Strategies to promote technical performance
(Source: Barbose et al., 2006; own researches)

	Performance factors				
Strategies	Geographical location	System design	Equipment quality	Installation workmanship	Maintenance
Promoting Equipment, design and installation standards	Including solar access regulations which guarantee solar access to each adjacent property	By requiring minimum standards to orientation, shading to subsidized PV systems etc -	By accepting only certain eligible systems/ equipment which meet minimum standards	By requiring certified installers. e.g. Australian PVRP or California ERP	-
Including maintenance requirements and services	-	-	-	-	By requiring that project contractors conduct maintenance services
Including performance monitoring and assessment	-	-	-	-	Collecting data of systems output. e.g. Field Test Project
Requiring post-installation site inspections and acceptance testing	-	e.g.: California CSI by paying the incentive after a Third Party Field Verification			-
Offering monetary incentives to run the PV plant properly	Feed-in tariffs. e.g.: German EEG or Spanish feed-in tariff by offering money per kWh produced during the time of operation				
Including installer requirements, assessments and voluntary training	-	By requiring minimum experience in designing PV systems	-	By including voluntary training for installers e.g.: Italian Tetti Fotovoltaici	-
Including warranty requirements	-	-	e.g. the California CSI requires a 10 year warranty be provided by installers and manufacturers. During these ten years, consumer is protected against defective workmanship, system and components.		

4.6 MARKET CONFORMITY

The contribution of a policy to a sustainable PV market will be analyzed. In this section, two perspectives will be considered:

- A first one dealing with small PV grid-connected systems and
- A second one dealing basically with larger PV plants.

In the first case, we have to evaluate the consumer's Willingness to Pay (WTP) for PV electricity, and in the second case the investor's Willingness to Invest (WTI). Moreover,

existing financing possibilities[23] (bottom-up approach), e.g. soft loans, will be evaluated.

4.6.1 Consumer's WTP in the Residential Sector

A good design of a program must capture the WTP of the citizens. Subsidies should be the difference between the real system costs and the amount which the consumer is willing to pay. Often the WTP is the difference between the grid electricity cost and the PV investment benefits with a fair rate of return on the PV investment. However, a greener cultural attitude, or changing a consumers preference with promotion schemes can often make the WTP price higher. A fundamental asset of any program is the right estimation of the WTP and to not offer more than necessary. Each program should have the following objectives:

a) increase the WTP over time and

b) exhaust the WTP.

WTP over time: Two opposite tendencies are observed regarding the WTP over time if we compare Germany and Japan.

- ***WTP has increased***: Over the twelve years of the RPVDP in Japan, grid electricity prices went up and PV system costs declined, thus increasing WTP, but at the end of the program, the demand continued even though investing in a PV system cost more the electric grid – customer's WTP preference was increased also. Up to 50 MW could have been installed in Japan without subsidies in 2005 (nevertheless subsidies in FY 2004 were only 45 000 JPY / kW_p and in FY 2005 20 000 JPY / kW_p)[24].
- ***WTP has remained invariable:*** Less installed capacity was added in 2005 than in 2004 in Germany. Among the reasons for the decrease of installed capacity in 2005 in Germany are the increase of system costs and the reduction of the feed-in tariff. Both reduce the profitability of buyers.

If the WTP remains invariable, market sustainability completely depends on the supply side as seen in chapter 2.1 and Figure 6 by means of factors explained in Figure 7.

Exhaust the WTP: In order to exhaust the WTP an important aspect is to avoid "STOP and GO" strategies as happened in California in 2000. Many applicants cancelled their request for a subsidy when they noticed that in the following year the subsidy was going to be higher. This is a clear example of not exhausting the WTP: consumers paid less than they were willing to pay. This fact is also depicted in Figure 22[25]. In Figure 22, the total amount of money paid by each participant in two large markets and one emerging market is depicted. The total amount paid by a participant is considered a parameter to analyze the consumer's WTP.

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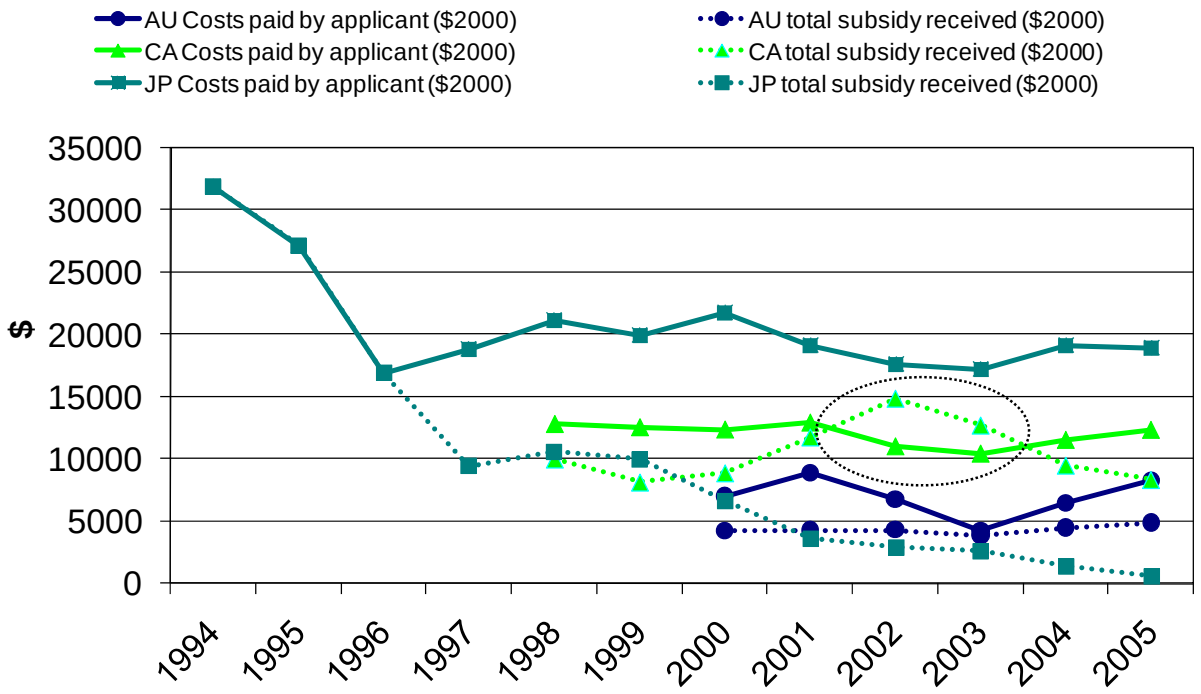
[23] The difference between a financing possibility and financial aid is that the first one refers to a bottom-up approach and the second one to a top-down approach

[24] 45 000 Yen ≈335 EUR in 2004 and 20 000 Yen ≈150 EUR in 2005

[25] For the calculation of the total given subsidy per installed system and the total money spent by the participant (residential sector), the average size of the installed systems is considered in each year.



Average plant size assumed (kW_p)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Japan	3,4	3,7	3,8	3,4	3,8	3,6	3,6	3,6	3,7	3,7	3,8	3,8
California					3,4	2,8	3	3	3,1	3,3	3,2	3,2
Australia							1,3	1,5	1,5	1,5	1,59	1,6

Figure 22: Money paid by the applicants per plant vs. subsidies granted per plant over time in two large markets (California and Japan) and one emerging market (Australia)

(Own Calculations)

Notes:
(1) Only systems between 2 kW and 5 kW_p are considered in California for the calculation of the average system size. (2) In Japan the subsidy amounted 50 % for 1994-1996

Two important aspects can be observed: First, only Japan has been able to reduce gradually and from the beginning the subsidy given per applicant, which indicates a greater public economic efficiency. On the other hand a slight increase of the money paid by each purchaser is generally observed in the last two years in all three countries. In terms of WTP, that is a very positive point. Considering that Japanese participants were paying less money every year from 2000 to 2003, and that in FY 2002 part of the budget remained unutilized and was transferred to FY 2003, it can be stated that WTP was well exhausted in the last two years. Although the subsidies received in the last years in Japan are the lowest of the three markets depicted, the money invested by the applicants in Japan is the highest of the three depicted markets. If we consider that the subsidy offered in Australia did not limit the size of the PV plants (although the amount of financed kW was limited to 1 kW_p), it can be affirmed that the WTP in the emerging Australian market is lower than in the other two large markets:

California and Japan. The WTP in Japan is obviously the highest. The fact that electricity price is expensive in Japan also motivates the public to invest in PV to reduce their electricity bill.

Voluntary programs which are based on the WTP deserve special mention. Figure 23 shows the evolution of the program offered by the EWZ in Zürich, considered one of the most important in Switzerland. The price paid per kWh by program participants has been reduced considerably from the beginning of the program in 1996 to the present whereas the household electricity rates have remained almost constant. Nevertheless, the rate of participation in the program has not increased over the years remaining at a constant 15% of the EWZ clients.

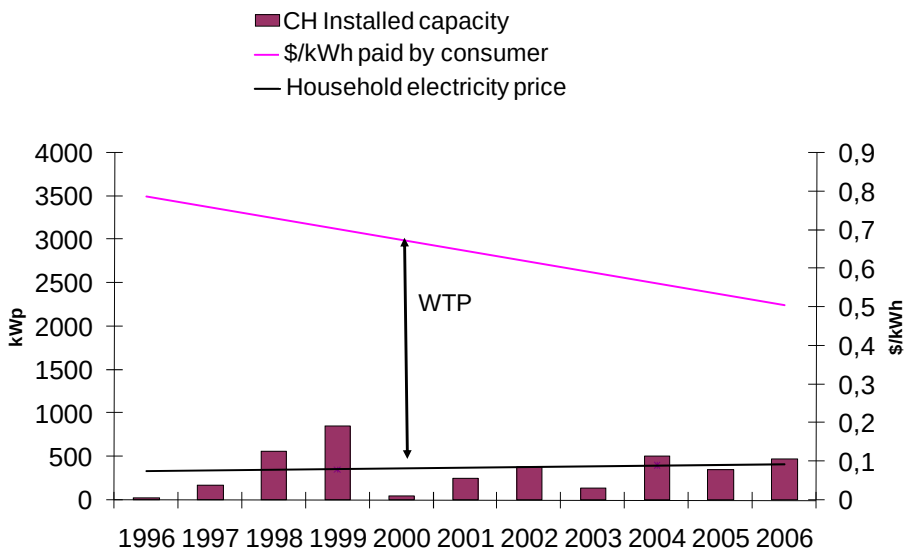


Figure 23: Installed capacity in the framework of the EWZ Solar Stock Exchange (Data available until March 2007)

(Source: EWZ - Homepage)

Although this type of initiative maintained the market in Switzerland, Figure 23 demonstrates that it was not enough to create a sustainable market in the long run.

4.6.2 Profitability for the Consumer

This chapter deals with the following question: How important were the economic margins in a policy/strategy/program? The higher the profitability of PV electricity, the more attractive PV is for the applicants. In the case of feed-in tariffs, it depends mostly on the height of the tariff and output of the system. In the case of rebates, it depends on the amount of subsidies, electricity rates and also output of the system.

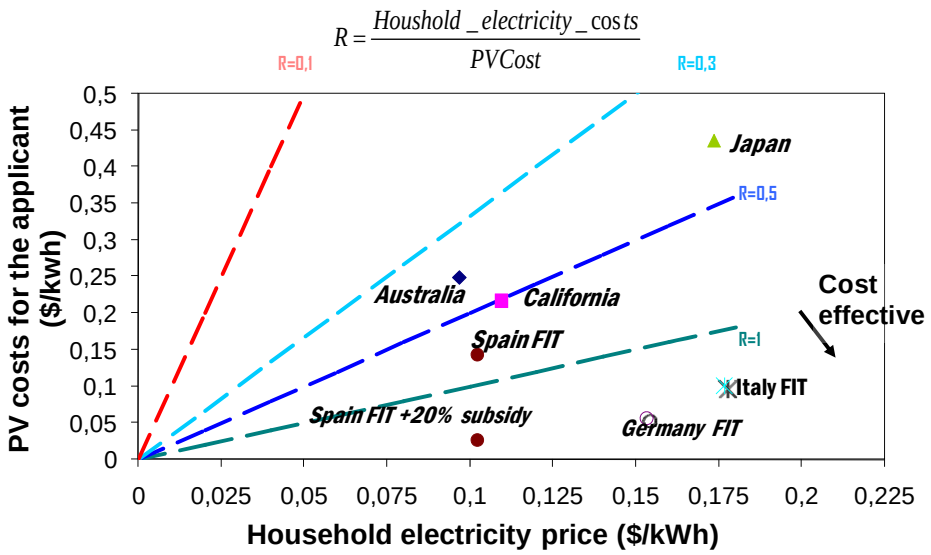


Figure 24: PV electricity cost-effectiveness for the consumer including subsidies in 2005
(Source: Eurostat - Homepage; IEA- Energy Prices & Taxes, 2006; Own calculations)

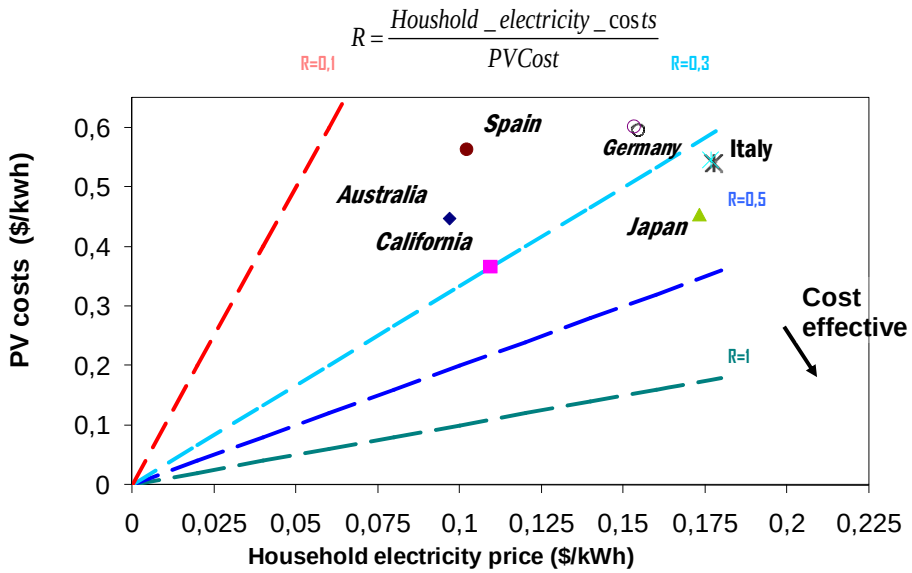


Figure 25: PV electricity cost-effectiveness for the consumer without including subsidies in 2005
(Source: Eurostat - Homepage; IEA- Energy Prices & Taxes, 2006; Own calculations)

Notes for Figure 24 and Figure 25:
(1) Japan: The household electricity prices depend upon the utility company (e.g. region) and the amount of consumption in one month. However, the average price would be about 23 JPY/kWh [own researches].
(2) California: Retail electricity rates contain only modest taxes, which may be ignored due to their size. The average retail price of electricity in CA is 11,63 USD-Cent/kWh, though this varies considerably across customer classes and different utilities [own researches].
(3) Household electricity prices include all taxes except VAT or sale taxes
(4) Assumptions for the calculation of PV electricity: Life time 20; IRC = 6%, Full load hours: Australia: 1 300 hours, California: 1 300 hours, Germany: 850 hours, Italy 1 000 Hours,Japan: 1 000 hours, Spain: 1 150 hours.

Figure 24 and Figure 25 show the cost-effectiveness of PV electricity from the point of view of a participant. Figure 24 considers the subsidies given in each case and the prices of the electricity in the domestic sector. Figure 25 does not consider the subsidies. Germany is at the margin of cost-effectiveness like Italy and Spain in the case of adding the existing FIT with a 20% subsidy[26]. In the case of Australia, the low prices of household electricity play against the PV cost-effectiveness in spite of the high levels of solar radiation in this region. It is remarkable that in spite of the relatively low cost-effectiveness in Japan (lower subsidies) many systems have been installed each year. This confirms the high WTP analyzed in the previous section.

4.6.3 Providing Financing Possibilities

In this study, financing is defined as the money to be borrowed or available for the start up of a project. In the residential sector, it is relevant to offer both a financing possibility and financial aid. Although the most common way to finance systems is by means of soft loans, Table 18 shows some worldwide examples of financing possibilities in the residential sector.

Table 18: Examples of financing programs

COUNTRY	*FINANCING TYPE*	*DESCRIPTION*
Germany	PV Soft loan	Solarstromerzeugen
Spain	PV Soft loan	Spanish Financing Line ICO-IDAE
California (US)	Special soft mortgage loans for renewable energy systems	Different banks are providing soft mortgage loans secured by property.
Japan	Soft loan for environmental –friendly houses	Some banks are providing low interest loans for costumers to buy environmental-friendly houses. Some Japanese prefabricated housing manufacturers sell environmental-friendly house and, recently, PV is standard equipment of such houses.
Germany(1)	Leasing	Customers rent the PV system. Payments are received by the leasing company which has financed the system and which transfer the system to the consumer after a period of time.

Notes:
(1) Leasing is mostly used for the financing of large plants.

Classic investment subsidies are also a way to have start-up capital for the financing of PV plants. Nevertheless and as already mentioned in section 4.5, they do not foster the efficient operation of the systems without additional measures. In this sense, the hybrid between subsidies and feed-in tariffs which is being applied within the framework of California CSI has to be mentioned: the "expected performance-based buydown" given is based on receiving an amount of money at the beginning of the program depending on the expected energy output of the system.

In this study two similar financing programs have been chosen for comparison: the Spanish ICO-IDAE Line and the German "Solarstromerzeugen." Figure 26 shows the capacity financed by both programs in 2005. The program "Solarstromerzeugen" offers a maximum loan of 50 000 EUR and, therefore, beneficiaries are mostly residential[27].

[26] Most of autonomous regions offer investment subsidies of at least 20%.

[27] Systems financed by ICO-IDAE and <10kWp only amount to 18.5% of the total financed systems.

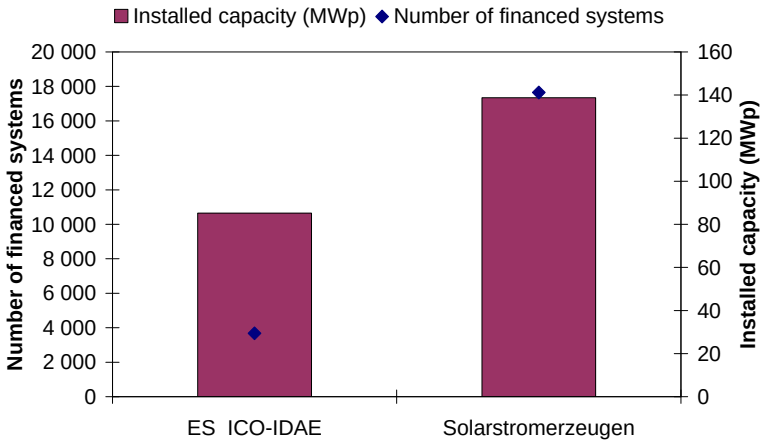


Figure 26: Capacity and number of systems financed by both programs in 2005

Whereas the ICO-IDAE has cooperation agreements with a list of financial organizations, the Solarstromerzeugen program is organized by the KfW but it is managed by the house banks. This generates significant transaction costs due to the lack of knowledge of the program among many house banks. On the other hand, the ICO-IDAE line did not differentiate between different plant sizes. Since the systems to finance were accepted according to the order of submission, large plants received systems financing, as well as an investment subsidy. Small plants often received only the soft loan but not the investment subsidy since the budget was depleted when they became aware of the program. It seems that larger (or more experienced) investors were better prepared for the call than small investors. Moreover, the improvement of the efficiency of the Spanish program stands out. While only 4,8% of presented projects were financed in 2001, this rate rose to 92,3 % in 2005. This is a positive example for WTP well exhausted as discussed in previous sections.

4.6.4 Investor's Effects on the System Sizes

Many authors maintain that the success of a policy depends on the attractiveness to investors in the long term. Certain countries have experienced a real boom in the sector coinciding with the introduction of certain policies. That's the very well-known case in Germany and also in Spain and is promising in Italy (see Figure 10 and Figure 12). Nevertheless, this situation entails some effects. The most important effect is the ever increasing plant sizes and the number of centralized plants. This indicates a market characterized by growing investments. This effect is depicted in Figure 27, Figure 28 and Figure 29.

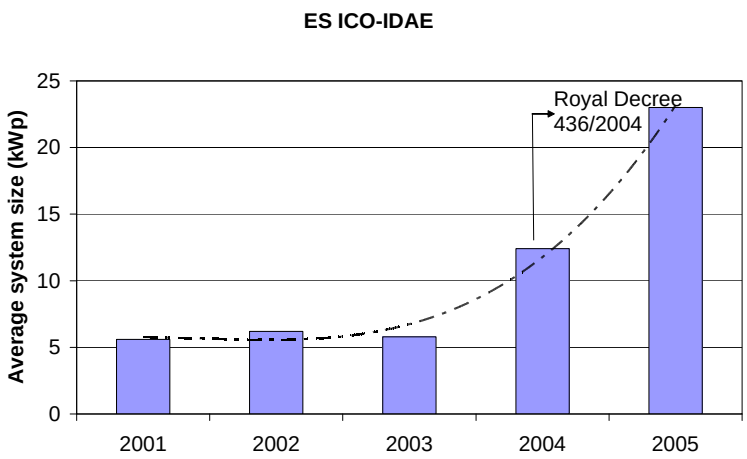


Figure 27: Average plant sizes approved in the Spanish Financing Line ICO-IDAE.

(IDAE, 2006)

Figure 27 shows the average size of requested plants in the program ICO-IDAE.

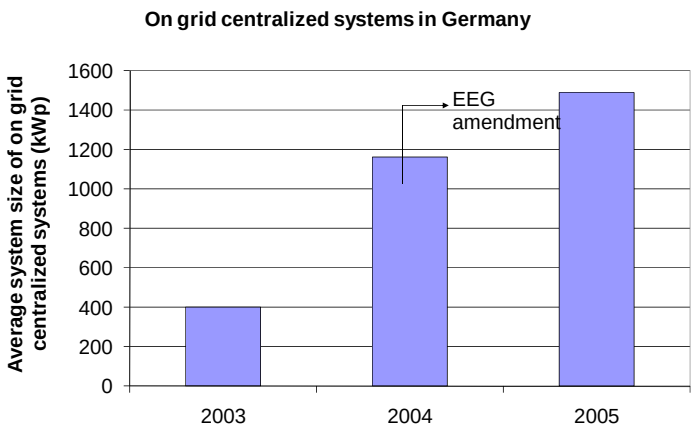


Figure 28: Average plant sizes of on grid centralized systems in Germany

(Source: ARGE, 2006)

Figure 28 shows the increasing size of grid centralized systems in Germany since 2003. The same effect is depicted in Figure 29 for Italian plants > 50 kW_p which have been accepted until recently in past calls.

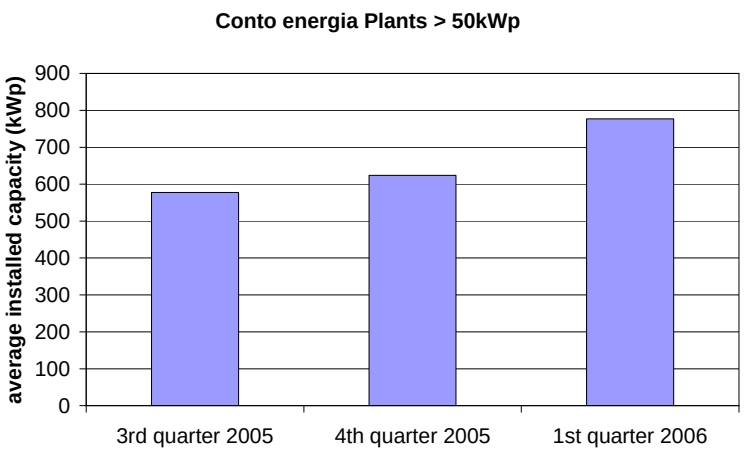


Figure 29: Average plant sizes of approved systems >50kW through the Italian "Conto Energia"

(Source: GRTN- Homepage)

This tendency is contradictory to one of the greatest advantages of PV use: its decentralized use as an integral part of a building. This advantage (so-called added value) affects and benefits both consumers and the general public due to the lack of acceptance problems and environmental benignity. It may indicate that the WTI was increased more for larger plants or that the electricity sector is still more comfortable with large, central generating plant, rather than small distributed generation.

4.7 ACCOMPANYING MEASURES

Definitively, some accompanying measures and conditions may strongly affect the dissemination effectiveness for one and the same deployment basic scheme (e.g administrative procedures, existence of a cap, information campagnes.etc). At last it is a question of successful resolution of existing non economical barriers and of reduction of transaction cost. The detailed analysis of these measures goes beyond the scope of this study. Nevertheless some examples are shown in Table 19. Table 19 shows some barriers according to the different phases of a PV Project from a demand side point of view. They should be addressed within a deployment program in order to increase the success.

Table 19: barriers related to time from a demand side point of view

BARRIERS
Planning phase
Lack of proper financial products
High investment costs for end users
Lack of proper finance opportunities
Problems in realising financial incentives
Lack of experience/trust among banks or investors
Lack of design tools in the market
Etc…
Implementation phase
Lack of professional institutions
Lack of variety of available products
PV systems do not fit into existing building and sizes
Lack of standard financial products make difficult a valuation
Existence of complicated legal requirements for installation and interconnection
Lack of know-how and experience by the professional sector
Long delivery time due to modules shortage
High amount of different permits and documentations are needed
Long time for processing of applications
High number of authorities are involved
Lack of purchasing channels
Etc…
Production phase
Uncertainty on the technical performance of the monitoring system
Utility is not very cooperative
Etc..

5 OVERALL PERFORMANCE: MARKET TRANSFORMATION

Figure 30 shows two curves each for the Japanese Residential PV System Dissemination Program and for California Energy Commission Program: the total system costs and the system costs for each consumer taking into account the rebates given. The figure follows the theory explained in Figure 8. The x-axis represents the yearly installed capacity per 100 000 inhabitants. It can be observed that in Japan both curves arrive at a single point, this indicates that a gradual long term decline of subsidies, as discussed in other sections results in the WTP of the population converging with the prices of the systems. This could indicate that the systems could be competitive without aid of more subsidies. The other rebate programs analyzed (e.g. California) are still far away from this converging point, but may show early tendency as observed in Japan. Although PV installation in 2005 by JP RPVDP was less than in 2004, total installation including "without subsidies" and "using other scheme" in 2005 was slightly over 2004. Although we have to wait in order to speak about a sustainable and mature market, there is no doubt that Japan is on the right path to achieving the needed market transformation.

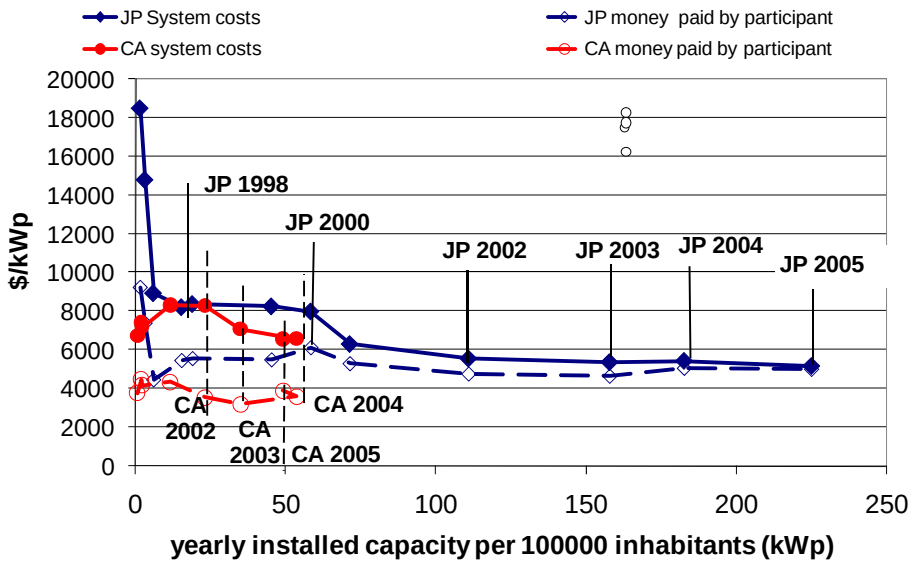


Figure 30: System costs per kW_p vs. costs for the applicant per kW_p – evolution in two large markets with investment subsidies (Japan and California)

(Own calculations)

Notes:

Due to the low relevance of the JP RPVDP subsidy received in 2005 Japanese installed capacity in 2005 includes also plants financed "without subsidies" and "using other scheme".

6 CONCLUSIONS

The development of the large grid-connected PV markets show that promotion policies and marketing programs are currently the most significant drivers for the increase in PV deployment. Worldwide a wide spectrum of promotion policies and programs exist. The success of these programs depends on many variables and has to be evaluated from both the supply and demand sides.

On the supply side the major conclusions are:

- Regarding the effect of promotion policies on system market prices, it can be stated that an imperfect market still exists. Although system costs decreased significantly in the last 10 years, they generally increased or only experienced a slight decrease in recent years. It can be argued that this increase is due to more than the global lack of silicon. Other important reasons include higher costs caused by increased demand and the fact that some sectors are increasing their benefits despite the decrease of production costs for modules. Both facts are short-term effects in imperfect markets.
- Whereas the module prices are determined essentially by international and global market dynamics, installation costs are mostly determined by the local market. Nevertheless, policies have to be designed in a way that they represent an incentive to primarily reduce installation costs.
- The Japanese Residential PV System Dissemination Program has proven to be the most efficient in terms of decreasing system costs. Savings were realized basically due to a long program continuity which boosted the confidence of the industry by creating a solid and stable market.
- Market transparency is essential. For this reason, it is necessary to encourage system standardization and to improve the supply chain. This can be done by including installer courses (as done in Italy), guarantee requirements (as done in California), requiring eligible certified installers (as done in Australia) or reference prices (as done in Spain).
- Although rebates on investments do not ensure an optimal performance of the PV system over its lifetime due to the lack of incentive to run the installation properly after the subsidy has been paid, other measures like monitoring programs, supervision or subsidies dependent on the system efficiency (as in the Field Test Project in Japan) can have a positive effect.
- Nevertheless long-term impacts of any policy/market framework should be considered. Rebates on investments are cheaper in the short term but they do not promote energy production and sustainability if they are not accompanied by other measures. Feed-in tariffs are expensive in the short time but they are able to develop a market quickly and to put sufficient pressure on the supply side and hence to achieve a cost reduction. The condition for this positive market development is that feed-in tariffs are not set too high.

The most important conclusions on the demand side are:

- More important than the achievement of cost-effectiveness is the convergence of system costs and consumer's Willingness to Pay. In this spirit, investment subsidies as in Japan, California or Australia have proven to be more successful than feed-in tariffs.
- Well designed feed-in tariffs have proven successful in order to boost larger projects with high investment volumes. In addition, feed-in tariffs in Spain, Italy and Germany proved successful in developing a market quickly by installing (or requesting) a large amount of capacity in a short time.
- The Italian, Spanish and German markets are characterized by increasing specific investments. The most important effects are the ever increasing plant sizes and the number of centralized plants. This tendency is contradictory to one of the greatest advantages of PV use: its decentralized use as an integral part of a building which permits a lack of acceptance problems and environmental benignity.
- Private and voluntary initiatives can sustain a market in the short term if a certain level of solar awareness is available (as occurred in Switzerland). Nevertheless, they are not sufficient to develop a sustainable local market. On the one hand they do not give the sufficient long-term confidence to the industry, and on the other hand saturation of consumer demand is reached. It can be stated as pioneer work.

The objective of this report was to identify and evaluate subsidies that are the least cost to the general public while still emulating mature market supply and demand relationships through the subsidised transition of the imperfect market. A few recommendations for policy-makers can be derived:

- Initial subsidy should be set at the difference between cost and willingness to pay
- Adjustments of subsidies corresponding to the market evolution such as cost changes and willingness to pay changes should be planned
- Continuity of the program until the cost and willingness to pay converge is essential for the transformation to a mature market
- Exhaust the willingness to pay. Subsidies set too high will not exhaust the willingness to pay and the market could expand too rapidly and not sustainable.
- Increase the willingness to pay over time either by decreasing the costs or increasing consumer preference
- Coordination between policies within a country is necessary in order to avoid over-subsidized markets.
- It is very important to avoid stop and go policies to give confidence to investors and consumers.

This type of examination and analysis cannot fully include the added values or political will. Though the German subsidy may appear to be costly, the job and manufacturing development that has resulted also has value. A trend towards larger systems is also a trend away from the

distributed generation benefits of on-site consumer generation closely matching the load. Yet the large centralized projects often involve utilities as either investors or developers and this utility experience will diminish the grid access barriers.

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KfW- Homepage: http://www.kfw-foerderbank.de

LCBP-Homepage: http://www.lowcarbonbuildings.org.uk/home/

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APPENDIX 1

Table 20: Major PV deployment programs and important milestones in the past

MAJOR MARKET DEPLOYMENT PROGRAMS AND IMPORTANT MILESTONES IN THE PAST			
Program	**Country**	**Year**	**Type of program**
Burgdorf Full Cost Rate	**CH**	**1991-1998**	**Feed-in tariff**
The city of Burgdorf introduced in 1991 the Full Cost Rate. It is considered the first feed-in tariff. 1Fr/kWh was paid.			
The German 1 000 roofs program	**DE**	**1989-1994**	**Investment subsidy**
The German 1 000 roof program was the first comprehensive international dissemination program. 2 250 German residential roofs were equipped with PV systems. A total capacity of about 6 MW was installed. The systems received average subsidies of 70% of the investment costs.			
California ERP	**US**	**1998-2006**	**Investment subsidy**
The ERP was funded by ratepayers of four investor-owned utilities in California. In the last period (July 2006) 2,60 USD/kW for systems up to 30 kW_p were offered.			
Green Pricing Programs	**Various (CH,DE,AU,AT, US,NL)**	**Early 90s until now**	**Voluntary generation-based financial incentives**
Utilities or other companies sell electricity generated from renewables at a higher price and take this premium to provide financial incentives for a PV generator. The incentive is paid by the green customer per kWh or kW_p.			
The Austrian 200 kW rooftop program	**AT**	**1992-1994**	**Investment subsidy**
About 100 small residential grid-connected systems were installed. They were subsidized by authorities and electric utilities with about 58% of the investment costs.			
SOL 1000	**DK**	**2001-2006**	**Investment subsidy**
The Danish SOL 1000 builds on the experience of the previous SOL 300 and is managed by the Danish Energy Agency. House owners received 40% of investment costs.			
Japanese Residential PV System Dissemination Program	**JP**	**1994-2005**	**Investment subsidy**
Rebates have been decreasing continuously over time. While in the first years of the program (1994-1999) the subsidies were a fixed percentage of the costs (decreasing from 50% to 33%) this concept changed into fixed amounts in EUR/ kW_p.			
German 100 000 Roof Program	**DE**	**1999-2003**	**Soft loan**
Within this program soft loans were put at public's disposal. In the last period of the program, PV installations with more than 1 kW_p were eligible for the program and the interest rate was still 4,5. More than 300 MW_p were installed.			
Italian "Tetti fotovoltaici"	**IT**	**2001-2005**	**Investment subsidy**
The program was managed in its second phase by the 19 Italian regions through local announcements. As a consequence each region has adopted its own amount of incentives. Some regions adopted a 70% incentive, while others adopted 65% with a maximum investment cost ranging from 7 to 7,5 EUR/W_p depending on plant size.			

Table 21: Major PV deployment programs (2008)

MAJOR PV DEPLOYMENT PROGRAMS				
INVESTMENT SUBSIDIES				
Program	**Country**	**Period**		
California Solar Initiative	**US**	**2007-2017**		
3 GW PV will be installed until 2017. Initial PV incentive levels of 2,50 USD per Watt will be set and they will be reduced by an average of approximately 10% annually.				
Field Test Project	**JP**	**Since 1992**		
With a budget of 11,2 billion Yen for FY 2006, PV systems for public, industrial facilities and other non-residential applications will be promoted on a large scale.				
Swedish PV Program	**SE**	**2005-2008**		
100 MSEK are foreseen for the installation of PV in public buildings. Subsidies amounts up to 70%.				
Solar Homes and Communities Program (former Australian PVRP)	**AU**	**2000-2009**		
Investment subsidies are provided to household owners and community builders. At present 8 AUD/W_p are granted.				
FITS FOR SMALL RESIDENTIAL ROOF TOP SYSTEMS (2007)				
Country	EUR-Cent/kWh	Years	Cap (MW_p)	Annual degression
BE (Flemish)	45	20	NO	NO
DE	49,2	20	NO	5%
IT	44,5	20	3 000	2%
PT	44	15	150	NO
GR	45	20	NO	NO
FR	30,51	20	n.a	5%
ES	44,04	25[28]	150	NO
Washington State (US)	0,35	10	n.a	n.a
KR	58	15	n.a	n.a
Canada (Ontario)	28			
GREEN PRICING				
Program	**Country**	**Period**		
EWZ Solar Stock Exchange	**CH**	**1996-now**		
Electricity is generated by private-owned PV systems and fed into the public grid. Other customers may buy this electricity and pay rates corresponding to the PV production costs. On the supply-side only the most cost-effective projects are selected by a bidding process.				
RENEWABLE PORTFOLIO STANDARDS (RPS)				
Program	**Country**	**Period of time**		
New Jersey's RPS	**US**	**2006-2020**		
The New Jersey Board of Public Utilities (NJBPU) approved 20% of electricity must come from Renewables by 2020. This mandate also includes 2% of solar electricity or approx. 1 500 MW. That is the US´s largest solar goal on a per capita basis.				
Japanese Renewables Portfolio Standard	**JP**	**Since 2003**		
The quota for new energy use was set at 16 billion kWh (1,63% of the total electricity sales) by FY 2014. PV generation is directly affected by this measure as 1 kWh PV power generated accounts for 2 kWh in order to equal PV to other less expensive renewable energy electricity generators.				

[28] After 25 years 35,23 EUR-Cent/kWh until decommission.

APPENDIX 2

In order to be able to consider monetary real values of costs and prices, the year 2000 has been used as reference just as it has been done by the OECD in some of the data offered in the OECD statistic data homepage. The used values results in $\$_{2000}$ (for clarity only $ is depicted in this report). This value indicates the real value of the currency in year 2000 considering the relative consumer price indices of each country.

That is to say:

$$\$_{2000} = (\text{Monetary value}_{\text{year x, country y}} * \text{Currency exchange rates}_{\text{year 2000, country y}}) / \text{relative consumer price indices (reference year 2000)}_{\text{year x, country y}}$$

The values of Currency exchange rates $_{\text{year 2000, country y}}$ and relative consumer price indices (reference year 2000) $_{\text{year x, country y}}$ are shown in following tables:

APPENDIX 3

Table 22 lists the reported countries, corresponding ISO country and currency codes.

Table 22: ISO country and currency codes

Country	ISO country code-Alpha 2	Currency and code
Australia	AU	Dollar (AUD)
Austria	AT	Euro (EUR)
Belgium	BE	Euro (EUR)
Canada	CA	Dollar (CAD)
Denmark	DK	Krone (DKK)
France	FR	Euro (EUR)
Germany	DE	Euro (EUR)
Italy	IT	Euro (EUR)
Japan	JP	Yen (JPY)
Korea	KR	Won (KRW)
Netherlands	NL	Euro (EUR)
Norway	NO	Krone (NOK)
Portugal	PT	Euro (EUR)
Spain	ES	Euro (EUR)
Sweden	SE	Krona (SEK)
Switzerland	CH	Franc (CHF)
United Kingdom	GB	Sterling (GBP)
United States	US	Dollar (USD)

Real effective exchange rates, Index 2000=100													
Country	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Australia	106,7001	104,9417	114,8451	113,8093	104,105	104,7117	100	96,15497	101,4975	114,8243	124,3252	128,0711	127,7469
Austria	106,4392	109,445	106,9742	103,36	103,7133	102,5942	100	100,1808	100,5442	103,3467	104,1992	103,5475	102,89
Canada	109,0325	106,7492	106,8292	106,0875	100,1333	99,38416	100	96,9325	96,0375	106,7475	112,56	119,4525	126,1558
Denmark	101,6933	105,3591	103,8233	101,1883	103,5091	103,5641	100	101,4983	103,3525	108,4099	109,1374	107,9283	107,5608
France	108,7817	111,0426	110,3393	106,0001	106,8726	104,6342	100	99,79083	101,1225	106,0076	107,6017	106,4434	105,9351
Germany	113,4766	117,824	113,0891	107,6516	108,9124	106,3499	100	99,915	100,6333	105,5341	106,8641	105,2533	104,6091
Italy	100,0467	92,89012	102,815	103,3558	104,8749	103,9183	100	101,1858	103,2216	108,894	110,6157	109,354	109,214
Japan	103,7483	105,5433	88,22667	83,35833	84,205	94,48917	100	89,47833	83,8925	85,03083	86,28416	81,27666	73,42
Korea	108,0992	109,3608	113,31	106,8717	81,48	92,80917	100	94,61333	99,5425	101,165	102,8133	115,605	125,1675
Netherlands	107,9049	112,0216	108,9699	103,2583	106,2783	105,5658	100	102,9291	106,7333	114,2265	115,8874	114,2915	112,9699
Portugal	98,85333	102,3775	102,2508	101,0567	101,9483	102,0258	100	102,5	104,7667	108,63	109,4558	108,6417	109,2883
Spain	102,415	103,9567	105,635	101,1067	102,1208	101,9592	100	102,0792	104,4434	109,3517	111,5568	112,3218	113,9493
Sweden	104,5975	103,7967	111,7317	106,2725	103,3333	101,3833	100	91,6625	93,98	99,3825	99,54667	95,3975	94,92667
Switzerland	108,2625	114,8025	110,6633	102,2575	104,0758	102,8692	100	102,15	105,8192	106,16	105,1742	103,1642	100,3658
United	83,91666	80,25083	81,59666	94,3325	99,60583	99,2075	100	97,38416	97,59333	93,18417	96,7275	95,08167	95,53833
United States	84,94096	83,7068	86,31678	90,79758	98,06918	96,82669	100	105,7183	105,8325	99,715	95,58504	94,12589	93,40005

Data extracted on 2007/04/05 from OECD Stat

Currency exchange rates, National units per USD													
Country	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Australia	1,369075	1,349558	1,276883	1,348025	1,5923	1,549667	1,726525	1,935375	1,841308	1,541542	1,359233	1,312783	1,3271
Canada	1,3659	1,372483	1,363783	1,385008	1,483492	1,485533	1,485108	1,548408	1,570042	1,400358	1,301092	1,211708	1,134317
Denmark	6,360209	5,60375	5,798242	6,604075	6,699308	6,9799	8,088034	8,320808	7,884284	6,577	5,987558	5,996092	5,943008
Japan	102,2286	94,06539	108,817	120,9966	130,8945	113,888	107,8347	121,4838	125,2549	115,9363	108,1469	110,0971	116,3544
Korea	804,2682	771,398	804,4202	950,5074	1400,477	1186,706	1130,64	1290,41	1251,045	1190,959	1145,197	1024,226	951,8166
Sweden	7,7157	7,133616	6,707067	7,634608	7,947075	8,26235	9,160583	10,33838	9,721042	8,078217	7,346	7,472408	7,373333
Switzerland	1,367058	1,182092	1,236133	1,450017	1,44965	1,502733	1,687933	1,686958	1,556758	1,344808	1,242742	1,24815	1,253192
United Kingdom	0,653258	0,6337	0,6408167	0,6105	0,6035666	0,6180916	0,660575	0,6942917	0,66655	0,6122833	0,5457583	0,5501167	0,5433916
Euro rea	0,843066	0,7649546	0,78779	0,8823804	0,8941227	0,9385333	1,085083	1,116625	1,061067	0,8851584	0,8048583	0,804625	0,7967

Data extracted on 2007/04/05 from OECD Stat