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Promoting electricity from renewable energy sources – lessons learned from the EU, U.S. and Japan

Reinhard Haas[1], Niels I. Meyer[2], Anne Held[3], Dominique Finon[4], Arturo Lorenzoni[5], Ryan Wiser[6], Ken-ichiro Nishio[7]

[1] Energy Economics Group, Vienna University of Technology,
Gusshausstrasse 27-29/373-2, A-1040 Vienna, AUSTRIA,
Tel. ++43-1-58801-37352, Fax. ++43-1-58801-37397
E-mail: Reinhard.Haas@tuwien.ac.at

[2] BYG, Technical University of Denmark, Brovej building 118
DK-2800 Kgs. Lyngby, DENMARK
Tel.: ++45 45 25 17 00
E-mail: nim@byg.dtu.dk

[3] Fraunhofer Institute for Systems and Innovation Research,
Breslauer Str. 48; 76139 Karlsruhe, GERMANY
Tel. ++49-721-6809-358, Fax ++49-689-152,
E-mail: Anne.Held@isi.fhg.de

[4] CIRED (Centre International de Recherche pour l'Environnement et le Développement),
32 avenue de la Belle Gabrielle, 94736 Nogent sur Marne, FRANCE
Affiliation: Ecole des Hautes Etudes en Sciences sociales et Centre National de la Recherche Scientifique,
Tel. ++33 1 4394 7384; Fax: ++33 1 4394 7370;
E-mail: finon@centre-cired.fr

[5] IEFE, Bocconi University,
Viale Filippetti 9, 20122 Milan, ITALY
Tel: ++39-02-5836 3820, Fax ++39-02-5836-3890
E-mail: arturo.lorenzoni@unibocconi.it

[6] Lawrence Berkeley National Lab
1 Cyclotron Road, MS 90-4000, Berkeley, CA 94720
Tel: ++510-486-5474, Fax: ++510-486-6996
E-Mail: rhwiser@lbl.gov

[7] Central Research Institute of Electric Power Industry,
2-11-1 Iwado Kita, Komae-shi, Tokyo 201-8511, Japan
Tel: ++81 3 3480 2111, Fax: ++81 3 3480 3492
E-Mail: nishio@criepi.denken.or.jp

Chapter summary

The promotion of electricity generated from Renewable Energy Sources (RES) has recently gained high priority in the energy policy strategies of many countries in response to concerns about global climate change, energy security and other reasons. This chapter compares and contrasts the experience of a number of countries in Europe, states in the US as well as Japan in promoting RES, identifying what appear to be the most successful policy measures.

1. Introduction

The current high standard of living enjoyed in industrialized countries owes much to the high per capita consumption of energy, an increasing portion of which from electricity. Yet, many experts believe that the current patterns of generating electricity, mainly from fossil and nuclear resources, are not sustainable in the long term. Moreover, as Ford explains in an accompanying chapter in the same volume, there are increasing concerns about the environmental costs associated with electricity generation, notably greenhouse gas emissions. For these and other reasons, some experts are convinced that we must find a way to gradually convert into a more sustainable energy conversion and use over time. Such a conversion is not easy for many energy-intensive applications such as the air transportation, but is relatively less painful in case of electricity generation.

A number of studies have concluded that with efficient use of energy, even a high standard of living can be sustained with renewable energy resources alone (e.g., Scheer, 2001, Flavin & Lenssen, 1994). While this may be an extreme case, many are convinced that we can – and should – rely on RES for an increasing portion of our energy needs. In a 2005 study, the European Renewable Energy Council (EREC), for example, concluded as much as 40% of our energy needs could be supplied from RES by 2040.

Theoretically at least, there is plenty of RES to go around. The amount of solar radiation falling on earth every day exceeds the energy we consume world-wide in a year. The problem, of course, is that it is widely dispersed and intermittent. But with human ingenuity and improved technology, more RES can be captured and put to use. Historically, the largest contributor has been hydro resources and biomass. Technically speaking, the resource with the largest additional future potential[1] for generating electricity from RES is wind energy, followed by photovoltaics (PV), solid biomass, hydro power and biogas. Other options with vast potential include tidal and wave power as well as solar thermal electricity.

The appeal of renewables continues to grow (e.g., Meyer 2003) due to:

- Their contribution in reducing greenhouse gas emissions associated with current electricity generation;
- Reduced dependence on imported energy resulting in energy security and a more diversified resource base;
- Contribution to increases in local employment and income; and

[1] There are a variety of definitions of the renewable energy potential, e.g., Voogt et al.(2001) specifies as follows: "theoretical potential" > "technical potential " > "realistic potential " > "realisable potential." Note the technical potential is substantially larger than the realizable potential that takes into account current non-technological factors.

- Working as a hedge against volatile fossil fuel prices, as well as avoiding risks of disruption in fossil fuel supplies.

Despite these advantages, renewables face a number of barriers if they are to contribute to the market on a large scale (e.g., Komor, 2003). The major barrier is the current cost disadvantage compared to electricity generated from fossil or nuclear fuels[2]. A significant switch to a renewable energy system would initially require substantial investments in infrastructure and will require technical innovations. Yet, such a future is, at least in principle, not far fetched because the costs of RES have been steadily declining and are likely to fall even faster as a result of learning-by-doing, the economies-of-scale and expected technological progress. Moreover, one convincing argument for supporting RES is that other energy technologies have traditionally received – and continue to receive – enormous subsidies from governments (e.g., Osterhuis, 2001).

Aside from technological and investment obstacles, there are institutional, political and legislative barriers as well as problems arising from lack of sufficient grid capacity and public and political awareness in many countries. Additional barriers include lack of adequate recognition and support in regulations[3], which limits RES's contribution.

To overcome these barriers, many governments have set ambitious targets and goals to promote electricity generation from RES in recent years. The European Union (EU), for example, issued a directive in 2001 with the target to increase the share of *electricity* from RES from 12 % in 1997 to 21 % by 2010 (EC, 2001). A more recent decision sets an even more ambitous 20% RES target for *total energy* by 2020.

Currently, a number of schemes are being implemented in different countries to increase the share of renewables in the energy mix. While the specifics vary, most schemes are attempting to:

- Enhance social acceptance and increase public awareness of renewable energy;
- Improve reliability, technical performance and standardisation;
- Remove obstacles to grid-connection;
- Reduce administration and transaction costs while and minimizing the financial subsidies; and
- Ensure sustainable growth of the renewable energy industry.

The major promotional strategies include have investment subsidies, feed-in tariffs (FIT), tax incentives, portfolio standards, quota-based tradable green certificates (TGC) and tendering systems. While each scheme has certain advantages, there is no consensus on what may deliver the best results at the lowest cost. This is a crucial issue, especially if we are going to rely on renewables for a growing percentage of energy mix in the future.

This chapter examines the experience gained from various regulatory and support strategies for the promotion of electricity generation from renewables. A secondary objective is to provide evidence to improve future policies. The chapter's primary focus is on countries with considerable experience including the EU, the U.S., and Japan.

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[2] This cost barrier is partly due to the lack of a level playing field as long as externalities from fossil fuels and nuclear are far from being included in the consumer price.

[3] See also chapter on Distributed Generation where the implications of absorbing large amounts of RES in the network are discussed

The chapter is organized as follows. Section 2 covers historical development and the future potential of renewables. Section 3 classifies different types of promotional strategies and summarizes the experience to date. Section 4 evaluates the most important promotional programmes in different countries, and section 5 discusses the relative merits of different strategies. The chapter's main conclusions appear at the end.

2. Historical overview

For millennia until the advent of industrial evolution, humans relied on renewable energy for most of their needs, albeit at a mere fraction of what we typically use today. Over the past two centuries, humankind has increasingly relied on fossil fuels, which are blamed for global climate change.

Figure 1 shows the recent pattern of electricity generation from renewables for EU-25, US and Japan for the period 1990 to 2004, where EU has managed a gradually increasing trend compared to the US and in Japan. The side bar in Figure 1 shows the mix of renewables with the dominance of hydro electric generation everywhere[4].

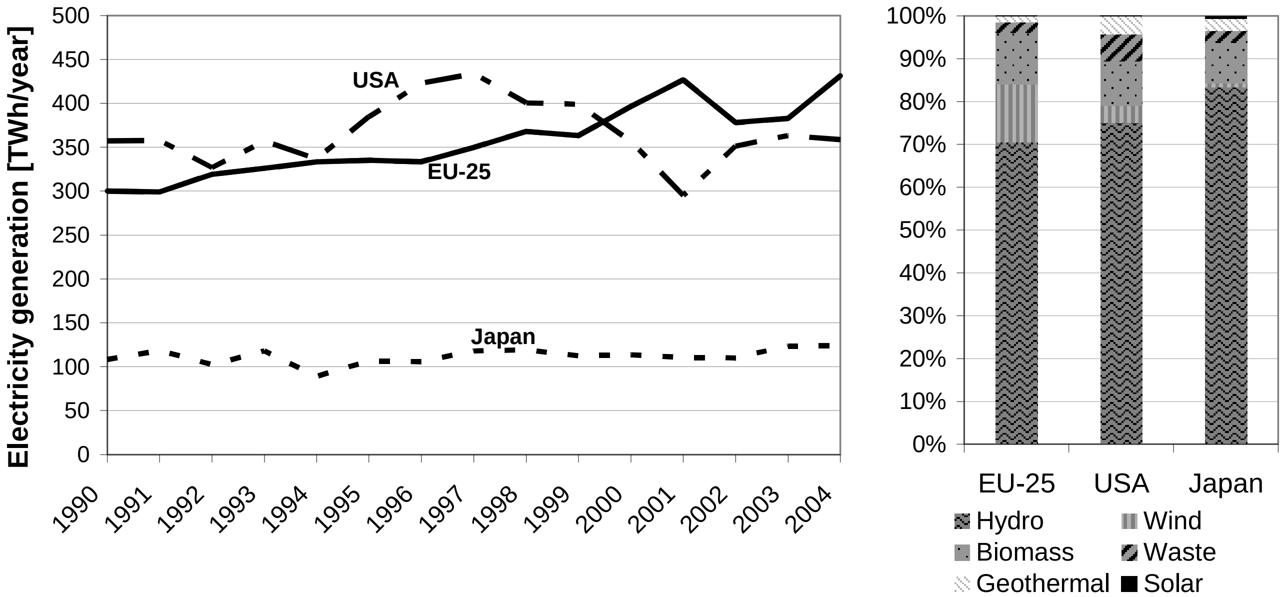

Figure 1 Recent pattern of electricity generation from RES in EU-25, U.S. and Japan (left) and breakdown of electricity generation from RES in 2004 (right)

Sources: EUROSTAT 2006, IEA 2006b, METI 2007; Black & Veatch 2006

An entirely new picture emerges if hydro power is excluded (Figure 2). While in the early 1990s the US had the highest non-hydro renewable generation, the EU has assumed this role since 2002, mostly due to a rapid growth of wind energy. The development in Japan can be characterised by modest growth in the waste-to-energy and geothermal power in 1990s and in PV and wind power in 2000s, with biomass resources such as black-liquor utilised in the pulp and paper industry playing an important role over the decades.

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[4] Annual fluctuations in meteorological conditions explain the year-to-year fluctuations.

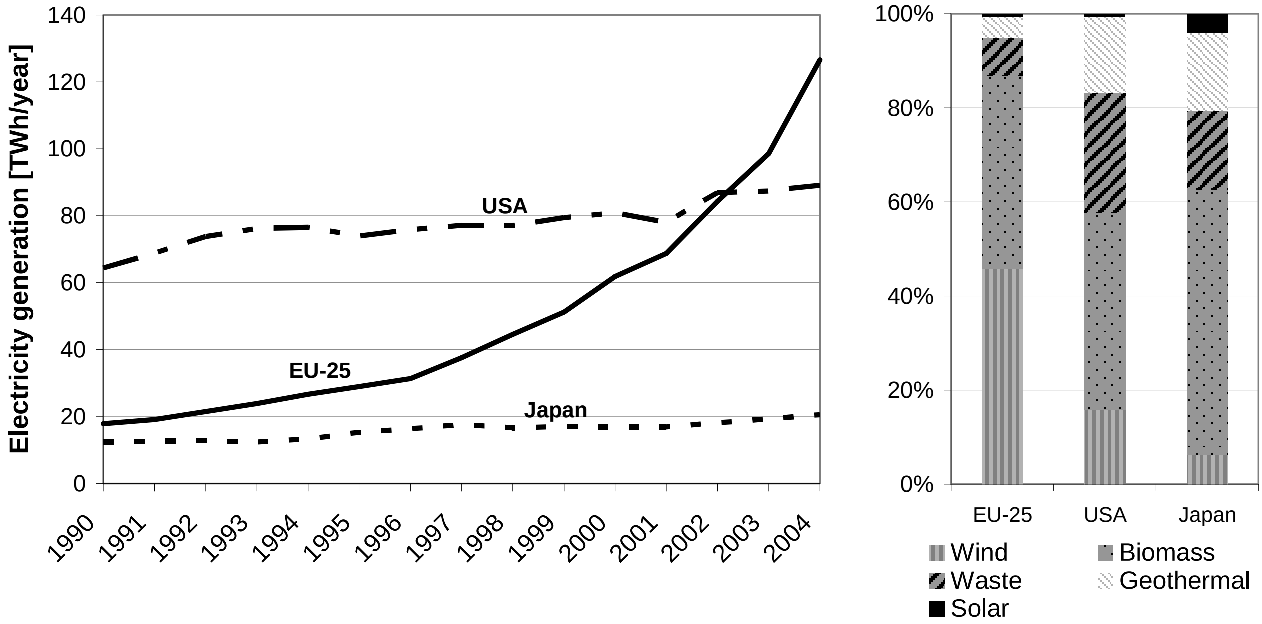


Figure 2 Historical pattern of electricity from non-hydro RES in EU-25, US and Japan (left) and breakdown of the mix for 2004 (right)

Sources: EUROSTAT 2006, IEA 2006b, METI 2007, Black & Veatch 2006

Despite the recent gains in Europe, the recent pattern of growth of electricity generation from renewables is far from a success story. Between 1997 and 2004, for example, no country or region has been able to significantly increase the share of renewables as a percentage of total electricity consumed as illustrated in Figure 3. In the EU, the gain is a modest 2% from 12% to 14%, Japan shows a slight decrease while there has been a significant drop in the US, from about 14% to 9%.

Within the EU, only a few countries such as Denmark, Finland, Hungary and Germany have managed to increase their renewable shares considerably during the period and may be considered to be on target to meet these indicative targets as set in Directive 2001/77/EC[5]. For the EU as a whole, the 2006 actual is far from the target set for 2010. For the US, no specific targets currently exist on the national level[6]. Elsewhere, renewables continue to grow in absolute terms, but the story is pretty much the same: as a percentage of total electricity generation, renewables have a hard time keeping their current penetration levels.

[5] In addition to these sector-specific targets, a 20% target on primary energy for all sectors except transport by 2020 was introduced in early 2007. Yet, no specific targets for electricity have been specified which is a weakness of the new strategy.

[6] However, in the US, a number of states have set targets and currently there is a proposal for a 15% mandate by 2020.

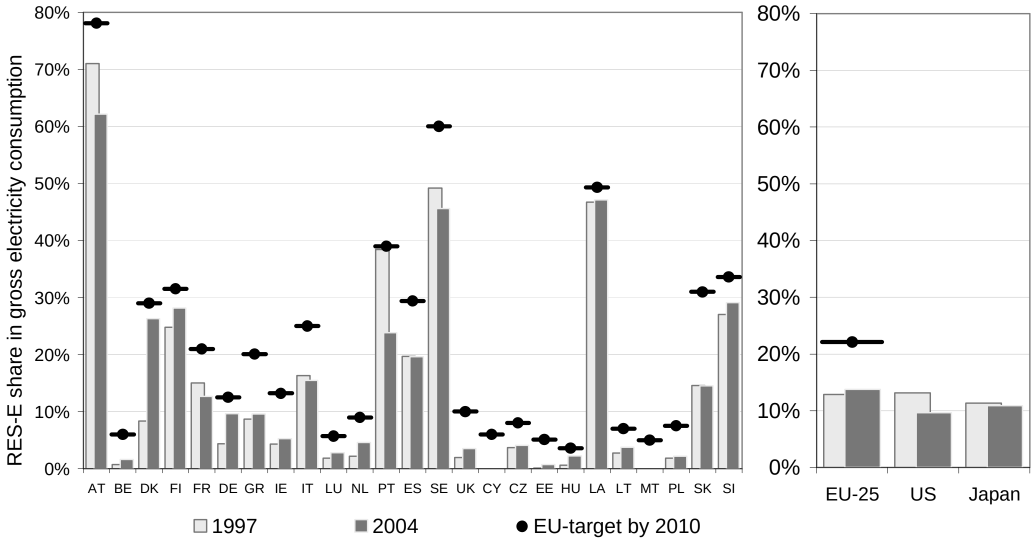


Figure 3 Share of RES incl. large hydro in gross electricity consumption in EU-25, US and Japan. For the EU-25, 2010-targets are shown
Source: Ragwitz et al 2007, IEA 2006b

3. Promotional strategies

With the exception of hydro, some biomass and wind energy plants at favourable locations, most renewable energy technologies currently are at a cost disadvantage relative to conventional technologies. As already mentioned, part of this cost disadvantage is due to the fact that most conventional technologies have traditionally received – and continue to do so – significant direct and indirect subsidies including those offered to nuclear energy and oil and gas exploration. Moreover, until recently, the full effect of the externalities, notably emissions of greenhouse gases, have not been reflected in prices.

Renewable energy advocates argue that RES deserve similar subsidies to overcome their current cost-disadvantage, pointing out that over time, these subsidies can be reduced or eliminated. Such arguments aside, the pace of development of electricity generation from RES is closely linked to the level of financial incentives and/or regulatory mandates, both of which are dependent on political decisions. And these are the main variables that differentiate the development pace and penetration of RES in different countries. This section examines a number of schemes for supporting renewables and compares the results.

Table 1. Promotional strategies for supporting RES (Menanteau et al 2004, Haas et al 2004)

		Direct		**Indirect**
		Price-driven	**Quantity-driven**	
Regulatory	**Investment focused**	• Investment subsidies • Tax credits • Low interest/Soft loans	• Tendering system for investment grant	• Environmental taxes • Simplification of authorisation procedures • Connection charges, balancing costs
	Generation based	• (Fixed) Feed-in tariffs • Fixed Premium system	• Tendering system for long term contracts • Tradable Green Certificate system	
Voluntary	**Investment focused**	• Shareholder Programs • Contribution Programs		• Voluntary agreements
	Generation based	• Green tariffs		

Table 1 provides a classification of promotion strategies (Menanteau et al 2004, Haas et al 2004). Fundamentally, there are four basic ways to subsidize or promote RES:

Regulatory price-driven strategies

Under these schemes no quantity goals or targets are established. Instead, the focus is on providing generators with financial support in terms of a subsidy per kW of capacity installed or a payment per kWh of energy produced. There are a number of variations under this scheme such as:

- Investment focused strategies where financial support is provided through investment subsidies, soft loans or tax credits, usually per unit of generating capacity installed;
- Generation based strategies where financial support is offered as a *fixed* payment or as a *premium* per unit of energy generated.

Under a fixed payment scheme such as feed-in-tariffs (FITs), generators receive a fixed amount per kWh generated regardless of the costs of generation or price while under a premium scheme a fixed amount is added to the electricity price. In practice, this makes a big difference for the renewable plant owner. In the latter case, the total price received per kWh (electricity price plus the premium) is less predictable than under the FIT because it depends on a volatile electricity price.

In principle, a mechanism based on a fixed premium – one that reflects an environmental bonus for RES and penalizes conventional energy for their externality costs – could establish a level playing field allowing fair competition between RES and conventional power sources. Such schemes have the advantage of allowing renewables to penetrate the market quickly as their production costs drop below the electricity-price-plus-premium. Together with other incentives and considerations which taxes conventional power sources in accordance with their environmental impact, well-designed fixed premium schemes are theoretically one of the most effective ways of promoting electricity from RES.

Regulatory quantity driven strategies

Under these schemes, the policy makers set a desired quota or goal, usually with a target date, to encourage the market penetration of RES. Examples include:

- Tendering or bidding schemes which call for tenders to acquire specific amounts of capacity or generation from specified types of RES. Competition between bidders leads to the winners of contracts which will receive a guaranteed tariff for a specified period of time
- Tradable certificate schemes such as renewable portfolio standards (RPS), which are popular in the US, or tradable green certificates (TGC) in Europe. These schemes typically obligate one or more parties involved in the electricity supply chain such as the generators, wholesalers, distribution companies, or retailers to acquire a certain percentage of electricity from RES in their energy mix. Most schemes allow parties to trade certificates to demonstrate compliance. Certificates can be obtained in three ways:
  - From their own renewable electricity generation;
  - By purchasing renewable electricity and associated certificates from other generators; and
  - By purchasing certificates without purchasing the actual power from a generator or broker.

The price of the certificates is determined by a market for certificates, such as in Nord Pool.

Voluntary approaches

Voluntary schemes are based on the willingness of consumers to pay a premium for green energy. There are two main categories:

- Investment based schemes driven where individuals voluntarily contribute to renewable energy by providing up-front capital and
- Generation based schemes where consumers pay a volumetric premium for renewable electricity deliveries.

Indirect strategies

Aside from the schemes already mentioned, there are other strategies which may have an indirect impact on the dissemination of renewables, including the following:

- Various forms of eco-taxes on electricity produced from non-renewable sources such as carbon taxes, sulphur taxes, or other[7];
- CO_2 emission allowances which are the subject of much talk[8]; and
- Removal of subsidies previously given to fossil and nuclear generation.

Indirect schemes could also include regulatory and institutional assistance including preferential permitting and siting, easy connection to the grid and the operational concessions that makes it easy to feed RES-generated power into the system. This is particularly important because most RES generation tends to be intermittent and unpredictable.

Preferential permitting and siting can reduce potential oppositions to RES plants if they address issues of concern, such as noise and visual or environmental impacts. Regulations can be used to set aside specific locations for development and/or to omit areas of higher risk of environmental damage or injury to birds.

Standardisation of interconnecting RES-generated power to the grid can ease requirements that are often overly burdensome and inconsistent and can lead to high transaction costs for RES project developers[9]. Safety requirements are essential, in particular in the case of the interconnection in weak parts of the grid. However, unusually burdensome criteria on interconnections can lead to higher prices for access to the grid – or in cases are used as an excuse to deny access. Clarity, transparency and reasonableness of safety and interconnection requirements are critical. Moreover the rules must be clear and fair for distribution of additional costs imposed by RES on the network. Finally, there must be clear rules delineating responsibility for physical balancing associated to intermittent production from some RES-E technologies, in particular wind power[10].

Historical milestones

The birth of today's modern renewable energy industries may be traced largely to the pioneering efforts of private Danish investors and developers in the early 1970s and to the passage in the U.S. of the Public Utilities Regulatory Policy Act of 1978 (PURPA), which arguably introduced the earliest form of a mandatory feed-in law in the power industry. The state of California, long a proponent of alternative forms of generation, developed an attractive and generous subsidy scheme – called standard contract for qualifying facilities or QFs – which, when combined with available federal and state tax credits, stimulated the deployment of renewable energy projects. Both PURPA and the California scheme, however, had their drawbacks because, arguably, they did not provide an adequate incentive for the deployment of efficient technologies.[11].

[7] Promotion of renewable electricity via energy or environmental taxes can be achieved either by exempting RES from energy taxes or by providing a partial or total refund of any taxes collected.

[8] Refer to section on global climate change for further discussion

[9] A companion chapter discusses regulatory aspects of encouraging distributed generation, RES and combined heat and power (CHP)

[10] These issues have become pronounced in countries like Germany and Denmark, with significant penetration of wind

[11] Although the federal government plays an important role in providing tax incentives for renewables, states have historically been the innovators in supporting the commercial application of RES technologies in the US.

Some critics have characterized the aggressive promotion of renewables in California as too much, too soon, and at too high a price[12]. In contrast, the Danes implemented a testing and certification procedure for wind turbines as early as 1978 as a pre-condition for receiving subsidies resulting in high reliability and productivity (Meyer, 2004a and 2004b).

In the early 1990s, promotional programs based on regulated and obligatory tariffs for the purchase of electricity from specified renewable sources became common and were refined in various European countries. The most important schemes include fixed FIT and fixed premium systems used in Denmark, Germany, and Spain to good effect. Under these schemes, utilities are legally obliged to pay the prescribed FIT as long as the RES plants meet certain technical standards. Not surprisingly, the 1990s saw a wind power boom in Europe – especially in Germany, Denmark and Spain where generous FIT schemes were introduced. More than 80% of the European wind capacity installed at the end of the 1990s was located in these three countries. The competitive tendering system, favoured in the UK and France has had limited success.

Meanwhile, in the U.S., after an initial growth spurt in the 1980s, the 1990s saw relatively little new development as the standard offers established in California and other states were no longer aggressively promoted.

With the ongoing liberalisation of electricity markets across Europe and other countries, tradable green certificates (TGC), based on quota obligations for RES have become more prominent. In Europe this scheme has been tried in Italy, the UK and Sweden in different variations, so far without great success. The first application of such a quota based system occurred in the U.S., at the state level with or without TGC. Renewable energy quotas have recently become the most popular support scheme in the US and an increasing number of states have implemented them.

In general, whilst the main goal of early subsidies was to increase the supply security and fuel diversity, the focus of programs in recent years has shifted to reduce the emission of greenhouse gases. Table 2 summarises the most important historical milestones for promotional strategies.

[12] This colorful phrase is attributed to Michael Peevey, a senior vice president at Southern California Edison at the time and currently the Chairman of the California Public Utilities Commission.

Table 2. Historical overview on promotion strategies for electricity generation from renewables (Haas et al, 2007)

Year	Country	Type of strategy	Program name	Technologies addressed
1979-1989	DK	Investment subsidies		Wind, biogas
1978-1989	US	Feed-in tariffs/Tax relief	PURPA	All technologies (except Large hydro)
1989-1996	DE	Investment subsidies plus feed-in tariffs	"100/250 MW Wind Programm"	Wind
1991-1993	DE	Investment subsidies plus feed-in tariffs	"1000-Dächer-Program"	PV
1990-1999	UK	Tendering system	NFFO / SRO / NI-NFFO	Selected technologies
1990-present	DE	Feed-in tariffs	"Einspeisetarif"	PV, Wind, Biomass, Small hydro
1992-1994	AT	Investment subsidies plus feed-in tariffs	200 kW PV-Program	PV
1992-1997	IT	Feed-in tariffs	“CIP 6/92”	All technologies
1994-present	US	Tax relief	Tax production credits	Varies over time; focus on wind
1991-1996	SE	Investment subsidies /Tax relief		Wind, Solar , Biomass
1992-1999	DK	Feed-in tariff		Wind, Biomass
1992-1999	DE, CH, AT	Feed-in tariffs	"Kostendeckende Vergütung"	PV
1994-present	GR	Investment subsidies	1994-now: Operational Program for Energy and Competitiveness”	PV, Wind, Biomass, Small hydro, Geothermal,
1994-present	ES	Feed-in tariffs or fixed premium systems	“Royal Decree 2366/1994” resp. “Royal Decree 436/2004”	All technologies (except Large hydro)
1994-2005	JP	Investment subsidies	“Residential PV System Dissemination Program”	PV
1994-present	JP	Voluntary net-metering	“surplus electricity purchase menu”	PV
1996-present	DE, CH, NL, AT, UK	Voluntary green tariffs	Various brands	Selected technologies
1996-present	CH	Voluntary stock exchange	"Solarstrombörse"	PV
1997-present	FI	Tax incentives	Energy Tax	Wind, mini hydro (<1MW), wood based fuels
1998-present	DE	Labelled “Green Electricity”	TÜV, Grüner Stromlabel e.V., Öko-Institut	PV, Wind, Biomass, Small hydro
1999-present	DE	Soft loans	“100,000 Dächer-Programm”	PV
1999-2000	NL	(Voluntary) Green certificates		All technologies (exempt municipal waste incineration)
2000-present	DE, FIT	Regulated Rates	“Renewable energy act”	Selected technologies
1998-present	US	Quota obligation with TGC/Renewable Energy Funds	“Renewables Portfolio Standards” “Clean Energy Funds”	Selected technologies
2001-2004	IT	Rebates	“Tetti fotovoltaici”	PV
2002-present	ES	FIT/premium		All technologies
2002-present	IT, UK, BE	Quota obligation with TGC		All technologies (wave, waste and large hydro depend on the country)
2003-present	JP	Quota obligation with TGC	“Renewables portfolio standard”	PV, Wind, Biomass, Small hydro (<=1MW), Geothermal
2003-present	AT	FIT	“Ökostromgesetz”	All technologies
2003-present	SE	Quota obligation with TGC		All technologies. No waste
2003-present	NL	Mixed Strategy (FITs, tax incentives, TGC)	MEP (Environmental Quality of Power Generation	All technologies except hydro and “non pure” biomass
2005-present	IT	PV feed in	“Conto Energia”	PV

Table 3 provides an overview of more recent promotion schemes to support electricity generation form RES in the countries investigated. In Europe, FITs serve as the main policy instrument, with the exception of Finland, which exclusively uses tax credits and investment incentives for the promotion of RES.

Table 3. Current promotion strategies for electricity from RES in major EU countries, the US, and Japan

	Major strategy	**RES-E TECHNOLOGIES CONSIDERED**			
		Large Hydro	**Small Hydro**	**'New' RES (Wind on- & offshore, PV, Solar thermal electricity, Biomass, Biogas, Landfill gas, Sewage gas, Geothermal)**	**Municipal Solid Waste**
Austria	**FITs**	No	Renewable Energy Act 2003. (Ökostromgesetz). Technology-specific FITs guaranteed for 13 years for plants which get all permissions between 1 January 2003 and 31 December 2004 and, hence, start operation by the end of 2006. Investment subsidies mainly on regional level. No decision yet on follow-up support after 2004.		FITs for waste with a high share of biomass
Belgium	**Quota/TGC + guaranteed electricity purchase**	No	Federal: The Royal Decree of 10 July 2002 (operational from 1st of July 2003) sets minimum prices (i.e. FITs) for RES-E.[13] On regional level promotion activities include: Wallonia: Quota-based TGC-system on electricity suppliers – increasing from 3% in 2003 up to 12% in 2010. Flanders: Quota-based TGC-system on electricity suppliers – increasing from 3% (no MSW) in 2004 up to 6% in 2010. Brussels region: No support scheme yet implemented.		
Cyprus	**FITs + government grants**	No	Government grants for 30-55 % of investment. FITs are in place since January 2006 and are guaranteed for 15 years. FIT level in 2006: Wind: 48-92 €/MWh[14], Biomass, landfill and sewage: 63 €/MWh, PV up to 5 kW: 204 €/MWh.		No
Czech Republic	**FITs and Premiums**	No	FITs in place since 2002 Adoption of the act in 2005 for plants installed after Jan 2006. Fixed tariff option and premium option are offered alternatively and are guaranteed for 15 years in the fixed option. FIT level for 2006: Wind: 85 €/MWh fixed and 70 €/MWh premium, Small Hydro: 81 €/MWh fixed and 49 €/MWh premium, Biomass/biogas: 77-103 €/MWh fixed and 44-69 €/MWh premium, biomass cofiring: 19-41 €/MWh premium, Geothermal: 156 €/MWh fixed and 126 €/MWh premium, PV: 456 €/MWh fixed and 435 €/MWh premium.		
Denmark	**FITs and Premiums, Net metering for PV**	No	Act on Payment for Green Electricity (Act 478): Fixed (and low) premium prices instead of former high FITs for wind onshore. Tendering for offshore wind. Biomass and biogas receive FITs of 80 €/MWh for the first 10 years, 54 €/MWh for the next 10 years. Net metering for PV used for individual houses		Subsidies available for CHP-plants using waste..
Estonia	**FITs**	No	Purchase obligation of RES-E only valid for amount of network losses. Level of FIT since 2003: 52 €/MWh for all RES guaranteed for 12 years. Programme will expire in 2015.		No
Finland	**Tax Exemption**	No	Tax refund: 4.2 € /MWh (plant <1MW)	Mix of tax refund and investment subsidies:Tax refund of 6.9 €/MWh for Wind and of 4.2 €/MWh for other RES-E. Investment subsidies up to 40% for Wind and up to 30 % for other RES-E.	Tax refun (2.5 €/MWh)
France	**FITs**	No	Up to mid 2007 FITs for RES-E plant < 12 MW (wind plants are not due to the capacity limit) guaranteed for 15 years (20 years PV and Hydro). Tenders for plant >12 MW. After mid 2007 no limitation of capacity for FITs, provided that the equipement are in specific zones decided by local communities and regional administrations. (Energy act of July 2005). FITs in more detail: Biomass: 49-61 €/MWh, Biogas and methanisation: 75 – 90 €/MWh, including premium for energy efficiency up to 120 €/MW, including premium for "methanisation" up to 140 €/MWh, Geothermal: 76-79 €/MWh, PV: 300 €/MWh (20 years) including premium (for "integration in buildings") up to 550 €/MWh; Sewage and landfill gas: 45-60 €/MWh; Wind Onshore[15]: 28-82 €/MWh; Wind Offshore[16]: 30-130 €/MWhHydro[17]: 54.9-61 €/MWh.		FIT: 45 50 €/MWh
Germany	**FITs**	Only refurbishment	Novel of German Renewable Energy Act in 2004: FITs guaranteed for 20 years[18]. In more detail, FITs for new installations (2006) are: Hydro: 66.5-96.7 €/MWh (30 years); Wind[19]: 52.8-83.6 €/MWh; Biomass & Biogas: 81.5-171.6 €/MWh; Landfill-, Sewage- & Landfill gas: 64.5-74.4 €/MWh; PV: 406-568 €/MWh; Geothermal: 71.6-150 €/MWh		No
Greece	**FITs + investment subsidies**	No	FITs guaranteed for 12 years with the possible extension to 20 years.Tariff level:[20] Wind onshore, small hydro, geothermal, biomass & biogas: 73 €/MWh (mainland) and 84.6 €/MWh (islands); Wind offshore: 90 €/MWh (mainland and islands); Solar Thermal: 230-250 €/MWh (mainland) and 250-270 MWh (islands); PV: 400-450 €/MWh (mainland) and 450-500 €/MWh (islands) and a investment incentives: 30-40 % of investment incentives or 100 % tax exemption are offered by law 3299/2004. Reduction of taxable income of up to 20%.		No
Hungary	**FITs + soft loans**	FIT: 35-69	Technology-specific FITs since 2005. Tariff level (2006)[21]: Geothermal, biomass, biogas, small hydro (<5MW): 39-108 €/MWh, Solar and wind: 95 €/MWh; Cogeneration: 36-69 €/MWh. Soft loans from the		Waste: 39-108

13 FITs are guaranteed on national level for the first 10 years of operation, e.g. in case of offshore wind in size of 90 €/MWh. Note, they can only be claimed exclusively – in other words, they cannot be claimed if support is given by the regional TGC-systems

14 Stepped FIT: 92 €/MWh for the first 5 years of operation and then between 48 and 92€/MWh for the next 10 years.

15 Stepped FIT: 82 €/MWh for the first 10 years of operation and then between 28 and 82 €/MWh for the next 5 years depending on the quality of site.

16 Stepped FIT: 130 €/MWh for the first 10 years of operation and then between 30 and 130 €/MWh for the next 10 years depending on the quality of site.

17 Producers can choose between four different schemes. The figure shows the flat rate option. Within other schemes tariffs vary over time (peak/base etc.).

18 The law includes a dynamic reduction of the FITs: For biomass 1.5 % per year, for PV 6.5 % per year, for wind 2 % and for geothermal 1 % per year.

19 Stepped FIT: In case of onshore wind 83.6 €/MWh for the first 5 years of operation and then between 52.8 and 83.6 €/MWh depending on the quality of site.

20 Depending on location (islands or mainland).

21 Tariffs are differentiated depending on load distribution.

		€/MW h	Hungarian development bank.	€/MWh
Ireland	**FIT**	No	FITs are granted for 15 years. Tariff level (2006): Wind: 57-59 €/MWh; Landfill gas: 70 €/MWh; Other Biomass: 72 €/MWh; small hydro: 72 €/MWh.	No
Italy	**Quota/TGC + FITs for PV**	Quota obligation (TGC-system) on electricity suppliers: 3.05% target (2006), increasing yearly 0,35% up to 2008; TGC issued for al (new) RES-E (incl. large Hydro and MSW) – with rolling redemption[22]; no penalty; 12,528 €/MWh (2006) to purchase TGCs from the grid operator, but market distortions appear[23]. Feed in tariff for PV and locally investment subsidies from regional administrations .		
Latvia	**Quota + FITs**		The FIT-scheme has been replaced with a yearly quota system in 2003, but some RES-E producers continue receiving the FITs. However, political framework conditions for the support of RES-E are currently under development.	No
Lithuania	**FITs**	No	FITs are in place since 2002. Tariff level: small hydro: 57.9 €/MWh; Wind: 63.7 €/MWh; Biomass: 57.9 €/MWh. The implementation of a quota obligation is planned for 2021.	No
Netherlands	**No support system**	No	FIT-scheme was abolished in summer 2006 since the government expects to fulfill the 2010 target set by the EC without further financial support and RES-E support costs were higher than expected.	No
Poland	**Quota/TGC**		Poland applies a green power purchase obligation since 2003 and started the certificate trading in December 2005. The quota target to be fulfilled is set at 3.6 % in 2006 and increases up to 7.5 % in 2010.	
Portugal	**FITs + investment subsidies**	No	FITs (Decree Law 33-A/2005) and investment subsidies of roughly 40% (Measure 2.5 (MAPE) within program for Economic Activities (POE)) for Wind, PV, Biomass, Small Hydro and Wave. Average FITs in 2006: Wind[24]: 74 €/MWh; Wave: n.a. €/MWh; PV[25]:310-450 €/MWh, Small Hydro: 75 €/MWh	FIT for urban waste: 75 €/MWh
Slovak Republik	**FITs and tax exemption**	No	FITs since 2005 (Decree N°2/2005): Wind: 75.1 €/MWh; Small hydro (<5MW): 61.7 €/MWh; Solar: 214.6 €/MWh; Geothermal: 93.9 €/MWh; Biomass: 72.4 €/MWh. Tax exemption for RES-E in first five years of operation.	No
Slovenia	**FITs or premiums**	No	FITs were introduced in 2004 and are granted for 10 years. There are two alternatives, the fixed tariff option and a premium payment which is paid on top of the market price. Tariff levels (2004 – present): Small Hydro: 59-62 €/MWh (fixed) and 26-28 €/MWh (premium); Biomass: 68-70 €/MWh (fixed) and 34-36 €/MWh (premium); Landfill & sewage gas: 49-53 €/MWh (fixed); Biogas: 121 €/MWh (fixed); Wind: 59-61 €/MWh (fixed) and 25-27 €/MWh (premium); Geothermal: 59 €/MWh (fixed) and 25 €/MWh (premium); Solar: 65-374 €/MWh (fixed) and 31-341 €/MWh (premium)	No
Spain	**FITs or Fixed Premiums**	Depen d-ing on the plant size[26]	FITs (Royal Decree 436/2004): RES-E producer have the right to opt for a fixed FIT or for a premium tariff[27]. Both are adjusted by the government according to the variation in the average electricity sale price. In more detail (2006): Wind, Biomass, Small Hydro (<25MW), Geothermal: 68.9 €/MWh (fixed) and 38.3 €/MWh (premium); Solar thermal & PV[28]: 229.8-440.4 €/MWh 194 €/MWh, Agricultural and forest residues: 61.3 €/MWh (fixed) and 30.6 (premium). Moreover, soft loans and tax incentives (according to "Plan de Fomento de las Energías Renovables") and investment subsidies on regional level	FIT: 53.6 €/MW h (fixed) or 23 €/MWh (premium)
Sweden	**Quota/TGC**	No	Quota obligation (TGC-system) on consumers: Increasing from 7.4% in 2003 up to 16.9% in 2010. For Wind Investment subsidies of 15% and additional small premium FITs ("Environmental Bonus"[29]) are available.	No
United Kingdom	**Quota/TGC**	No	Quota obligation (TGC-system) for all RES-E: Increasing from 3% in 2003 up to 10.4% by 2010 – Buyout price is set at 32.33 £/MWh for 2005/2006. In addition to the TGC system, eligible RES-E are exempt from the Climate Change Levy certified by Levy Exemption Certificates (LEC's), which cannot be separately traded from physical electricity. The current levy rate is 4.3 £/MWh. Investment grants in the frame of different programs (e.g. Clear Skies Scheme, DTI´s Offshore Wind Capital Grant Scheme, the Energy Crops Scheme, Major PV Demo Program and the Scottish Community Renewable Initiative)	No

22 In general only plant put in operation after 1st of April 1999 are allowed to receive TGCs for their produced green electricity. Moreover, this allowance is limited to the first 8 years of operation (rolling redemption).

23 GSE (Italian Agency for renewable support schemes) influences strongly the certificates market selling its own certificates at a regulated price – namely at a price set by law as the average of the prices paid to acquire electricity from RES-E plant under the former FIT-programme (CIP6) minus the income from the sale os such electricity on the market..

24 Stepped FIT depending on the quality of the site.

25 Depending on the size: <5kW: 420 €/MWh or >5kW: 224 €/MWh.

26 Hydropower plants with a size between 10 to 25 MW receive a tariff of 68.9 €/MWh (fixed) or 38.3 €/MWh €/MWh, larger plants (25 to 50 MW) can opt for a fixed tariff of 61.3 €/MWh or a premium payment of 30.6 €/MWh.

27 In case of a premium tariff, RES-E generators earn in addition to the (compared to fixed rate lower) premium tariff the revenues from the selling of their electricity on the power market.

28 In case of PV the expressed premium tariff refers to plant > 100 KW. For small-scale plants (<100 kW) only a fixed FIT is applied.

29 Decreasing gradually down to zero in 2009

United States	**Quota/TGC + tax incentives + state funds**	No	Quota obligations established in 21 U.S. states – covering 40% of U.S. load – by 2006. Design and level of quotas varies by states. 10-year, 1.9 cent/kWh federal production tax credit available to certain "new" RES-E sources. 30% federal investment tax credit available fort solar installations. 15 states have developed renewable energy funds, typically collected through electricity surcharges, and these funds have developed incentive programs that spend roughly $500 million per year on various RES-E technologies, through a variety of different kinds of programs. The largest of these programs involves rebates and production incentives for customer-sited photovoltaic systems in California.	
Japan	**Quota/TGC + tax incentives + voluntary net-metering**	No	Quota obligation (TGC-system): Increasing from 3.3TWh in 2003 up to 12.2TWh (approx. 1.35%) in 2010, 16TWh (approx. 1.63%) in 2014. TGC issued for all RES-E (exempt large hydro (>1MW), non-biomass fraction of MSW, conventional geothermal). Maximum price of TGCs is set at 11JPY/kWh. Voluntary net-metering for PV offered by power companies: The current purchase price is about 23JPY/kWh.	Yes (exempt non-biomass fraction)

Over time, many countries have gone through major changes and occasional reversals in their renewable support policies, either in response to what was or was not working, to make it more effective, or in response to political or public sentiment. Figure 4 shows the evolution of the main support instrument for selected countries over time. Countries where the FIT has been continuously in effect since 1997 are Austria[30], Germany, Greece, Luxembourg, Portugal and Spain. Countries with major changes include:

- The UK and Ireland who replaced their problematic tender schemes by a quota regulation in combination with a TGC-market in 2002 and 2005 respectively;
- A few others including Belgium and Italy who substituted their FIT-systems for a quota regulation;
- Sweden which switched to a quota obligation complementing the already existing tax and investment incentives in some cases;
- The US where tax credits have been complemented by the introduction of RPS obligations in a number of states starting in 2000; and
- Japan which introduced a quota system in 2003 on top of an existing voluntary net metering for PV that has been offered by utilities since 1992.

30 with a short interruption for small hydro in 2001

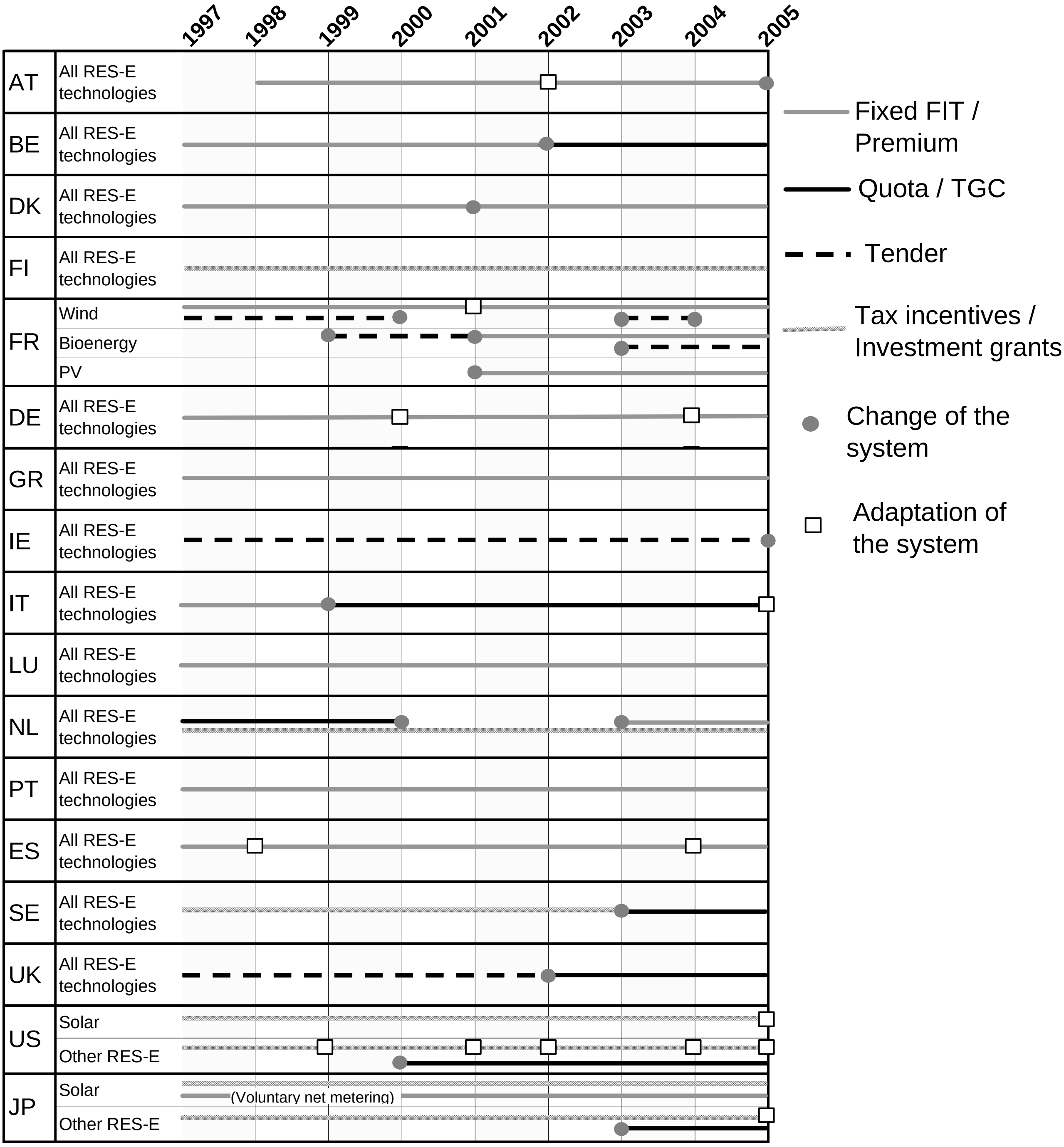


Figure 4 Evolution of the main support schemes in EU-15 Member States and in the US[31] (based on Ragwitz et al. 2007, Wiser et al.2007).

Institutional and political determinants of policy

The wide variations in the choice of instruments, their timing and intended goals may be largely explained by variations in political developments and intentions of different countries. Indeed, one can speculate a strong collation between the choice of instruments, the level of FIT or premium offered, and stability of the policies with the institutional and political environment in each country. Three main sets of parameters are at play in the institutional arena and further described in Box 1.

[31] There are also some limited FITs in the US, but these aren’t too significant and are not indicated in this table

- The political, culture and policy style – Countries with a market-oriented political culture and a liberalistic government tend to choose the most market-based instrument in the belief in the efficiency of market incentives and the desire to make the RES promotion instrument compatible with the electricity market principles.
- The convergence of supply security and CO2 emissions reduction – Countries with meagre domestic energy supply and/or little fuel diversity tend to be concerned with energy security and may be concerned about CO2 emissions.
- The absence of a strong conventional energy equipment-related industry – Countries who lack major manufacturing capabilities in fossil or nuclear power sector tend to be strong proponents of a national RES industry.

Box 1

Why European countries differ on their RES promotion policies?

- **United Kingdom** – UK's energy sector is focused on market forces and competition as the main means of controlling costs. This explains the government's early reliance on tending process with cost cap, and then TGC obligations with buy-out provisions, at the expense of effectiveness of the instrument. UK currently enjoys a high degree of energy self-sufficiency in conventional energy resources and is less concerned about supply security. Moreover, Britain has been able to dramatically reduce emissions by replacing coal generation with natural gas.
- **Germany** - The promotion of RES is primarily driven by the politics of CO_2 reduction, the phase out of nuclear energy and an increased dependence on imported energy. This explains why Germany was among the two first countries to introduce generous and stable FIT instruments.
- **Denmark** - Since 1990s the Danish government has given high priority to RES and energy conservation for environmental reasons. Wind power has traditionally been promoted through generous schemes. Another motivating factor has been a fast growing domestic wind power industry. The Danish strategy has changed after a shift of government in 2001. The incoming liberal-conservative government is relying mainly on market forces to promote RES. As a result no net increase in land based wind power has taken place since 2003.
- **Spain** - Increasing energy dependence and CO_2 emissions are major issues. Spanish government and industries feel constrained by a nuclear moratorium. The regional and local communities contribute to the momentum by helping to facilitate the planning and location process.
- **Italy** - Cogeneration and renewables have been promoted since the 1990s under a FIT system inspired by the PURPA experience in the US and to alleviate investment constraints. Renewables are also seen as contributing to reduce the country's growing energy imports exasperated by the nuclear moratorium of the mid-1980s. Italy has adopted intensive market reforms and has introduced a TGC system in place of the FIT system to be consistent in its electricity market reform.
- **France** - Thanks to the powerful political lobby for nuclear energy, France relies on atom for roughly 70% of its electricity generation, complemented by hydro production. Energy equipment manufacturing industry is quite successful in the exports markets. A renewables policy was developed to maintain the nuclear option

while giving a perception of support for renewables. Despite the adoption of a generous FIT system in 2001, the net effect has been modest to date due to planning and siting difficulties.

4. Comparison of strategies

This section summarizes the major national programs which have been implemented in different counties including a description of support system and policy targets including and changes over time; a discussion of the attractiveness of the scheme from investors' point-of-view; an overview of the effect of the policy as well as an overview of the pros and con of alternatives.

Feed-in tariffs and premiums

In Europe, FIT began to attract attention in the late 1980s especially in Denmark, Germany and Italy followed by Spain in 1990s. It is the most widely used promotion instrument in Europe. Figure 5 shows variations in FIT for electricity from onshore wind turbines between 2003 and 2005 [32] indicating a broad range of support, some varying over time. In 2005, the schemes varied between from 60 and 90 EUR/MWh due to differences in wind conditions and different levels of support in different countries.

The FITs attract a lot of capacity, since a fixed tariff is guaranteed, but only if the FIT is set at a level sufficient to meet investors' needs. This is evident in countries with substantial growth in wind power such as in Denmark in the 1990s, and Germany and Spain in the recent past.

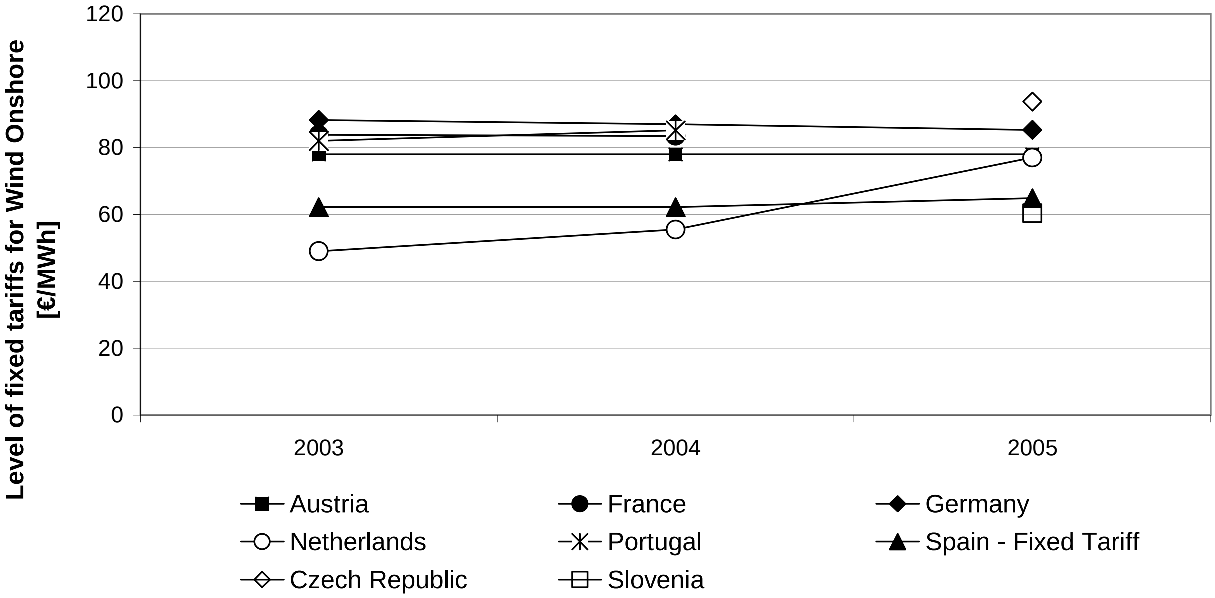


Fig. 5. FITs for electricity generated from onshore wind in selected European countries

The experience of US, Germany and Spain with FIT are highlighted below.

Implementation of PURPA in the US

The earliest form of a mandatory FIT may be traced to Public Utilities Regulatory Policy Act of 1978 (PURPA) in the US. PURPA required utilities to purchase power from qualifying facilities (QF) including small renewable generators and combined heat and power plants.

[32] The performance of FIT is discussed in section 5.

Pricing varied by state but, especially in California, prices were tied to the price of the marginal conventional fossil fuel, which was high and projected to increase at the time, yielding highly attractive returns to renewable energy investors (Martinot et al. 2005).

PURPA faced early legal challenges, but once it was underway, and where it was implemented aggressively, it enabled an environment in which renewable developers could secure financing for their projects because they could sell their output under attractively priced long-term standard contracts. There was little risk under the scheme.

PURPA was implemented differently in each state. The state of California developed a particularly generous standard contract, some as long 15-30 years with a fixed tariff for the first 10 years of facility operation. Combined with favourable state and federal tax credits, the growth of QF capacity, which included renewables, was astounding, aided by California's diverse and abundant renewable energy resources. Over a short period of time, about 12,000 MW of geothermal, small hydro, bio-power, solar thermal, and wind power capacities were constructed in the US in the 1980s, of which more than half were in California (Martinot et al. 2005).

But PURPA also had unintended negative consequences. By providing high profitability, it created an over-heated renewable energy market in which project development arguably occurred at a pace that exceeded the ability of the industry to efficiently deliver. Moreover, because the incentives were capacity based, there was more of an incentive to deploy capacity (MW) rather than generate electricity (MWh). Finally, because of the generous incentives that were offered and the high number of project failures, PURPA-inspired QFs resulted in a backlash within the regulated utility industry, which was obligated to buy the power, but also within the financial community and among some policy makers. This negative reaction arguably set the industry back to some degree (e.g., Martinot 2005, Wiser 2006). Partly as a result of these factors, the US renewable energy market remained largely stagnant between the late 1980s and the year 2000 as state level implementation of PURPA became less aggressive and certain Federal and state tax incentives were allowed to expire.

Implementation of FIT in Germany

In Germany, a fixed FIT scheme has been in place since 1991 when the Electricity Feed-in Act was passed. In 2000 this act was substituted by the Renewable Energy Act and a 12.5% target for the share of RES in electricity generation to be achieved by 2010 was established. The most important change has been the uncoupling of the tariff level from the electricity retail price and the setting of new tariffs based on the actual generation costs of a technology. This means that tariffs are not only differentiated by technology, but also within a given technology. Moreover, the tariff is adjusted according to location-specific generation costs influenced by wind speed, size of a plant or the fuel type in case of biomass.

Another feature of the Renewable Energy Act is a tariff degression for new installations designed to encourage technological development and learning. The act was amended in 2004 with a 20% target for the share of renewables in electricity generation by 2020. The FIT for onshore wind has been reduced and sites with poor wind conditions have been excluded. Tariffs for geothermal electricity, small-scale biomass plants and PV were increased. Furthermore, additional bonuses were granted for innovative technologies and refurbishment of large hydro plants. Investment security for generators of green electricity is virtually guaranteed by FITs for a time scale of up to 20 years.

As shown in Figure 6 depicts, roughly two third of the increase in electricity generation from RES of about 40 TWh since the early 1990s may be attributed to onshore wind. Since 2000 – the year of the implementation of the Renewable Energy Act – more wind capacity has been connected to the German grid than all previous years. By 2005, Germany was getting about 11% of its electricity from RES in 2005, compared to about 4% in 1997.

Despite the impressive gains, the German FIT scheme has its share of critics, mostly large incumbent utilities and energy intensive customers who complain about the extra cost burden for the promotion of RES. Proponents of the FIT point out (Figure 23) that the German scheme is only marginally more generous than others in Europe. Another problem is that wind power plants are concentrated in the Northern part of Germany straining the local transmission network, which is also influencing load flows in neighbouring European countries. In balance, the German FIT may be considered a success story, albeit coming at a price.

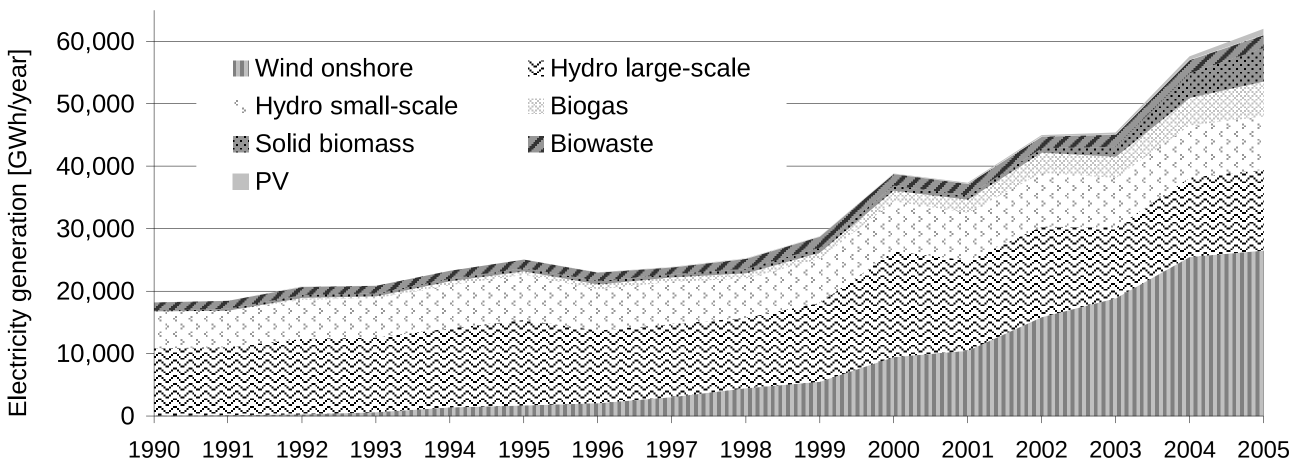


Figure 6. Impact of German FIT on RES in Germany

Source: International Energy Agency 2006, Eurostat 2006

FIT in Spain

The dominant policy instrument for the promotion of electricity from renewables in Spain is an FIT, which has been in place since 1994[33]. The same year, Spain established a 12% national target for renewables in total energy consumption by 2010. To further encourage investment in wind, the FIT scheme was amended in 2004 to effectively guarantee payments during the whole lifetime of a plant and additional incentives were introduced. Green electricity can either be sold in the market by using a bidding system or through bilateral contracts. By the end of 2004, the overall remuneration level under the market option has increased more than was expected due to rising electricity market prices.

[33] In 1998 two alternative payment options for green electricity generation were introduced, a fixed tariff scheme and a premium tariff, which was paid on top of the electricity market price. The choice is valid for one year, after which the generator may decide to maintain the tariff option or change to the alternative option. Under both payment options, grid connection and purchase of the green electricity are guaranteed

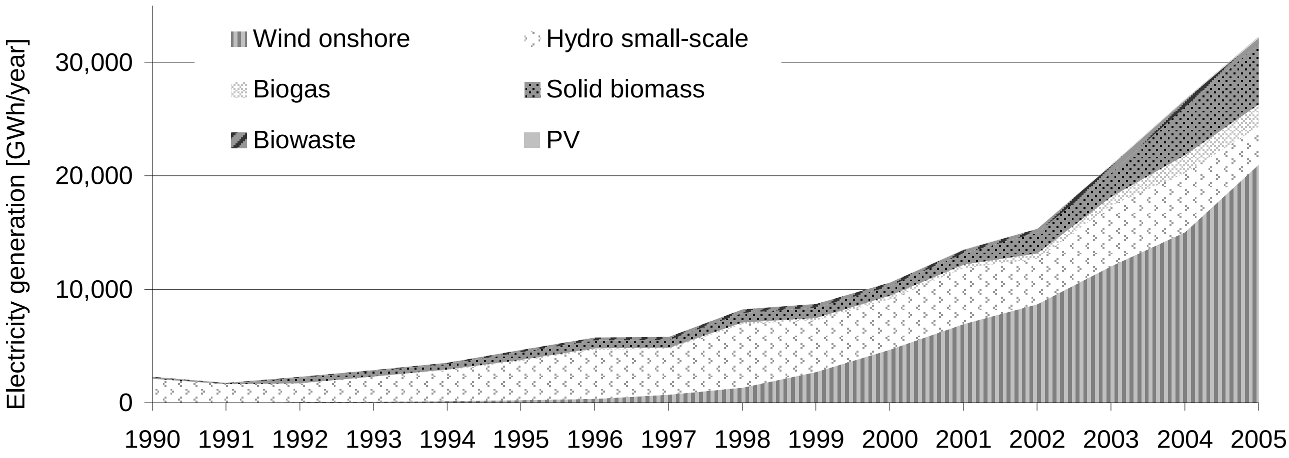


Figure 7. Growth of electricity generation from renewables excluding large hydro in Spain

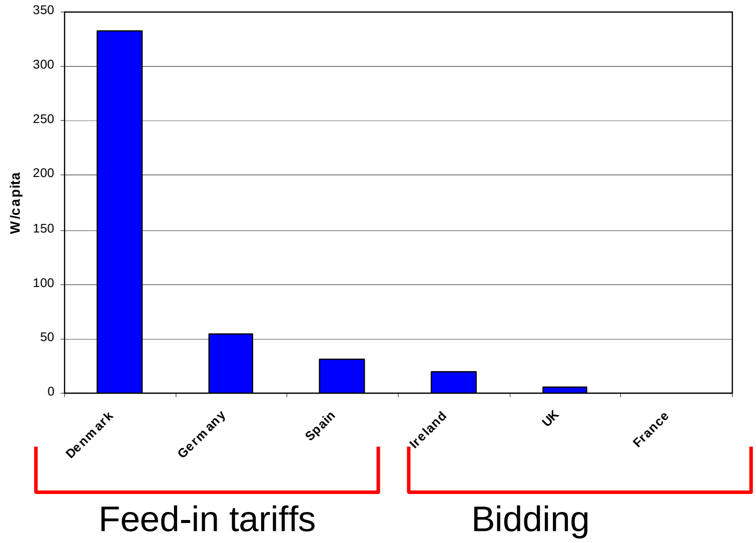
Source: Eurostat 2006

As a result of these favourable conditions, the deployment of RES in Spain started to take off in the late 1990s with 30 TWh of additional generation in 2006, mostly from onshore wind (Figure 7). The only criticism of the scheme is that the premiums offered may be too generous for wind generators. Yet, by and large, the Spanish scheme may be characterized as another European success story because it has resulted in a significant increase in deployment of renewables with modest subsidies (Figures 5 and 12) in a relatively short period of time. Continuity and stability of the policy even under changing governments have contributed significantly to the success of the policy.

Bidding/Tendering systems

Government tendering schemes to promote RES have been used in the 1990s in France (for wind energy and biomass), Ireland (The Irish Alternative Energy Requirement), Denmark (the last two off-shore wind farms) and the UK, as well as in many states in the U.S. The most well-known of these promotion strategies is the non-fossil fuel obligation (NFFO) in England and Wales, which is further described below. Similar schemes have been used in Scotland (Scottish Renewables Order, SRO), and Northern Ireland, NI-NFFO).

However, in most cases, the schemes did not work effectively and starting in 2001/2002 the competitive tendering schemes were abandoned. Figure 8 compares the relative effectiveness of bidding vs FITs for wind energy in Europe prior to 2001 clearly showing the superiority of FIT schemes. Partly as a result of this, the UK switched to a renewables obligation scheme in 2002. More recently, both Ireland and France have also changed to FIT systems.



1.1

1.2

Figure 8. Comparison of the relative effectiveness of FIT and competitive tendering schemes in promoting wind power deployment, 1990-2001

Source: Haas et al 2003

UK's non-fossil fuel obligation (NFFO)

As originally envisioned, the UK's NFFO was to deliver 1,500 MW of installed capacity from RES by the year 2000. The rational for the competitive tendering scheme was to invite developers to bid to construct renewable energy capacity. The tendering process would select among the viable proposals the least cost options within each technology grouping. To facilitate financing, the winners would be awarded relatively long-term contracts, up to 15 years with a guaranteed surcharge per unit of output for the entire contract period. The difference between the surcharge paid to NFFO generators (premium price) and a reference price (Pool Selling Price) was to be financed by a levy on all electricity sales of licensed electricity suppliers. The costs of this levy[34] were to be passed on to consumers (Mitchell, 1996).

In total five tendering rounds were conducted in England and Wales resulting in 880 contracts being awarded. The competitive bidding resulted in declining prices over time as expected. Since the first round in 1990, average prices have decreased from 6.5 p/kWh to 2.71 p/kWh (Figure 9). Even lower prices, less than 2 p/kWh, were obtained in Scotland for wind power, lower than electricity from coal, oil, nuclear and some natural gas. The scheme provided revenue security as long as the plant operated. On surface, this appeared to be a successful scheme.

However, things did not go smoothly in practice. Many of the awarded contracts did not materialize while others failed to meet the expected capacity targets (Figure 10). Many factors contributed to this including submission of unrealistic bid prices to secure a contract and failure to obtain planning and other consents. Similar experiences with contract failure have been common in other bidding schemes (e.g., Wiser et al. 2006a). One lesson from this experience is that tendering schemes lacking penalties for non-delivery may be deficient compared with other subsidy schemes. In 2002, the NFFO was replaced by the renewable

[34] The levy remains now only to continue the previously contracted arrangements.

obligation,RO (see section 4.4) while contracts already awarded continue to be valid under the older terms.

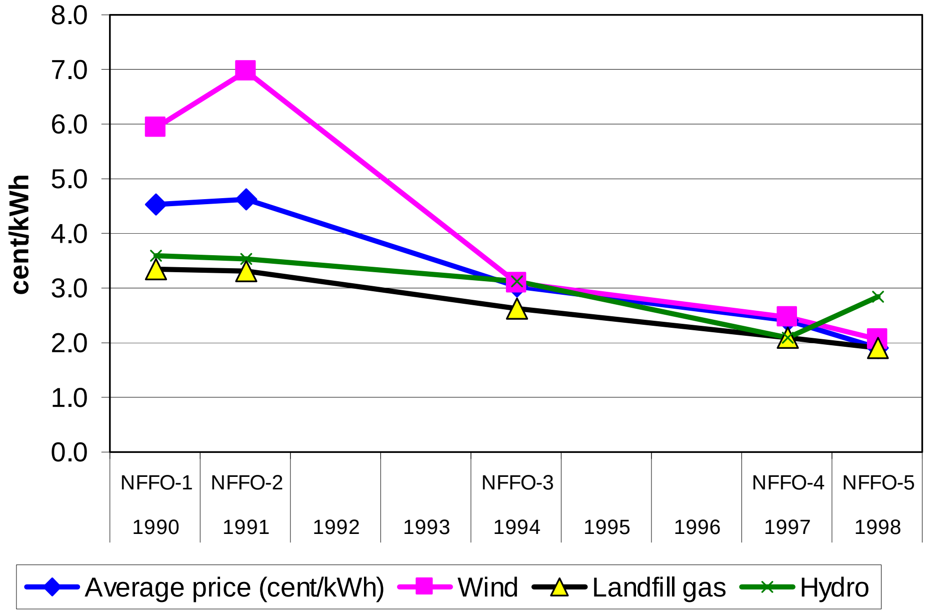


Figure 9. Bid prices under NFFO in England & Wales, prices in EUR-cent/kWh

Source: www.ofgem.uk

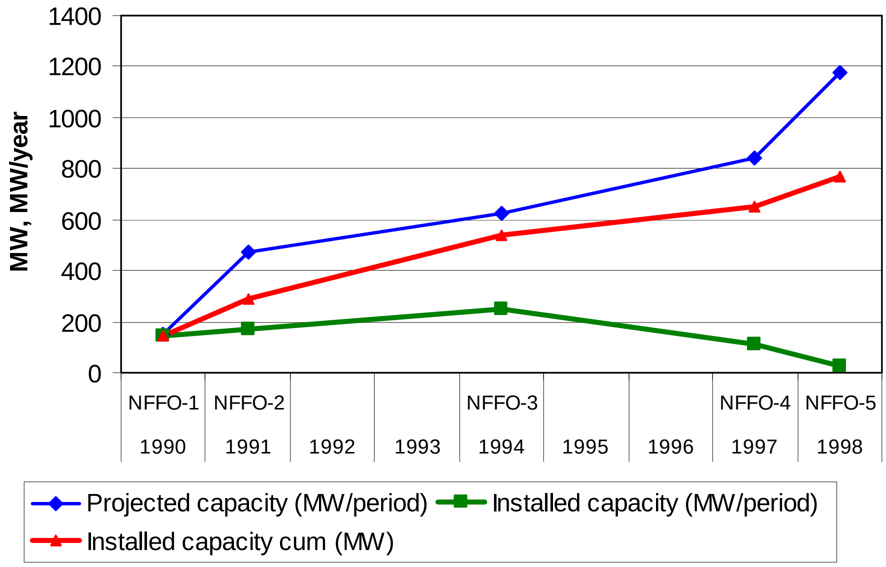


Figure 10. Capacities installed vs. projected under NFFO in England & Wales
Source: www.ofgem.uk

Quota-based Trading systems

Alternative forms of quota-based systems are now in place in five EU countries, in some 21 states and the District of Columbia in the U.S. and in Japan. The European quota systems are based on tradable generation certificates, TGC (Table 4) while in the US, the schemes are referred to as renewable portfolio standards, RPS (Table 5).

Table 4. Quota-based TGC systems in EU and Japan

Source: Ragwitz et al 2007, METI 2007

	UK	Belgium (Flanders)	Belgium (Walloon)	Italy	Poland	Sweden	Japan
Period	Start 2002	Start 2002	Start 2002	Start 2001	Start 2005	Start 2003	Start 2003
Obligation	3% in 2003, 10.4 % in 2010	1.2% (2003), 2% (2004) increasing up to 6% in 2010	3% in 2003 increasing up to 12% in 2010 From September 2010 onward, the quota will be multiplied by 1.01	2% in 2002 and increased annually by 0.35% between 2004 and 2008	7.5% in 2010	7.4% in 2003, 16.9% in 2010	approximately 0.4% in 2003 approximately 1.4% in 2010 approximately 1.6% in 2014
obligation on	Supplier	Supplier	Supplier	Producers and importers	Supplier	End-user	Supplier
technology bands (baskets) within overall quota	No (introduction of technology banding is planned for the future)	No	No	No	No	No	No
involved technologies	small hydro****, wind, biomass, solar -, geo-thermal energy, no waste	all renewables, no solid municipal waste	all renewables and high quality CHP	all new renewables (incl. large hydro, MSW, hydrogen and CHP),	Small and large hydro, wind, biomass	small hydro (<1,5 MW), large hydro (only some cases), wind, biomass, geothermal, wave	PV, Wind, Biomass, Small hydro up to 1MW, Geothermal (exempt conventional type)
Existing plants eligible	No	Yes	Yes	No (for certificate issue), Yes (for quota fulfillment)	No	Yes (small hydro)	Yes
international trade allowed	No.	No	No	yes, but only in exchange with physical electricity and with countries that allow reciprocity	No	Trading scheme with Norway planned BUT NOW ABOLISHED	No
Floor price	not planned.	at federal level: From 1st of July 2003 onward the grid operator is obliged to buy TGC issued anywhere in Belgium for the minimum prices per TGC (in size of 1MWh) of: offshore wind 90 €, on-shore wind 50€, hydro: 50€, solar energy: 150€, biomass: 20€, Within the Wallon-region, RES-E producers may exchange their TGC for a subsidy at a fixed price of 65 €.		Not planned	No	Floor prices for the introductory phase (in €/MWh): 2003: 6.6; 2004: 5.5; 2005: 4.4; 2006: 3.3; 2007: 2.2; from 2008 onwards no floor price is planned.	No
Penalty	The Buy out price is £30,51/MWh (for 2003/2004) (~45 €/MWh)	75 €/MWh (in 2003; 10 €/MWh in 2004; and 125 €/MWh in 2005	From 1st of April 2003 onward: 100 €/MWh (100€ per missing TGC in size of 1MWh)	No penalty is set; the grid operator sells certificates at a fixed price 12,528 €/MWh (2006)	The Buy out price is 100 EUR/MWh	150% of the market price – but with a maximum of about 19 €/MWh in 2004, and 26 €/MWh in 2005	1 million JPY to non fulfillment supplier.
Trading scheme	stock exchange	stock exchange	Open, trading and direct support	bilateral or in the TGC Market.	Power exchange	open	bilateral or in the market managed by private brokers

A comparison of recent TGC prices are presented in Figure 11, showing relatively flat price levels in most countries, over this three-year period, but wide disparities in pricing across systems. . The salient features of some of the schemes follow.

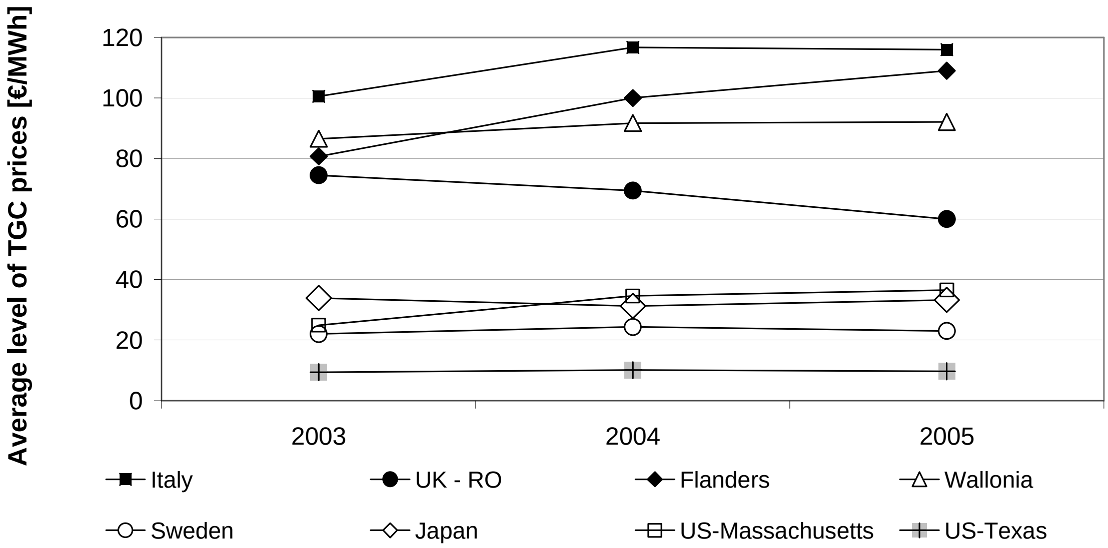


Figure 11. Comparison of TGCs[35] price levels in selected countries

Sources: Held et al 2006, METI 2006, Wiser et al. 2007.

European TGC schemes

Currently, quota-based TGC systems are in effect in the UK, Sweden, Italy, Belgium, and Poland. In the UK, Belgium and Poland suppliers have to demonstrate compliance with the obligation; in Sweden the end-users are responsible while in Italy the quota has to be fulfilled by the producers and in a rather complicated way described below. In all cases the obligations can be met by:

- Producing certificates by generating electricity from qualifying renewable plants;
- Purchasing TGCs from other eligible generators, other suppliers, traders, or through organized exchanges; or
- Paying a penalty or “Buy-Out Price” set by the regulatory authority.

In the UK the Renewables Obligation (RO) scheme came into effect in 2002, starting at 3.4% coverage of electricity demand for the period of 2003/2004, gradually increasing to 10.4% by 2010/2011 and remaining at that level until 2027. The major problems with the British RO scheme are that certificate prices are high, although slightly decreasing from 2003 to 2005 (Figure 11), and that so far the quota has never been fulfilled. For example in 2004 only 2.2 % of electricity has been generated from new RES vs. the 3.4 % specified in the quota[36].

There are several explanation for this. In fact, not meeting the target is also a function of at least[37] three major factors: (i) the low penalty, respectively the fact that this penalty is recycled to the renewable generators (see above); (ii) location and permitting constraints; and

[35] Since TGC prices in the US vary by state, Massachusetts and Texas are used as examples

[36] Notice that, because of multi-riks for the producers, developers and for obligated suppliers, most of the quotas are complied within long term contracts between suppliers and producers and the exchange of certificates does not play the role that the theory could suggest.

[37] Of course, more investigations are necessary to get detailed insight on the effects of a hybrid instrument (control by quantity –the quota – and by price –the buy out price) to explain its poor effectiveness

(iii) banking is not allowed so RES generators fear (with good reasons) that the closer they come to the quota the lower will be the ROC price. Note that this is despite the fact that long term contracts are possible and most of the certificate handling takes place within vertically integrated large companies.

The penalty mechanism in the UK deserves special attention. All penalty payments are placed in a central fund. This fund is redistributed to suppliers which have met the obligation in proportion to the number of ROCs each supplier has presented. Therefore the real costs for a supplier who is not complying with the obligation are higher than their total Buy-Out Price payments ('fines'). In contrast, accomplishing and surpassing the RO target provides additional economic incentives. That explains why ROC prices were higher than the Buy-Out price in the first years. This situation can be expected as long as the market is short of electricity from RES. Figure 12. depicts the number of ROCs issued in UK between October 2002 and March 2005 by technology and country[38]. Clearly, in England the cheap options landfill gas and biomass co-firing dominate. In Wales and Scotland onshore wind and hydro are also among the preferred options.

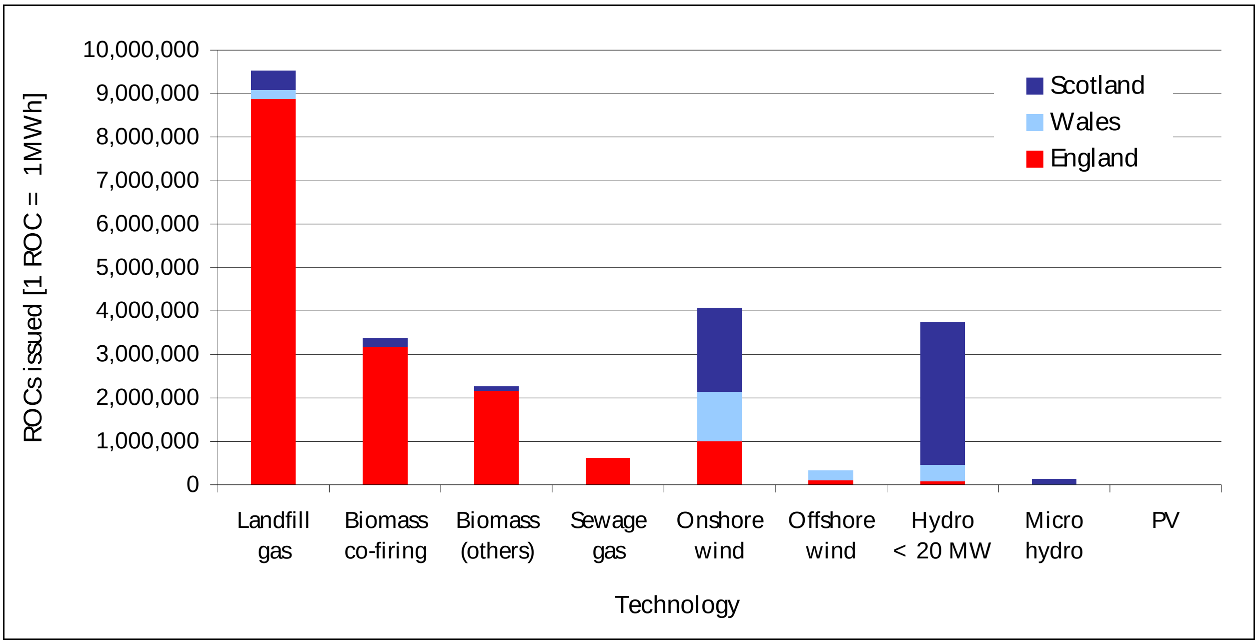


Figure 12. Number of ROCs issued in the period April 2002 to March 2005 by technology and country (Note: 1 ROC = 1MWhel). Source: OFGEM (2006)

Italy introduced its TGC scheme in 2002, obligating all producers and importers of electricity to supply 2% of their power from new renewable electricity, with exceptions for combined heat and power (CHP) plants, renewables and companies generating less that 100 GWh.

Today the situation in Italy is similar to the British case. TGC prices are among the highest in Europe[39] (Figure 11) mainly because they expire in eight years. Two types of TGC

[38] The UK ROCs system has not directly affected small generators, e.g. roof PV, small wind, and small hydro.

[39] The high price of the TGCs sold by GSE is due to the mechanism for the price setting. When the generation of low price sources like hydro power is low, the weighted average of the price paid for former feed-in contracts is higher and so the price of certificates. The same happens when the avoided cost, which has a cost factor related to the fuel prices, rises as happened in 2006.

are on the market: those from qualified facilities and those sold by the market operator Gestore Servizi Elettrici (GSE), who trades the certificates issued to generators under contract with the previous FIT program at a price calculated each year. The role of the certificates sold by (GSE) is to reconcile the previous FIT scheme with the new, a delicate task since the quota of the obligations has to be managed to avoid the supply of certificates from new plants exceeds demand, which will result in zero price for the certificates. To facilitate this control and give elasticity to the supply, banking of certificates has been allowed for two years.

In Belgium, two TGC schemes have been in existence in parallel since 2002, one in Flanders and the other in Walloon. The former was designed to promote energy generation form waste, biomass and wind and it was clear from the beginning that the limited market may result in liquidity problems. Currently, TGC prices in Flanders are among the highest in Europe (Figure 11). But as shown in Figure 25, if the windfall profits due to the promotion of prior capacity are taken into account, the additional costs for customers for generating new electricity from RES increase to about 18 cent/kWh (Verbruggen (2005). The current penalty for not fulfilling the quota, of the order of 100–125 EUR/MWh, is not considered a major barrier since it is in the same range as the actual certificate prices (Figure 11).

In the case of Sweden, new RES capacity increased significantly in 2004 and 2005 when certificate prices were low (Figures 13 and 26). The Swedish quota system allowed some old capacity to qualify for certificates[40] resulting in a free-rider problem and generating windfall profits for plants constructed before the TGC scheme went into effect. The availability of additional tax incentives and investment subsidies, especially for wind power plants, has contributed to the problems.

Renewable portfolio standards in the US

In the US Renewable Portfolio Standards (RPS) have become the most common instrument for promotion of renewables at the state level, with 21 states and the District of Columbia adopting such schemes (Langniss and Wiser 2003, Wiser et al 2007). These schemes collectively encompass 40% of electricity supply in the US and set minimum standards for renewable energy in the energy mix. As detailed in Wiser et al. (2005), the design of quotas varies considerably across states (see Table 5).

Table 5. Current RPS schemes in the US (Source: Wiser et al. 2007)

State	**Start Date**	**Ultimate Target**	**Existing Plants Eligible**	**Technology Bands or Tiers**
Arizona	2001	15% (2025)	No	Yes (Distributed Generation)
California	2003	20% (2010)	Yes	No
Colorado	2007	10% (2015)	Yes	Yes (Solar)
Connecticut	2000	10% (2010)	Yes	Yes (Class I/II Technologies)
Delaware	2007	10% (2019)	Yes	Yes (Vintage)
Hawaii	2010	20% (2020)	Yes	No
Iowa	1999	~2% (1999)	Yes	No
Maine	2000	30% (2000)	Yes	No
Maryland	2006	7.5% (2019)	Yes	Yes (Class I/II Technologies)
Massachusetts	2003	4% (2009)	No	No
Minnesota	2005	10% (2015)	Yes	Yes (Biomass, Community Wind)

[40] Recently, this system has been modified and currently mainly new capacities qualify for certificates traded.

Montana	2008	15% (2015)	No	Yes (Community Wind)
Nevada	2003	20% (2015)	Yes	Yes (Solar)
New Jersey	2001	22.5% (2021)	Yes	Yes (Solar, Class I/II Technologies)
New Mexico	2006	10% (2011)	Yes	No
New York	2006	24% (2013)	Yes	Yes (Distributed Generation)
Pennsylvania	2007	8% (2020)	Yes	Yes (Solar)
Rhode Island	2007	16% (2020)	Yes	Yes (Vintage)
Texas	2002	~4.2% (2015)	Yes	Yes (Goal, Non-Wind)
Washington	2012	15% (2020)	No	No
Washington DC	2007	11% (2022)	Yes	Yes (Solar, Class I/II Technologies)
Wisconsin	2001	10% (2015)	Yes	No

The full effect of these RPS policies has not yet registered since only a few states have more than five years of experience and some of the quotas have been set but have not yet produced results. In the past few years, however, these policies have begun to have a sizable impact on the renewable electricity market in the US[41]. Figure 13, for example, shows that roughly half of the non-hydro renewable energy capacity additions since 2000 in the US have occurred in states with quota obligations, most from wind power. Importantly, because of technology set-asides that exist in a number of states, a growing amount of solar energy is also being supported by these obligations. By some estimates, these quota systems could result in the installation of over 40 GW of new RES capacity by 2020 generating roughly 3% of projected US electric sales.

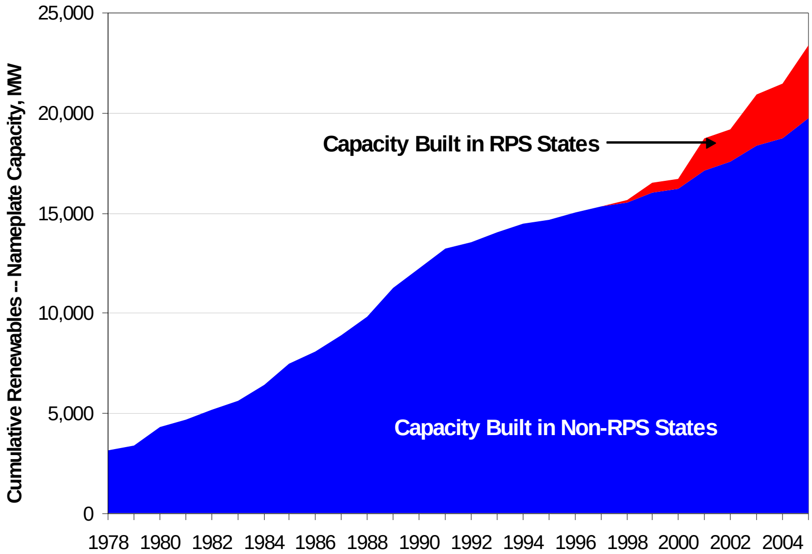


Figure 13. Cumulative non-hydro capacity from renewables in the U.S.

Source: Black & Veatch 2006

In general, the most successful quota systems in the U.S. are those that have required or motivated long-term contracting with RES developers, with short-term contracts of unbundled TGCs used as a secondary compliance tool. These long-term contracts are typically the result

[41] It is important to note that most of the state RPS policies work in combination with federal tax incentives available for RES projects. In addition, many of these policies are applied in still-regulated electricity markets in which regulated utilities solicit long-term renewable electricity contracts to comply with the standards.

of a competitive bidding procedure conducted by retail suppliers obligated to meet the quota. Though a significant degree of contract failure has occurred in some states, and government oversight has been required in others, many schemes appear to be functioning with efficiency and effectiveness.

In some states where unbundled, short-term trade in TGCs dominate the market, however, problems similar to those in the UK have arisen, with TGC prices set by the penalty level, rather than based on market forces. In these instances, renewable electricity projects struggle to receive financing, despite potentially high prices and profits due to the risk involved. This has especially been the case in restructured electricity markets[42], where load obligations are uncertain, and retail suppliers have typically been reluctant or unable to enter into longer-term contractual arrangements for electricity from renewables or unbundled TGCs[43]. It remains to be seen whether this factor will complicate new project development in the long term and whether the resulting aggregate cost of the quota will be acceptable.

Though short-term trade in TGC is not common in many of the RPS markets in the US, several states have TGC markets that are sufficiently liquid to have transaction price data available (in the US, TGCs are referred to as renewable energy certificates, or RECs).. These states are typically those in which both retail electric competition and liquid wholesale electricity markets exist. Figure 14 presents monthly data on the average price of RECs in six different states and the District of Columbia.

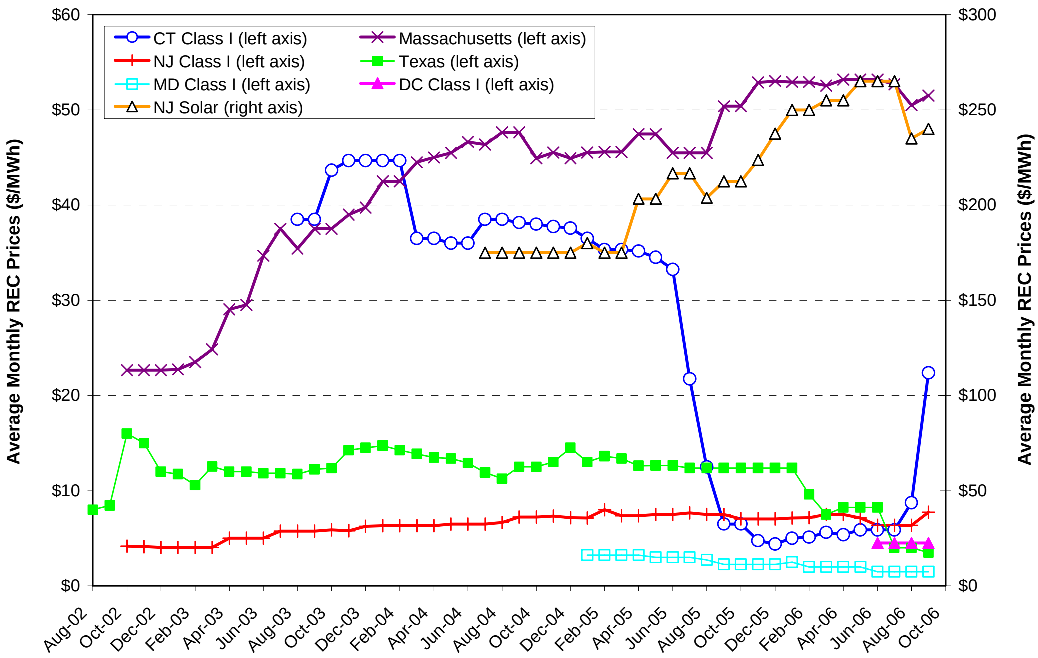


Figure 14. REC prices in selected states
Source: Wiser et al. 2007

Clearly, TGC prices in the US have experienced considerable variations among markets, and even within a single market over time. TGC price differences across markets reflect

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[42] Some states have restructured their electricity markets in the United States to allow competition among retail electricity suppliers,while others have not.
[43] Customers in restructured markets can switch suppliers, adding to retailer uncertainties in securing long-term contracts

dramatically different state RPS designs as well as differences in available resources, vintage and geographic eligibility rules, the level of the RPS compliance target, the cost and availability of renewable generation in the region and the level and design of any cost cap, to name a few. Variations in TGC prices within a given market and over time reflect the influence of changes in RPS rules or expectations of those rules, the actual and/or expected speed of renewable energy development relative to the RPS targets and the degree of competition for renewable energy from other states or from the voluntary green power market, among other factors.

In a number of states, a variety of design pitfalls including the following have been experienced, causing quota systems to under-perform:

- Uncertainty in the duration or design of the quota policy;
- Quota targets and eligibility rules that do not require new renewable capacity development;
- Unclear or inadequate enforcement of the quota;
- Quota targets that are too aggressive to be achieved;
- Extensive exemptions of potential retail suppliers obligated to meet the quota; and
- Inadequate compliance flexibility.

Overall, experience with the quota schemes in the US has been decidedly mixed. Where the RPS scheme is mainly based on competitive bidding and long-term contracts with suppliers, they appear to be working effectively and efficiently. As previously mentioned, RPS programs appear particularly problematic in restructured electricity markets where retailers are uncertain of their future load obligations, and are therefore sometimes unwilling to enter into long-term contracts. Despite the mixed experiences, quota policies are likely to remain the predominant form of support for renewables in the US, at least in the near term.

4.3.3. Renewable energy schemes in Japan

In 2003, Japan introduced an RPS scheme requiring that approximately 1.35% of each retail supplier's sales in 2010[44] come from eligible RES, defined as PV, wind, biomass, geothermal and small hydropower (1MW or less), rising to 1.63% by 2014. Electricity from PV is credited at two times the value from 2011 to 2014. To be certified the renewable electricity must be sold to the grid. The total target has been set to increase from 3.3 TWh in 2003 to 12.2 TWh in 2010 and 16 TWh by 2014. The targets are low[45] compared to those in the Europe and the US, partly because large hydropower and geothermal are ineligible under the scheme and also because a considerable amount of electricity generated from biomass is consumed for self use.

As with other RPS schemes, retail suppliers and renewable generators may trade certificates and banking as borrowing of certificates up to 20% of the target are allowed. The maximum price of the certificate is set at 11 JPY/kWh (approx. 9 US cents/kWh). The total amount of RES supplied in 2005 was 5.6TWh[46], which exceeded the actual target of 3.8TWh. The targets from 2006 to 2009 were revised upward by 4 TWh in total as a part of the review process conducted in 2006.

[44] All dates are fiscal year (from April to March) in Japan
[45] Renewables currently account for roughly 10% of Japanese generation
[46] The mix was PV 0.46TWh, wind power 1.91TWh, biomass 2.50TWh, and small hydropower 0.70TWh.

Since the enactment of the RPS scheme, renewable generation has steadily increased (Figure 4), a trend that is expected to continue (Nishio and Asano, 2006), while prices have declined. The certificates were traded at a relatively stable price range of around 5 JPY/kWh (approx. 6 US cents/kWh) from 2003 to 2005 (Figure 11), presumably because the transaction prices are determined with taking the banking into consideration from a long-term viewpoint.

Promotion of PV

Several large-scale programs to promote PV have been implemented in different parts of the world, the cumulative effect of which are shown in Figure 15. Three of the most significant are briefly described.

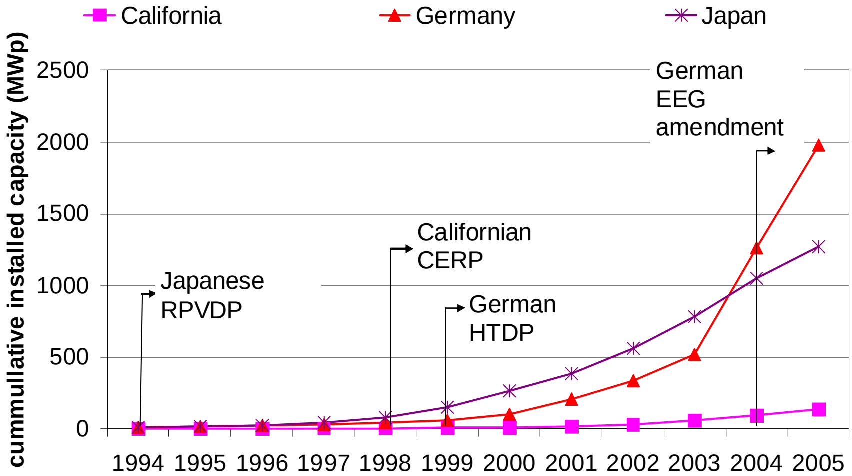

Figure 15. Cumulative installed PV capacity in selected markets

Source: Lopez et al 2007

Japanese Residential PV Dissemination Program

A subsidy program for promotion of PV in the residential sector in Japan was launched in 1994. By the end of 2005 when the subsidy program was terminated[47] it had resulted in over 1 GW of new capacity and the average cost of a residential PV system had dropped by more than half (Figure 16). The subsidy program succeeded in creating a market, which accounted for less than 1% of the whole residential market, but was large enough to justify large investments in mass-production facilities.

Several factors contributed to success of the program including a consistent technology-push policy[48] (Kimura and Suzuki, 2006). However it is not clear if the momentum of the program will continue following the termination of investment subsidies in 2005. It is not likely that additional promotion schemes in the residential sector will be launched by the government, currently focusing on R&D support for innovative PV technologies as well as subsidies in the non-residential sector. Moreover, the future role of the voluntary net-metering schemes currently offered by the power companies is not certain.

[47] Several local governments are continuing financial support programs.

[48] The Japanese government has been providing larger and more stable R&D budgets for PV over the last quarter century than other major producing countries such as the US and Germany according to IEA's R&D statistics. Also, for reference, the overall budget related to new energy technologies by METI (Ministry of Economy, Trade and Industry) has tripled from 48 billion JPY in FY1996 to 156 billion JPY in FY2006.

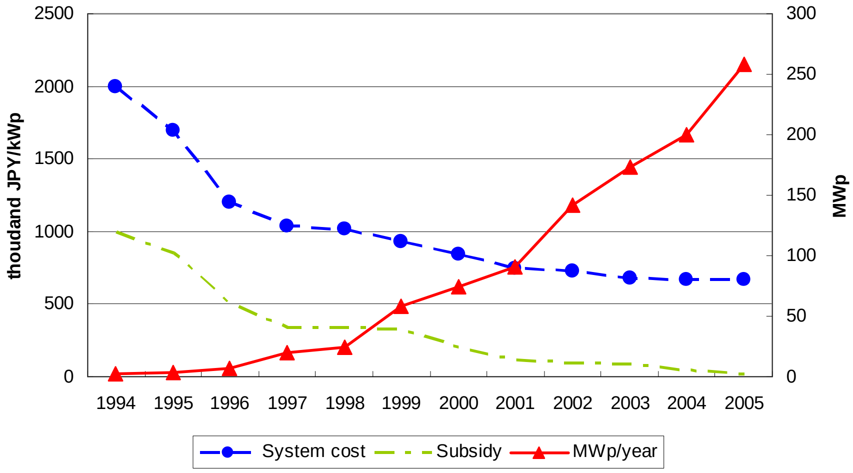

Figure 16. The Japanese residential PV promotion program
Source: Lopez et al 2007, NEF2006

German Rooftop PV Programs

The first major promotional program for residential PV was the 1000 roofs program launched in Germany in 1989 and completed in 1994. The scheme resulted in installation of PV systems with an average size of 2.6 kW and a total capacity of 6.15 MW on some 2,250 German roofs. Average system cost was US$15,000/kW with subsidies covering 70% of the investment costs.

An expansion of the first scheme, called the 100,000 Roofs Program, was launched in 1999 with the aim of reaching 100,000 installations with an average size of 3kW for a total installed capacity of 300 MW. Low-interest loans were provided as the main inducement, initially set at 0% and with a payback time of ten years. The initial response to the program between 1999 and 2002 was rather modest (Figure 17) and the program suffered from a number of stops and starts. In 2000 the interest rate was raised to 1.8% and favorable feed-in tariffs of 50.6 €Cent/kWh were introduced. The combination of the low interest and FIT led to an impressive uptake resulting in deployment of 261 MW.

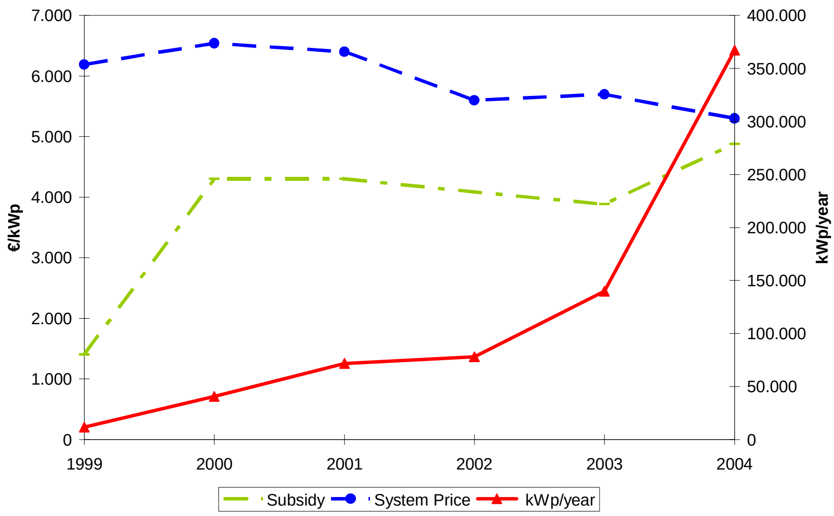

Figure 17. The German 100,000 roofs programme
Source: Lopez et al 2007

California's PV Programs

California is the market leader for grid-connected PV in the US driven by a mixture of state and local incentives as well as plentiful sunshine. Historically, PV technology has been supported through capital cost rebates – denominated in $ per Watt – offered to PV system installers or owners to buy down the installed cost of solar installations , though more recently performance based incentives have also been used. Incentive programs have been supported by the California Energy Commission (CEC) and the California Public Utilities Commission (CPUC), as well as the state's publicly owned utilities.

The CEC has administered a PV incentive program called the Emerging Renewables Program since 1998. As of the end of 2005, the CEC had paid out incentives to over 15,000 PV systems, totaling 62 MW in capacity. The CPUC's Self-Generation Incentive Program (SGIP) began accepting applications in 2001 and offered rebates for customer-sited PV systems of at least 30 kW in size[49] and installed by customers taking electric or gas service from one of the state's private utilities. As of the end of 2005, the CPUC had paid out incentives to 403 PV systems, totaling 49 MW.

Over time, both the CPUC and the CEC programs have altered the structure and size of their incentives for PV installations. The CPUC initiated its incentives at $4.5/W and dropped the incentive level to $3.5/W in December 2004; the CPUC further reduced the incentive to $2.8/W for applications received after December 2005. The CEC's standard incentive started at $3/W, increased during the state's electricity crisis to $4.5/W and then declined to $2.6/W. At the beginning of 2007, California's solar programs were been restructured, including a move towards performance ($/kWh) based incentives.

As shown in Figure 18 customer response to these incentives was disappointing at first, with relatively little PV capacity being added through 2000. Demand for PV increased substantially after 2000, mainly as a result of the state's electricity crisis in 2001 and in response to the higher rebates offered at that time (Bolinger and Wiser 2002). Cost reductions under the program have been substantial, at least for smaller systems.

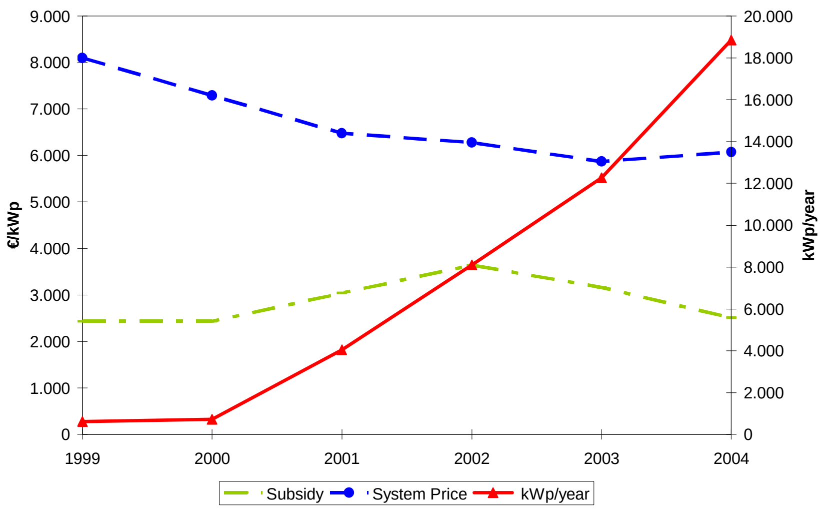

Figure 18. California's Emerging Renewables Buydown Programme (CERBP)
Source: CEC

[49] Systems can exceed 1 MW in size, but the rebate only applies to the first 1 MW

Meanwhile, the state government in 2006 established the California Million Solar Roofs initiative, with a goal of encouraging 3,000 MW of new solar PV systems through a long-term, sustained, declining incentive program. The CPUC – in conjunction with the CEC – has developed an implementation plan for this initiative, which includes performance-based payments for the majority of systems over 30 kW in size, replacing the current up-front rebates. The program is envisioned to be significant is size (~$3.2 billion) and stable (~11 years) enough to significantly reduce system costs over time.

Investment-based Tax Incentives

A number of options have been used to promote renewables with fiscal instruments including:

- Lower VAT-rate applied for renewable electricity systems;
- Making dividends from RES-investment exempt from income taxes; and
- Tax credits for investments in RES.

These options have similar impact, acting as investment subsidies for new installations. Table 6 gives an overview of existing investment-based tax incentives in EU countries, and the US.

Table 6. Investment-based tax incentives in various EU countries and the US as of end of 2006

Sources: Ragwitz et al 2007, www.dsireusa.org

Country	Investment-based tax incentives
Austria	Private investors get tax credits for investments in using renewable energies (personal income tax). The amount is generally limited to 2.929 € per year
Belgium	13.5 – 14% of RES-investments deductible from company profits, regressive depreciation of investments. Reduced VAT on building retrofit if energy efficiency is included (6% instead 21%)
Denmark	The first 3000 DKK of income from wind energy are tax free.
France	Deduction of 15% investment costs with a maximum of 3000 € per person. Reduced VAT (5.5%) on renewable equipment (not applicable to installation costs)
Germany	Losses of investments can be deducted from the taxable income. This fact increases return on investments into wind projects
Greece	Up to 75% of RES-investments can be deducted
Ireland	Corporate Tax Incentive: Tax relief capped at 50% of all capital expenditure for certain RES-investments
Italy	VAT reduced to 10% for investments in wind and solar; 36% deduction of PV, solar thermal and energy efficiency investments up to 54.000 € (55% from 2007)
Portugal	Up to 30% of any type of investments on RES can be deducted with a maximum of 700 € per year. Reduced VAT (12%) on renewable equipment
Spain	Corporation Tax: 10% (up to 20% in some autonomous regions) tax liability instead of 35% for investments in environment friendly fixed assets.
The Netherlands	EIA scheme: RES-investors (most renewable energy systems) are eligible to reduce their taxable profit with 55% of the invested sum. Lower interest rates from Green Funds: RES-investors (most renewable energy systems) can obtain lower interest rates (up to 1.5%) for their investments. Moreover dividends gained are free of income tax for private

	investors.
United States	30% federal investment tax credit available for solar installations (capped at $2000/system for residential users; up-capped for commercial systems). Favorable 5-year accelerated tax depreciation for most “new” RES-E A number of states offer their own income, sales, and property tax exemptions and incentives.

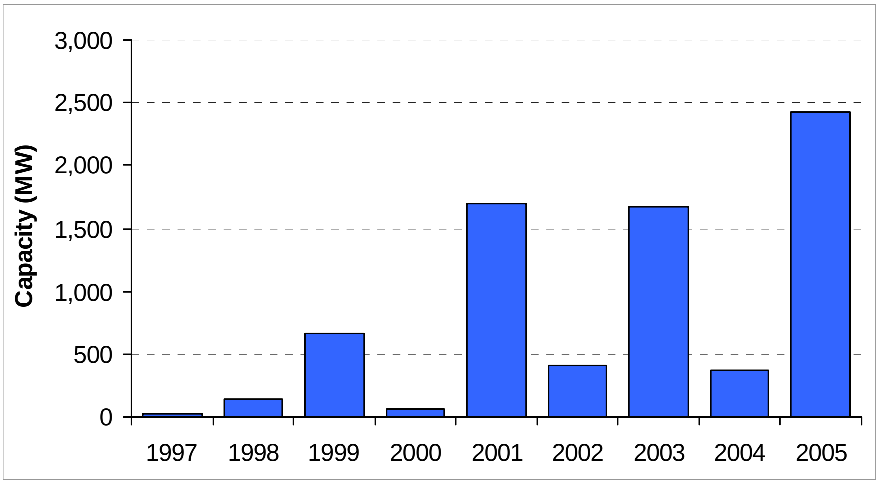

Figure 19. U.S. wind power additions, by Year,

Source: AWEA 2007, www.awea.org/faq/instcap.html

One of the best-known tax incentives is the US federal production tax credit (PTC), which has been in place since 1994. The incentive is based on production, rather than investment, and is currently valued at 2.0 cents/kWh. Development of wind power in the US in recent years has been strongly tied to the PTC combined with a number of state-level quota systems. Even where quota systems are not in place, wind development now occurs in some states based on the PTC alone. Unfortunately, the PTC has expired and been re-instituted with regularity making it difficult for developers, investors and financiers to plan ahead, and resulting as a boom-and-bust cycle of wind development as shown in Figure 19.

Mixed strategies: Wind energy in Denmark

In terms of large-scale integration of wind power in the electricity system, Denmark is in a class of its own. In 2005, nearly 20% of the country’s electricity consumption was produced with wind power[50]. The western part of the Danish grid, which is not connected to the grid in the east, gets 24% of its electricity from wind power (www.ens.dk).

The major reason for this impressive record is that wind power has had a prominent role in the Danish energy plans from 1990 and 1995. The target for wind in 2005 was an installed capacity of 1,500 MW or around 10% of Danish electricity demand. This target was exceeded by a factor of two by 2003, where the installed wind capacity passed the 3,000 MW mark (Meyer, 2005).

Additionally, Denmark has enjoyed a stable legal framework and a favorable FIT scheme supported by successive governments. This created a stable investment climate in the 1990s

[50] Adjusted to an average wind year.

and ensured that the overall energy policy did not change dramatically until a shift occurred in 2001 with the arrival of a liberal-conservative government. Another contributing factor was the introduction of a comprehensive wind atlas showing the local potential for wind energy in different parts of the country (Petersen et al 1981).

Prior to 1990s, the majority of renewable generators were cooperatives who enjoyed tax exemptions for their shareholders, guaranteed minimum price system and preferential treatment for the neighborhood. Starting in early 1990s Danish municipalities were forced to indicate sites suited for wind power generation. At that time many farmers saw an advantage in owning their own turbines as a financial investment that could be written off on the business account of the farm. This possibility was not available for the cooperatives. As a result many of the new turbines in the late 1990s were owned by farmers and developers. Since 2001, anyone, including investors from abroad, may own wind turbines in Denmark. At the end of 2006 nearly 5,500 wind turbines were operating in the country.

In 2004, a political agreement was reached by the Danish Parliament to increase wind power capacity over the coming years by some 350 MW through a repowering scheme. Furthermore, the agreement included two tenders for offshore wind farms of 200 MW each, together with a decision to introduce full legal and ownership unbundling by separating transmission and production of electricity. This is expected to increase wind power's share of Danish power generation to 25% by 2008. Beyond 2008 it is expected that most of the development will have to be offshore and by the replacement of older onshore turbines.

The Danish Wind Associations has proposed a goal of 50% wind power by 2025 in the Danish energy mix with the installation of 200 MW per year. A recently published analysis from the association[51] shows that wind power's share of Danish electricity consumption could be increased from the 20% or 6.6 TWh in 2004 to 50% or19 TWh while reducing the number of wind turbines by more than two thirds, from the current 5,500 to 1,750. The turbine types onshore are assumed to be 1 MW, 1.5 MW and 3 MW machines, all commercially available today, while the offshore turbines are assumed to be 4 MW and 6 MW turbines.

51 As recently published in (Danish Wind Turbine Owners Association, 2005).

5. What works and why?

Reviewing the variety of schemes and instruments described above one is tempted to ask whether these programs have been successful and if so by what measure? The two most important criteria are effectiveness and economic efficiency. Additional criteria include credibility of the scheme for investors and the reduction of generation costs over time. Table 8 provides a summary of the relevant performance parameters, which are further described below.

Table 8. Summary of performance parameters

	Period of time analysed	RES quantity deployed (W/cap yr)	Magnitude of absolute support level	decrease in support over time?	Risk for investors	Other important aspects
FIT&premium:						
US (PURPA)	1978-1990	Medium	high	No	low	
Denmark	1992-1999	high	low	No	low	
Germany	1998-2005	high	medium	Yes	low	
Spain	2002-2005	high	low (fixed option); medium (premium)	Yes	low	
Austria	2002-2005	high	Medium	No	low	Support level to high because of parallel investment subsidies
Portugal	2002-2005	high	Low	No	low	
France	2002-2005	low	Medium	No	low	High administrative barriers
RPS and quota-based TGC:						
UK (RO)	2003-2005	low (quota not met)	High	Yes	Medium/hi gh	Penalty too low
Italy	2003-2005	Low	High	No	high	Time of validity of RES plants for certificates too low (8 years)
Sweden	2003-2005	high (quota met)	Low	Constant	medium	Windfall profits due to some old capacities also qualifiying for certificates
Belgium	2003-2005	low (quota not met)	High	No	Medium/hi gh	low penalty, Windfall profits due to some old capacities also qualifiying for certificates
Texas	2003-2005	High (quota met)	Low	No	Low/Medi um	Low with long term contracts available
Massachusetts	2003-2005	Medium (quota not met)	High	No	High	Few longer-term contracts available TGCs
Japan	2003-2005	Low (quota met)	Medium	No	Low	
Tendering:						
UK (NFFO)	1990-1998	low	Low	Yes	Low after selection	Capacities to low

Effectiveness of policy instruments

To examine the effectiveness, one must look at the relevant outcome, in this case the quantities generated or capacities installed and so on. To make relevant comparison among different countries, the figures must be examined by capita. Moreover, one must examine all new RES as well as specific types such as wind and PV.

Figure 21 shows policy effectiveness of different policies for electricity generation from all new RES for the period 1998-2004 for EU, US and Japan measured in terms of incremental amount of RES installed per year and capita. Not surprisingly, Denmark ranks the highest on this score with about twice as high renewable electricity deployed than the next ranked countries Finland, Sweden, Spain and Germany. It should be noticed, however, that since 2003 the net increase in wind power capacity has been close to zero in Denmark.

Many of the variations in Figure 20 can be attributed to different promotion schemes such as the quota-based TGC system in Sweden as opposed to investment incentives in Finland and FITs in the other countries. Other factors also play a role such as the availability of inexpensive hydro electricity in Nordic countries and plentiful supplies of cheap electricity from biomass. Moreover, progress was generally much slower in new EU member states than in the old EU-15 countries. Of the former, Hungary and Latvia showed the highest relative growth in the period considered. The US and Japan deployed clearly less new RES electricity per capita than the EU-25.

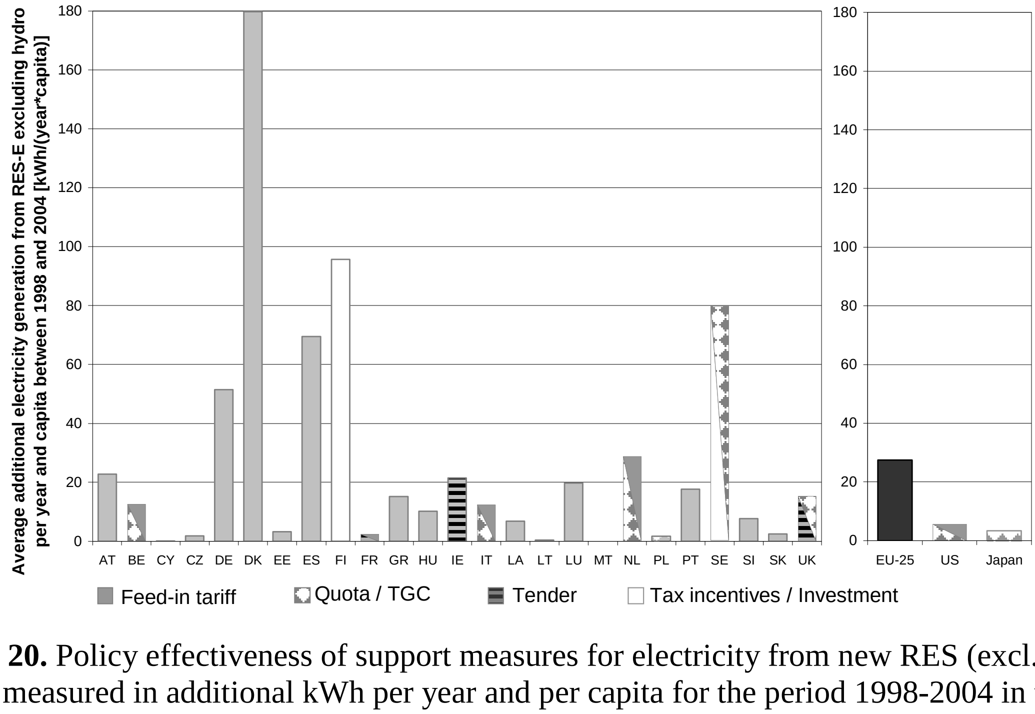

Figure 20. Policy effectiveness of support measures for electricity from new RES (excl. hydro) measured in additional kWh per year and per capita for the period 1998-2004 in the EU, the US and Japan
Sources: EUROSTAT 2006, IEA 2006b, METI 2007, Black & Veatch 2006

Looking at onshore wind (Figure 21) the EU countries with the highest policy effectiveness during the considered period – Demark, Germany, and Spain – are the ones that applied fixed FITs during the entire period 1998-2005, except for Denmark which had a change in 2001. The resulting high investment security as well as low administrative barriers stimulated a strong and continuous growth in wind energy during the last decade. By contrast, high administrative barriers in countries like France can significantly hamper the development of wind energy even under a stable policy environment combined with reasonably high FITs.

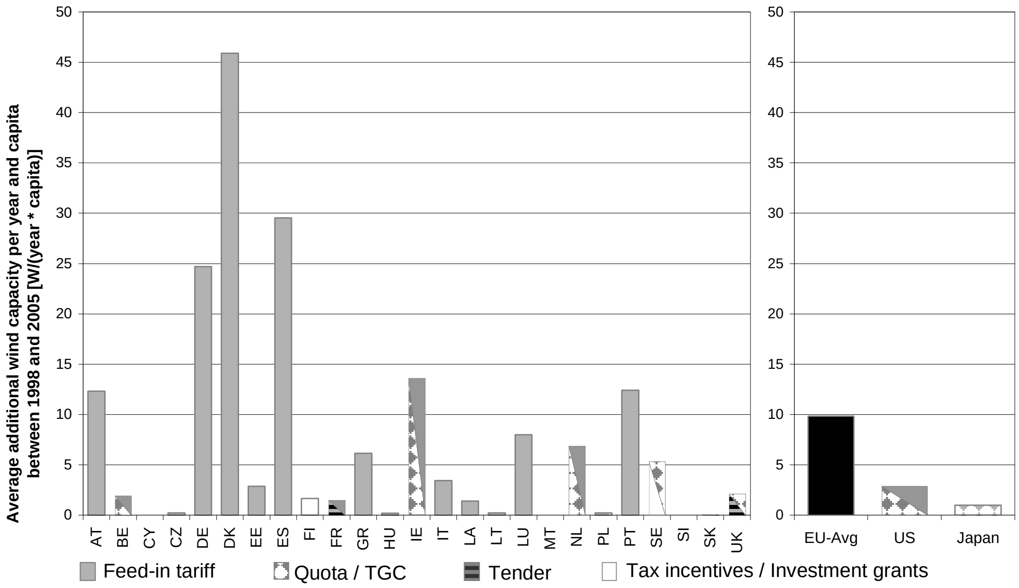

Figure 21. Policy effectiveness of onshore wind onshore measured in additional capacity per year and per capita in the period 1998-2005 in the EU, the US and Japan
Sources: EUROSTAT 2006, IEA 2006b, METI 2007, Black & Veatch 2006

With respect to PV – currently one of the most expensive among renewable technologies – Germany and Japan show the highest effectiveness based on this particular measure (Figure 22). Obviously, generous FITs – as in Germany and Luxembourg, combined with net metering and rebates in Japan, produce results.

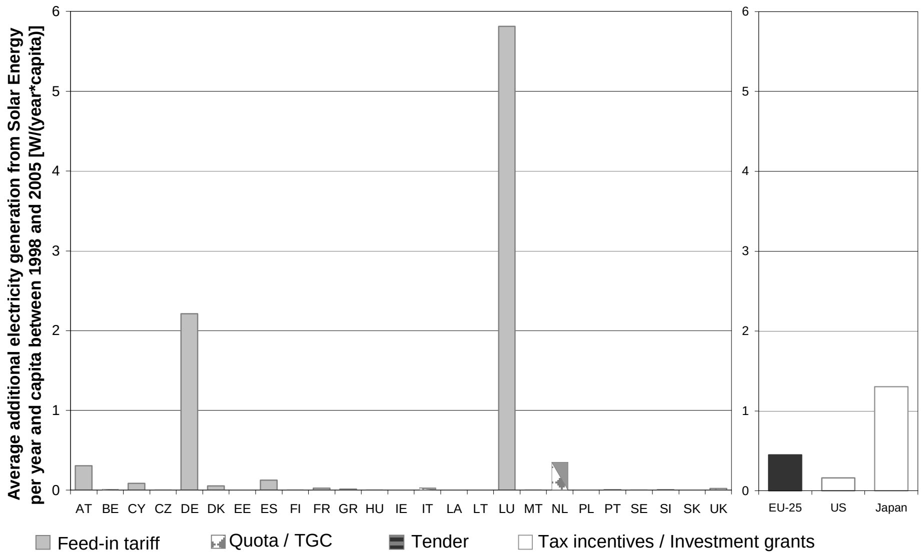

Figure 22. Policy effectiveness of PV electricity support measured in additional capacity per year and per capita in the period 1998-2005 in the EU, the US and Japan
Sources: EUROSTAT 2006, IEA 2006b, METI 2007, Black & Veatch 2006

Economic efficiency

In examining economic efficiency three parameters are of interest: absolute support levels, total costs to society and dynamics of the technology. As an indicator in the following the support levels are specifically compared for wind power in the EU-15[52].

Figure 23 shows that for many countries the support level and the generation costs are very close. Countries with rather high average generation costs frequently show a higher support level. A deviation from this trend can be found in the three quota systems in Belgium, Italy and the UK, for which the support is presently significantly higher than the generation costs. The reasons for the higher support level expressed by the current green certificate prices may differ. Main reasons are risk premiums, immature TGC markets, and short validity times for the certificates, which apply to Italy and Belgium.

For Finland, the level of support for onshore wind is too low to initiate any steady growth in capacity. In the case of Spain and Germany, the support level indicated in Figure 23 appears to be above the average level of generation costs. However, the potentials with rather low average generation costs have already been exploited in these countries due to the recent successful market growth. Therefore a level of support that is moderately higher than average costs seems to be reasonable even if it results in windfall profits for some wind power owners.[53] In an assessment over time also the potential technology learning effects should be taken into account in the support scheme.

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[52] A comparison of all new RES would provide too broad ranges for generation costs as well as for support measures.

[53] Under TGC all the technologies receive the marginal cost, i.e. there is a higher profit for some low cost technologies (wind power, biogas in Italy). Under high quantitative targets this can result in higher costs for the electricity consumers.

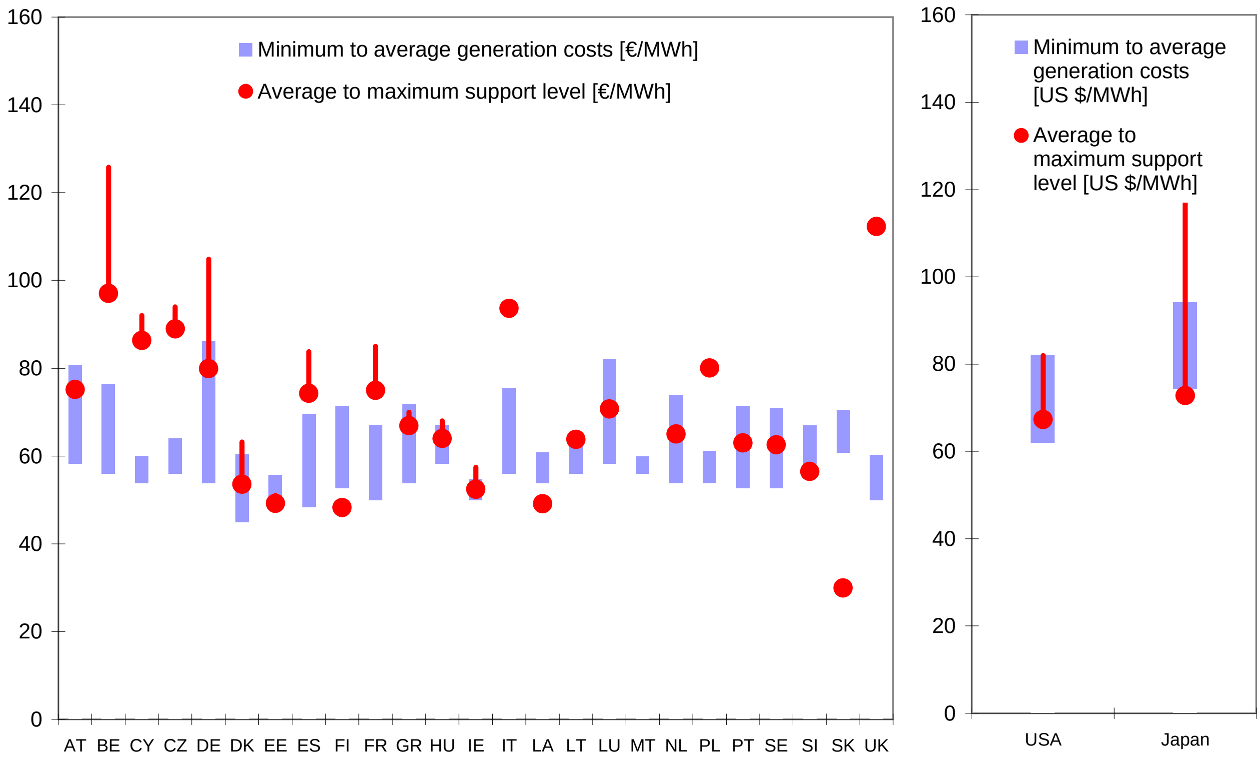

Figure 23. Support levels for onshore wind (average to maximum) in the EU, US, and Japan in 2005[54] (Source: Adapted from Ragwitz et al 2007).

Quantities vs costs of support

Next the relation between quantities deployed and the level of support is analysed. It is often argued that the reason for higher capacities installed is a higher support level. And it is accepted that the resource endowments of RES vary from country to country. Paradoxically, countries with highest support levels – Belgium and Italy for example – are among those with the lowest specific deployment (Figure 24). On the other hand, high FITs especially in Germany and Spain are often named as the main driver for investments especially in wind energy. However, the support level in these countries is not particularly high compared with other countries analysed here.

[54] Minimum to average generation costs are shown because this range typically contains presently realisable potentials which investors would normally deploy in order to generate electricity at minimum costs. Furthermore, the maximum generation costs can be very high in each country so that showing the upper cost range for the different RES-E would affect the readability of the graphs

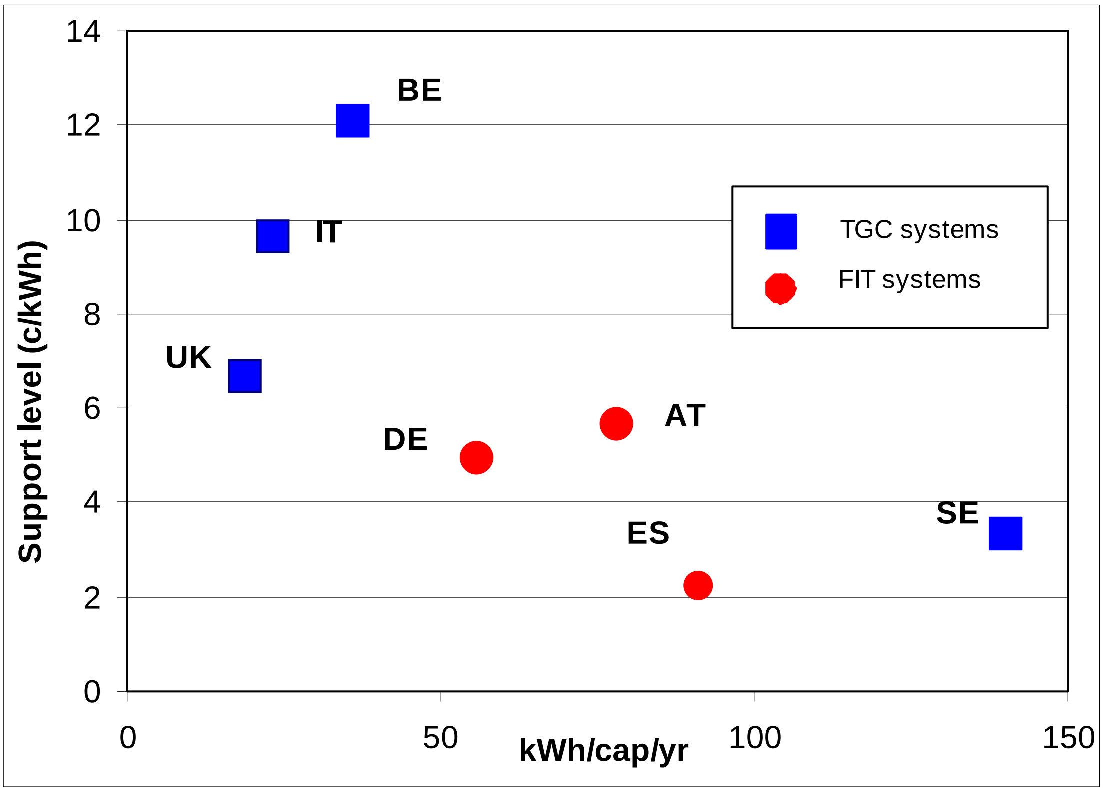

Figure 24. Effectiveness vs costs of promotion programmes for electricity from RES in selected countries (2002-2004)

Source: own investigations

What triggers investments?

Analyzing the various promotional strategies from the point-of-view of investors may allow a better understanding of program costs and help in the design of more efficient schemes (Langniss, Wiser, 2003; Finon, Perez, 2007).

FIT schemes and tendering instruments may work well in combination to promote both mature and less mature technologies. In fact there are similarities of producer-buyer arrangements with respect to these systems. The risks to purchasers and generators is largely alleviated in cases of FITs and tendering. This is due to long-term contracts ensured by governments. One should note, however, that in the tendering system, transaction costs are much higher for the developer than in the FIT system, due to the cost of preparation for the bid in the tendering process.

In the quota-based TGC systems, multiple risks for the investors may emerge resulting in strong preference for long-term arrangements. The strong bilateral interdependence between developers and obligated purchasers may lead to long-term contracts and to vertical integration. Recourse to spot transactions of green certificates has turned out to be only marginal in determining the certificate price. For small and medium sized suppliers with uncertain demand, there remains a tension between the risk associated with the uncertainty of future loads and the certificate obligation as well as the efficiency of managing the risks by long term contracting - as shown in the RPS programs which are set in some of the most liberalized US electricity markets.

However, some authors (e.g., Lemmings, 2003) argue that with regard to financial risks, the TGC/quota systems may give incentives to renewable electricity developers to avoid contracts with forward fixed price because the spot market will give higher prospects for profit.

Four elements play against this view. Firstly, volatility and price risk are high because the size of the certificates market is small. Secondly, in the case where RES producers sell green electricity as two products (electricity sale on one hand and green certificates on the other), the risk to the green certificate price is added to the risk of the wholesale electricity price. Certificates banking which is supposed to help the obligated suppliers to respect their quotas can increase the lack of liquidity in a period of tight supply of certificates. Thirdly, transactional complexity which results from intermittence of RES generation also influences the choice of long-term contract. The absence of a purchase obligation on physical electricity (it is only a quota of certificates) reinforces the producer's incentive to conclude long term contracts in order to simplify transactions[55]. Fourthly, the price of certificates is affected by a number of risks, in particular the regulatory risk arising from an eventual alteration in the renewables portfolio of eligible technologies (adding a cheap technology – e.g. co-firing or burning waste – may lower the prices because it increases the quantity of available certificates). In addition comes the risk of large actors exercising market power. So the RES producers have good reasons for negotiating contracts with buyers who are subject to quotas.

Furthermore, it is important to underline than most of the quantity-based instruments (European TGCs, American RPS programs) win in effectiveness when they benefit from reinforcement by subsidy on investment or on production In the UK, technology-specific investment grants selected by tendering for projects based on second-ranked technologies complement TGC systems in order to mitigate their drawback in fostering variety in technological deployment. In the US the quite recent combination of the renewed federal support by tax credit on production and RPS programs have had important revival effect as shown by the recent wind power capacity growth (see Fig. 19).

The above reflections indicate that a long-term and stable policy environment for potential investors - with favourable economic support schemes – may be the key criteria for the success of developing renewables markets.

Cost evolution of technologies

The cost reduction of the renewable technologies is another important criteria for evaluating the efficiency of policy instruments in relation to technological learning. In the following the development of costs for onshore wind and PV are examine.

The development of investment costs for wind turbines from the early 1980s until 2005 in Europe and the US is shown in Figure 25. In both regions, costs have dropped significantly. In Europe, costs decreased from around 2,500 EUR/kW in 1982 to 1,500 EUR/kW in 1990 and further to below 1,000 € in 2000. Since then costs have stagnated due to shortage of turbines in a fast growing market.

[55] Long-term contracts also define the party which pays the balancing costs: generally the obligated suppliers assume them.

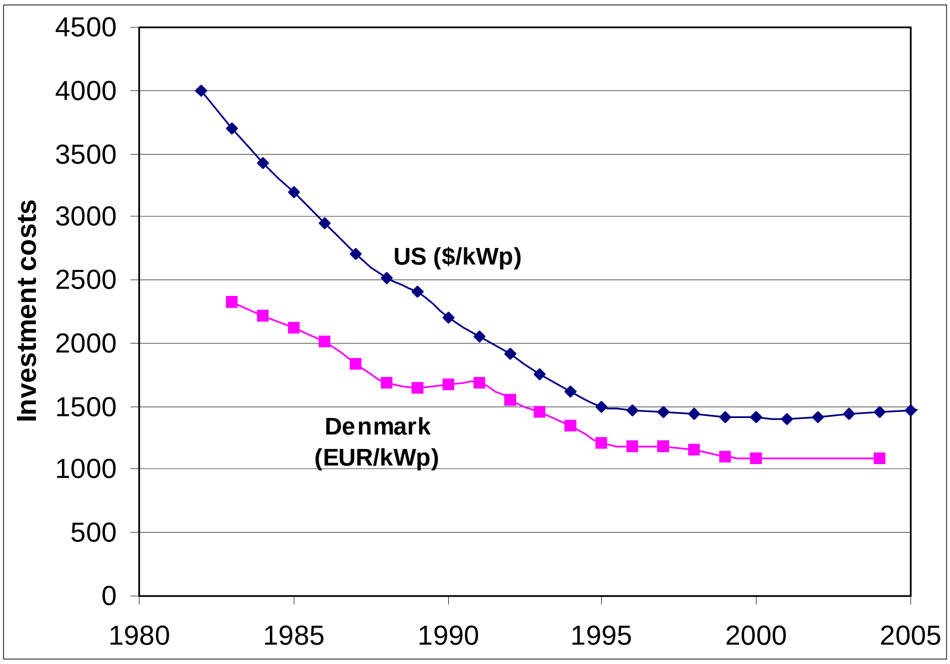

Figure 25 Development of the investment costs of wind turbines in Europe (data based on Denmark and Germany.
Source: Nej at all 2003, Morthorst 2006, Wiser and Bolinger 2007. Data are in real 2006 prices.

A similar trend can be observed in the US where installed wind projects costs are shown extending back to 1982, including both proposed and online projects. A significant drop in investment costs[56] up until about 1996 can be seen, and followed by stagnation and, more recently a rise. Similar trends can be observed for PV system costs, where high global demand have resulted in high profits for developers.

The cost development for electricity generation from (small) PV systems in different countries is shown in Figure 26 where the decreasing cost trend has been replaced by stagnation and even a slight increase in costs during recent years. This is mainly due to shortage of basic silicon material for the production of traditional PVs in a fast growing market. Also, the recent stagnation of cost reduction implies that a further technology innovation is required for PVs in order that they become economically competitive with conventional power plants[57].

[56] The data included in this graphic include information on 265 wind projects totaling 17,420 MW.
[57] For a more detailed analysis of the development of the costs of different components see Lopez/Haas (2006).

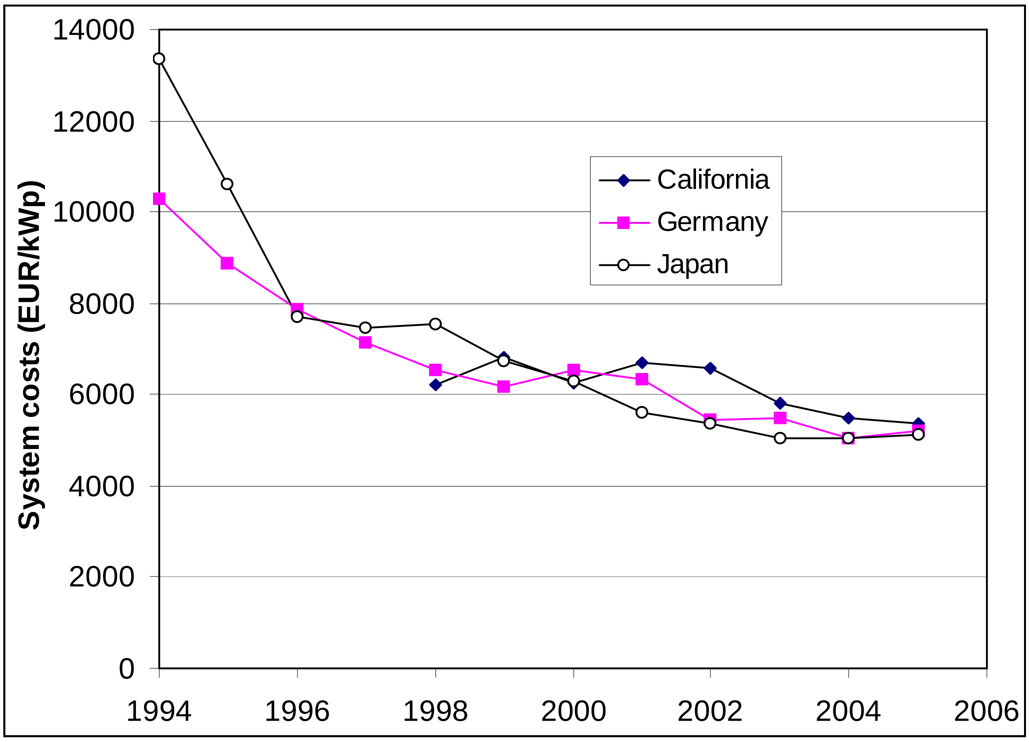

Figure 26. Cost reductions of PV systems over time (Source: Lopez/Haas et al 2007, Data are in real 2000 prices)

With respect to the price development in California Wiser et al. (2006) argue that the lack of a sustained long-term policy commitment may be reducing the incentive for cost reductions. Moreover, PV prices have been fluctuating along side rebate levels; PV prices increasing with rises in rebate levels - and falling with rebates drops. This means that subsidy variations, if not designed with care, may be used by retailers to increase their own profits to the disadvantage of consumers in a sellers market. Perfect competition only exists in theory, and this should be taken into account when designing support schemes.

6. Conclusions

Clearly, a wide range of policy instruments have been tried and are in place in different parts of the world to promote renewable energy technologies. The design and performance of these schemes varies from place to place, requiring further research to determine their effectiveness in delivering the desired results. The main conclusions that can be drawn from the present analysis are:

- Generally speaking, promotional schemes that are properly designed within a stable framework and offer long-term investment continuity produce better results. Credibility and continuity reduce risks thus leading to lower profit requirements by investors.
- Despite their significant growth in absolute terms in a number of key markets, the near-term prognosis for renewables is one of modest success if measured in terms of the percentage of the total energy provided by renewables on a world-wide basis. This is a significant challenge, suggesting that renewables have to grow at an even faster pace if we expect them to contribute on a significant scale to the world's energy mix.

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