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The Performance of Feed-in Tariffs to Promote Renewable Electricity in European Countries

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Abstract
Over the past decade, feed-in tariffs have been a major instrument of European countries to promote the generation of electricity by means of renewable energy sources. This paper discusses the performance of feed-in tariffs to stimulate renewable electricity in European countries, particularly in Germany, Denmark and Spain. It concludes that a system of premium feed-in tariffs has shown to be an effective instrument to promote the generation of renewable electricity, notably to ensure a low-level market take-off of wind power at the national level. In the longer term, however, such a system may become hard to sustain as it may suffer from some major drawbacks, especially when the generation of green electricity accounts for a significant share in total power production. These disadvantages refer particularly to the fact that a system of fixed premium prices tends to be costly, inefficient, distortive of competitive pricing and, hence, incompatible with the creation of a single, liberalised electricity market in Europe.

CONTENTS

1. INTRODUCTION

Over the past decade, feed-in tariffs have been a major instrument of European countries to promote the generation of electricity by means of renewable energy sources. More specifically, these tariffs have been very effective in stimulating wind power, notably in countries such as Germany, Denmark and Spain. On the other hand, feed-in tariffs have been criticised for being costly, inefficient, distortive of competitive pricing and, hence, in the long run not compatible with the creation of a single, liberalised electricity market in Europe in which renewable energy sources account for a major share in total power production.

This paper discusses the performance of feed-in tariffs in European countries with regard to the generation of electricity from renewable energy sources. First of all, Chapter 2 will pay some brief attention to the definition and determination of feed-in tariffs. Subsequently, some experiences in European countries – notably in Germany, Denmark and Spain – will be dealt with in Chapter 3. Next, Chapter 4 will evaluate the performance of feed-in tariffs in European countries, followed by some concluding remarks in Chapter 5.

2. DEFINITION AND DETERMINATION OF FEED-IN TARIFFS

In the literature, the concept 'feed-in tariff' is sometimes used in slightly different meanings. Usually, this term refers to the regulatory, minimum guaranteed price per kWh that an electricity utility has to pay to a private, independent producer of renewable power fed into the grid. Occasionally, however, the concept 'feed-in tariff' is used for the total amount per kWh received by an independent producer of renewable electricity, including production subsidies and/or tax refunds, while in exceptional cases it refers only to the premium price paid above or additional to the market price of electricity (Monthorst, 1999; Huber et al., 2001; Haas et al., 2001). Unless stated otherwise, feed-in tariffs in the present chapter will be used to express the full price per kWh received by an independent producer of renewable energy, i.e. including the premium above or additional to the market price, but excluding tax rebates or other production subsidies paid by the government.

Feed-in tariffs may be based on either the so-called 'avoided costs' of non-renewable power producers or the electricity price charged to the end-user, supplemented by a bonus or premium in order to account for the social or environmental benefits of renewable electricity. On the other hand, feed-in tariffs may also be fixed at a certain level just to encourage the generation of renewable electricity without any direct relation to the costs or price of non-renewable power production. Although feed-in tariffs may be set at a uniform level, they are often differentiated depending on the renewable technology used – wind, PV, biomass, etc. – or on other variables such at the time or season of feeding renewable energy into the grid. In addition, the system of determining feed-in tariffs may be either fixed for a certain, multi-annual period – in order to provide renewable energy producers certainty in the medium or long term – or adjusted periodically in order to maintain some flexibility and to account for unforeseen cost reductions of renewable power production. Finally, the level and importance of feed-in tariffs may vary significantly among countries, depending on national characteristics such as the potential and costs of renewable resources or the political preferences regarding policy instruments to promote renewable electricity.

3. EXPERIENCES WITH FEED-IN TARIFFS IN EUROPEAN COUNTRIES

3.1 Germany

Feed-in tariffs in Germany have been officially introduced since January 1, 1991 when the so-called 'Electricity Feed Law' (EFL) came into force. In April 1998, the EFL was amended at certain points, while two years later – in April 2000 – it was decisively revised and replaced by a new act called the 'Renewable Energies Law' (REL).

The EFL of 1991 regulated the purchase and price of electricity generated in the territory of the Federal Republic of Germany from specified renewable sources (i.e. hydropower, wind energy, solar energy, landfill gas, sewage gas, and biomass). Excluded from the law were (i) installations using resources other than wind or solar energy with an installed capacity of more than 5 MW, and (ii) installations in which the Federal Republic of Germany, a federal state, a public electricity utility or one of its subsidiaries held shares of more than 25 percent (Gipe, 2001).

The EFL obliged the grid companies to purchase renewable electricity from eligible sources and to pay the producers concerned an annually fixed feed-in tariff. For power generated from solar or wind energy, the tariff was set at 90 percent of the average electricity utility rate per kWh of all final consumers charged over the last but one calendar year. Hence, if consumers had paid, on average, 10 €ct/kWh in 1993, a farmer exploiting a wind turbine received 9 Eurocents for every kWh fed into the grid in 1995. For electricity produced from other eligible sources of renewable energy, the corresponding feed-in tariffs were set at lower rates – i.e. either 80 or 65 percent of the average consumer price – depending on the output capacity of these sources (for details, see Table 3.1).

Table 3.1 *Germany: Feed-in tariffs for electricity from renewable energy sources during selected years of the EFL-period January 1991 – March 2000 [€ct/kWh][a]*

	1991	1994	1997	March 2000
Wind/solar[b]	8.49	8.66	8.77	8.23
Biomass (< 5 MW)/Hydro, sewage and landfill gas (< 500 kW)	7.08	7.21	7.80	7.32
Hydro, sewage and landfill gas (500 - 5000 kW)	6.13	6.25	6.33	5.95

a. The exchange rate of 1.96 DM/Euro is used throughout.
b. Starting from 1998, the feed-in tariff for solar was 50.6 €ct/kWh.
Source: IWR (1999)

As part of the EFL amendment of 1998, a so-called 'hardship clause' or 'cap' of 5 percent on the purchase obligation of grid companies was introduced. This clause stipulated that if the amount of renewable electricity to be supported by a power utility surpassed 5 percent of its total deliveries in one calendar year, the upstream system operator had to reimburse the costs of purchasing additional renewable electricity until it also reached the 5 percent ceiling in its grid area. Actually, this implied that beyond the 5 percent threshold, the utility was no longer obliged to purchase renewable electricity offered to the grid.

Besides other support mechanisms such as preferential planning guidelines and lower interest rates for loans to invest in wind turbines, the EFL was particularly successful in stimulating the installed capacity of wind energy in Germany. After the law was passed, this capacity more than doubled each year during the period 1990-95. The average annual growth of installed wind power slowed down to some 40 percent in the second half of the 1990s, but in absolute terms the installed capacity expanded substantially from 1100 MW in 1995 to 6100 MW in 2000, making Germany the world leading country in wind energy (see Table 3.2). Although wind turbines have been installed throughout the country, they have been particular concentrated in the northern coastal states – notably Schleswig-Holstein, Lower Saxony and Mecklenburg-West Pomerania – which have been characterised by favourable meteorological and geographical conditions for wind energy. At end 1999, these states accounted for approximately 58 percent of the installed wind power in Germany (WEC, 2001).

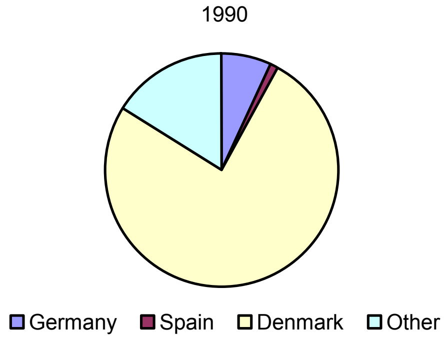
Table 3.2 *Installed onshore wind capacity in Western Europe*

	Installed capacity [MW]			Average annual growth rate [%]			Share in total capacity of Western Europe [%]		
	1990	1995	2000	1990-1995	1995-2000	1990-2000	1990	1995	2000
Germany	31	1133	6107	105	40	70	7	47	45
Spain	4	114	2836	95	90	93	1	5	21
Denmark	343	609	2291	12	30	21	76	25	17
Netherlands	39	252	454	45	12	28	9	10	3
Italy	2	23	424	63	79	71	0	1	3
UK	7	195	421	95	17	51	2	8	3
Greece	1	28	274	95	58	75	0	1	2
Sweden	6	49	252	52	39	45	1	2	2
Ireland (Rep.)	-	7	122	-	77	-	-	0	1
Portugal	1	9	111	55	65	60	0	0	1
Austria	-	-	69	-	-	-	-	-	1
France	1	2	63	15	99	51	0	0	0
Finland	1	2	39	15	81	44	0	0	0
Belgium	5	7	19	7	22	14	1	0	0
Norway	1	4	13	32	27	29	0	0	0
Luxembourg	-	-	6	-	-	-	-	-	0
Switzerland	-	-	3	-	-	-	-	-	0
Total	453	2432	13504	40	41	40	100	100	100

Source: BTM Consult ApS (2001)

Despite its success in promoting wind power and its rather broad support in the socio-political arena, the EFL was increasingly criticised – notably by the German electricity industry – mainly because of the following reasons:

1. The EFL led to rapidly rising costs and, hence, to significant competitive distortions between regional electricity utilities as it mainly stimulated wind power in the northern coastal states. For instance, according to the northern utility PreussenElektra, it had to pay 9 Eurocents for each kWh of wind power – with total spending amounting to some 300 million Euro in 1997 – whereas its avoided costs were said to be only about 2 Eurocents (Rehnelt, 1998). This issue became particularly relevant when competition was introduced in the second half of the 1990s as utilities in northern states were faced by either lower profits – due to the comparatively higher EFL costs – or the threat of consumers switching to cheaper suppliers if these costs were passed on to the end-users. In addition, the EFL came under increasing pressure from EU circles due to the fact that the premium feed-in tariffs were considered as undue subsidies that distort competition and which were, hence, not compatible with a single, liberalised electricity market in the EU. Because of these (supposed) effects, German electricity utilities – especially those operative in coastal states – have brought several judicial actions against the EFL to different courts. So far, these lawsuits have not been successful, although one is still pending at the European Court of Justice (Boots, et al., 2000; Espey, 2001).
2. On the one hand, the competition distortions mentioned above were limited by the (double) 5 percent threshold on obliged purchases of wind power by grid companies. On the other hand, however, this threshold threatened to halt the dynamic development of renewable energy in Germany, particularly in those states where the share of wind power in total electricity consumption was rising above 10 percent. In Schleswig-Holstein, for instance, this share had already risen to some 16 percent in the late 1990s (Wagner, 1999).



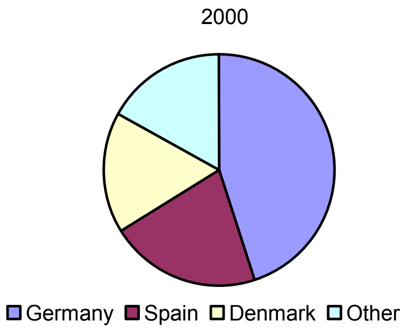


Figure 3.1 *Shares in total onshore wind capacity of West European countries in 1990 and 2000*

3. The EFL has been far less – or even hardly – effective in promoting other forms of renewable energy besides wind power. In 1998, the share of renewable energy sources in total electricity consumption in Germany was 5.2 percent compared to 4.3 percent in 1992. This increase was almost completely due to a rapidly rising share of wind power, whereas the shares of other renewable energy sources remained either stable – e.g. hydro at 3.6 percent in the years 1992-98 – or insignificant, for instance PV at 0.003 percent in 1998 (Boots, et al., 2000). Overall, EFL feed-in tariffs were either set relatively low – for instance, for PV – and, hence, hardly effective or fixed at relatively high rates – as for wind power – and, therefore, very effective as they offered high profits and investment security to independent power producers, especially in the short and medium term. In the long run, however, the costs of effective feed-in tariffs may become too high, thereby threatening the socio-political instability of such tariffs. This may apply particularly to the feed-in tariffs for PV electricity that were significantly raised from 9 Eurocents per kWh in the mid-1990s to 50 Eurocents after the second amendment of the EFL in April 1998. Either the latter tariffs may not be effective or they may not be sustainable from a long-term, socio-political point of view.
4. Other (putative) disadvantages and drawbacks of the EFL included: (i) the feed-in tariffs did not apply to the renewable energy sources of the utility sector, thereby distorting the allocation of these sources between the utility and non-utility sectors, (ii) apart from the (double) 5 percent threshold, the EFL provided neither for a time limitation nor for a gradual reduction of feed-in payments to eligible producers and, hence, did not provide incentives for cost reductions and technological innovations, and (iii) due to increasing market liberalisation and competition, electricity prices of final consumers were falling substantially in the late 1990s, leading shortly to lower feed-in tariffs as well because the latter were based on the consumer prices of the last but one year.

Because of the reasons outlined above, the EFL was decisively revised into a new act called the ‘Renewable Energies Law’ (REL). This law came into force on April 1, 2000. It continued with the practice of regulatory fixed feed-in tariffs for different forms of renewable energy and a purchase obligation for the grid companies. Compared to the EFL, however, the REL included the following major changes (EUREC, 2000; Schaeffer, 2001; and Schleich, et al., 2001):

- Feed-in tariffs are no longer linked to average consumer prices but based on generation costs of various renewable energy sources. In addition to the sources specified by the EFL, the REL feed-in tariffs also apply to geothermal and biomass plants up to 20 MW_{el} as well as to electricity from eligible renewable energy sources generated by utilities unless the federal government or the states own more than 25 percent of the utility’s shares. Besides varying by type of renewable energy technology, the feed-in tariffs – which are paid for 20 years – are digressive, depending on the size of the installations, i.e. they are lower as the installed capacity is larger. Moreover, feed-in tariffs for PV, biomass and wind energy decrease over time by a certain annual percentage, starting for plants installed after January 1, 2002 (for details, see Table 3.3 providing feed-in tariffs for different categories of renewable energy technologies according to the REL of April 2000). In addition, bi-annual revisions of feed-in tariffs are possible depending on the cost evolution and the degree of market introduction of the renewable energy technology concerned. These revisions are based on an evaluation report that the ministries of Economy, Environment and Agriculture have to submit to parliament every two years.

- The 5 percent cap has been removed, whereas the burden of feed-in payments is shared equally among all grid companies in the whole federal republic corresponding to their amount of delivered electricity. This implies that cost distortions among electricity utilities due to REL feed-in payments are largely absent within the borders of Germany, although they are still present outside these borders, particularly within the international context of the EU. Moreover, the new feed-in law is expected to cost utilities still about 1.23 billion Euro compared to 0.67 billion Euro under the old law, and to increase electricity prices for consumers by 0.05-0.10 €ct/kWh (Schleich, et al., 2001).

Table 3.3 *Germany: Feed-in tariffs under the Renewable Energy Law, 2000 [€ct/kWh]*

	0-0.5 MW	0.5-5 MW	5-20 MW	>20 MW	Annual decrease [%][a]
Wind[b]	6.2-9.1	6.2-9.1	6.2-9.1	6.2-9.1	1.5
Biomass	10.2	9.2	8.7	-	1.0
Photo Voltaics[c]	50.6	50.6	-	-	5.0
Geothermal	8.9	8.9	8.9	-	No
Hydro	7.7	6.6	-	-	No
Landfill gas	7.7	6.6	-	-	No
Mine gas	7.7	6.6	6.6	6.6	No
Sewage gas	7.7	6.6	-	-	No

a. Annual decrease of feed-in tariff, starting from the year 2002 (in %).
b. In the case of wind power, the feed-is tariff is determined by location.
c. PV installed after the year in which 350 MW is reached is no longer eligible to the feed-in tariff.
Source: Schleich, et al. (2001) and Schaeffer (2001).

The REL has been applauded by environmental associations as well as by parliamentarians of the Social Democratic and Green Parties. It has been criticised, however, by the Association of German Electricity Supply Companies, which has appealed to the Constitutional Court and the European Commission for the perceived failing of the REL to meet fundamental criteria such as market orientation, neutrality towards competition, and economic efficiency (EUREC, 2000).

3.2 Denmark

Between the mid-1980s and the late 1990s, feed-in tariffs in Denmark have played a prominent role in stimulating electricity generated from renewable energy sources. Due to the introduction of the new Electricity Supply Act on 1 January 2000, however, this role will be less important in the coming years as – starting from 2003 – feed-in tariffs will apply only for existing renewable energy installations during a temporary, transition period of 10 years while for new installations a more market-oriented mechanism – i.e. tradable green certificates – will be used as the main instrument to encourage renewable power production. Below, this changing role of feed-in tariffs in Denmark before and after the year 2000 will be discussed briefly.

Before 2000, the system of feed-in payments in Denmark differed by type of renewable energy technology. For electricity from biomass fed into the grid, the utilities paid a feed-in tariff based on the principle of avoided costs, depending on the specific time at which the electricity was supplied. As a result, feed-in tariffs for biomass varied between 2-13 €ct/kWh in the late 1990s, with the average price received by independent power producers amounting to approximately 4.3 €ct/kWh. For electricity from wind power, on the other hand, the feed-in tariff was based on 85 percent of the consumer price of electricity in the given distribution area. Hence, as the tariff depended on the location of the wind turbine, it varied between 3-5 €ct/kWh in the late 1990s.

On average, the price paid to wind power producers was some 4.4 Eurocents (Cerveny and Resch, 1998; Schaeffer, et al., 1999).

In addition to the direct feed-in tariffs paid by grid companies, independent producers of renewable electricity used to receive a carbon tax refund as well as a production subsidy from the government, totalling 3.6 €ct/kWh. Therefore, in the late 1990s, the total reimbursement paid to a producer of wind power fed into the grid amounted to, on average, some 8 €ct/kWh.

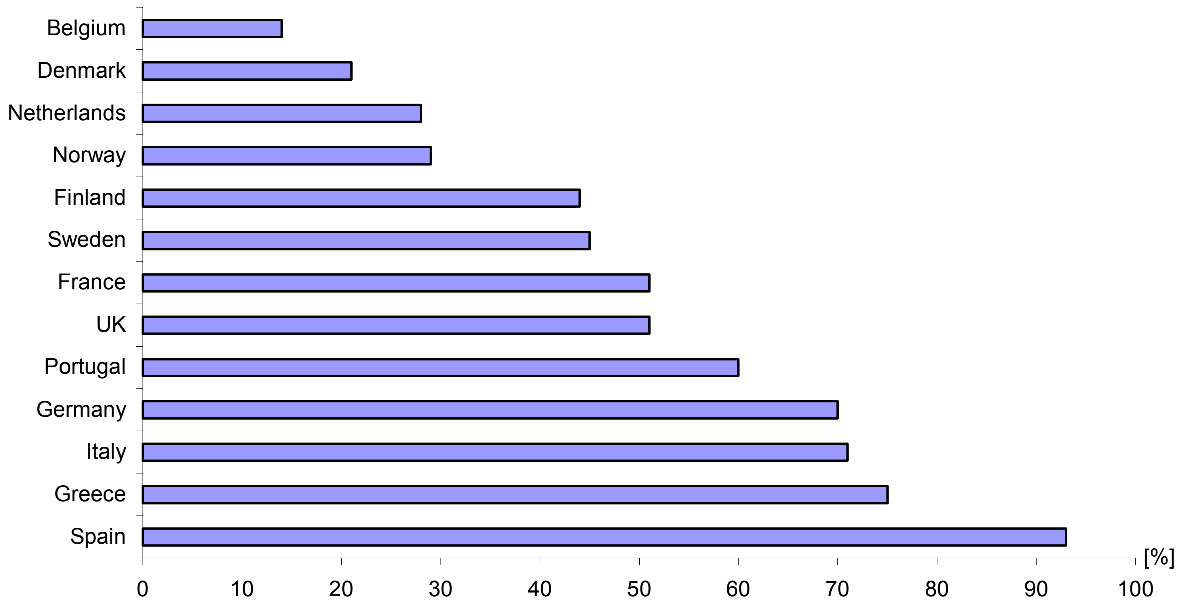


Figure 3.2 *Average annual growth rate of installed onshore wind capacity in Western Europe during the period 1990-2000 [%]*

The total reimbursement received by wind power producers resulted in an internal rate of return for an average 600 kW wind turbine varying between 5 and 22 percent per annum after payment of tax, accounting for variations in both feed-in tariffs and wind conditions per location area. Hence, even a turbine operating in an area with the lowest wind speed and with the lowest feed-in tariff was profitable compared with the normal discount rate of 3.25 percent per annum (Monthorst, 1999).

The relatively high internal rate of return mentioned above implied a strong incentive for investment in wind power. In 1990, the capacity of installed onshore wind power in Denmark amounted already 343 MW, i.e. some 76 percent of total capacity installed in West Europe (Table 3.2). Over the years 1990-2000, wind capacity in Denmark grew by, on average, 21 percent per year to almost 2300 MW in 2000. Although in absolute terms of wind power capacity, Denmark has been overtaken in the 1990s by Germany and Spain, at the end of this decade it still outrivaled these countries in per capita terms of wind power (see Table 3.2 as well as Figures 3.1 and 3.2).

The development of a high wind power capacity in Denmark, however, was achieved at high, rapidly rising costs to society. In 1998, the tax refunds and output subsidies paid by the government to wind power producers amounted already to some 75 million Euro (Monthorst, 1999). This heavy burden on the state budget – and the prospect that it would significantly rise in the years thereafter following the expected growth in wind power capacity – was a major reason for the policy reforms regarding the system of feed-in payments effective from January 1, 2000. In brief, these reforms included (Odgaard, 2000; Grohnheit, 2001):

- Existing wind mills receive a fixed feed-in tariff of 4.4 €ct/kWh until the mill is 10 years old, but at least until the end of 2002. In addition, these mills will be paid a fixed subsidy of 3.6 €ct/kWh, but only for a limited amount of full-load hours, depending on the capacity size of the windmill. Above this amount of full-load hours, the subsidy will be only 1.3 €ct/kWh. Moreover, starting from 2003, existing windmills – when 10 years old – will get a green certificate for each kWh of electricity generated.
- New windmills installed during 2000, 2001 or 2002 receive a fixed feed-in tariff of 4.4 €ct/kWh for 10 years. In addition, they will get a green certificate for each kWh of power produced, but no further output subsidies.
- Existing biomass and biogas plants will also receive a fixed feed-in tariff of 4.4 €ct/kWh (without any time restriction). Moreover, they will be offered an additional output subsidy of 3.6 €ct/kWh, but no green certificate.
- New biomass and biogas plants will be paid a feed-in tariff of 6.7 €ct/kWh. In addition, they will get a green certificate for each kWh of power produced, but no further output subsidies.
- From 2003 onwards, all new plants generating renewable energy will immediately receive the market price for electricity plus a green certificate for each kWh produced.

Although the impact of the above-mentioned policy reforms regarding feed-in payments can not yet be assessed, the most striking point of these reforms is that, starting from the year 2003, Denmark has opted for a system of promoting renewable electricity in which the role of feed-in payments is gradually reduced in favour of more market-oriented instruments such as competitive pricing and tradable green certificates.[1]

3.3 Spain

Since the mid-1990s, feed-in tariffs have been a major instrument to promote renewable electricity in several other countries in West Europe such as Austria, Greece, Italy, Luxembourg, Portugal and – particularly – Spain (Joosten and Van Zuylen, 1997; Cerveny and Resch, 1998; Haas, et al., 2001, and Cerveny and Veigl, 2001). In the latter country, i.e. Spain, feed-in tariffs have been introduced in 1994 by means of the so-called 'Royal Decree 2366'. In addition to the market price of electricity, producers of renewable energy in Spain receive a premium feed-in tariff, which amounted to some 3 Eurocents per kWh in 2000 for most renewable energy sources and even 36 €ct/kWh for small-scale solar plants (Haas, et al., 2001). Since the mid-1990s, Spain – together with Germany and Denmark – has belonged to the group of countries with the highest feed-in payments to renewable power producers (CEC, 1999). These payments have resulted in a major impetus to generating renewable electricity, especially wind power. Over the years 1995-2000, installed onshore wind capacity in Spain almost doubled every year from 114 MW in 1995 to more than 2800 MW in 2000. In the late 1990s, Spain even surpassed Denmark in total wind power capacity installed, thereby becoming the second leading country in Europe – behind Germany – with regard to generating wind power (Table 3.2).

[1] It should be noted that in October 2001 it was decided to postpone the introduction of the Green Certificate Scheme for some years. The associations representing the different renewable energy sectors opposed the early introduction of green certificates in Denmark, mainly because of concerns on the lack of policy stability – which is required for investments in renewable energy – and the lack of RE policy harmonisation within the EU (de Lange, et al. 2002).

4. EVALUATION

Based on the experiences of the European countries outlined above – supplemented by some general, theoretical reflections from the literature – the performance of feed-in tariffs in promoting renewable electricity will be evaluated below with regard to the following criteria:

- Investment certainty
- Effectiveness
- Efficiency
- Market compatibility and competition
- Administrative demands

Investment certainty

The core argument to apply feed-in tariffs is that they offer a high level of investment certainty to independent (risk-averse) producers of renewable electricity by guaranteeing a fixed price for each kWh of power fed into the grid over a certain period, for instance 5-15 years. As noted above, however, this certainty may particularly apply to the short or medium term as in the long run fixed feed-in tariffs may be unsustainable either because of high cost-inefficiencies involved or because they are not compatible with a liberalised, competitive market and a system of harmonised, renewable energy policies within the EU (see below).

Effectiveness

Owing to the investment certainty offered by fixed feed-in tariffs, the latter have been very effective in promoting renewable electricity, notably wind power in countries such as Germany, Denmark or Spain. Their effectiveness, however, depends largely on the particular level of the tariffs set as well as on other factors such as the production costs involved, the existence of other promotion schemes, administrative procedures, natural conditions or other specific characteristics at the local, regional or national level. Moreover, it should be remarked that, apart from wind power, feed-in tariffs seem to have been far less effective in encouraging other forms of renewable electricity.

Efficiency

The major criticism with regard to feed-in tariff is that they have failed to be efficient in both static terms – i.e. able to ensure that electricity is generated and sold at minimum costs – and dynamic terms, i.e. able to foster innovations and, hence, further driving down costs. Compared to other promotion schemes, feed-in tariffs have generally failed to result in price reductions for renewable electricity (CEC, 1999). For instance, between 1994 and 1998, the minimum bid prices for contracts under Britain's auction model of support – the so-called Non-Fossil Fuel Obligation (NFFO) – fell 40 percent in real terms, whereas feed-in tariffs in Germany and Spain remained more or less stable (Kjaer, 1999). This lack of cost/price efficiency of feed-in tariffs can be subscribed to the following factors (CEC, 1999):

1. Feed-in tariffs are generally fixed by a regulatory authority. This authority, however, usually lacks adequate, up-to-date information regarding the production costs of renewable electricity from a variety of different sources and technologies, notably in dynamic terms over a certain period. Therefore, it is very hard to fix the 'right' price and to differentiate it adequately over time or by different types of renewable energy sources and technologies. Moreover, it may be unpopular and, hence, politically difficult to reduce feed-in tariffs as existing producers have strong economic interests in ensuring continued high feed-in payments.
2. As a system of feed-in payments is not based on direct competition – either among renewable power producers or between these producers and non-renewable electricity generators – the incentive for innovations will, by definition, be less pronounced than under schemes based on competition.

Wagner (1997a and 1999), however, has contested that a system of feed-in tariffs would create little downward pressure on wind energy costs. According to him, the contrary is true. Firstly, feed-in tariffs in Germany and Denmark fell slowly in the mid-1990s because of lower electricity rates charged to final consumers. Secondly, these tariffs were not adjusted for inflation and, hence, fell in real terms. Most importantly, the Danish and German manufacturing industry of wind turbines has been very dynamic, competitive and innovative during the mid-1990s, resulting in significantly lower turbine costs as indicated by the so-called 'progress ratio'of 0.86. The latter implies that every doubling of installed capacity has led to ex-works cost reductions of 14 percent (Wagner, 1999). It should be noted, however, that as far as the latter argument is correct, this cost reduction has not led to a similar reduction in feed-in tariffs and/or consumer electricity prices and, hence, it has mainly resulted in higher profits for the producers concerned rather than to lower costs and prices for the society as a whole.

In a recent study (Huber, et al., 2001), it is shown that feed-in tariffs are also an efficient instrument to promote renewable electricity if certain conditions are met. These conditions include:

- The cost curve of the renewable energy technology concerned is flat and predictable with high probability.
- The feed-in tariffs decrease over time in line with the expected learning curve of the investment costs.
- The time period over which a producer receives a guaranteed price is limited, i.e. a feed-in tariff is restricted to a certain, pre-defined duration.
- Granted feed-in tariffs should be lower if actual output of renewable electricity is higher.

Although these conditions may be theoretically sound, in practice they may be hard to meet (notably the first condition). For several renewable energy technologies, reliable knowledge on the exact shape of the cost curve – particularly in a dynamic sense – is often scarce. Moreover, the available evidence suggests that the static cost curve of renewables is usually (steeply) rising – i.e. costs rise significantly when output increases – whereas the dynamic cost curve is generally (steeply) declining, i.e. costs decline substantially over time. Therefore, it may be hard to determine the feed-in tariffs over time in line with the expected learning curve of a certain renewable technology. Moreover, the decrease in feed-in tariffs should not be so fast that it prevents an efficient outcome with regard to the actual output of renewable electricity. Nevertheless, by observing the conditions mentioned above as carefully as possible, the efficiency of feed-in tariffs may be significantly enhanced.[2]

Market compatibility and competition

Another major criticism of a system of feed-in tariffs is that it implies a distortion of free competition and, hence, that it is not compatible with a single, liberalised electricity market in Europe. Basically, there may be three problems with regard to this issue of competitive pricing and marketing. Firstly, feed-in tariffs do not go together with competitive pricing between generators of green electricity, which may result in less efficiency in renewable power production (as discussed above).

Secondly, a national system of feed-in tariffs that is eligible to domestic generators of green electricity only and excludes imports of renewable electricity may conflict with EU rules regarding non-discrimination of domestic versus foreign producers and free international trade among Member States. On the other hand, non-discrimination of producers and free international trade may lead to major imports of green electricity and major outflows of financial resources, which may be unacceptable for a country offering relatively high feed-in tariffs.

[2] For a more detailed consideration of these conditions to improve the efficiency of feed-in tariffs, see Huber et al. (2001).

Thirdly, grid utilities that are located in areas with a large potential of renewable energy sources will likely be offered more green electricity and will, therefore, have to pay more premium tariffs. In a liberalised electricity market, this puts these utilities at a competitive disadvantage relative to utilities in areas with low renewable energy potentials. Some kind of compensation mechanism could be designed to avoid this problem, as has been introduced in Germany since April 1, 2000 (see Section 3.1). Such a national mechanism, however, would complicate the administrative demands of a feed-in tariff system, while it would not solve similar problems at the international level.

Both the second and third problems discussed above could, in principle, be solved by introducing a system of feed-in tariffs at the EU level that covers all generators of green electricity within the EU, including a compensation mechanism that covers all grid utilities within the EU. However, apart from the costs and inefficiencies involved, such a system would be administratively quite demanding and rather complicated in sharing the costs and benefits among the member states in an equal and acceptable matter. Moreover, such a system would not solve the first problem mentioned above, i.e. a lack of competitive pricing among the generators of renewable electricity.

Administrative demands
A major advantage of a system of feed-in tariffs is that its administrative demands are, in principle, low and simple. The one-page text of the 'Electricity Feed Law' (EFL) used to be one of the shortest and simplest laws implemented in Germany during the 1990s (Wagner 1997b). However, as already indicated above, both the administrative demands and the informational needs of a feed-in tariff system will rise rapidly if (i) a compensation mechanism covering all grid utilities is introduced, (ii) the system is extended from the national to the international level, and (iii) the system becomes more fine-tuned and complicated in order to meet the efficiency conditions discussed above.

5. CONCLUDING REMARKS

Overall, it may be concluded that a system of premium feed-in tariffs has shown to be an effective instrument to promote the generation of renewable electricity, notably to ensure a low-level market take-off of wind power at the national level. In the longer term, however, such a system may become hard to sustain as it may suffer from some major drawbacks, especially when the generation of green electricity accounts for a significant share in total power production. These disadvantages refer particularly to the fact that a system of fixed premium prices tends to be costly, inefficient, distortive of competitive pricing and, hence, incompatible with the creation of a single, liberalised electricity market in Europe.

In the long run, the best way to encourage renewable electricity within a free European market is probably either to internalise the external costs and disadvantages of non-renewable energy sources – e.g. by means of taxation – or to introduce market-conform instruments such as a well-functioning system of tradable green certificates (where the price of these certificates accounts for the social and environmental benefits of renewables compared to non-renewables). However, it may take quite some time – if ever – before either one of these ‘best means’ (or a combination of both) will be achieved. In the meantime, feed-in tariffs can and will be justified in several European countries as the best alternative instrument to encourage the generation of a certain amount of green electricity, notably when this amount is still small.

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