Harmonization of renewable electricity feed-in laws in the European Union

AUTHORS:

- Miquel Muñoz[1]
- Volker Oschmann
- J. David Tàbara

AFFILIATIONS:

- Environmental Science and Technology Institute (ICTA), Autonomous University of Barcelona (UAB)
- Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany

ABSTRACT:

This paper focuses on the harmonization of feed-in laws in the European Union as a support mechanism for the promotion of renewable electricity. In particular, it proposes a methodology for harmonization based on a feed-in law with a modular and transparent premium for renewable electricity producers. This premium considers technology costs, some grid services, political incentives and national priorities. The proposed approach includes flexibility mechanisms to update and revise premiums, to avoid windfall profits for producers, and to share technology innovation benefits with electricity consumers while maintaining incentives for innovation. Our approach is based on the review of the main features of the German and Spanish feed-in laws, and takes into account other necessary considerations for harmonization, such as grid access, funding, definitions and standards, ownership of rights derived from renewables, and exceptions for small non-commercial producers and energy-intensive industries.

Keywords: renewable electricity; EU harmonization; feed-in law; premium; Spain; Germany; economic modeling

1. INTRODUCTION.

Increasing the share of renewable energy sources, and in particular the share of electricity from renewable energy sources (renewable electricity) is a stated goal of the European Union, which aims to have 21% of renewable electricity by 2010, as formulated in Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources. This Directive, as amended by the Accession Treaty (Annex II, Part 12, 1802-04), sets national indicative targets on renewable electricity and obliges EU Member States to take appropriate steps toward those targets. All EU Member States have introduced policies and support schemes for the promotion of renewable electricity in compliance with Directive 2001/77/EC. Support schemes include feed-in laws, quotas, and, to a lesser extent, tendering and tax incentives.

Feed-in laws have proven to be both effective and cost-efficient, as demonstrated by the German and Spanish examples and as acknowledged by the European Commission in COM(2005) 627. Feed-in laws are compatible with liberalized electricity markets, and

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[1] Corresponding author: Miquel.munoz@uab.es

as established by a European Court of Justice ruling (PreussenElektra vs. Schleswag AG.) and the directive 2001/77/EG, are compatible with EU state-aid and competition rules (see e.g. Cremer 2006, Klinski 2005; Koenig et. al. 2006, Altrock et. al. 2006, Allwart 2006), and – regarding their cost efficiency - preferable in respect of commensurability. Therefore, feed-in laws merit consideration for harmonization as the EU support mechanism for renewable electricity.

This paper develops a suitable methodology for EU harmonization of feed-in laws based on a modular premium system. Harmonization is not of the premium itself, but of the *methodology* used to calculate the premium. This paper defines what elements should be included into the premiums, describes flexibility mechanisms for those premiums, and draws attention to issues that need to be considered for effective and efficient harmonization.

In particular, the next sections: (1) describe support schemes for renewable electricity and the prospects for harmonization in the EU: (2) review the experiences in the implementation of feed-in laws in Germany and Spain; (3) present a modular premium methodology which addresses technology costs, some grid services, EU support for renewables, and national priorities; (4) further present flexibility mechanisms used to account for technology innovation, fulfillment of objectives, and to avoid windfall profits for renewable electricity producers, and (5) consider other relevant issues such as grid access provisions, funding, definitions, ownership of rights derived from renewable electricity, and special provisions for small non-commercial producers and energy-intensive industries.

2. SUPORT SCHEMES FOR RENEWABLE ELECTRICITY AND PROSPECTS FOR HARMONIZATION IN THE EU

The main support schemes used for the promotion of renewable electricity in the EU are feed-in laws and quota systems. Feed-in laws comprise two main components: (1) an obligation for the grid operator to buy all renewable electricity produced and (2) a pricing scheme, generally a *feed-in tariff* or a *premium*:

- Under *feed-in tariffs,* producers sell their renewable electricity at a pre-set price per kilowatt-hour (kWh). This fixed price, or tariff, is normally above market price for electricity and guaranteed for a number of years.
- In a *premium scheme,* producers sell renewable electricity at market price, and a premium, also guaranteed for a number of years, is added to that price. It is common to refer to feed-in laws as feed-in tariffs, which can lead to confusion because not all feed-in laws comprise a tariff.

In a quota promotion scheme, the government sets a percentage (quota) of electricity that must be of renewable origin, and the electric utilities and operators must fulfill that quota. In addition, a certificate market is established where producers are issued tradable certificates for the renewable electricity they produce. These certificates are known under different names, such as green certificates, renewable energy certificates (REC), renewable obligation certificates, etc. Under the quota promotion scheme, the income of renewable electricity producers comes from regular sales of electricity plus sales of certificates. Those certificates can be sold independently of electricity and become tradable assets. Electric utilities and operators can buy those certificates and redeem them to fulfill the obligation imposed by the quota. For detailed descriptions, case studies, and comparisons of quota systems, feed-in-laws, and other support schemes, see for example ADMIRE REBUS 2003, Held et al. 2005, Lauber 2004, Menanteau et al., 2003, Ragwitz et al. (2006, 2005), REN 21 2005, and Sawin 2004(a,b).

Directive 2001/77/EC does not indicate a preferred support mechanism for renewable electricity, but its Art 4 mandates that the European Commission had to report and assess by the end of year 2005 the success of the different national support schemes. Additionally, Art 4 entitles the Commission to propose a “Community framework with regard to support schemes”, i.e., to propose harmonization of renewable electricity support schemes. Such a proposal according to Art 4, should: contribute to the achievement of national targets; be compatible with the principles of the internal EU electricity market; consider the different sources, technologies and geographical characteristics of renewable electricity; be simple, effective and cost-efficient; and include sufficient transitional periods of at least seven years. At the time of drafting Directive 2001/77/EC, harmonization was mostly understood to be harmonization of a quota system with EU-wide tradable certificates (Rowlands 2005). Quota support schemes were favored by DG Competition (Lauber 2004), and often seen as more cost-efficient and in line with the EU single electricity market objectives than feed-in laws. An industry association was set up in 2001, RECS International, to experiment with renewable energy certificates, establish standards and serve as an embryo for a future mandated European-wide certificate-based system.

On December 2005, the European Commission issued its report on the support of renewable electricity, COM(2005) 627 Final. Two main conclusions can be extracted from this Communication regarding the effectiveness and cost-efficiency of quotas and feed-in laws. First feed-in laws have proven so far to be more effective than quotas in promoting deployment of renewable electricity generation capacity. This was expected because the largest increases in renewable electricity generation (mostly wind power) happened in two Member States (Germany and Spain) with active feed-in laws, while Member States with quota systems have so far shown little progress in additional renewable electricity generation. Second, and this was unexpected, feed-in laws have proven so far to be the most cost-efficient support scheme for renewable electricity.

These findings effectively put an end to any short-term plan for European harmonization of quotas as renewable electricity support schemes. In its conclusions from report COM(2005) 627 Final, the European Commission does not regard a harmonized European system appropriate at this stage, focusing instead on optimization of existing systems and co-operation among member states with similar support systems (that is cooperation among countries with quotas and cooperation among countries with feed-in laws). These conclusions are supported by the results of model-based prospective analyses, which suggest that the most significant efficiency gains can be achieved simply by strengthening and improving national support schemes (Ragwitz et al. 2006b). According to these analyses more than two thirds of the overall cost-reduction potential of policy harmonization can be attributed to the optimization of national support schemes. Co-ordination and harmonization might lead to lower transfer costs for consumers only if technology-specific support instruments are applied. Therefore, from the legal point of view regarding the principle of proportionality (Art 5 EC-Treaty), a harmonized feed-in law would be preferable to a harmonized quota system (Oschmann et al. 2006).

However, it is generally assumed that harmonization of feed-in law support schemes is not feasible or, in European Commission's words, "difficult" (COM(2005) 627 Final, page 4). Some of the stated arguments against feed-in law harmonization are that it is difficult to establish an adequate value for an EU-wide tariff and that there is the possibility of over-pricing, which creates windfall profits for producers and undue costs for consumers.

Such drawbacks to harmonization may be overcome if attention is given to harmonizing the methodology used to calculate the premium rather than to harmonizing the premium values. Hence the proposed flexibility mechanisms would also be harmonized. This approach has some advantages. Electricity markets have been liberalized to some extent in all Member States, following Directive 96/92/EC on common rules for the internal market in electricity and subsequent Directive 2003/55/EC. Nonetheless, electricity markets have different rules and characteristics, and show different wholesale and retail electricity prices across the EU. These differences make a straightforward EU-wide feed-in-tariff or fixed premium un-feasible. With the proposed approach of a harmonized methodology, premium values would initially differ from one Member State to another, according to their national circumstances. Nevertheless, since the same methodology would be used, if national electricity markets converged into the single European electricity market as planned, then, premiums and support for renewable electricity, by construction, would do likewise.

Harmonization would most likely take place under a new Directive on the promotion of renewable electricity, thereby updating Directive 2001/77/EC. This new/revised Directive could result from current discussions on the *Green paper for a European Strategy for Sustainable, Competitive and Secure Energy*, or from a separate process.

3. EXAMPLES OF SUCCESSFUL FEED-IN LAWS

3.1 Feed-in tariff: Germany

In 2005 Germany was the world leader in wind power (18430MW of installed capacity), solar photovoltaics (1400MWp of installed capacity), production of bio-diesel (1.9 billion liters), and, with China, overall investment in renewables (REN21 2006). Deployment of renewables in Germany has been largely due to strong support policies, particularly its feed-in tariff law, embodied in the Renewable Energy Sources Act. The 2004 German Renewable Energy Sources Act (known as EEG, the German acronym for *Erneuerbare-Energien-Gesetz*) was a major revision of the 2000 Renewable Energy Sources Act, which in turn replaced the 1991 Electricity Feed law (StrEG). For a review of renewable energy policy history and evolution in Germany, see Jacobsson and Lauber 2006.

The EEG has three core elements: grid access and priority of renewable electricity; degressive tariff; and nation-wide equalization.

Grid access and priority of renewable electricity:

The EEG regulates renewable electricity plants' grid access as well as renewable electricity's priority of purchase and transmission. The Transmission System Operators (TSOs) are mandated to connect renewable electricity plants to the grid. The costs of grid extension are allocated to renewable electricity plant operators, and grid upgrading costs are allocated to the TSO. TSOs can reflect upgrading costs due to renewable electricity in transmission charges, provided those costs are properly documented. TSOs are also obliged to buy and transmit all renewable electricity generated by power plants in their grid. Exceptions are allowed under mutual agreement between TSOs and renewable electricity generators in order to improve efficiency and/or functioning of the grid.

Degressive tariff

The EEG guarantees a feed-in tariff to renewable electricity producers for a period of 20 years (except hydropower, with tariffs lasting 15-30 years, depending on the installed capacity).

Table 1 summarizes the tariffs for different technologies and installed capacities. One of the innovations of EEG is the use of degressive tariffs. Each renewable electricity plant is guaranteed the tariff at the level of the year it was commissioned, but for new installed plants that tariff level declines a certain percentage every year. The objective of the degression clause is to account for technological innovation and to promote early deployment of renewables.

Equalization and other provisions

The EGG includes an explicit nation-wide equalization scheme (Art 14) to distribute evenly among different regions the costs associated with the renewable electricity feed-in tariff.

The EEG also contains provisions for (1) energy intensive consumers (Art 16) which are granted reduced cost from renewable electricity obligations; (2) transparency and publicly available data (Art 15); and (3) guarantees of origin (Art 17), as mandated by Directive 2001/77/ EC.

3.2. Feed-in premium: Spain

In 2005 Spain ranked second in the world in total installed wind power capacity (10030MW), and was among the top three in newly installed wind capacity (REN21 2006). In addition, as many as 20 solar thermo-electric projects, totaling 1000MW and 4000m€ in investment are being considered (Energías Renovables 2006). Investment in renewable electricity in Spain has been largely driven by its feed-in law, which is particularly beneficial for wind power. Spain's feed-in law was first enacted in 1998 (RD 2818/1998) and modified in 2004 (RD 436/2004). Spain's electricity system is mostly an isolated power system, with small interconnection capacity with the EU.

Spain's feed-in law guarantees grid access and priority of renewable electricity; security and predictability of the economic supports; and nation-wide equalization. Spain's feed-in law also contains incentives to improve the quality of renewable electricity fed into the grid, and to participate in the power market, in order to reduce balancing costs.

The Spanish feed-in law offers two modalities for renewable electricity producers to choose from: (a) a fixed tariff, or (b) market price plus a premium plus an incentive to participate in the market. Given current prices for electricity, most producers choose the market price plus premium option. Premiums, tariffs and the incentive are calculated as a percentage of a reference yearly electricity tariff. A separate Spanish bill (RD 1432/2002) establishes the methodology used to calculate the reference yearly tariff. This reference tariff is also used for many purposes unrelated to renewable incentives. The incentive to participate in the market is 10% of the reference yearly tariff, amounting to 0.73c€/kWh in 2005. The premiums and feed-in tariffs are shown in Table 2.

Under RD 436/2004 premiums must be revised every four years. RD 436/2004 also includes many technical provisions to improve the quality of renewable electricity fed into the grid. Among them are (1) compensation for reactive power (Art 26); (2) calculation of deviation costs (Art 31); and (3) specific compensation for wind power installations equipped to cope with voltage faults (Add 4)[2]

4. A METHODOLOGY FOR A HARMONIZED PREMIUM

4.1. Definition of the Model.

The approach to feed-in law harmonization proposed in this paper consists of a feed-in law with a modular premium guaranteed for a period of 20 years. This feed-in law would: (1) guarantee access to the grid and transmission for renewable electricity; (2) establish a premium; and (3) provide flexibility mechanisms. Premiums are chosen rather than tariffs because tariffs embody the price of electricity, while premiums let the market determine the price of electricity and then add the incentive. Therefore premiums have more flexibility and less potential for market distortion and over/under funding than tariffs, particularly if prices for conventional power change significantly; they tend to impose greater market discipline.

In a harmonized feed-in law with a premium, renewable energy producers sell their electricity in the market. In addition to market prices for electricity[3], renewable electricity producers receive a premium. The revenue for a renewable electricity producer in a particular Member State is calculated according to the following formula:

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[2] Art 26 guarantees an economic complement as compensation for reactive power. This complement is set as a percentage of the yearly reference tariff, specific for each technology. Art 31 sets the limit for deviations at 20% for solar and wind power, and 5% for the rest of renewable sources, and establishes the cost of deviations exceeding that limit. Addendum 4 establishes a complement of 5% of the yearly reference tariff (approx 0.35c€/kWh) during four years for wind power plants equipped to withstand voltage faults.

[3] Which are determined by the spot market or through bilateral or long term contracts

$$R_x = \int_t P_{x,t} \cdot kWh_t \cdot dt + \sigma \cdot kWh \qquad \text{(Eq.1)}$$

where: R = revenue; P = market price; x = country; σ = premium; and kWh the power delivered to the grid.

The first component of Eq.1 reflects revenues from selling electricity in the market. Market price depends on the time of the day, with one kWh generated at peak hour being more valuable than one kWh generated in the middle of the night. Prices in real electricity markets are updated in quasi real time, with updates calculated every few minutes.

The second component reflects revenue from the premium σ. Under the proposal for harmonization suggested in this paper, σ is not a constant number, but is set separately for each country and technology. Although σ varies for each country and technology, and is adjusted over time, σ should remain constant for any particular installation in order reduce uncertainty on future revenue flows and to make financing accessible. Under the proposed scheme, when a renewable electricity plant is commissioned, the premiums it receives are fixed for the next 20 years. Because premiums can be revised over time, a second renewable electricity plant of the same technology commissioned in a different year might receive a different premium, also constant for the 20 years after its commissioning.

Under the proposed feed-in law the premium is calculated in a modular way that explicitly accounts for the different elements being supported under this promotion scheme. The modular approach has the advantage that specific elements can be added or removed from the premium over time, thus providing flexibility. Moreover, allocation of premium components to specific elements provides transparency to the policy and allows for different funding provisions for each component.

The following elements are included in the proposed harmonized premium: (1) investment costs; (2) some grid services; (3) a political incentive. Additionally, a non-harmonized component is allowed to account for national priorities. This modularity is reflected in (Eq.2):

$$\sigma = \overbrace{\underbrace{\sigma_{RoI}}_{Investment} + \underbrace{\sigma_{Grid}}_{Grid\_Services} + \underbrace{\sigma_{EU}}_{EU\_Political\_Incentive}}^{Harmonized} + \underbrace{\sigma_{Nat}}_{National} \qquad \text{(Eq.2)}$$

Next the three suggested harmonized components of σ (σ_{RoI}, σ_{Grid}, σ_{EU}) and σ_{Nat} are described.

σ_{RoI}: Investment

The objective of σ_{RoI} is to provide a reasonable expectation of cost recovery for investment on renewable electricity plants. Following a system similar to Spain’s, each renewable electricity source/technology has a defined premium value. This value would be calculated considering a variety of factors including the technology costs, the expected revenues from electricity sales, and the cost of financing.

The component σ_{RoI} needs to be revised periodically to account for technological innovation, changing prices of electricity, changing financing conditions and fulfillment of national/EU goals. Those revisions must be based on transparent, pre-established, technical criteria, in order to minimize uncertainty and reduce political interference and lobbying. In this paper’s section, “flexibility mechanisms”, options are described for the revision of σ_{RoI}.

σ_{Grid}: Grid Services

The objective of σ_{Grid} is to compensate renewable electricity producers whenever they provide grid services which are not explicitly reflected in electricity prices. Examples of such services include grid stability, distributed generation, resilience, or sustaining tension gaps. Some of these services are reflected in electricity pricing schemes in some Member States, but there is no homogeneous approach. This heterogeneity is because liberalization (the process by which electricity systems were divided into generation, transmission and distribution segments) was designed according to the particular technical characteristics of each system, generally based on large centralized fossil, nuclear and/or hydroelectric plants. In most cases, the technical provisions of current pricing systems amount to market barriers to renewable electricity deployment.

The component σ_{Grid} is country and technology dependent. Ideally σ_{Grid} would not be limited to renewable electricity producers, but include all power plants. In the long-term and under ideal conditions, σ_{Grid} would be phased out because compensation for grid services would be fully integrated into the pricing system in a non-discriminatory way, eliminating current bias benefiting large centralized fossil fuel, nuclear and hydro power plants.

σ_{EU}: Political incentive

The political incentive premium, σ_{EU}, signals the degree of political willingness from the European Union to promote renewable energy sources. Under the proposed scheme, this component is linked to the EU stated targets on renewable electricity and is the same across Member States for all renewable electricity generators of the same kind.

σ_{EU} can be the same across technologies, or, if alternative technologies are deemed a priority at the EU level, then σ_{EU} can vary accordingly. This premium is the component that gives "teeth" to EU targets, by linking them to a financial instrument.

σ_{Nat}: National Premium

The objective of the component σ_{NAT} is to allow national priorities (which may include regional priorities) to be reflected in the support scheme. In some cases, Member States might want to promote some renewable energy technologies beyond the official targets agreed at European level. In other cases, the use of renewable energy technologies is part of an integrated solution to a particular environmental or social problem. To allow for these special cases the national premium σ_{NAT}, compatible with the Directive, is proposed. Under the proposed scheme, σ_{NAT} is optional, unlike the harmonized σ_{RoI}, σ_{EU}, and σ_{Grid}. The national premium σ_{NAT} is highly configurable, and when used, changes from country to country, or within a country, according to national circumstances. Possible items included under σ_{NAT}, include social benefits, environmental benefits, regional distribution and other benefits, as shown in (Eq.3).

$$\sigma_{NAT} = \underbrace{\sigma_{NAT-soc}}_{social\_benefits} + \underbrace{\sigma_{NAT-env}}_{environmental\_benefits} + \underbrace{\sigma_{NAT-reg}}_{regional\_distribution} + \underbrace{\sigma_{NAT-ext}}_{other\_externalities} \qquad \text{(Eq. 3)}$$

Examples of integrated solutions to a social/environmental problem in which renewable electricity can play a key role are manure treatment in areas with high concentrations of livestock, or forest fire prevention.

A different application for σ_{NAT} can be regional distribution. It might be in a Member State's interest to achieve broader distribution of renewable electricity plants even if that means exploiting sub-optimal (resource wise) locations, in order to share the co-benefits (and impacts) of the plants, such as creation of local employment and infrastructure or visual impacts from wind turbines. If a Member State wants to provide incentives for regional distribution, it can use σ_{NAT} to complement σ_{RoI}.

A further application of σ_{NAT} is that it can be used as the basis for a transition mechanism from previous support schemes to the harmonized feed-in law.

4.2. Flexibility mechanisms

One of the keys for a successful feed-in law is that it needs flexibility to allow adjustment for technology innovation, changes in the economics of the energy sector, and fulfillment of established targets, while providing a fair distribution of costs and stable investment framework.

Three flexibility mechanisms are proposed in this paper: (1) a profitability threshold to avoid windfall profits; (2) a semi-linear step function to revise σ_{RoI}; and (3) a target revision trigger. These mechanisms are based on objective, pre-set criteria, to prevent interference from lobbying and short-term political interests, as well as to minimize regulatory uncertainty. The proposed mechanisms also ensure that the benefits of technology innovation are passed down to final electricity consumers, while maintaining incentives for innovation.

Profitability threshold

To protect against windfall profits while ensuring an adequate incentive, the use of a profitability threshold is proposed. Windfall profits for renewable electricity producers are one of the main risks of feed-in laws. Windfall profits can occur when premiums are set too high or rendered too high by innovation, and/or by increases in the price of electricity. Windfall profits impose an undue burden on electricity consumers, weaken political support for otherwise necessary incentives to renewable electricity, and increase regulatory uncertainty.

The proposed profitability threshold specifies the overall remuneration for renewable electricity that would make a technology competitive at the time of deployment without the need of any support scheme. If the price of electricity increased enough to make total revenue per kWh (price plus premium) higher than the profitability threshold, then the premium would be reduced until total revenue equals the profitability threshold. The threshold affects σ_{RoI}, and $\sigma_{EU,}$ but not σ_{Grid}, which is a compensation for grid services. In other words, if the price of electricity alone was enough to reach the threshold, the renewable electricity producer would not receive σ_{RoI} or σ_{EU}, but would still receive σ_{Grid} on top of the electricity price.

Under the proposed scheme, the profitability threshold must be defined at the same time as the premium, and be locked for each installation for the 20-year duration of the support scheme. In that way, if future technological innovation reduces the profitability threshold, current investors are still guaranteed recovery of their actual costs.

Strategic behavior could occur as a result of the profitability threshold, and should be avoided. Producers of non-dispatchable renewable electricity (wind, solar) are unlikely to display a strategic behavior pattern because their incentive is to produce as much electricity as possible when the resource is available. Producers of dispatchable renewable electricity such as hydro and biomass, however, may engage in strategic behavior in order to maximize profits. In particular, if electricity prices are high, those producers could collude with conventional peak power plants under some benefit-sharing scheme and sell at times of the day when electricity is cheap, allowing peak power plants to reap the benefits of peak time electricity prices. To reduce perverse effects and strategic behavior, an average electricity price (instead of hourly prices) should be used when calculating the profitability threshold for dispatchable technologies. This way, dispatchable electricity sources have the incentive to sell at peak hours, thus increasing the electric system's efficiency.

The proposed profitability threshold does not address the issue of "windfall" losses for renewable electricity generators in case of significant rapid reductions in electricity prices. Those price reductions can be caused, for example, by falling fossil fuel prices, low carbon emissions prices (or collapse of carbon emissions markets), or increased rainfall in countries with a high hydropower share in their electricity mix. A possible approach to address "windfall losses" would be to establish a minimum compensation threshold, modeled similarly to the profitability threshold.

Premium σ_{RoI} revision and technology innovation

There are different ways to revise premiums to account for technological innovation. One is fixed degression rates combined with regular revisions, such as those used in the German EGG. Fixed degression rates foster early deployment.

Another possibility is a revision for premium σ_{RoI} using a semi-linear step function, as illustrated in Figure 1. In such an approach, σ_{RoI} is adjusted in 4-year periods to reflect the decreasing costs due to technology innovation. For the first four years after the policy is enacted, σ_{RoI} remains constant at σ_0. After two years the cost per kWh of newly commissioned plants is assessed, (as shown in point "a" of Fig. 1) determining a new value, σ_1, for σ_{RoI}. In year 4 (point "b") σ_{RoI} begins being linearly adjusted from σ_0 to σ_1 over the next 4-year period (line "b-d"). In year 6 (point "c") the cost per kWh of newly commissioned plants is assessed again, determining a new value, σ_2, for σ_{RoI}. In year 8 (point "d") σ_{RoI} begins being linearly adjusted from σ_1 to σ_2 over the next 4-year period (line "d-f"). The process is repeated at points "e" and "f" and thereafter, in four-year periods.

The two years between assessment and actual adjustment reduce uncertainty for investors, and strategic behavior. The linear adjustment, which can be calculated monthly or quarterly, guarantees a smooth adjustment, reduces uncertainty and prevents stop-and-go effects at the end/beginning of newly adjusted values for the premium σ_{RoI}. The four-year period is suggested because it adjusts well to business cycles.

The semi-linear step function has the advantage of adjusting σ_{RoI} according to real technology innovation patterns. The rents from technology innovation can be described as the sum of shaded areas A and B in Fig.1. Through the adjustment of σ_{RoI}, the innovation rents in shaded area B are passed to consumers. However, the four-year adjustment period plus the two year gap between assessment and adjustment allow renewable electricity producers to capture part of innovation rents, reflected in shaded area A. Allowing producers to keep part of the innovation rents is important because it provides and incentive to invest in innovation and seek maximum efficiency in their equipment, thus creating a competitive market among renewable technology manufacturers, which further fosters innovation.

There is the possibility that costs for a particular renewable electricity technology increase over a period of time. These increases could be caused by renewable market factors, such as increased demand for renewable technology components from other countries, or extraneous factors, such as a hike in the price of steel or other materials. It is important to ensure that the σ_{RoI} revision mechanism, intended to pass on innovation benefits to consumers, does not hamper deployment of renewables in the case of cost increases caused by extraneous circumstances. Therefore, the regulator should be given the capacity to extraordinarily freeze the proposed downwards adjustment of premiums if cost increases not attributable to market dynamics are observed. Such a freeze would trigger a new cost assessment and adjustment curve for σ_{RoI}. In order to maintain market confidence, the revised adjustment curves could, in no case, result in lower premiums than without the extraordinary revision.

Assessment of the cost curve should be done at the sector level based on industry data, preferably using international figures. Using sector data rewards the most efficient producers and promotes competition among manufacturers of renewable electricity technology and components. Using international figures prevents national players from attempting to influence the assessment of technology costs.

Target revision trigger

Support systems for renewable electricity are eventually limited by cost and, ideally, by fulfillment of the goals that motivated them in the first place. Most existing renewable electricity policies limit support by stating upper limits of installed capacity after which the policy is no longer in effect. Linking support schemes to the achievement of established targets is one way of delimiting the total cost of a policy. However, this approach can be counterproductive if targets are unambitious or there is unexpected technology innovation. In the case of unambitious targets, the linkage renders support schemes ineffective. In the case of unexpected technology innovation, the linkage imposes limits below the support levels initially envisaged by the policy. These negative effects are compounded by the usual years-long time lags in policy making.

Setting an early trigger for revision of targets can be a particularly useful approach. With the early trigger, when a technology is nearing its goal (e.g. 50%), a revision of established goals would be mandated. This would set in motion the policy-making process and allow enough time for policy-makers to decide whether it is necessary/convenient to expand the target, or whether the support is no longer necessary.

5. COMPLEMENTARY CONSIDERATIONS

The effective and efficient implementation of a harmonized feed-in premium scheme and the proposed methodology may depend on other complementary issues, such as grid access, funding, definitions and standards, ownership of rights derived from renewable electricity, and exceptions for small non-commercial producers and energy intensive industries. These are not directly considered in the model stated above, but may need to be taken into account to a differentiated degree in the harmonization of feed-in-laws.

5.1. Grid access

A key feature for the success of feed-in laws is precisely the “feed-in” provision, or in other words, the grid access and purchase obligation for renewable electricity. The fact that the grid is required to connect renewable electricity producers and to buy all their production is one of the main elements of the success of feed-in laws. This structure guarantees the producers a steady flow of revenue, which makes financing possible for the up front investment. It is the initial investment that tends to be the main expenditure in renewable electricity projects (with the exception of biomass), so financing options are critical.

A directive on harmonization of feed-in laws needs to include explicit provisions to guarantee connection and transmission of renewable electricity. These provisions should include the technical requirements for connection of plants and delivery of electricity, as well as the allocation of costs for connection and, when necessary, grid upgrading. In this regard, an approach similar to the EEG (Art 4 and Art 13) seems appropriate, where renewable electricity generators bear the costs of connecting their plants to the grid, and TSOs bear the costs of upgrading the grid.

Another access-related issue is the degree of the deviations allowed for intermittent renewable sources, and the length of the time gap between the bidding process and actual delivery in the electricity market. This particularly affects wind power and photovoltaics. Clear guidelines are needed to ensure both grid efficiency and that regulations designed for other technologies do not become barriers to renewable electricity deployment.

5.2. Funding

A critical question for any policy is how that policy is funded. A feed-in law as proposed here does not involve a direct subsidy from the state. In a fully liberalized electric system, remuneration for renewable electricity with the proposed feed-in law premium, would work in the following way: (1) all electricity producers (including renewable electricity producers) make their bid in the daily or intra-day electricity market; (2) electricity producers bidding under the clearing price, have their electricity programmed for delivery; (3) the TSO or an independent body pays electricity producers for their sold electricity at the clearing price; (4) in addition to the clearing price, renewable electricity producers get paid by the TSO or the independent body the premium established for each one of them; (5) the TSO or the independent body sells electricity to distribution companies, using total costs (prices + premium + transport) to calculate its selling price for a particular period; (7) distribution companies sell electricity to final consumers, competing among themselves, at a price determined by the market and their commercial strategies.

The cost of the proposed premium system is imposed on the electric system, eventually being passed onto the final electricity consumers. Initially, as Member States transpose the new harmonized feed-in premium into their legislations, premiums are paid at the national level by national consumers. In countries with more than one electric system, an equalization provision, such as the one in Germany, can be necessary to evenly spread the cost of the policy. If and when a single EU electricity market is established, some components of the premium σ, particularly σ_{EU}, can be shifted from the national consumer to the European electricity consumer.

The funding of σ_{NAT} can be different. Because of its special nature, designed to accommodate Member State priorities and needs, σ_{NAT} can either be funded through the same mechanism as the harmonized premium or by other entities. For example, the National Parks System could finance σ_{NAT} in the case of a biomass plant clearing public forests for forest fire prevention.

5.3. Definitions and standards.

Currently different Member States allow different energy sources and renewable technologies to qualify or not for their renewable electricity support schemes. A consensus on standardized definitions is essential for harmonization. In particular, agreement is needed on what constitutes a renewable energy source, what technologies qualify for support, and what technical standards will be used or developed for those technologies.

Directive 2001/77/EC provides a definition of renewable energy sources (wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases), however, it does not require Member States to adopt those definitions, nor does it indicate which technologies require support. This is relevant, for instance, in the case of hydropower. Generally large hydropower is not supported and small hydropower is. The definition of what constitutes large or small hydropower changes from one Member State to another. Other areas that need clear definitions are (1) waste-related processes; (2) combinations of renewable and fossil fuels (co-combustion) and/or co-generation; and (3) small domestic installations.

Standards are needed to guarantee safety and efficiency, to meet environmental and other criteria, and to avoid deployment of sub-optimal equipment. In addition, agreement on standards at the EU level promotes industrial development and helps with the creation of EU-wide markets for renewable electricity technology and components.

From a longer-term perspective, the setting of international standards and definitions can have significant impacts on future rulings regarding WTO-compatibility of renewable electricity promotion measures (Howse 2005). This applies to the physical trade of electricity, or, more plausibly, the international trade of renewable electricity technology, components, and related financial instruments (RECs, carbon credits, etc). In this respect, the European Union, with leading companies in most renewable technologies, is in a privileged position to shape international definitions and standards.

5.4. Ownership of rights derived from renewable electricity

It is important to clarify the issue of ownership of tradable assets that are derived directly or indirectly from generation of renewable electricity. These assets include but are not limited to: green electricity certificates; carbon allowances under the ETS and other carbon markets; and NO_x, SO_x and other pollutant credits. Under the proposed scheme ownership falls on the TSO or entity in charge of pooling the premiums and equalizing costs. It is also proposed that any revenue derived from the sale, transfer or in any other way from such tradable assets must be used first to offset the costs of the premiums, and second to offset the costs of grid upgrading required to accommodate renewable electricity. Any additional revenue can be used for grid improvement or environmental measures relating to the grid system.

It is further proposed that if a renewable electricity operator forfeited the premiums for renewable electricity, it would retain ownership of any tradable assets related to generation of renewable electricity, while still enjoying the grid-access provisions of the harmonized feed-in law.

5.5. Exceptions for non-commercial producers and energy-intensive industries

Small non-commercial producers, such as a home owner with a photovoltaic roof, generally do not have the capacity to operate in the electricity market. Requiring individuals to participate in the electricity market is a barrier to the deployment of renewable electricity. Therefore a simplified system is needed for small non-commercial producers. Simplified systems can be either a non-commercial feed-in tariff or an aggregation system in which commercial players are allowed to aggregate small non-commercial installations and act as brokers of renewable electricity in the market.

Non-commercial producers also need specific taxation and accounting provisions. In order to allow for individuals and small non-commercial players to invest in renewables, it is important to eliminate any requirement to acquire commercial licenses or to follow business accounting practices. Taxation on possible benefits from renewable energy, if not exempt, should be included in personal income taxes, just as property or stock.

Special consideration may be needed for energy-intensive industries regarding their obligation to fund the premium These industries include sectors such as steel or aluminum smelters and railway transport.

Because electricity is a significant part of electricity-intensive industries, those industries' competitiveness is particularly vulnerable to changes in price of electricity, especially if they are competing in the global markets. Lost competitiveness can lead to relocation or closure of production facilities. Penalizing electricity-intensive industries would be self-defeating policy, because social and economic cohesion is one of the reasons for promoting renewable electricity, as stated by the European Commission in its White Paper "*Energy for the future*" and reaffirmed in Directive 77/2001/EC.

Nonetheless, recent studies and models (Martin 2004, Bode 2006, Neubarth et al. 2006, Ragwitz et al. 2006a) show that renewable electricity can actually reduce the overall costs of electricity, particularly by shaving off extreme price peaks during peak demand and by affecting the merit-order in a cost-reducing way. Therefore, any special provision for energy-intensive industries would have to be based on actual electricity price increases, if any, associated to the feed-in premium, once the savings to the electricity system due to renewable electricity generation have also been factored in.

CONCLUSION:

The main objective of this paper has been to study the main elements and convey a theoretical model that would make possible an EU framework for schemes to support renewable electricity based on harmonization of feed in laws. The further aim has been to suggest ways in which such harmonization model could be implemented. Our intention has not been to advocate for harmonization, or propose any timetable for this purpose, but rather to articulate a clear conceptual framework on the main components that need to be considered if such harmonization is to take place.

As shown here, feed-in laws are an effective and cost-efficient way to increase the generation of renewable electricity and achieve renewable electricity targets. Feed-in laws are compatible with EU state-aid, competition rules, preferable in respect of commensurability, and compatible with liberalized electricity markets. Harmonization of feed-in laws would provide the necessary long-term market stability and flexibility, and promote technology innovation.

The basis of the proposed approach is to build upon the successful factors of existing feed-in laws, and to incorporate the innovation of a modular premium, a profitability threshold and semi-linear revision for premiums. The modular premium provides flexibility and transparency, clearly distinguishing what is being supported under each component. This approach also creates a robust policy, makes official target more relevant and removes policy uncertainty.

In the long term, renewable electricity should be a mature industry with no need for specific support above that provided for today’s conventional energy sources. The proposed premium incorporates its own obsolescence by being phased out as specific technologies reach maturity and renewable electricity goals are attained. When a renewable technology becomes competitive, σ_{RoI} will be capped first by the profitability threshold and then by the revision according to industry costs. σ_{EU} is limited by achievement of established goals. If no further support is deemed necessary for a particular technology after achieving established goals, σ_{EU} can be discontinued for that particular technology. σ_{Grid}, as discussed, should not be considered a support mechanism, but rather a remuneration for a service provided to the grid.

In concluding, it must be highlighted that, despite some elaboration in calculating initial premiums, in practice, the final result is simple and straightforward for policy-makers, developers, and system operators: a guaranteed premium for 20 years, with low transaction costs and easy enforcement which developers can use to finance their projects.

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