Efficiency and effectiveness of promotion systems for electricity generation from renewable energy sources – Lessons from EU countries

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Abstract

Currently, a wide range of strategies is implemented in different countries to increase the share of electricity from renewable energy sources (RES-E). A still controversial discussion is whether quantity-driven (like Tradable Guarantee-of-Origin Certificates (TGCs) based on quotas) or price-driven (like feed-in-tariffs (FIT)) instruments lead to preferable solutions for society. The core objective of this paper is to compare the perspectives of quota-based certificate trading systems for an efficient and effective increase of RES-E with FIT. The major results of this analysis are: (i) The success stories of growth in RES-E in EU member states in recent years have been triggered by FIT implemented in a technology-specific manner at modest costs for European citizens; (ii) At present, TGC systems in most countries applied show a low effectiveness with respect to RES-E deployment of less mature technologies such as solar PV (with improving tendencies in e.g. the UK or Italy with respect to certain technologies); (iii) Compared to short term trading in TGC markets the intrinsic stability of FIT systems appears to be a key element for success; (iv) Hence, currently a well-designed (dynamic) FIT system provides a certain deployment of RES-E in the shortest time and at lowest costs for society.

1. Introduction

Increasing the share of renewable energy sources for electricity generation (RES-E) has a high priority in the energy strategies of many countries world-wide. In Europe the European Union has set ambitious targets for RES-E since the late 1990s, see e.g. EC [1], EC [2], Resch et al. [3] and Johnston et al. [4]. However, to facilitate a breakthrough for RES-E, several economic, institutional, political, legislative, social and environmental barriers have to be overcome, see e.g. Lior [5], and Haas et al. [6]. From our point-of-view economic aspects state a superior barrier and of core relevance to meet the targets set is the implementation of proper financial support systems. In this context a still controversial discussion is whether quantity-driven – like Tradable Guarantee-of-Origin Certificates (TGCs) based on quotas – or price-driven (like feed-in-tariffs (FIT)) instruments lead to preferable solutions for society. Major pros and cons of support systems have been evaluated e.g. by Refs. [7–13].

The most important issue in the current discussion is the request for a more or less European-wide TGC system to promote RES-E, see e.g. EWI [14], or Midtun [15]. This discussion appears to be odd at least because of two major issues:

- It interprets a quota-based trading system as the best solution simply because it is trading-based. But, the core objective has to be kept in mind which is to achieve an accelerated deployment of RES-E in an effective and efficient manner – and which is not to introduce a level playing field for trade;
- In the current discussion the measure of harmonisation is often equated to (technology neutral) quota systems. This ignores the fact that there are other, potentially more favourable options, to form a harmonised support system;
- It completely ignores the lessons learned so far which do actually not identify any success story. On contrary, most of the European success stories of promoting RES-E over the past decades in an effective and economically efficient way were driven by feed-in-tariffs, which are implemented in a technology-specific manner.

An important issue in this context is that both systems are actually market-based and introduced by policy makers and, hence, create an artificial market. Eventually, in both systems the final
electricity customers (or the tax payers) will have to cover the support costs.

The core objective of this paper is to compare the theoretical and practical perspectives of quota-based TGC for an efficient and effective increase of RES-E with other instruments like FIT.

2. Regulatory promotion strategies

In this section a survey on regulatory promotion strategies and their features is given. Table 1 provides a classification of regulatory strategies for encouraging the use of RES-E.

Within the category of regulatory price-driven strategies no quantity goals or targets are established. Instead, the focus is on providing generators of electricity 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 — as implemented e.g. in Spain — 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.

Regulatory quantity-driven strategies are based on a government decision on the desired level of generation or market penetration of electricity from different RES. The price is in principle set through competition between generators. 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 TGC in Europe. These schemes typically oblige 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 the market. For further details on how instruments work see Haas et al. [16].

<table>
<thead>
<tr>
<th>Regulatory Type</th>
<th>Price-driven</th>
<th>Quantity-driven</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voluntary</td>
<td>Investment focused</td>
<td>Investment subsidies</td>
</tr>
<tr>
<td>Generation based</td>
<td>Fixed Premium system</td>
<td>Tendering system for investment grant</td>
</tr>
<tr>
<td></td>
<td>Fixed Premium system</td>
<td>Tendering system for long-term contracts</td>
</tr>
<tr>
<td></td>
<td>Shareholder Programs</td>
<td>Tradable Green Certificate system</td>
</tr>
</tbody>
</table>

2.1. How promotion schemes work

The following analysis is based on the concept of static (and further-on dynamic) cost resource curves of RES (see e.g. Haas [16], Ragwitz et al. [17]). It is important to differ between (theoretically existing) continuous cost curves, and (in real life used) stepped (discrete) cost curves, see Fig. 1. The major reason for the shape of this cost curve is the difference in the costs of different technologies. A continuous cost curve considers the fact that every location is slightly different from each other and, hence, looking at all locations e.g. for wind energy in a certain geographic area a continuous curve emerges. Fig. 1 takes into account that in real life this accuracy is impossible. Different sites are put into certain categories and then a stepped curve emerges. Moreover, as Fig. 1 depicts these cost curves are associated with uncertainties. These uncertainties are the higher the more right we move in the diagram.

Based on this static (and further-on dynamic) cost resource curves a TGC-based quota system works as follows: A quantity (=quota = a certain percentage of electricity to be guaranteed from renewable energy sources) is set by a government. The generators (producers), wholesalers, retailer or consumers (depending who is obligated in the electricity supply chain) are obligated to supply/consume a certain percentage of electricity from renewable energy sources. At the date of settlement, they have to submit the required number of certificates to demonstrate compliance. A FIT works vice versa: the price is set and the quantity finally generated is decided by the market.

2.2. Objectives of promotion schemes

To finally identify which strategy is most proper the following basic reflections are of core relevance:

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1 Of course, a specific promotion programme put into practice may consist of a mix of different strategies.

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1. The core objective of a promotion scheme for RES-E must be to increase its market deployment;
2. It is of core relevance to bear in mind that actually all these systems rely on a command & control approach of a planned economy. In one case the price is set, in another case the quantity is set;
3. Yet on the other hand all of these systems are market-based: the goods are produced in a competitive market. (Private or public) Companies decide whether to invest or not. Only if the proper incentives are provided the proper investments will be made on a “free” competitive market. And it is important to note that this market in all cases is created by some kind of artificial demand. Hence, in both cases an artificial market is created
4. What should be the economic target of a support system for RES? As it is based on an artificial market and not on the voluntary decisions of the consumers/voters the objective should be to minimize the overall additional costs for these group to finally reach a maximum of support/acceptance possible.

2.3. Acceptance of support systems by customers and investors

Quota-based TGC systems as well as feed-in tariff systems create an artificial market and cause policy costs (=additional costs to be paid typically by all electricity customers). One of the major criteria for a successful promotion system is the acceptance by the electricity customers (or in exceptional cases the society if reimbursement is done through state budget) who finally have to pay the required expenditures. This acceptance is of course strongly depending on the magnitude of overall support. So it is important to analyze what are the additional extra costs for the electricity consumers.

The objective is to minimize additional costs for consumers, where

\[
\text{Additional costs for consumers} = \text{Producer Surplus} + \text{Generation costs} - \text{Revenues electricity market} - \text{(Avoided External costs)}
\]

These additional costs (=policy costs) have to be paid finally by the electricity customers. Of course, the lower these additional costs are the higher will be the public acceptance and the larger will be the amount of additional electricity generated from RES. As can be seen from Fig. 2 this minimisation will especially focus on Producers’ surplus (PS) and finally leads to a technology-specific support system which allows less profits for the cheapest technologies.

In Fig. 2 the cost definitions and the various cost elements used in the following are depicted. The total direct costs of this system consist of the generation costs, the producers’ surplus (PS) minus the revenues from the sale in the conventional electricity market. In addition, it can also be argued that RES-E reduce external costs or impact economic welfare and these terms may also be taken into account.

Moreover, investors in new RES-E generation plants should be compensated in a fair way but not by means of exaggerated profits. The FIT and premium systems in country without trading systems have proven that the RES-E investors accept this approach and provide the proper corresponding investments.

The idea of the TGC system relies on the reflection that trade in a market finally leads to the best allocation of resources. Special attention in this figure deserves the PS. The comparison of Figs. 3 and 4 shows the impact of the shape of the cost curve on producers’ surplus. If the cost resource curve is flat – Fig. 3 – PS is small or almost negligible and the additional extra costs which finally have to be paid by the electricity consumers/tax payers will not be influenced significantly by the design of the policy. Hence, there is no urgent need for a technology-specific support system.

Yet, if the cost resource curve is steep – Fig. 4 – PS is considerable and may even be higher than generation costs! Hence the additional extra costs which finally have to be paid by the

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Fig. 2. Basic definitions of the cost elements (illustrated for a tradable GoO certificate system) (Source: [4]).

Fig. 3. Producers’ surplus if the shape of the cost curve is flat (Source: [7]).

Fig. 4. Producers’ surplus if the shape of the cost curve is steep (Source: [7]).
electricity consumers/tax payers rise tremendously in comparison with a technology-specific FIT. This case is by far the overwhelming one in EU-27 countries and leads straightforward, to the request for a technology-specific support system e.g. FITs as depicted in Fig. 5.

A uniform European TGC price for all RES-E would be set by the marginal price of the most expensive technology sold (analogous to current quota systems). If the marginal price is set by a medium or high cost technology, this would lead to windfall profits for low-cost technologies (this is one reason why the UK government has introduced technology banding for the UK ROCs market). These windfall profits could offset the potential efficiency gains of European trade.

In this context, Fig. 6 illustrates in a schematic way the possible PS arising in EU-27 from a technology neutral support scheme. It plots the cost resource curve of the additional realisable potential for renewable electricity in the EU-27, where the whole basket of available RE technologies is clustered into several bands, indicated by their marginal generation cost and the corresponding realisable future potential. Thereby, several low-cost options such as biowaste incineration, biomass co-firing or most preferable sites for wind onshore form the left part of the merit order curve, followed by moderate RES-E options – e.g. wind onshore at moderate sites, wind offshore, small-scale hydropower or large-scale biomass plants. On the margin with regard to the required additional RES-E deployment up to 2020 large-scale agricultural biogas and medium-range biomass plants appear in this simplified depiction. Consequently, in case of technology neutral support as appearing under a mandatory TGC trading scheme, high producer profits can be expected, indicated by the shaded area above the cost curve in Fig. 6.

In addition, it has to be born in mind that in a trading system the risk to recover investments leads to the effect of an additional risk premium, see Fig. 7. This Figure finally explains why the support costs in most trading schemes tend to be higher than in FIT countries.

3. Country-specific lessons learned from TGC markets

This section summarises the major lessons learned from trading systems implemented in specific countries. Quota-based systems are now in place in the UK, Sweden, Italy, Belgium, and Poland, see Table 2 below. Analyses on the effectiveness of TGC systems have been conducted e.g. by van der Linden [18], Jacobsson et al. [19], Ragwitz et al. [20], Toke [21].
Table 2
Survey on TGC systems in EU countries.

<table>
<thead>
<tr>
<th>Period</th>
<th>UK</th>
<th>Belgium (Flemish region)</th>
<th>Belgium (Wallon-region)</th>
<th>Italy</th>
<th>Poland</th>
<th>Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obligation</td>
<td>Start 2002 3% in 2003, 10.4% in 2010</td>
<td>Start 2002 1.2% (2003), 2% (2004) increasing up to 6% in 2010</td>
<td>Start 2002 3% in 2003 increasing up to 12% in 2010 From September 2010 onward, the quota will be multiplied by 1.01</td>
<td>Start 2001 2% in 2002 and increased annually by 0.35% between 2004 and 2008</td>
<td>Start 2005 7.5% in 2010</td>
<td>Start 2003 7.4% in 2003, 16.9% in 2010</td>
</tr>
<tr>
<td>Obligation on Technology bands within overall quota</td>
<td>Supplier</td>
<td>Supplier</td>
<td>Supplier</td>
<td>Producers and importers</td>
<td>Supplier</td>
<td>End-user</td>
</tr>
<tr>
<td>Involved technologies</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Existing plants eligible</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No (for certificate trade), Yes (for quota fulfilment)</td>
<td>No</td>
<td>Yes (small hydro)</td>
</tr>
<tr>
<td>International trade allowed</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes, but only in exchange with physical electricity and with reciprocity countries</td>
<td>No</td>
<td>Trading scheme with Norway planned</td>
</tr>
<tr>
<td>Floor price</td>
<td>Not planned.</td>
<td>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 1 MWh of: offshore wind 90€, onshore wind 50€, hydro: 50€, solar: 150€, biomass: 20€. Within the Wallon-region, RES-E producers may exchange their TGC for a subsidy of 65 €.</td>
<td>No</td>
<td>Not planned</td>
<td>No</td>
<td>Only in the introductory phase.</td>
</tr>
<tr>
<td>Penalty</td>
<td>Buy-out price</td>
<td>75€/MWh (in 2003; 10€/MWh in 2004; and 125€/MWh in 2005)</td>
<td>From 1st of April 2003 onward: 100€/MWh (100€ per missing TGC in size of 1 MWh)</td>
<td>No. The grid operator sells certificates at a fixed price 12,528€/MWh (2006)</td>
<td>The buy-out price is 100 EUR/MWh</td>
<td>150% of the market price with a maximum of about 19€/MWh in 2004, 26€/MWh in 2005</td>
</tr>
</tbody>
</table>

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In Sweden, certificate prices are still lowest — see Fig. 8a — although prices have been rising in recent years. In Sweden some old capacity were also allowed to participate in the Swedish quota system. This resulted in the situation that more certificates were produced than redeemed until 2006. In 2007 it was the first time that more certificates were redeemed than issued (see Fig. 8b)!
Moreover, additional investment subsidies for wind power plants were available, improving further the economic incentives for wind power investments.

In the UK, the major problem — aside from high certificate prices — is that the quota has never been fulfilled so far. In the accounting period 2007/2008 4.9% of electricity was generated from “new” RES while the quota was 7.65% (see Fig. 9a) resulting in a quota fulfillment of 64% (see Fig. 9b). One main reason for this failure is that ambitious RES targets were introduced in a non-mature market environment, where besides policy-driven investor’s uncertainty (e.g. on future certificate prices) several administrative barriers appear of relevance. There is a similar situation in Italy. Certificate prices here are high (see Fig. 7) and quota fulfilment is moderate (about 90% of the quota of 3% was fulfilled in 2007).

In Belgium there are two parallel TGC systems in Flanders and Wallonia. The TGC prices in Flanders are among the highest in Europe and as reported in Verbruggen [22] and Verbruggen [23] the associated policy effectiveness has been very low until 2008. Yet, it appears to be on a rising trend starting in 2009.

Furthermore, it is of interest to analyse whether the financial support decreases over time. Fig. 8a shows the premium support level in selected countries. As can be seen the requirement of a noticeable dynamic decrease in the promotion costs is not met for TGCs despite increasing market prices for conventional electricity. For all other EU countries — especially Poland — it has to be stated that the experiences available so far do not yet allow any appraisal of the success of the implemented policies.

4. Criteria for effective and efficient promotion schemes

A comparison of the different support schemes has been conducted in several projects and investigations see e.g. RWI [24], Sensfuss et al. [25], Gomez et al [26].

Next the relation between quantities deployed and the level of support is analysed for some trading and some FIT systems in

Fig. 8. a. Value of certificate in different European TGC markets, b. TGC’s in Sweden issued and redeemed.

Fig. 9. a. Quotas and actual shares achieved in different European TGC markets, b. Quota fulfilments in different European TGC markets.

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Recent years. It is often argued that the reason for higher capacities installed is a higher support level. Paradoxically, countries with highest support levels – Belgium and Italy for example – are among those with the lowest specific deployment (Fig. 10). On the other hand, high FITs especially in Germany and Spain are often named as the main driver for successful investments especially in the area of wind energy. However, the support level in these countries is not particularly high compared with other countries analysed here.

Summing up a major result of these analyses is that the investigated FIT systems are effective at a relatively low producer profit. A well-designed (dynamic) FIT system provides a certain deployment of RES-E in the shortest time and at reasonable costs for society.

The most important design criteria for FITs are: (i) a carefully calculated starting value; (ii) a dynamic decrease of the FIT that takes into account technological learning; (iii) the implementation of a stepped and technology-specific tariff structure.

If any TGC system is implemented (e.g. to allow for some burden sharing between countries) the following conditions are of superior relevance:

- Ensure a large liquid market, which may be difficult in the case of fragmented TGC systems according to technology and by country;
- Ensure an equilibrium between short term spot markets and long-term contracts for TGC

Another important issue is to ensure a long-term planning horizon. It has to be guaranteed by highly credible authorities that a TGC system will exist for a specified and sufficient time horizon. Otherwise the uncertainty for potential investors is too high and it is likely that only few investments take place;

- A quota-based TGC system has to focus mainly on additional installations of RES-E capacity. If a large share of the required capacity to meet a quota already exists, TGCs lead to windfall profits for the owners of existing plants. More precisely, no existing or at least no fully depreciated plant should be included in a quota system, otherwise substantial windfall profits occur;
- Hence, from the public’s point-of-view, TGCs qualifying for a quota should only be issued over a pre-defined period of time. A rolling redemption may provide a proper solution;
- It is highly relevant that the penalty for not purchasing a certificate is higher than the expected market price for TGCs. Otherwise there is no incentive to fulfil the quota.

5. Conclusions

The success of European promotion strategies for RES-E is depicted in Fig. 11. An almost exponential growth took place since the beginning of the 1990s. The major conclusions of the theoretical reflections and the empirical findings presented in this paper are:

The major success stories of this growth in RES-E in EU member states in recent years has been triggered by FIT which are implemented in a technology-specific manner and involve rather modest costs for European citizens. The main reason for this observation is the long-term price security of the system combined with technology diversification of support. Compared to short term trading in renewable certificate markets the intrinsic stability of feed-in systems appears to be a key element for success.

Currently, a well-designed (dynamic) FIT system provides a certain deployment of RES-E in the shortest time and at rather low costs for society. The experiences made with FIT systems have shown several advantages compared to trading schemes at least for three reasons: (a) a FIT system is easy to implement and can be revised to account for new capacities in a very short time; (b) administration costs are usually lower than for implementing a national trading scheme. This fact is especially important for small countries where a competitive national trading scheme is difficult to implement; (c) The advantage of a technology-specific FIT, which helps to diminish the producer surplus, is the higher the steeper the cost curve is.

In recent years, quota-based TGC systems have shown a lower effectiveness (but with improving tendencies where support is applied technology-specific via banding) although comparatively high profit margins are possible. Firstly, a major problem are the high producer profits for the cheapest options in the market given a steep cost curve as depicted in Fig. 4. This leads to correspondingly high additional costs for customers. Secondly, market mechanisms seem to fail in TGC systems.

Finally, the following reflections are of core relevance when thinking about changes of promotion schemes or harmonisation based on trading systems:

- It has to be born in mind that all support systems (quota-based TGC systems as well as other instruments like FIT) are based on an artificial market created by policy maker. It is not based on the voluntary decisions of the consumers/voters! Hence to ensure

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Fig. 10. Effectiveness vs costs of promotion programmes for electricity from RES in selected countries 2003-2008 (excl. Photovoltaics, source: own investigations). Only countries are considered with promotion policies since 2003.

Fig. 11. Development of “new” RES for electricity generation in EU-27 (Source).

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3 Remark: Why should competition work in a TGC market if it does not function in the conventional European electricity market?.
broad acceptance of such a promotion system the objective should be to minimize the overall additional policy costs for these group. Moreover, investors in new RES-E generation plants should be compensated in a fair way but not by means of exaggerated profits. The FIT and premium systems in country without trading systems have proven that the RES-E investors accept this approach and tend to provide the proper corresponding financial incentives;

- Many currently implemented FIT schemes have proven that they are efficient and effective. Why should they be abandoned and be replaced by a TGC system which has so far only shown that it is in most cases inefficient and ineffective?
- Another major current question is whether a fully harmonised EU-wide promotion scheme should be pursued. The major conclusion here is: It cannot be recommended at all to try to introduce currently a fully European-wide harmonised trading scheme. Munoz et al. [27], Klessmann et al. [28] and Klessmann [29] have soundly argued that there are more convincing design options under the new Directive. Or as Toke [30] puts it: “Problems begin to creep in when people start making proposals for the same incentives to be given anywhere in Europe... A harmonised EU-wide market-based system, would not improve cost-effectiveness, and may serve to reduce, rather than increase, local investment in renewable energy”. However, we also have to bear in mind what happens in the mid-term (after the first wave of investments comes to the end of their deprecation periods). In the light of the dynamic development in the RES-E market (e.g. wind turbine manufacturers, biomass plant developers, photovoltaic system component producers) and in the conventional electricity market (increasing prices due to rising demand and capacities becoming scarce, highly volatile natural gas prices and highly volatile prices for CO2-emission certificates), it is of course necessary to improve and further develop the promotion schemes for RES-E.

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