【Report】

Analysis of Feed-in and Tradable Green Certificates (TGC) support mechanisms for renewable energy in Europe

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Abstract

After a short overview of the consistent development of renewable energies in the EU, this paper analyses the two main incentive schemes, FEED-IN and Tradable Green Certificates (TGC) mechanisms, adopted to stimulate the diffusion of "clean energy" in the European Union. In the first chapters, a brief description of these instruments is provided and considerations about positive and negative aspects with also suggestions to improve the systems are presented. The last part is dedicated to the assessment of these policies, by means of an analysis of their effectiveness, economic efficiency and expected revenues and profits for investors. In addition, the reasons why the FEED-IN system is more successful than the TGC one are illustrated, and general characteristics of a credible incentive system are presented.

1. Introduction

As conventional energy sources damage the environment significantly, in order to substitute them with more environmentally friendly ones, renewable energy sources (RES) seem to be the solution and they are being increasingly supported by public authorities. Therefore, with the aim of reaching the Kyoto targets and going beyond them, as the risks of climate change are continuously demonstrated [1], support schemes to foster renewables have been reinforced. Aiming at achieving the European commitment to reduce greenhouse gas emissions, the European Union adopted two directives on renewable energies, in 2001[2] and in 2009 [3] respectively, to increase the electricity from RES (RES-E). This procedure made it important to improve these incentive schemes [5]. The new directive [3] was approved under Germany's presidency and is part of the European climate and energy package. It entered into force in June 2009 and places an ambitious target for Europe, since the binding level of 20 % of energy produced from renewable sources has to be achieved by 2020 (in comparison with the 8.5 % level in 2005) [4]. As nowadays the targets for the renewables have grown considerably, the aim of achieving these goals at a lower cost has became relevant, so the instruments used to promote RES must be reexamined closely and improved [5].

At the present time, conventional energy sources, such as coal, oil and gas, are consistently cheaper in comparison with the renewables ones, since they have benefited for a long time from mass production and learning effects. In contrast, almost all the renewable energy technologies are not economically competitive (with the exception of hydropower), although some of them have experienced considerable progress in the last decade, as for example wind power. This means that these energy options for the future are still immature and not economically competitive [5], so instruments to stimulate their deployment have to be assessed and improved.

An important aspect related to the fossil fuels is that the external costs of using them is not accounted for by the producers and so it is not reflected in the electricity bill. A clear level playing field has to be established, therefore this market imperfections should be corrected, so that fair competition between different technologies can be established. One of the options for achieving this goal is to place an environmental tax on the use of fossil fuels, as a result of the aim of internalizing the external costs that arise from the use of these harmful sources. This would lead to technological innovation and also to changes in consumer behaviour. The first problem related to this option is that taxes are doomed to the political acceptability, and secondly the environmental tax may not be enough to stimulate the market of RES. As a consequence, the establishment of incentives for electricity producers to adopt renewable energy technologies, is seen as a good opportunity to stimulate their market and bring down the costs to achieve economical competitiveness [5].

In Europe many different support schemes have been adopted in order to speed up the development of renewables, and this paper will analyse the two main ones, the Feed-in and the Tradable Green Certificates mechanisms. The paper is organised as follows: Section 2 gives a briefly overview of the situation of electricity production from renewable sources (RES-E) in the EU. In section 3, the feed-in tariff and Tradable Green Certificates (TGC) promotion strategies for the development of renewables in European countries are described. The policy assessment approach of these schemes and the results are presented in Section 4. The major conclusions for policy makers derived from the analysis complete the paper.

2. Supply of electricity from renewable energy sources in the EU

In 2007 the electricity produced with renewables reached 525 TWh (Figure 1), equivalent to 15.6 % of the total electricity supply, showing a growth of around 4.1 % p.a. since the entry into force of the EU directive in 2001. With the exemption of hydropower, the development in renewable electricity supply increased by an average of just under 20% per annum during this period, corresponding approximately to a three-fold growth. Considering that a typical household consumes 3,500 kWh/a, the growth in electricity from renewables of 60 TWh in 2007 corresponds to an additional renewable electricity supply of more than 16 million households in the European Union. The sectors which show the most relevant development are the wind energy one and the biomass one, with an average growth around 25% p.a. and 16% p.a. respectively, in the period under survey. Although staring from a low level, the photovoltaic has shown consistent development, with an average growth of 64% [4].

Figure 2 presents the breakdown of RES-E in the year 2006 for each European country, so that the different contributions of the various technologies can be visualized. A striking point is that the most important renewable energy source for electricity generation in most European countries is large-scale hydropower. However, there are countries which have opted significantly for non-hydro renewables, such as Denmark, Germany, Finland, Hungary, Ireland, the Netherlands, Spain and the United Kingdom. Wind energy is especially important for Denmark, Germany, Ireland and Spain [6].

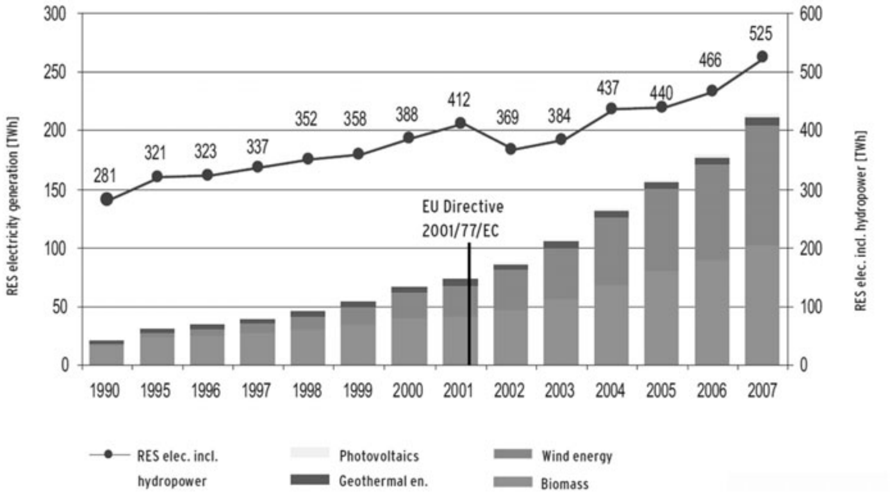

Figure 1. Supply of electricity from renewable energy sources in the EU (1990-2007). Source: [4]

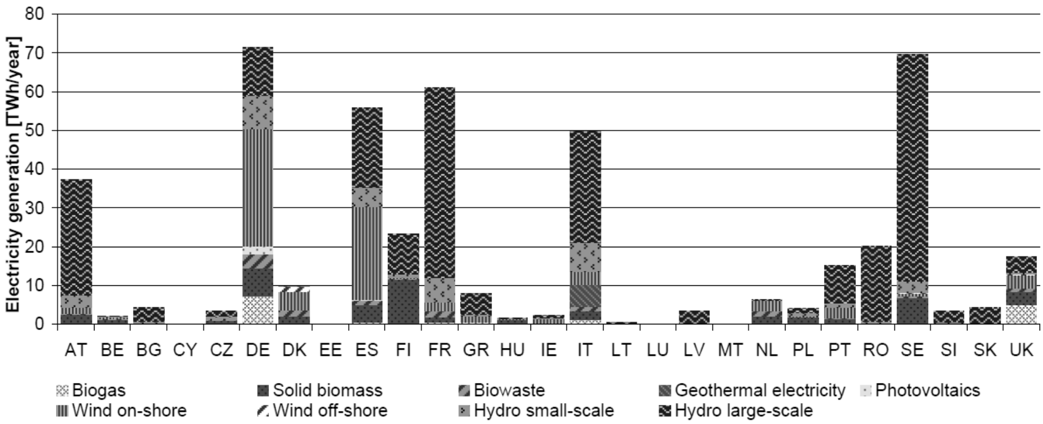

Figure 2. RES-E generation in the 27 EU Member States in 2006. Source: [6]

3. Principal support mechanisms for renewable energy sources in the EU

This section outlines the main policy schemes applied in Europe and includes a brief characterisation of the schemes. A fundamental distinction can be made between direct and indirect policy instruments (Figure 3). In this context, immediate stimulation of RES-E is achieved by direct instruments, while the establishment of long-term framework conditions is related to indirect ones [7]. Besides regulatory instruments, there are also voluntary approaches to the promotion of RES-E, which are mainly based on consumers' willingness to pay premium rates for green electricity. Another important classification principle is whether policy instruments address price or quantity, and whether they support investment or generation.

Within this paper, the assessment of direct promotion strategies is carried out by focusing on the comparison between price-driven (feed-in tariffs (FITs)), and quantity-driven (Tradable Green Certificates (TGC)) strategies, see also Figure 3. An important note is that the tender scheme which is present in the figures just for Ireland has recently been substituted by a feed-in system.

		Direct		Indirect
		Price-driven	Quantity-driven (quotas)	
Regulatory (obligated)	Investment focussed	• Investment subsidies • Tax credits	• Tendering system	• Environmental taxes
	Generation based	• (Fixed) Feed-in tariffs • Fixed Premium system	• Tendering system • Tradable Green Certificate system	
Voluntary	Investment focussed	• Shareholder Programs • Contribution Programs		• Voluntary agreements
	Generation based	• Green tariffs		

Figure 3. Fundamental types of promotional strategies.

3.1 Feed-in tariff scheme

Feed-in tariffs (FITs) are generation-based, price-driven incentives. In this scheme, regional or national transmission system operators (TSO) can feed-in the full production of green electricity at defined prices which differ on the base of the various generation sources (wind, hydro, etc.). There are two types of tariff: (i) fixed tariff (fixed feed-in scheme) and (ii) additional tariffs added to the current electricity price (premium feed-in scheme). The role of these tariffs is to cover the cost disadvantage of the renewable energy sources. Furthermore, the additional costs paid by the producers are added to the electricity bills of the consumers [8].

Nowadays, FITs are applied by 20 of the 27 EU Member States as main instrument to support the generation of RES-E and by one country (Italy) only for electricity generation from PV and certain small scale application (Figure 4).

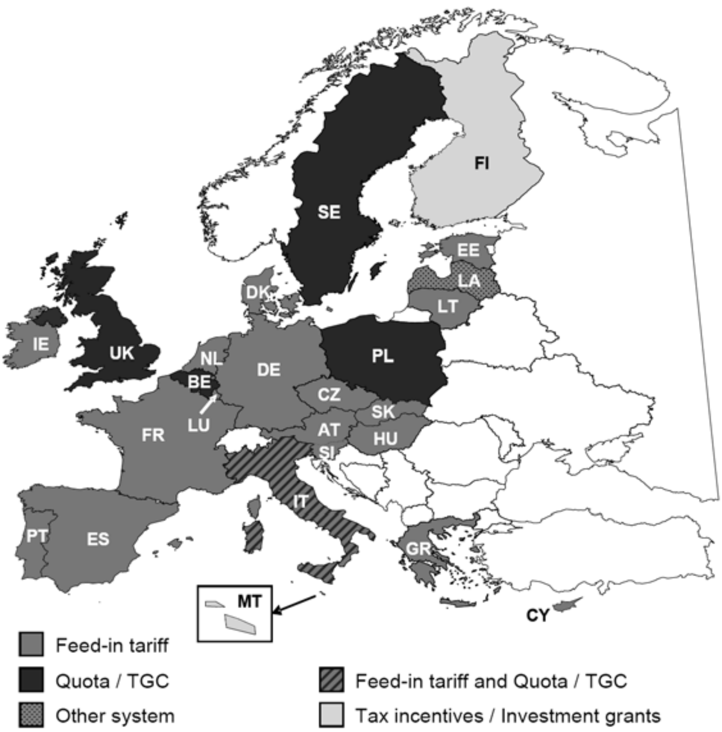

Figure 4. Support mechanisms for renewable energy in the EU. Source:[6]

As stated above, there are two different types of feed-in systems. In the first case, the fixed tariff design, RES-E producers receive constant amounts of money per kWh of electricity generated, independently from the electricity market price. In the second case, defined as premium tariff and considered a more market orientated system, the value of the electricity price is relevant and therefore the producers get different levels of support during their production. In this situation, a fixed premium is added to the varying market electricity prices [6]. At present time, most of the European countries with feed-in systems opted for the fixed tariff model, which is the one that will be discussed in this paper.

The feed-in tariff operates as a subsidy allocated to producers of renewable energy. FIT mechanism functions as shown in Figure 5. An upward-sloping long-run marginal cost curve represents the supply of electricity produced by the technology considered. Investors projects result in being profitable in two cases: (i) when the price is below the electricity price, so that no support is needed and (ii) above the electricity price, where the support is required in order to make the production profitable for the investors. Once the FIT rate has been reached, investors expenses are not covered above that level, so no additional production will take place. The total cost for supporting RES-E is represented by MFXY, the additional cost over the electricity price, while the rents of producers correspond to the triangle MFX [11].

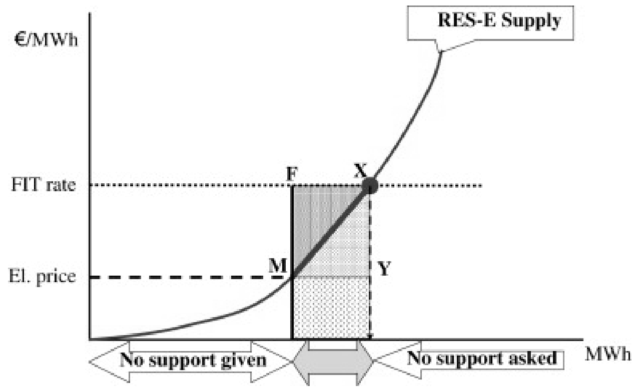

Figure 5. Operation of FIT scheme. Source:[11]

3.1.1 General characteristics of a FIT design

In this part I listed the important aspects which are necessary in order to design an efficient and effective feed-in tariff scheme:

1. *determination of the level of tariff*. The first option is to base the tariff on the cost of the generation of electricity from RES (levelised-cost based). The advantage of this approach is that the investors are sure to receive a reasonable rate of return [10]. In the second case FIT payments are dependent on the value of that generation to the society. One way of defining this value is to internalize the externality costs of the traditional generation (such as the value of climate change mitigation, health and air impacts, and/or effects on the energy security [6]). As this approach may not provide sufficient economic support for the investors, the first one is preferred [10].
2. *technology specificity*. In order to be efficient, a FIT scheme must provide technology-specific tariff levels, as different RES-E have various generation costs. The remuneration should cover the electricity generation costs and provide a reasonable profit margin, but it should also assure that technological diversity is guaranteed. A well-designed technology specific approach, with FITs applied to three different RES-E categories (e.g.

biomass, wind and PV) is shown in Figure 6. These technologies present different costs, with A (e.g. biomass) the cheapest and B (e.g. wind) and C (e.g. PV) increasingly more expensive. It can be seen that for the least expensive RES just a limited amount of output is FIT-supported, while it increases in the case of category B and it is completely covered in the case of the most expensive one. This last situation may be the PV sector, whose technology is still far distant from the market, but highly qualified, indicating that effective support is needed to reach the market competitiveness [11].

3. *various types of tariff.* Tariffs could also be divided into *Stepped Tariff* and *Flat Rate Tariff*. In the first case a constant amount of money is paid to producers of a defined technology, regardless of the electricity generation costs. Since different producers have various levels of costs also on the base of the size and the full-load hours of their facilities, this first method leads to over-subsidizing producers who work at high full-load hours (usually large and cheaper plants), as can be seen in Figure 7. There are two negative aspects related to this approach. The first one is that larger and cheaper power plants will earn more money than the small ones which usually operate al lower full-load hours, and secondly the consumers will have to pay higher costs. The possible solutions to this problem are two. The first one is to reduce the level of the tariff. Although this measure could reduce the revenues of big producers, it would also put out of the markets smaller plants which operate at higher costs. The second option represents also the second type of tariff, the stepped one, where different levels of remuneration are paid for electricity of the same RES-E technology. The tariff may change on the base of the location, the plant size and the type of fuel [6]. In Figure 7, it is shown the different effect which a stepped tariff has on the level of support for power plants in comparison with the flat option.

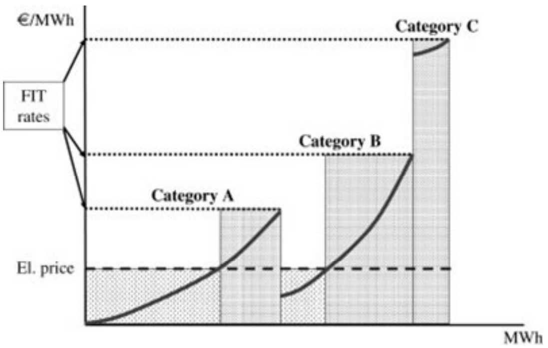

Figure 6. FITs tuned to three qualified RES-E categories. Source:[11]

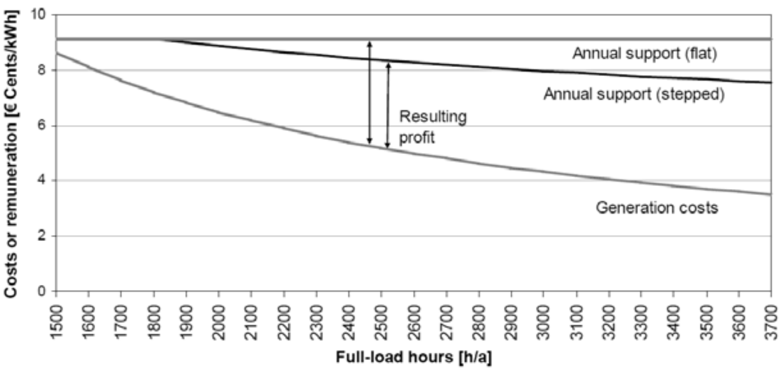

Figure 7. Stepped tariff and Flat rate tariff. Source:[6]

4. *stimulus of technological improvement and revision of tariff*. Technological progress plays an important role in reducing the long-run marginal costs of the projects, as lower costs increase the rent investors can obtain. This situation is presented in Figure 8, which shows that FIT stimulates investors to reduce their long-run marginal cost curves, shifting the curve down to P1, and later to P2. In this situation of a constant FIT rate, the community will benefit from the increased generation of RES-E and producers will raise their revenues obtained by technical change [5]. Nevertheless, since the costs decline continuously and maintaining the same level of remuneration would lead to a higher burden on consumers, some countries (such as Germany) have applied declining rates (degression) to each year's new crop of installations, while keeping them constant for each particular installation (Figure 9) [6].

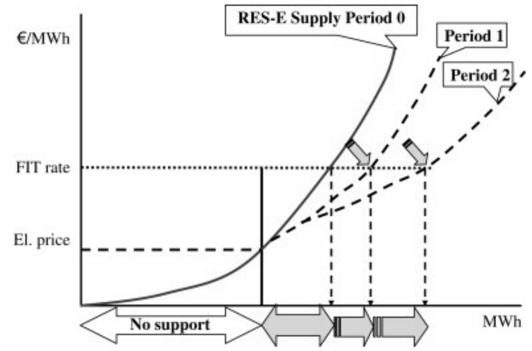

Figure 8. Support by finetuned FIT induces innovation. Source:[11]

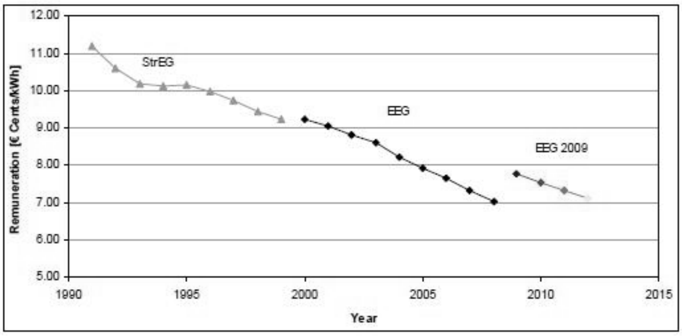

Figure 9. Development of the remuneration of electricity from onshore wind energy in Germany. Source:[6]

3.1.2 Considerations about feed-in system

This scheme is the preferred tool to stimulate the development of renewable energy. Over 80% of additional installed capacity in Europe in 2000 took place in 3 countries, all with feed-in schemes: Germany, Denmark and Spain [5]. The main reasons of feed-in success are [5]:

- relatively high prices of the tariffs guarantee a good return on investment;
- the long-term pay off period (usually 15-20 years) and the fact that all new projects are eligible for subsidies, reduces considerably the risk perceived by project developers. Therefore, the crucial problem of price volatility is also overcome by means of a guaranteed feed-in tariff;
- the transaction costs (project preparation, selection procedure), which are usually quite costly, are considerably lower than for other systems.

3.2 Tradable Green Certificates (TGC) mechanism

Tradable Green Certificates are generation-based, quantity-driven incentives. The main feature of this quantity-based or Quota mechanism is that a pre-determined amount of electricity which should be generated from Renewable Energy Sources (RES) is fixed by public authority. The systems performs as follows: (i) the amount of electricity produced by renewables is set by the governments, and it increases continuously during the years; (ii) the regulatory (usually a government office) submits certificates to generators which demonstrate the production of renewable energy; (iii) the generators (producers) are obliged to supply a certain percentage of electricity from renewable energy sources; (iv) at the settlement date, the suppliers have to submit the required number of certificates in order to demonstrate compliance to the regulator [14].

Those obliged can demonstrate compliance by providing certificates (every certificate corresponds to 1 MWh produced). They can obtain these certificates by [13]:

- owning their own renewable energy generation, so that each defined amount of energy produced by these facilities would represent one certificate;
- purchasing electricity and associated certificates from another renewable energy generator;
- purchasing certificates without buying the actual power from a generator, i.e. purchasing certificates that have been traded independently of the power itself.

An important point about this system is that, with the aim of achieving the desired green electricity output, it is compulsory for consumers/producers to buy a certain number of green certificates from RES-E generators according to the percentage, or quota, of their total consumption/production. Who does not comply with the quota is doomed to penalty payments, whose entity depends on the number of kWh not supplied with renewable energy. This money are transferred either to a renewable research, development and demonstration fund or to the producers on the basis of the percentage of certificates submitted at the settlement date.

Another relevant aspect of tradable green certificates is the creation of a certificates market, in addition to the electricity one, as producers/consumers wish to buy these certificates as cheaply as possible. For this reason, TGC is a marked-based instrument, which could ensure the best value for investments, if well functioning. Furthermore, reduction in generation costs induced by competition on the supply side, is an additional upside [16]. With this system, the sources of income of a producer are two. Firstly, the electricity produced can be sold on the market at a standard price. Since the price paid to produce such electricity is higher than that paid using conventional sources, competition is not possible and producers risk to incur in losses. As a result, the producer can move to the certificates market and sell his green certificates, at a price that covers his loss [17]. It is possible to say that the profit obtained by selling the certificates is the extra cost required to produce cleaner energy compared to traditional one.

The demand for TGC is created by the gradually increasing quota, and it is the market which has to deliver the supply of certificates. If the supply is outrun by the demand for certificates, the government quota is in the situation of not being reached, so the market price of certificates increases. When new capacity is installed and the quota is going to be met the price will stop its growth. In practice, as in the UK, a cap is set for the maximum TGC price by allowing obligated companies to pay a “fine” (buy-out price) for lack of compliance [14] (see also Figure 10).

The amount of green electricity to be generated is decided for the whole country, and is then divided among each of the operators (consumer, retailer, distributor or producer). The TGC mechanism allows to reduce the overall costs, as quotas can be allocated in an efficient way. This concept can be better understood considering Figure 11. In this picture, two distributors are assigned production objectives indicated by q. Having a higher marginal production cost (MCA), distributor A will incurr higher expenses to reach the objective q. By means of trading, distributor *A* can buy certificates at the equilibrium price *p* to reach the target amount *q*. This is possible because distributor *B*, whose marginal production curve is lower, can produce a higher quantity of electricity, above the *q* level, and sell the surplus certificates at price *p*. The shaded areas in Figure 11 illustrate the reduction in the cost of reaching the overall objective ($Q=Q_A+Q_B$=2q) [5].

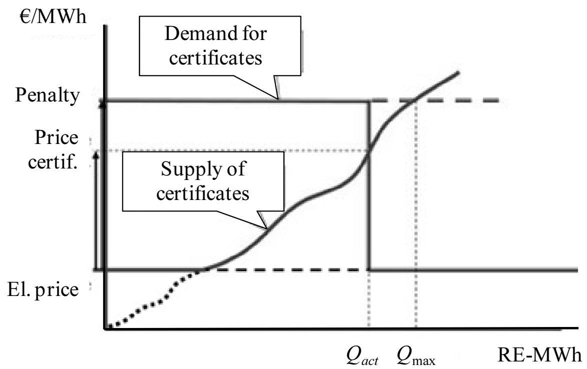

Figure 10. Certificates market on- top of physical electricity trade. Source:[11]

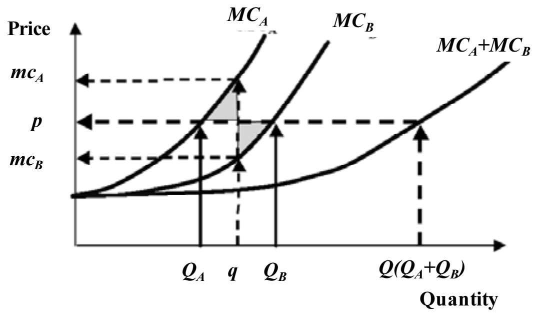

Figure 11. Operation of green certificates market. Source:[5]

These systems could work well in a single European market and have in theory a lower risk of over-funding compared to feed-in schemes. In contrast, nowadays, green certificates pose a higher risk for investors and higher administrative costs [15].

3.2.1 Considerations about TGC system

As Tradable Green Certificate mechanism is seen as the scheme which will replace the feed-in one in the European electricity-liberalized market, some aspects about the former system are presented:

1. *promotion of least costly technologies*. In this system, the retailers/distributors must reach determined RES-E generation objectives, but it is not specified what type of renewable technology they should adopt. Therefore, least cost technologies, both for a single technology (coastal regions before inland areas) and also for several competitive technologies (wind power before photovoltaic), are preferred as this allow the producers to sell their certificates at a lower price and so to be more competitive. If a dynamic viewpoint is adopted, this advantage may become a drawback, since more expensive, but promising, technologies may not be developed. This effect is pictured in Figure 12, where the quantity of green certificates (GC) is plotted against the price (P)/marginal costs (C') of the producers on the y-axis. The vertical line represents the demand, which corresponds also to the quota, and different power sources are shown by various supply curves. The aggregated

supply curve is presented in bold. Considering the price of green certificates constant, it results clear that the only technologies which will be competitive and will allow producers to sell certificates, would be the wind, the hydro and the biomass one. This results in a consistent exclusion of some more expensive options, leading to a drop in technological diversification [17].

2. *excess profits issue*. In the case that the scheme does not take into account qualification of RES-E sources, large free-riding opportunities are generated. Figure 13 illustrates the case with the distinction between rents and excess (swindle) profits. This example considers three technologies (A,B,C), with A showing constant (flat) marginal costs, whilst Bss and C increasing ones. If an amalgamation takes place, with the result of an uniform price, fixed at the height of the crossing between the marginal cost curve of edge source C and the quota limit, the areas comprised between this horizontal line and the marginal cost curves of the sources are revenues earnt by the producers. Figure 13 distinguishes also between real rents and swindle or excess profits caused by the amalgamation process. Two crucial consequences can be derived: (i) investors would prefer to earn “easy” money choosing the least costly technologies, in order to maximise their profits; (ii) the market of renewables could be considerably harmed by the reduced willingness to pay of consumers, once they get aware of the fact that a consistent amount of their support is reaped by free-riders [18].

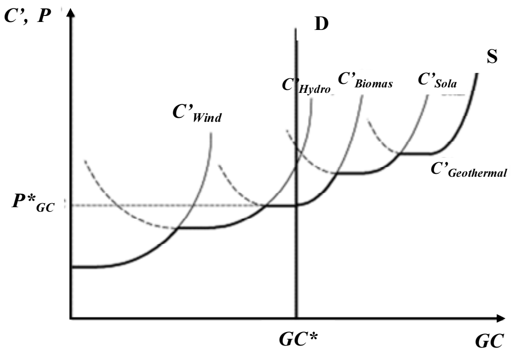

Figure 12. Economic efficiency on the market for green certificates. Source:[17]

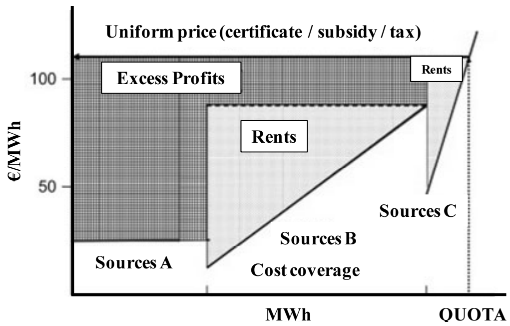

Figure 13. Rents and excess profits in the case of a uniform price. Source:[18]

3.2.2 Green certificates: how to improve the system

Nowadays this system has not given great results in comparison with other schemes, such as feed-in, and so, for a green certificate market to work, new functions must be guaranteed - certification of RES-E producers, trade register, accounting and auditing, with penalties imposed in the event of failure to respect obligations (this is considered a fundamental aspect for the promotion of such mechanism) - all of which leads to high administrative costs. As high initial quota levels would lead to excessive pressure on the price of certificates, Menanteau [5] says that the initial level should be quite low and increase steadily.

The volatility of the certificate price is the principal risk perceived by investors, and is also the reason why this scheme has not experienced a great success till nowadays. Reducing this risk from the supplier side can be achieved by allowing suppliers to anticipate future certificates prices (throughout the creation of futures markets), so that they can make a "bankable" project, which can benefit of secure loans to be able to invest in new production. Future markets can be seen as solutions to limit the volatility in the certificate price caused by meteorological conditions, and may also be useful to envision the possible profitability of new projects.

Limiting the possible range of fluctuations of the prices for certificates can also reduce the investment risks considerably. This can be done setting floor and ceiling prices. The first one operates in the case of an excessive supply of certificates. In this situation the regulator reduces the number of certificates on the market, buying them until the price reaches again an acceptable level. The ceiling price could be useful when a shortage of certificates affects the market. This solution sees the regulator selling certificates at guaranteed prices in the case that the ceiling level is overcome [5].

In order to overcome the problem of excess profits and to stimulate the development of renewable technologies whose costs are relatively higher than those of other renewables, a solution could be a differentiated level of support depending on the type of technology. This has been introduced in the UK, with the Renewable Obligation Order 2009 [19]. According to the banding provision, less improved (high cost technologies) like wave, tidal, solar photovoltaic and geothermal will receive 2 Renewable Obligation Certificates (ROCs) against per 1 MWh. Offshore wind and onshore wind will receive 1 and 1.5 ROC per 1 MWh respectively. Other technologies, like landfill gas and co-_ring of biomass will get fewer certificates per MWh. With this system, as suppliers are obliged to present specified amount of ROCs, they can choose to (i) produce energy by themselves; (ii) purchase certificates which represent less than 1 MWh (*multiple* ROC); (iii) buy certificates whose value is less than 1 MWh (*fractional* ROC). In the case of multiple ROCs the supplier would be supplying less actual energy coming from RES than basic Renewable Obligation (RO) system but mainly this energy would be generated from more expensive and less improved technologies. In the second case, the supplier would be supplying more actual energy than basic RO, but mainly from well established technologies with low generation costs [12].

4. Methodology of policy assessment and results

The methodology and the results applied to evaluate the FIT and TGC schemes, depicted in Figure 3 are presented in this section, based on the criteria of effectiveness, economic efficiency and expected revenues and profits for investors. The analysis and results are taken from [8] and [9].

4.1 Effectiveness of policy instruments

The effectiveness of a policy for renewable electricity is defined by Ragwitz et al. [9] as the ratio of the change in the electricity generation potential over a given period of time to the additional mid-term potential by 2020 for a specific technology. The definition of effectiveness is given in the following equation [8]:

$$E_n^i = \frac{G_n^i - G_{n-1}^i}{ADD - POT_n^i} \tag{1}$$

where,

E_n^i : Effectiveness indicator for RES technology i for the year n,

G_n^i : Existing normalized electricity generation by RES technology *i* in year *n*,
$ADD\text{-}POT_n^i$: Additional generation potential of RES technology *i* in year *n* until 2020.

The absolute growth of normalised RES-E generation respectively to a reference quantity, the additional available mid-term potential to generate RES-E, is calculated by this indicator. The RES-E output potential of all the plants installed up to the end of each year represents the normalised RES-E generation, which is defined by the product of the installed capacity and the fixed amount of full load hours per year. The upside of this approach is that the indicator gives specific information about individual countries on the basis of their potentials. This is useful as RES-E directives are based mainly on the realisable generation potential of each country [8]. The results of policy effectiveness indicator presented in the next part are taken from [9].

4.1.1 Effectiveness of wind onshore support

Figure 14 shows the average annual effectiveness indicator for wind onshore electricity generation for the 1998-2005 period for EU-15 countries. It is to note that the tender scheme indicated for Ireland is a kind on quota mechanism, similar to the TGC one but less market oriented. Nevertheless it is not discussed in this paper, so the case of Irelenad will be ignored. However, some considerations can be obtained from this figure. Denmark, Germany, and Spain, which all applied fixed feed-in tariffs, showed the highest effectiveness during the period under survey. This consistent and steady growth of wind energy is due to low administrative and regulative barriers and the high investment security which this scheme secures. It is usually believed that this situation is related to high levels of tariff, but in the next section (Figure 15) it will be shown that this is not the case [9]. In contrast, in countries where quota systems and not long-term and steady policy as applied, the effectiveness is dramatically reduced, such as Belgium, France, Italy and the UK.

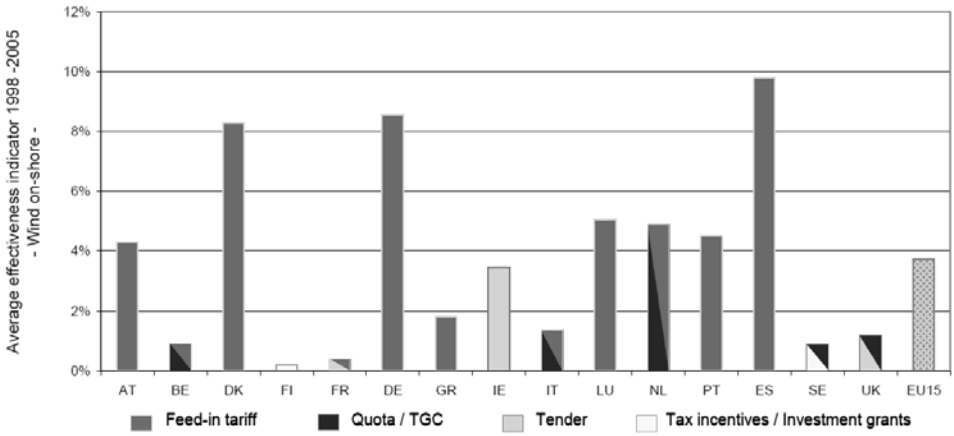

Figure 14. Effectiveness indicator for wind onshore electricity in the period 1998-2005 in the EU-15 showing the relevant policy schemes. Source:[9]

4.2 Economic efficiency from society's point-of-view

The current level of RES-E support varies significantly among the different EU Member States. Country-specific cost resources and resources conditions are the main reasons for this effect. In order to compare prices paid for the different RES-E generation options to the costs occurring in the Member States, Ragwitz et al. [9], analysed both quantities. In the following section the case for wind onshore is presented.

4.2.1 Current level of RES-E support in Europe and costs of RES-E generation

Figure 15 illustrates the country-specific costs and support level for the year 2005 for wind onshore in the EU-15. As can be seen from this figure, there is a correlation between the support level and the generation costs in many countries. Nevertheless, there are some exceptions, as for example Finland, where any stable growth of wind generation cannot be expected, since the support level is too low in comparison with the generation costs. In addition the three countries which used tradable green certificates benefited of considerably higher support levels. Held et al. [8] attribute this negative aspect to _he relative immaturity of the TGC markets, the non-technology-specific application form of the currently applied TGC-systems, as well as the higher risk premium requested by investors. Another relevant point indicated by Held et al. is that countries which presented a higher effectiveness indicator, like Spain and Germany, presented also a higher support level. This is explained by the fact that these nations had already exploited low cost potentials as a result of rapidly growing markets, so that slightly higher supports seems to be justified [8].

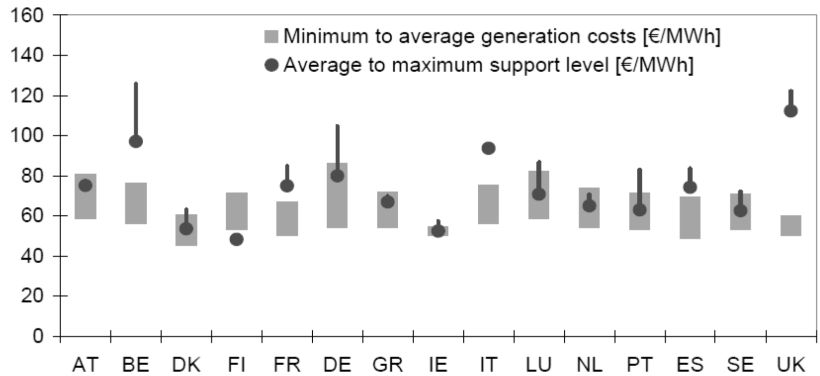

Figure 15. Comparison of support levels and generation costs for wind onshore in EU-15 Member States for the year 2005. Source:[9]

4.3 Evaluation of the profitability of RES investments in relation to the policy effectiveness

The profitability of investments in renewable energy projects, or in other words the actual support over the entire lifetime from an investor's perspective is determined by the average expected annuity (or levelised profit) of the renewable investment. The annuity calculates "the specific discounted average return on every kWh produced by taking into account income and expenditure over the entire lifetime of a technology" [9] . Cash inflows are seen as revenues, while cash outflows are expenses. The annuity can be expressed as:

$$A = \sum_{t=0}^{n} \frac{(I_t - E_t)}{(1+i)^t} \cdot \frac{1}{Q} \cdot \frac{(1+i)^n i}{(1+i)^n - 1} \tag{2}$$

where,

A : Levelised profit per unit electricity generated [€ Cent/kWh],
I_t : Cash inflows (revenues) in t [€ Cent],
E_t : Cash outflows (expenses) in t [€ Cent],
Q : Total amount of electricity generated [kWh],
i : Interest rate,
n : Lifetime[years].

Country-specific renewable resources, the duration of support as well as additional promotional instruments like soft loans and investment incentives are taken into account in the calculation of the annuity. An important limitation of this approach concerns the fact that it requires an estimation of the future evolution of certificate prices in quota systems [9].

In the next section, the analysis of the correlation between levelised profits for investments and the effectiveness reached by the support instruments is presented for the case of wind onshore.

4.3.1 Case of wind onshore

In this part the countries analysed are Austria, Belgium, the Czech Republic, France, Germany, Ireland, Italy, Lithuania, Spain, Sweden and the UK.

By plotting the effectiveness versus the levelised profit (annuity) as shown in Figure 16, the correlation between the levelised profit for investment and the level of effectiveness attained by the support instrument is analysed for the year 2004 in the case of wind onshore.

The expected levelised profits (annuity) as well as effectiveness show a broad spectrum in quantitative terms for the countries under consideration. Ragwitz et al. [9] stress the point that the different instruments have different levels of maturity and that policy schemes in some countries - in particular quota obligation system - are still in a transitional phase. However, it is noticeable that countries with TGC systems, like Italy, the UK and Belgium, appear in the low-right part of the figure, indicating high expected levelised profits but low effectiveness. The extrapolation of the observed certificate prices is the main reason for this effect. Ragwitz et al. [9] say that, although this assumption may be questionable, higher producers revenues related to high investments cost in the certificates system are a relevant result. As far as FITs are concerned, the situation is consistently different, as they are in many cases more effective at generally moderate support levels.

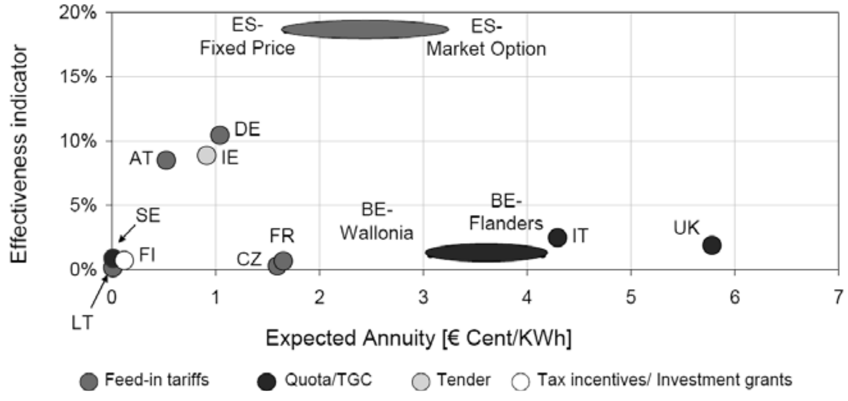

Figure 16. Effectiveness indicator versus annuity (levelised profit) for wind onshore for the year 2004. Source:[9]

5. Discussion and conclusions

As it has been shown in section 2 the generation of electricity from renewable has grown by approximately 4.1% between 2001 and 2007, contributing in this last year to the 15.6% of electricity supply in the EU. Therefore, it results clear that renewables can play an increasing role in the EU electricity market, if favourable conditions for their development and deployment are enforced. As most of them are still not economically competitive with conventional energy sources, such as coal, gas and oil, various support schemes have been implemented in the

European countries. In this paper, just two of them have been presented and analysed, as they are the main mechanisms adopted nowadays. The first one is the feed-in tariff system, which has resulted in being the most effective and efficient tool in supporting the growth of renewables. Its main successful characteristics are:

1. they are easy to implement and can be revised to account for new capacities in a very short time;
2. a guaranteed tariff is effective, flexile, fast and easy to install;
3. administration costs are ususally lower than for implementing a national trading scheme.

The most important design criteria which are required for a successfull FIT design are: (i) a carefully calculated starting value for the tariff; (ii) a dynamic decrease of the FIT that takes learning into account; (iii) the implementation of a stepped and technology-specific tariff structure [8].

The second scheme presented was the quota-based TGC one, which at present shows a low effectiveness, although comparably high profit margins for investors are possible. The main considerations about this scheme are:

1. as investors risk is higher than in the feed-in scheme, primarily as a result of the uncertainty about the future price of the certificates, this system should be modified if a significant expansion in RES-E generation capacity wants to be reached with this instrument. Risks can be reduced by guaranteed floor price or by allowing the banking and borrowing of TGCs, but risks still remain higher compared to other support schemes.
2. excess profits for investors and promotion of least cost technology, which leads not to the development of some promising but still more costly options like photovoltaic, are two striking problems which should be addressed in the future;
3. once markets mature and investment risks are able to be significantly reduced, quota obligation systems based on tradable green certificates may lead to minimal total RES-E generation costs, Ragwitz et al. [9] pointed out;

Regarding the comparison of the different support schemes, the investigated FIT systems are effective at a relatively low producer profit. The lowest cost on the society is imposed by a well-designed FIT system, which also provides a quick deployment of RES-E in the shortest time. In fact, in terms of installed capacity, FITs have given far better results than TGCs. The difference can always be seen in the security guaranteed by the fixed prices of the tariff. However, the incentive to reduce costs is much stronger in the quantity-driven mechanism, since competition between producers is strong, while in the price-driven one, there is less incentive to lower costs, since decreases in production costs have not systematically always been reflected in the feed-in tariff. Nevertheless, as indicated above and as has been done in Germany, it is possible to provide for a gradual reduction in feed-in tariffs to take into account the progress made in renewable technologies [5].

The general conclusions of this paper are:

- the credibility of the system for potential investors affects dramatically the effectiveness of such scheme. Regardless of which instrument is adopted, it must be assured that the incentive strategy carries on for a defined planning time. Without such condition, although the scheme may theoretically be effective, no investment could take place due to the uncertainty perceived by potential investors;
- considering the investor’s perspective, it is important to state that, at low risk (the case of FITs), the profitability expected is much lower and, hence, so are the additional costs finally paid by all consumers.

Finally, in order to become effective, a support instrument should be based on: (i) stimulation to increase the demand for RES-E; (ii) technology specificity to adopt various levels of support for different technologies on the basis of their generation costs; (iii) long-term planning security to stimulate more investment for RES; (iv) degressive support scheme to take into account the “learning by doing effect”.

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