Green Electricity Certificates in Flanders: The Gradual Extension of a Market-Based Mechanism and Doubts Over its Cost-Efficiency

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Abstract At the time of its introduction in 2002, the Flemish system to support renewables was a pure market-based green electricity certificate system. Starting in 2004 a string of changes to the system, up till the current year 2013, culminated in the addition of a minimum allowance for green electricity certificates. This minimum allowance presents a minimum market price for green electricity certificates. The gradual transformation of the system took place as a consequence of a series of policy responses to imperfections of the system as perceived by policy makers. In our analysis, we investigate whether the system has been effective and efficient in reaching its goals. We focus on four consequences of the system's structure: three related to the aspect of minimum allowances (the time-lagged nature, the technological orientation and the differentiated rights for technologies) and one related to the market-based green certificate aspect (the short-term target setting by limited annual quota increases). At present Flemish renewable targets have been reached, thus the system seems to have been effective but there are doubts about its efficiency. Whether the current form of the system will still be effective in the future, so that Flemish renewable energy targets can be met, and whether the system will turn out to be efficient, is as yet undetermined.

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E. Michalena and J. M. Hills (eds.), *Renewable Energy Governance*, Lecture Notes in Energy 23, DOI: 10.1007/978-1-4471-5595-9_19,

1 Introduction

In Belgium the legislative power in the field of renewable energy is delegated to the three regions: Flanders, the Walloon region and the Brussels Capital Region. In support of renewable electricity generation Flanders implemented a Flemish green electricity certificate system (abbreviated as the FGECS) that assigns green electricity certificates to producers of renewable electricity and obliges electricity suppliers to hand in a number of certificates (quota) yearly. The FGECS was revised multiple times and evolved into a market-based certificate system with the addition of technology multipliers (banding factor) and bottom prices for certificates (minimum allowance)..

We will present an analysis of the FGECS and the direct and indirect effects of its implementation.

The central question of this chapter is: "Is the Flemish implementation of a technology-based hybrid certificate system an effective and efficient tool to support renewable electricity deployment and does it help to achieve the renewable energy target?"

The consequences of the FGECS's implementation on which our analysis is based, are:

(1) The time-lagged nature of the system (related to the minimum allowance aspect)
(2) The pure technological orientation of the system (related to the minimum allowance aspect)
(3) The way in which the implementation of green electricity goals influences investment decisions
(4) Differentiated rights for technologies (related to the minimum allowance aspect).

In order to substantiate some of the consequences of the system's implementation, we will make use of a tailor-made cost benefit analysis (financial gap analysis) of renewable electricity technologies compared to reference technologies. This methodology is based on financial concepts such as the income statement and resulting cash flow on a project basis and plays a major role in the FGECS.

2 Setting the Scene: The Flemish Green Electricity Certificate System

The Flemish green electricity certificate system has evolved throughout several iterations since its adoption in 2000 up to the latest changes taking effect in 2013.

2.1 Why a Certificate System?

The FGECS was registered in the Electricity Decree on 17 July 2000 (Belgian government 2000) and became effective in 2002. The introduction of the Decree referred to a draft Directive of the European Commission on harmonising support systems for renewable energy within the European Union. This Directive aimed at a Member State obligation to introduce market-oriented systems. Member States could choose between two alternatives: the introduction of green electricity certificates to impose minimum market shares for renewable energy, or initiating tendering procedures to stimulate construction of new green electricity production installations. In 2001 the European Commission considered introducing a harmonised system throughout the European Union and there were strong indications that a system of tradable green certificates would be preferred. In anticipation of an international green electricity certificate system in Europe the Flemish government choose to introduce quota controlled by green electricity certificates as the central instrument in its renewable electricity policy (Bollen et al. 2011). Afterwards, the European Commission decided to defer its decision about a harmonised system.

2.2 General Functioning of the Flemish Green Electricity Certificate System

The Flemish green electricity certificate system consists of rights and obligations.

The system assigns a green electricity certificate to producers (installation owner) of renewable electricity for each MWh_e of renewable electricity produced. The system obliges electricity suppliers to hand in, to the regulator, a fixed amount of green electricity certificates each year. In case an electricity supplier does not hand in sufficient green electricity certificates he will incur a fine per missing certificate. The systems rights and obligations are integrated by means of a certificate market among renewable electricity producers and electricity suppliers. The Flemish energy market regulator (VREG) assigns the certificates and facilitates the certificate market. The certificates are tracked by means of an online database (see Fig. 1, Initial functioning of the system). Besides income generated by the selling of certificates, producers also generate income by selling green electricity on the wholesale market.

The certificate database is no trading platform and initially trade took place via bilateral contracts which were reported to the regulator. This system had the disadvantage that some parties exerted substantial market power caused by the combination of many sellers of certificates (renewable electricity producers) and one dominant buyer of certificates (electricity supplier). The situation was to be rectified by the introduction of an electronic exchange for the trade of green electricity certificates in 2010. This electronic exchange was realised by the

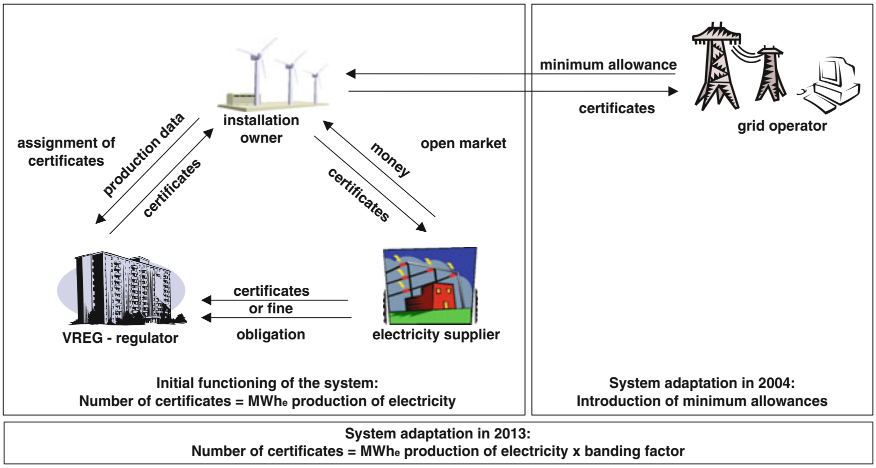

Fig. 1 Functioning of the FGECS: initial functioning, system adaptations in 2004 and 2013

coupling of the certificate database to the Green Certificate Exchange (GCE) of the Belgian Power Exchange (Belpex).

The number of transactions via the GCE is rather limited so far, among others because of the economic crisis of 2008–2009 has led to a decrease of electricity demand and, subsequently a decrease in the number of certificates to be handed in. Moreover there are serious doubts that the GCE resolves the market power of the dominant buyer. Anonymity in the transactions does not reduce the market power of the dominant buyer (Bollen et al. 2011).

The price of green electricity certificates is determined by the balance between supply and demand, where the demand level is a consequence of the obligation of the electricity suppliers. However, the price in this market is limited by the level of the fine, since in the case of prices being higher than the fine, the obligated parties would rather pay the fine than purchase certificates. Figure 2 shows that the evolution of the market price follows the evolution of the fine, but from 2010 on there was a decline of the market price compared to the fine because of the supply surplus of green electricity certificates at that time. This surplus was caused by the massive investments in solar energy due to the high level of the minimum allowance for this technology at that time (see Sect. 2.3). In direct response to this threat of market failure, the Flemish government decided to raise the green electricity certificate quota in 2012 and to further adapt the system, introducing regular evaluation and adaptation of the minimum allowance (see Sect. 2.3).

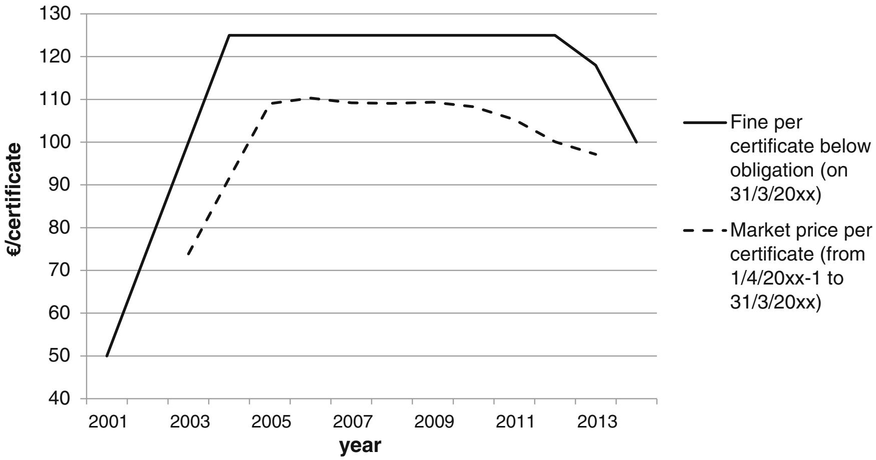

Fig. 2 Evolution of the fine and the market price per green electricity certificate

2.3 Key Innovations of the System: Minimum Allowance and Banding Factor

Besides the trade mechanism described above, the system also contains the concept of a *minimum allowance*, which was introduced in 2004. The minimum allowance is granted to renewable electricity producers by grid operators who have the obligation to buy certificates at the price of the minimum allowance (see Fig. 1, System adaptation in 2004). If the market price is less than the minimum allowance then electricity producers prefer to sell their certificates to the grid operator at the price of the minimum allowance. Grid operators can resell these certificates on the certificate market in order to, at least partially, recuperate the cost of their obligation. The remaining part of the cost (the positive difference between the minimum allowance and the market price) is charged to electricity consumers by means of distribution tariffs imposed by the grid operators. Since this mechanism of cost recuperation leads to different costs for different grid operators, and therefore different costs for their consumers, it was decided in 2010 to consolidate all costs among the grid operators.

After its introduction in 2004 the height of the minimum allowance has been changed several times but no systematic evaluation has been performed because there was no legal binding obligation to do so. Instead an ad hoc evaluation took place which was triggered by signals from the energy market and societal actors. The method of the financial gap (FG) (see Sect. 3) was used several times to determine the optimal level of the minimum allowance per technology. In theory the concept of minimum allowances was introduced to guarantee financial stability to green electricity producers, but in practice the level of the minimum allowances was adapted slowly and in an ad hoc fashion which in turn leads to windfall profits

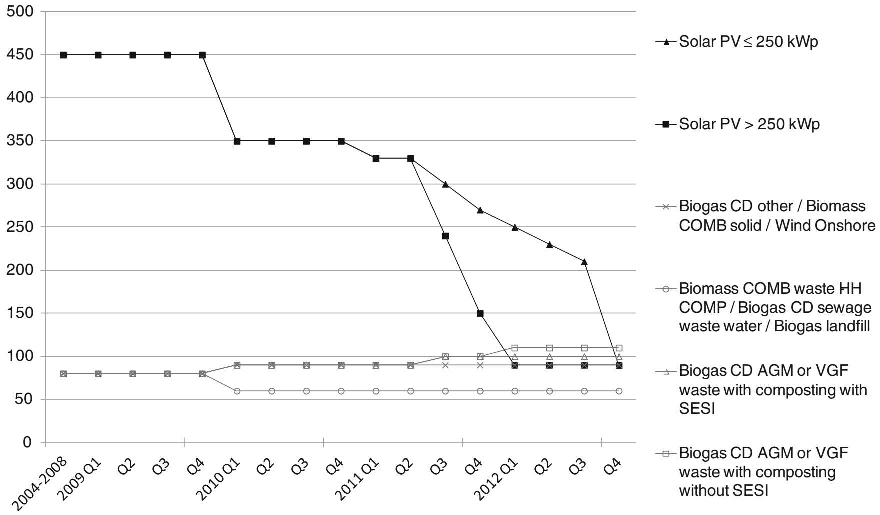

Fig. 3 Evolution of the height of the minimum allowance for new renewable electricity installations[1]

(if the minimum allowance is too high) and losses (if the minimum allowance is too low). This is demonstrated by Fig. 3 which depicts the evolution of the height of the minimum allowance for the different technologies. For solar PV the minimum allowance amounted to 450 €/MWh$_e$ until the end of 2010 while the financial gap for installations amounted to maximum 300 €/MWh$_e$ at the end of 2010. Installations which entered into production in the course of 2010 gained considerable windfall profits. Hence, the concept of minimum allowance and the linked ad hoc evaluation did not succeed in its endeavour to guarantee a smooth course of the FGECS.

To overcome these problems, the Flemish government introduced drastic changes to the FGECS in 2012 (see Fig. 1, System adaptation in 2013). The concept of the *banding factor* is a central pillar in the adapted system. With its application each technology receives a number of green electricity certificates per MWh$_e$ equal to its banding factor. This banding factor differs per technology and it is calculated by dividing the financial gap (see Sect. 3) by the expected certificate value (also called banding divider), which is set at 97 €/MWh$_e$ from 2013 on. For instance: a project with a financial gap of 48.5 €/MWh$_e$ will have a banding factor of 48.5/97 = 0.5 and thus receives a green electricity certificate for each 2 MWh$_e$ of renewable electricity produced. The Decree of 13 July 2012 (Belgian government 2012), in which also the value for the banding divider is set, stipulates that the Minister of Energy can determine the maximum authorised banding factor for

[1] Legend: COMB = combustion; HH = households; COMP = companies; CD = co-digestion; AGM = agrarian and/or manure; VGF = vegetable, fruit and garden; SESI = subsidy for ecologically sound investments.

new projects from 2014 on in an annual cycle and that in any case the banding factor is capped at 1.25. For 2013 the banding factor is capped at 1.

Besides the introduction of the banding factor the adapted system comprises an annual update of the financial gap for different installation types. To this end a new team called Monitoring and Evaluation has been established within the governmental administration. The methodology and parameters to be used in the financial gap model are established by the Flemish government in a transparent way to guarantee a clear investment framework. Parameters are based as much as possible on publicly available data, such as for example exchange indicators for electricity and (fossil) fuels. Only when no references are available for a parameter does the Monitoring and Evaluation team make assumptions based on expert judgment which are in turn objectively legitimised as much as possible.

The ultimate result of all changes to the FGECS is to assign a different number of certificates to each technology in order to realise a more adjusted support, which in turn should correspond to the real cost price. *In effect these changes have turned the tradable green electricity certificate system into system very similar to a feed-in premium system with only a minor trade component.*

The principal aim of the changes implemented in 2012 and 2013 is to increase the cost efficiency of the system, to guarantee an equitable distribution of the costs over the different societal actors and to provide a stable and beneficial investment climate for green electricity producers.

The future will reveal whether these changes are sufficient to be able to cope with the diverse requirements for a green electricity support system.

3 A Methodology for Analysis: The Financial Gap Analysis

The methodology to determine the minimum allowance per renewable energy technology is the so called “Financial Gap Analysis.” The methodology was developed and detailed by the Dutch research institute ECN in 2003 and was used to calculate the production subsidy levels for renewable energy projects in the Netherlands. In 2005, the method was revised and adapted in order to match the specific needs/requirements of the Flemish context.

For the purpose of this chapter, we define the financial gap (FG) as the deficit in a project’s revenue that is needed for the net present value (NPV[2]) of the project to equal zero based on a discount rate[3] set equal to a predefined Internal Rate of Return (IRR).[4] The financial gap is expressed per unit of electricity produced:

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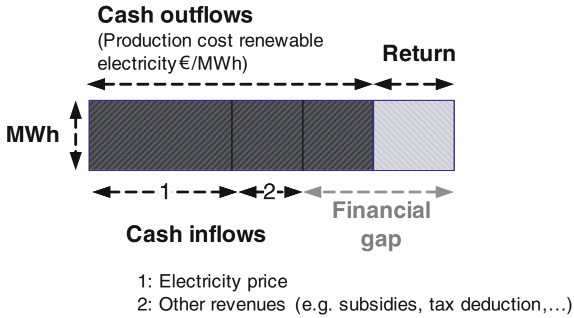
[2] In finance, the net present value (NPV) of a time series of cash flows, both incoming and outgoing, is defined as the sum of the present values of the individual cash flows of the same entity.

[3] The discount rate is the rate used in discounting future cash flows.

[4] The Internal Rate of Return (IRR) is used in capital budgeting to measure and compare the profitability of investments.

Fig. 4 The construction of the financial gap: a cash flow approach



$$NPV(FG) = 0\, \textit{with discount rate set to target IRR}$$

A cash flow approach is used to gain insight in the cash inflows and outflows over the projects life time. However, there is an important difference with a conventional cash flow approach. Here, the overall return of the project is not the output of the calculation. Instead, the FG is computed as a function of the cash flows and a presupposed return (IRR) of the project. Hence, the value of the IRR is determined in advance and serves as an input. The IRR percentages can be found in the Decision of 2012 (Flemish Regulator for Energy and Gas 2012) and differ per type of installation. The values vary between 5 and 12 %. These values are used in the financial gap calculations.

In order to determine the net present value of the project, the *cash flows* which will accrue during the lifetime, are estimated. In Fig. 4 the cash outflows include production and operating costs such as fuel, maintenance, insurance contracts, etc. The cash inflows include the electricity price and other possible revenues. At the cash inflow the value of the generated green electricity is determined. Sometimes the investor can apply for a subsidy for ecologically beneficial investments or a tax deduction for investments in renewable energy production. In these cases this additional cash inflow is also taken into account.

Investments in renewable electricity projects require financial incentives. Investors[5] do not only look for a cost-neutral project, they also request a higher *return* on their investment to compensate for additional project risk.

As illustrated in Fig. 4, the financial gap is the area needed to fill the gap between expenditures, revenue and requested return. Although the FG analysis is straightforward, the selection of parameters and assumptions are always prone to criticism.

In order to perform an FG analysis, a hypothesis with respect to the timing of the cash flows is required. The FG assumes the capital cost is incurred right at the start in year 0 after which the construction of the green electricity project may take

[5] The term 'Investor' refers to all organisations or individuals who contribute capital and/or resources to the development of renewable electricity projects, small or large scale, and who anticipate a financial benefit.

some time. After the construction period the investor receives periodic public financial support for a period equal to the depreciation period. Any assumed bank loans are assumed to have the same duration. This approach however is not feasible for all technologies. In some cases the economic life time of an installation is longer than the policy period (support period) which is used in the FG analysis. In these cases, the model assumes that there is financial support for a shorter period than is actually true and hence the FG will be overestimated. It is because of this issue that, in the Decree of 2012 (Belgian government 2012), the FGECS is extended with a possibility to level down the FG.

In terms of funding an FG analysis evaluates each project in a vacuum. As a result possible tax benefits only influence the project budget, and if needed they can be transferred to the following year(s). This does not allow for fiscal optimization where profit and loss of multiple projects are combined.

While the FG model processes revenue and expenditure, it does not take into account future price adjustments. This might lead to somewhat defective estimated cash flows as energy related prices do fluctuate over time and they, for their part, affect expenditure and revenue. Because of this, the Flemish government decided to adjust the methodology in July 2012. Since then the model is extended with the expected average annual change in the value of electricity and other fuels.

4 Flanders Green Electricity Certificate System: Consequences of Implementation

To answer our central question we will address a number of consequences of the FGECS's implementation which merit an in-depth discussion. In this section we present an analysis of four "issues" which we identified.

4.1 A Time-Lagged System

Time lag plays an important role in the effectiveness of economic policy. Today's information, which is translated into parameter values of the FG analysis, is used to reach a future goal. Aiming at an attractive investment climate, the financial gap analysis should reflect the actual market situation, year after year.

In order to calculate the financial gap, a lot of techno-economic (e.g. investment, maintenance, operating time, electrical/thermal return,…) and financial-economic (e.g. ratio equity/debt capital, electricity and fuel prices,…) assumptions are made. On top of the uncertainty resulting from parameter estimates, there is an additional uncertainty that the parameter values will change substantially over time.

After the system reform of 2012, the team Monitoring and Evaluation evaluates the financial gaps and banding factors of different technologies on an annual basis, with an exception for photovoltaic which is evaluated every 6 months. Additionally, the FG model is extended with an assumed pathway for some parameters (as discussed in Sect. 2).

Before these changes in 2012 the FGECS was rigid: Once the minimum allowance of a project was determined, it was fixed for the entire policy period (20 years).

Because the minimum allowance remained constant for such a long period, and the model did not include dynamic pathways for the economic parameters (technology learning), the FGECS casted doubt upon the accuracy of the support level. It is obvious that outdated calculations can cause incorrect levels of financial support and economic parameters change rapidly. Probably, the decrease of PV system costs is the most spectacular and unpredicted change. In 2006, the FG was calculated with an estimated investment cost of 7,000 €/kW$_e$ (residential installation). During the reassessment in 2010 the cost was scaled down to 4,235 €/kW$_e$. In the latest update of 2012 the cost is again reduced to 1,702 €/kW$_e$. This large and unforeseen price erosion gave the market an additional stimulus to invest in the technology.

In 2011 the economic and financial impact (Meynaerts et al. 2011) of the FGECS was calculated. The authors of the study assessed per technique a FG pathway by incorporating potential evolutions for some parameters. It became clear that the FG of most green electricity techniques decreased over time.

From a sensitivity analysis which provides a basic understanding of how strongly the FG reacts to a modification of a parameters value, we learned that in some cases the change in evolution of a parameter over time has a more profound impact than the introduction of variation in its absolute value. In a similar fashion, by introducing pathways for some core parameters and by evaluating the FG annual, the policymakers tried to tackle the time-lag problem. In the current iteration of the FGECS anno 2013, the problem is not solved, e.g. the banding factor is still fixed for a year.

4.2 A Technology-Oriented System

The Flemish government defines typical project categories for which a financial gap and banding factor are calculated. These categories are differentiated towards technology (solar PV, wind onshore, co-digestion of biomass and biomass combustion) and within the different technologies towards capacity range and type of biomass.

For the typical project categories, average parameters for the FG calculation have been established. The choice of categories implies that for particular technologies or situations, basic parameters can vary widely and to a large extent influence the FG and resulting banding factor.

To demonstrate the effect of variation in parameters for a particular technology, we take a closer look at the following example: the variation of the number of full load hours in the category of onshore wind turbines. The reference installation for calculation of the FG for 2013 is a turbine of 2.3 MW_e with 2,000 full load hours a year and a life time of 15 years. By using the average number of full load hours the difference in the number of full load hours between windy locations and less windy locations was not taken into consideration. Based on 2,000 full load hours the financial gap amounts to 80 €/MWh_e. A wind turbine in the more windy locations of the Flemish region demonstrates 2,500–3,000 full load hours a year. The FG of a wind turbine with 2,700 full load hours amounts to 47 €/MWh_e (no variation in other parameters to calculate this FG). On the other hand, turbines in the less windy locations demonstrate to have 1,700–1,800 full load hours a year. The FG of a turbine with 1,750 full load hours is about 98 €/MWh_e. Using the banding divider of 97 €/MWh_e the corresponding banding factors are: 0.48 (windy); 0.83 (reference) and 1.00 which is the maximum banding factor for 2013 (less windy). According to the current system, the banding factor of 0.83 applies to all wind turbines that will be installed in the year under consideration. As a result, wind turbines in more windy locations receive more total subsidy than turbines in the less windy locations.

Another clear example to demonstrate the importance of varying parameters for a particular technology is the price of biomass in the category of solid biomass combustion up to 20 MW_e. The reference installation (10 kW_e, 7,900 full load hours) is assumed to combust wood chips of recycled wood. The price of recycled wood is assumed to be rather low compared to the price for clean wood chips and wood pellets. In general, price information for solid biomass is rather limited, especially for recycled flows. Best estimates are based on limited information from recycled wood flows in Flanders and market information from the German market for clean wood chips. One of the questions to be asked here: *is the assumed price high enough to stimulate the building of new combustion installations?* The FG with the price for recycled wood chips (0.0141 €/kWh) amounts to 81 €/MWh_e (corresponding banding factor (BF) = 0.84). The FG with the price for clean wood chips (0.0228 €/kWh) amounts to 117 €/MWh_e (corresponding BF = 1 = max BF).

The consequence: if investors in new installations cannot obtain recycled wood flows then there will be no new investments in such installations. In reality the existing recycled wood flows are indeed limited in the Flemish region. Moreover, these flows are wanted as a raw material by the wood and paper industry which is specialised in processing recycled material because of the small wood areal in the Flemish region. The wood and paper sector requested sufficient allocation of material (recycled and fresh wood) to its use as a raw material. Since the Flemish region has a strong tradition of recycling, the Flemish government granted the wood and paper sector its request and stipulated that only short rotation wood and wood flows, which cannot be used as an industrial raw material, should be considered to receive green electricity certificates.

Another effect that plays a significant role at the technology level is the application of a cap on the banding factor, set at a maximum of 1.25 by the Flemish Government (for 2013 there is a maximum banding factor of 1 set by ministerial decision). For 2013 we observe that the BF reaches its cap for the following technologies: all biogas technologies, except co-digestion of sewage water sludge and biogas from landfills, and all fluid biomass combustion. This cap implies that investments in these technologies are discouraged and will probably be slowed down for some years to come. A possible consequence of this choice is that the accrued knowledge on these technologies (e.g. for co-digestion of manure and agrarian flows) is at stake. On the other hand this can be a conscious choice to stimulate other technologies like solar PV, wind and solid biomass combustion. For the first two this might seem reasonable because of fuel independence. On the other hand these sources demonstrate a highly intermittent supply profile and hence require a more intensive mitigation of—and adaptation to intermittency. Biomass combustion can be used as a base load source and could hence has a distinct appeal to be included in the (renewable) electricity mix. While the above arguments seem reasonable and logical it is by no means clear that these are the real reasons behind the cap on the banding factor.

The fact that the FGECS is a technology-oriented support system is amplified by establishing typical project categories for calculating the FG and BF. The examples illustrate the necessity to carefully make choices. It is important to introduce sufficient differentiation in order to stimulate investments in desirable technologies and to limit support for other costly technologies. On the other hand a higher number of different categories considered necessitates more information gathering on underlying parameters and hence higher administrative costs. The choice between many or few typical technology categories should be based on a conscious weighing of the pros and cons for both approaches.

A global renewable energy vision for the next decades, in which the importance of the different technologies is estimated, could be a valuable foundation for these choices.

4.3 Green Electricity Goals and Investment Decisions

Another important consequence of the Flemish green electricity certificate system's implementation is the way in which it implements its green electricity certificate goals. The FGECS obliges electricity suppliers to turn in a fixed amount of green electricity certificates each year and allows electricity suppliers to buy those certificates on a certificate market should their own green electricity production be insufficient to cover their obligation. In such a market mechanism, the value of a certificate is based on total supply and demand of these certificates. By means of quota, the FGECS fixes the demand level along the lines of an annual incremental path starting at 14 % in 2013 up to 20.5 % green electricity in 2020.[6]

[6] The incremental demand path has already been changed a few times in the past. E.g. from 01/01/2011 to 29/07/2012 the 2013 target was 8 % and the 2020 target was 12.5 %.

The supply of green electricity certificates is determined by technology specific certificate rights per MWh_e of green electricity produced. Given *the nature of the demand and supply side of the green electricity certificate market, it is defined by strong market power at the demand side*. The final quantity of green electricity certificate demand is largely[7] determined by the Flemish government and one could argue this market resembles a market with one final consumer with a price-inelastic demand.[8] For this comparison the demand of the Flemish government acts as the one final consumer and its demand level is fixed by law at a predefined level and hence is largely price-inelastic. As such the green electricity certificate market exhibits traits of a consumer monopoly. There are two traits of this demand level setting that we will discuss further: the small annual increments and the fact that the path is fixed for the short to medium-term future.

A first question we pose ourselves is: *if and how small annual demand level increments impact green electricity investment?* If we translate the small annual increment in green electricity certificate demand to an energy quantity it approximates somewhere around 1.8 PJ[9] of green electricity for each percentage increase in green electricity certificate demand.[10] While this is a significant amount of green electricity, it is still small compared to the green electricity output of one big green electricity plant. For illustration take the E.ON coal plant of Langerlo in Genk which will be converted to a biomass plant by 2014. After conversion this plant would generate somewhere around 9 PJ of green electricity which matches approximately 5 % of total green electricity demand in 2011. Obviously, the addition of one or more of these large installations would severely impact the green electricity certificate value and hence the profitability of all operational green electricity installations. If such an installation is implemented too early, the green electricity certificate value might plummet, and if it is implemented too late, the green electricity certificate value might soar. Based on this observation, we would state that the green electricity certificate demand level setting *promotes small to medium installations* and entails a *risk on expected returns should one implement a large scale installation*. The previous statement holds true in the context of a green certificate market on the limited Flemish

7 In addition to final demand for green electricity certificates as set by the Flemish government, the possibility to bank green electricity certificates for 10 years allows for a temporal increase or decrease in demand. (banking of certificates = storing obtained certificates for later usage) The decision to bank green electricity certificates can be based on an expected future certificate price increase.

8 A price-inelastic demand translates to a demand level which remains constant regardless of an increase or decrease in price.

9 PJ = Petajoule = 10^{15} Joule: a derived metric for energy where one joule is equivalent to the work required to produce one watt of power for one second.

10 Final electricity consumption in Flanders was 181.7 PJ in 2011. Flemish Energy Balance 2011, http://www.emis.vito.be/sites/default/files/pages/1332/2012/balans_2011_versie_nov_2012_correctie_0.xlsx.

regional scale. In case a similar system is applied to a larger region the above statement becomes less of an issue.

A second question we would like to discuss is: *how the fixed path demand level*[11] *influences green electricity investment decision*s*?* The fixed path demand level seems to have an upside and a downside. An upside is a certain level of *market stability* and *market information*. Information on the current green electricity generation capacity is publicly available and, in combination with information on the fixed green electricity certificate demand path, this provides good market information for investment decisions. Since every market participant has access to this market information, it is safe to assume a relatively stable market which in turn adds to a good investment climate. A downside to the fixed path demand level is the lack of incentive to go beyond the set green electricity certificate target in a given year. Investing in overcapacity for green electricity production seems undesirable since such an investment would incur diminishing returns based on a lower green electricity certificate value. Additionally, past investments would also incur the diminishing returns based on the lower certificate value.

As shown by the previous discussion, there are multiple consequences tied to the way in which the green electricity certificate goal is set. The choice for an annual incremental fixed path demand level leads to a relatively stable market. On the other hand, it does not promote large ambitious projects nor does it offer a financial incentive to go beyond the preset green electricity target. Whether or not this trade-off is desirable depends on the point of view. The fixed target almost guarantees that renewable electricity production will be sufficient to cover Flemish international obligations and, in that way, is a safe choice. If on the other hand a longer term, more ambitious goal has been envisioned, this way of demand level setting might not provide an optimal incentive to step up to far reaching green electricity targets.

4.4 Differentiated Technology Rights

The Flemish green electricity certificates system, with the addition of a technology dependent banding factor, confers differentiated rights to the different technologies. In the text below we will explain the concept of *differentiated rights,* the consequences of its application and the reasoning behind its importance as a consequence of the systems implementation.

[11] With the expression "fixed demand path level" we refer to the mechanism where the Flemish government defines a fixed number of green electricity certificates to be handed in each year and hence defines the demand for green electricity certificates. The quantity to be handed in each year is known years in advance. So the demand for certificates is known as well as the yearly evolution of this demand. We call this a "fixed" (by law) "demand path" (yearly evolution) "level" (known quantity).

Differentiated rights, what do we mean by this term? To understand its meaning we will take a closer look at the financial gap analysis and the resulting banding factor for a given technology. The financial gap analysis asserts the gap amongst revenue and expenditure in order to achieve a set Internal Rate of Return (IRR) over a projects operational lifetime. Assuming the targeted IRR is the same for different technologies, the resulting financial gap might differ based on technology specific operational parameters. In these cases we state them having *differentiated rights* because the FGECS grants them a different number of certificates albeit with the same IRR.

To illustrate this concept with an example assume:

- two different technologies A and B both have a lifetime cost of 10,000 €
- a green electricity certificate has a value of 50 €
- technology A its IRR is 13 % and technology B its IRR is 14 % without green electricity certificates
- the targeted IRR for both technologies is 15 %
- hence technology A will receive 4 certificates (10,000 * (15−13 %)/50) and technology B 2 certificates (10,000 * (15−14 %)/50). They both have different rights.

Differentiated rights, what are the consequences of its application? The consequences of the application of differentiated rights are numerous but they all resolve around the way the FGECS influence the free choice of potential investors and hence define the short-term and medium-term future technology mix for electricity generation.

Assuming the targeted IRR is the same for multiple technologies, a potential investor has no financial incentive in terms of IRR to choose one technology above another. Hence the financial incentive *does not provide directional guidance* to green electricity investments. For the investor's part, he/she will still perceive advantages and disadvantage which are, amongst other, project risk, project payback period, capitalization rate, feasible financial leverage and sometimes genuine irrational human perception. Whether this aspect is seen as positive or negative depends on whether one adheres a policy of being reluctant to picking winners or to a policy that is guided by a shared vision on the energy mix needed in the future.

Another possible consequence of differentiated rights is the *non-optimal use of financial community resources*. As different technologies present a different financial gap to obtain the same IRR, the community resources used to support them will also differ. One could argue that an optimal use of community financial resources can only be obtained if financial incentives are granted solely to the best performing technologies and only to a level where total expected green electricity production would match the predefined desired quantity of green electricity.

Furthermore differentiated rights allow for *more competition*. By means of differentiated financial incentives, different technologies become economically feasible with a resulting market entrance. Since multiple technologies strive against each other for market share there is a strong incentive to lower costs and increase performance. If only one technology would be economically feasible there would be less incentive to improve product performance and competition might shift from cost lowering and performance increases towards better service to gain a competitive advantage. While this is valuable for investors, it does nothing to alleviate the future community cost of green electricity support.

Another interesting effect of differentiated rights is their contribution to market diversity and as such the *guarding against future technology lock-ins.*[12] As differentiated rights make multiple technologies economically feasible, potential investors will most likely implement a more or less differentiated mix of technologies based on perceived advantages and disadvantages. As argued above this could be labelled as non-optimal use of financial community resources. On the other hand this same technology mix avoids overcommitting to one single technology. While such over commitment would be a good thing should this technology indeed turn out to be the optimal choice, there is always a chance that the financial gap analysis turns out faulty. This possibility exists because a financial gap analysis requires various assumptions about future costs and operational parameters and in real life there is no such thing as prescience in these matters. Hence differentiated rights guard against a technology lock-in with what in hindsight might proof to be a sub-optimal technology.

Differentiated rights, is it any good? With the upsides and downsides of differentiated rights discussed above, one cannot draw a clear conclusion whether it is a concept worth keeping or an aspect of the FGECS which should be subject to change. It largely comes down to personal belief in terms of forecasting ability and ones view on the role of the policy maker. If one strictly believes in the ability to accurately assess the financial gap of technologies now and in the future, one could opt for an optimal strategy based on perfect foresight and as such revise the current system of differentiated rights. If one questions the ability to make this assessment with reliable and robust results, one would indeed be better off with the current concept of differentiate rights and the resulting technology differentiation.

5 Discussion—Conclusions: The Flemish Green Electricity System: Did it Deliver?

At the onset of this chapter we formulated the research question: “Is the Flemish implementation of a technology-based hybrid certificate system an effective and efficient tool to support renewable electricity deployment and does it help achieve

[12] A technology lock-in is a situation where past investment decisions limit the number of present technology investment options. If an investor has committed a large amount of capital to a new installation it is unlikely that he will end its exploitation before the end of its technical life. Hence he will not make new investment decisions during this time.

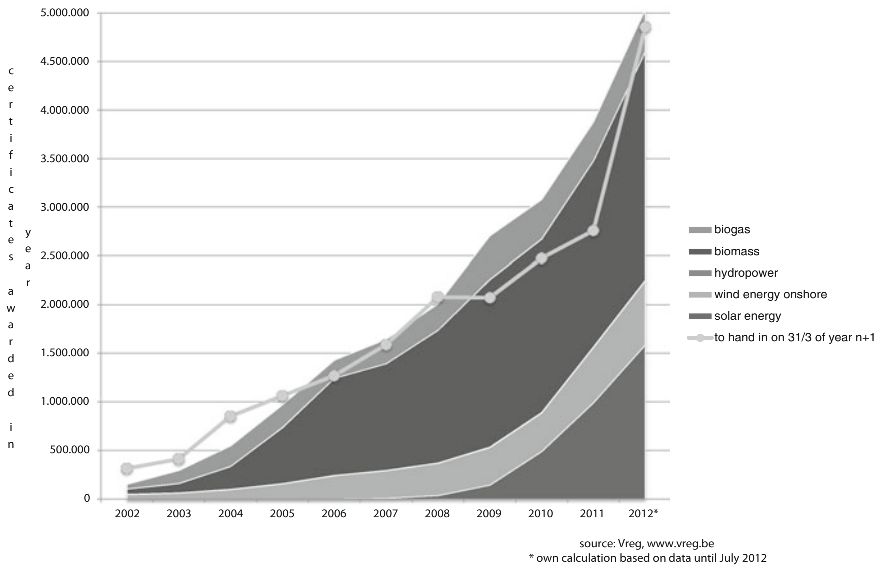


Fig. 5 Evolution of the number of awarded certificates and the certificate obligation

the renewable energy target?" Throughout the chapter we discussed several consequences of the system's implementation and their effect on green electricity production within Flanders. To conclude the chapter we will present the demonstrated results of the FGECS and discuss its effectiveness as well as its efficiency.

The evolution in the number of awarded certificates versus the certificate obligation shows a shortage during the period 2002–2005, a market balance, after the introduction of minimal allowances, during the period 2006–2008, and a surplus during the period 2009–2011 (Fig. 5).

Based on the above supply and demand figures one can conclude that the FGECS demonstrates a good efficacy,[13] or in other words, the Flemish green electricity targets are met.

Still, while these supply and demand figures inform us of the FGECS efficacy, they do not inform us on its effectiveness[14] or efficiency.[15] Based on currently available data it is not possible to draw definite conclusions on effectiveness and efficiency of the FGECS. In 2011 the Social and Economic Council of Flanders published the book Energy for a Green Economy in which this topic was also discussed for the FGECS before its revision in 2012 (Bollen et al. 2011). The

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[13] Efficacy measures in how far goals are met.

[14] Effectiveness measures the causal relation between an action and goal satisfaction. Has the action resulted in the goal satisfaction or would the goal also be obtained without the action?

[15] Efficiency measures the balance between effort and result. Is the amount of effort proportional to the obtained result?

writers noted the lack of data but based on what was available they drew some general conclusions: the cost of the FGECS was increasing more rapidly than the green electricity certificate goal during the period 2002–2009, some case-specific technologies generated significant windfall profits, some technologies got more support than the financial gap suggested, and future electricity consumers could become heavily penalised for the FGECS past liabilities. While some of these conclusions might be invalidated by the FGECS's 2012 revision, they still serve as a cautionary tale of what the consequences can be of a green certificate system that started out as a pure market-based system, but was later on expanded with minimum allowances.

The Flemish green electricity certificate system can best be described *as a market-based certificate system with the addition of technology multipliers (banding factor) and bottom prices for certificates (minimum allowance)*. The resulting system exhibits certain advantages and disadvantages compared to the commonly used pure feed-in tariff systems. In conclusion we give an overview of some of these advantages and disadvantages.

(+) The market-based character ensures least-cost implementation of green electricity production by price competition and allows for free choice whether or not to deploy renewable technologies.

(+) Another advantage of a market-based system is that it is less prone to a financial backfire. A pure feed-in tariff gives the same tariff when suddenly huge amounts of new capacity would be installed. A market-based system its certificate value would decrease and hence it is not opportune to overinvest in renewable technologies.

(+) The addition of minimum allowances ensures a minimum level of certainty for investors. In case the certificate price would plummet, the minimum allowance functions almost like a feed-in tariff, the only exception being that the certificates can be stored for later use.

(+) The addition of technology multipliers (banding factors) enables a level playing field for a diverse set of technologies so that all can be cost-effective investments while at the same time preventing windfall profits by over subsidising.

(−) The disadvantage of a market-based system is an increased risk for investors when compared to feed-in tariffs. The value of a certificate is dependent on the market and hence on the actions of all market players. In a pure feed-in tariff system the level of financial support is known in advance and not a resultant of a certificate market.

(−) There is an additional administrative cost related to the support of the certificate system. Certificates have to be awarded, a market needs to be established and certificates need to be recalled as per predefined quota. The cost of establishing the multiplier is comparable to the cost of establishing the level of the feed-in tariff and as such does not present an extra administrative cost.

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