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*Citation for published version (APA):*
Huijben, J. C. C. M., Podoynitsyna, K. S., van Rijn, M. L. B., & Verbong, G. P. J. (2016). A review of governmental support instruments channeling PV market growth in the Flanders region of Belgium (2006-2013). *Renewable and Sustainable Energy Reviews*, *62*, 1282-1290. https://doi.org/10.1016/j.rser.2016.04.058

*DOI:*
10.1016/j.rser.2016.04.058

*Document status and date:*
Published: 01/01/2016

*Document Version:*
Publisher’s PDF, also known as Version of Record (includes final page, issue and volume numbers)

Renewable and Sustainable Energy Reviews 62 (2016) 1282–1290

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

# A review of governmental support instruments channeling PV market growth in the Flanders region of Belgium (2006–2013)

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ARTICLE INFO

*Article history:*
Received 1 July 2015
Received in revised form
22 December 2015
Accepted 26 April 2016
Available online 1 June 2016

*Keywords:*
PV market growth
Flanders region of Belgium
Governmental support instruments
Green certificates
Societal costs

ABSTRACT

How did a country in the middle of Western Europe, starting almost from scratch, reach the European top 3 in terms of solar PV capacity in five years? And what were the costs? We provide a systematic chronological review of the different governmental support instruments that drove the exponential growth of the solar energy market in the Flanders region of Belgium and calculate their relative contributions. The results of the economic calculations show that green electricity certificates had by far the greatest effect on both the rise and stagnation of the market, costing about 1.5 billion euro only for 2006–2013. The long-term societal costs of such growth proved to be even higher (6.7 billion for 2014–2031) and unevenly distributed, with residents paying the highest price via their energy bills. Companies continuously adapted their organizations to enact the available support instruments. Counter-intuitively, the substantial support shifted the attention of companies to the larger systems, even though the incentive for investment in PV was lower than for the smaller systems.



**Contents**



## 1. Introduction

Over the past decade it has become increasingly clear that our current electricity system is unsustainable. An uneven spread of resources, depletion, and air pollution have caused problems and conflicts all over the world. In response, many developed countries have designed renewable energy policies. Renewable energy sources like PV could provide the solution to energy-related environmental and political issues.

Belgium, by no means a champion in terms of sun irradiation due to its geographical location, entered the European top 3 in 2012 in terms of installed capacity per inhabitant in Europe [1]. The Belgium federal state is divided into three main regions: Flanders, Wallonia, and Brussels. By the end of 2013 about 70% of Belgium's 3 GW capacity was installed in the Flanders region [2]

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http://dx.doi.org/10.1016/j.rser.2016.04.058
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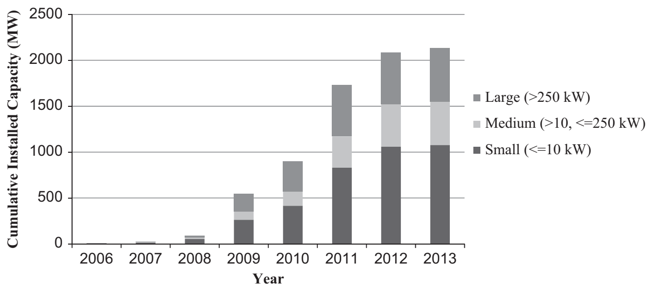


**Fig. 1.** Cumulative installed capacity of small ( < =10 kW), medium ( > 10, < =250 kW) and large systems ( > 250 kW) [adapted from [3]].

and [3]. From 2007 onwards, the PV market for small, medium and large systems grew exponentially in Flanders (see Fig. 1). These were mostly Building Added PV (BAPV) or stand-alone systems. However, by mid-2012, severe cuts in support led to stagnation. In this paper we employ transition studies literature to explore what governmental support instruments caused this considerable growth and stagnation.

Society is facing many negative externalities from our current production and consumption systems for energy, mobility and food. There is a major need for the transition of such *socio-technical systems* toward more sustainable ones [4]. Such a process is systemic in nature and requires a radical shift from the status quo. However, the mainstream system in place has its own logic, forming a barrier to sustainable innovation [4] and [5]. Therefore, a protected space called a *niche* is needed as a nurturing place, from where new innovations can scale up and alter the mainstream system [4].

Governments enable the development and implementation of new sustainable innovations by actively shielding them from mainstream selection pressures [6]. Active shielding measures influencing the supply side include various financial incentives covering production, investment and financing support [6–8]. It is also possible to influence the demand side through for example quotas or providing information to end users. Thereby the government directly influences the 'volume, distribution and types of opportunities available' [9, p 341]. Additionally, institutional theorists argue that institutional processes (rules, norms, beliefs) influence economic systems [10].

The influence of governmental policies on the expanding renewable energy market has been widely studied (e.g. [7,8,11–18] and [19]). Some studies evaluate support instruments for PV market deployment specifically, often with a focus on the impact of feed-in-tariffs (e.g. [20–26]). Mormann uses empirical evidence from the US to demonstrate how its existing tax credits system is providing an incentive for renewable energy market players to create investment structures that lead to higher transaction costs and less efficient support, indicating the importance of careful policy design [27]. Verbruggen and Lauber indicate the cost-benefit allocation of support instruments as important indicator [8]. Considering the variety of the possible support instruments, our research aim is to investigate which form of active shielding had the greatest impact on the growth of installed capacity in Flanders in 2006–2013 and what were the costs of this support. Additionally, we aim to investigate the effect of such support instruments on Flemish PV companies' activities and performance. In the following we first discuss our research methodology after which we present the results of our study. We provide an overview of the different support instruments in place and their relative contributions as well as discuss in detail the main support instrument during the time of our study, the green certificate scheme. We continue by an analysis of the effect of such support instruments on firm activities and performance and end the paper with a discussion of our main findings and a conclusion section.

## 2. Methodology and data collection

We conducted a mixed methods study, employing a sequential quantitative-qualitative approach, where the qualitative part had a complementary and developmental function [28]. We used primary and secondary data sources to explore the effects of governmental support instruments on market growth in the Flanders region of Belgium from 2006 until 2013 – the period when Flanders experienced exponential installed PV capacity growth. Due to the complex structure of the Belgian energy market, we searched databases and official reports of players operating at various levels to map the energy market and installed PV capacity over time, also to identify the PV-related support instruments in place during our studies. The Committee for Regulation of Electricity and Gas (CREG) controls and evaluates the regulations set by the Belgium government [29]. It also organizes the accreditation of supply permits for the transmission network [30]. Additionally, the Flemish Regulator for the Electricity and Gas market (VREG) specifically regulates the distribution network (i.e. tariff setting is controlled by CREG), deals with complaints, acts as mediator in conflicts, advices the Flemish authorities and grants green certificates and heat and power certificates [31]. The Flemish Energy Agency (VEA), an autonomous agency of the Flemish ministry of environment, nature and energy, designs, implements and evaluates new energy-related policies [32]. Additionally, we read International Energy Agency (IEA) and PV Vlaanderen (Flemish PV trade association) reports. We also calculated the fluctuations in relevant support over time (see Appendix A). The main assumptions for our calculations were a system lifetime of 20 years, linear degradation of the system (0.8% annually [33]), and considering prices excluding VAT unless we found evidence in data suggesting otherwise, thereby taking a conservative stance. Additionally, unless indicated else we assume tax deduction schemes to be applicable for one year only, again following a conservative line of thought. This data, together with the changes in PV panel and electricity prices per segment, enabled us to calculate the relative importance of each governmental support instrument and the resulting financial attractiveness of typical small, medium and large-scale PV installations. For all systems we assumed self-investment, which also corresponds to the conservative calculation of the governmental support since the financing support from the government is not being used under this assumption. The results also showed the high importance of the green certificate instrument which was therefore further analyzed in terms of working and analysis of costs involved [8] and [34]. In the second, qualitative phase we held a series of interviews with CEOs and key managers of typical firms operating in the market for small, medium and large sized systems to create a heterogeneous sample. Interviewees were selected based on a desk study and an initial interview with an external expert, the chairman of PV Vlaanderen (Flemish PV trade association). We conducted a total of seven semi-structured interviews. The main goal was to obtain in-depth input on how changes in support instruments had influenced the firms' activities and performance, thus supplementing and validating our quantitative findings. The interviews were transcribed and verified by the interviewees. In the final phase, we triangulated our findings with two experts in the field: the chairman of the Flemish PV trade association, and a business developer in a European semi-governmental incubator in sustainable energy who also co-founded a PV company during our time of study.

**Table 1**
Average electricity prices in Belgium from 2007 until 2013, for residents (2500–5000 kWh, including taxes and levies) as well as industrial customers (2006: 2000 MWh, 2007-2013: 500-2000 MWh; including taxes and levies) [39] and [40].

| Year | Residents (€/kWh) | Industry (€/kWh) |
|---|---|---|
| 2007 | 0.1683[a] | 0.1149[a] |
| 2008 | 0.2062 | 0.1228 |
| 2009 | 0.1890 | 0.1325 |
| 2010 | 0.1967 | 0.1275 |
| 2011 | 0.2128 | 0.1355 |
| 2012 | 0.2275 | 0.1321 |
| 2013 | 0.2194 | 0.1315 |

[a] Based on price in second semester only, because first semester data was not available.

## 3. Results

VEA (Flemish Energy Agency) calculates the required levels of governmental support by taking electricity and PV system prices (including replacement of the inverter) as input [35]. We followed this approach to first study these prices in the various customer segments in Flanders. We then reviewed the types of support in the Flemish market between 2006 and 2013 and calculated their relative contributions for typical small, medium and large sized systems (see Appendix A). Taking the overall electricity and PV system prices as input, we subsequently put our findings on support instruments into perspective. Next, we addressed the most influential support instruments in place during our time of study, the Green Certificate scheme. We end with an analysis of the effect of support instruments on firm's activities and performance.

### 3.1. Electricity and PV system prices

Belgium's electricity market was liberalized from 1999 onwards [36]. This led to varying electricity prices in the market, but the trend is that large scale users (industry) pay lower prices than residents [37–40]. Prices consist of several components including the electricity price, contribution to renewable energy, heat and power technology implementation, transmission and distribution net tariffs, public charges, energy taxes and VAT [37]. Table 1 [1] shows the average electricity prices for residents and industrial customers in Belgium during our study.

On an average, industrial customers paid about two-thirds of the residential price [39,40]. For 2012, large scale industrial users (20 GWh per year) paid about half of the residential price [38]. Over time, prices for residents increased slightly, while medium size industry prices remained stable [39,40].

Additionally, PV system prices in Flanders have decreased substantially (Fig. 2; [41]). This is in line with a general trend of increasing production volumes resulting in lower system prices [42].

We could not find any data directly comparing the prices for small and large systems in Flanders. However, Barbose et al. mapped US PV system prices for 1998–2012 and found that system prices dropped by between 8% and 13% when comparing the median price of residential systems ( < 10 kWp) to medium sized (10–100 kWp) and large scale commercial systems ( > 100 kWp) respectively [43]. We took the above as input for our calculations on various support instruments (for support per Wp, see Section 3.2 and Appendix A) and to review their relative importance.

[1] Such data are not available at Flanders level. We followed Flemish Energy Agency and Flemish PV trade association calculations, which are based on EUROSTAT Belgium average electricity prices.

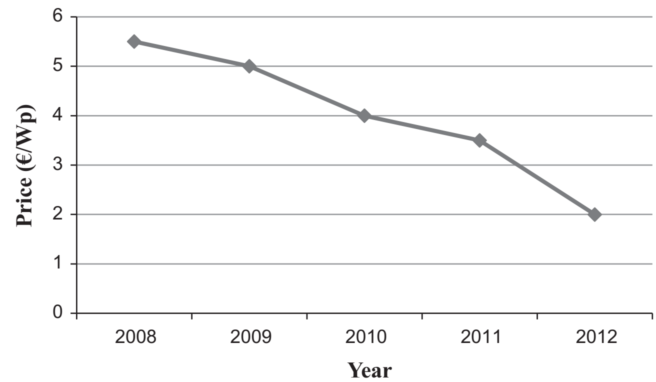


**Fig. 2.** The drop in PV system prices for households ( < 10 kWp) in Belgium excluding operation and maintenance and VAT from 2008 until 2012 (adapted from [41]).

### 3.2. PV support instruments

Our review of PV financial support instruments showed that some are only available for a specific size of system or are only provided to a certain investing party (e.g. company with profit). We identified three types of support: investment support instruments and tax deduction schemes aimed at reducing initial investment barriers, production support instruments targeting electricity production (i.e. support per kWh produced), and financial support instruments to cut credit costs (Table 2) (in line with [6,7] and [8]). As one can see, some of these were started or terminated at a later stage. Although the government did mostly foot the bill, production support instruments also had a financial impact on energy suppliers, Distribution System Operators (DSOs), residential, and industrial electricity consumers (including non-PV owners), as we will further discuss below. Moreover, production support instruments overlapped: green electricity certificates ('Groene stroom certificaten', GSC, a kind of feed-in-tariff per 1000 kWh produced for a fixed period, see below), net metering (or net injection for a set rate if net metering was not allowed), and direct self-consumption avoided buying electricity from the grid, the latter two relating directly to the electricity price in place. Furthermore, the level of GSC compensation was independent of the amount of electricity self-consumed or fed into the grid [44]. Finally, individual support instruments changed substantially over time, which is explained in Sections 3.2.1 and 3.2.2.

#### 3.2.1. Development of support instruments over time

In order to better understand the relative volume of support instruments over time, we have calculated the support per Watt peak of installed capacity (€/Wp) for three standardized systems: a small residential system (2.23 kWp), a medium sized system (25 kWp) at an SME, and a large industrial application (250 kWp), corresponding to the typical gradation in support differentiation (see Tables 3–5). Sector specific support was not included in these calculations. For example, farmers could apply for 30% investment support (excluding VAT) [45]. This support could not be combined with other forms except GSC compensation. The source data, calculation method, and intermediate results are shown in Appendix A.

Until 2011, the support for small systems was similar to medium and large systems (see Tables 3–5). Electricity prices for large industrial users were a factor two lower than those for residents (see also Section 3.1 on electricity prices above) [38]. At the same time, PV system prices for larger systems were only about 13% lower [43]. It is therefore surprising that medium and large scale systems received similar levels of support as small systems. Though PV system prices and electricity prices are not directly linked per definition (i.e. a large industrial user may opt for a small

**Table 2**
Financial support instruments for residential and large scale systems from 2006 to 2013.

| System size | Support instrument | Terminated |
|---|---|---|
| **Residential** ( < 10kWp) | ***Production support*** | |
| | GSC (a kind of feed-in-tariff: a fee per 1000 kWh produced) | |
| | Self-consumption (avoid buying electricity from the grid) | |
| | Net metering (bidirectional reversing meter; electricity injected to the grid is deducted from electricity taken from the grid) | |
| | ***Investment support*** | |
| | Investment support for the Flanders region (certain amount to cover the investment costs) | 31/08/2007 |
| | Premium by local municipalities (certain amount to cover investment costs, provided by local municipalities) | |
| | Tax deduction on investment | 27/11/2011 |
| | VAT reduction of 6% for renovation of private houses | |
| | ***Financing support*** | |
| | Tax deduction on mortgage loans | |
| | Green loan or mortgage interest reduction | 27/03/2009[a] 31/12/2011 |
| | Bond fund providing low interest loans | |
| **Medium and large commercial systems** ( > 10 kWp) | ***Production support*** | |
| | GSC | |
| | Self-consumption (avoid buying electricity from the grid) | |
| | Net injection tariff (individual deals for selling electricity to the grid) | |
| | ***Investment support*** | |
| | Ecology premium (certain amount to cover investment costs) | 31/01/2011 |
| | Tax deduction on profit | |
| | Investment support for farmers (certain amount to cover investment costs, only available to farmers) | 10/3/2006 [a] 20/7/2012 |
| | ***Financing support*** | |
| | Interest reduction for farmers | 10/3/2006[a] 20/7/2012 |

[a] regulations not in place in 2006, implemented on day/month/year.

**Table 3**
Development of support per Wp for a small residential system ( < 10 kWp) from 2006–2013 (€/Wp).

| Year | Regional investment support | Municipal investment support | Tax discount | VAT discount | GSC | Net metering and self consumption | Total |
|---|---|---|---|---|---|---|---|
| 2006 | 0.70 | 0.28 | 0.84 | 1.08 | 6.52 | 2.55 | 11.96 |
| 2007 | 0.64[a] | 0.28 | 1.08 | 0.95 | 6.52 | 2.57 | 12.04 |
| 2008 | | 0.28 | 0.93 | 0.83 | 6.52 | 2.60 | 11.16 |
| 2009 | | 0.28 | 0.85 | 0.75 | 6.52 | 2.62 | 11.02 |
| 2010 | | 0.28 | 0.68 | 0.60 | 5.07 | 2.65 | 9.28 |
| 2011 | | 0.28 | 0.59[b] | 0.53 | 4.46[c] | 2.68 | 8.53 |
| 2012 | | 0.28 | | 0.30 | 2.28[c] | 2.70 | 5.56 |
| 2013 | | 0.28 | | 0.17 | N.A.[d] | 2.73 | N.A. |

[a] Until August 2007.
[b] Until November 2011.
[c] Average value over a year.
[d] GSC support fluctuates over time for systems installed in 2013 making it impossible to calculate the overall contribution of GSC support.

**Table 4**
Development of support per Wp for a medium sized system of an SME (10–250 kWp) from 2006–2013 (€/Wp).

| Year | Ecology premium | Tax discount | GSC | Net metering and injection | Total |
|---|---|---|---|---|---|
| 2006 | 1.63 | 0.30 | 6.52 | 1.69 | 10.14 |
| 2007 | 0.99[a] | 0.26 | 6.52 | 1.70 | 9.47 |
| 2008 | 0.31 | 0.23 | 6.52 | 1.72 | 8.77 |
| 2009 | 0.55 | 0.21 | 6.52 | 1.74 | 9.02 |
| 2010 | 0.15 | 0.17 | 5,07 | 1.75 | 7.14 |
| 2011 | | 0.15 | 4.46[a] | 1.77 | 6.37 |
| 2012 | | 0.08 | 2.28[a] | 1.78 | 4.14 |
| 2013 | | 0.05 | N.A.[b] | 1.80 | N.A. |

[a] Average value over a year.
[b] GSC support fluctuates over time for systems installed in 2013 making it impossible to calculate the overall contribution of GSC support.

**Table 5**
Development of support per Wp for a large industrial system ( > 250 kWp) from 2006–2013 (€/Wp).

| Year | Ecology premium | Tax discount | GSC | Net metering and injection | Total |
|---|---|---|---|---|---|
| 2006 | 1.09 | 0.30 | 6.52 | 1.21 | 9.12 |
| 2007 | 0.63[a] | 0.26 | 6.52 | 1.22 | 8.63 |
| 2008 | 0.14 | 0.23 | 6.52 | 1.23 | 8.12 |
| 2009 | 0.26 | 0.21 | 6.52 | 1.24 | 8.23 |
| 2010 | 0.07 | 0.17 | 5.07 | 1.25 | 6.56 |
| 2011 | | 0.15 | 3.80[a] | 1.26 | 5.21 |
| 2012 | | 0.08 | 1.04[a] | 1.28 | 2.40 |
| 2013 | | 0.05 | N.A.[b] | 1.28 | N.A. |

[a] Average value over a year.
[b] GSC support fluctuates over time for systems installed in 2013 making it impossible to calculate the overall contribution of GSC support.

system), we found smaller systems to be corresponding to small electricity users paying higher electricity prices and vice versa. Thus, smaller systems were relatively more attractive to the end users. However, the level of support for large systems was still sufficient for them to grow extensively (see Fig. 1). Some companies even deliberately decided to focus on the large scale segment at the expense of lower margins for organizational efficiency reasons.

Another conclusion is that the GSC feed-in-tariff compensation (€/Wp) was the main driver for the exponential growth of installed PV capacity in Flanders. This was further confirmed by all our interviewees and [36]. We will discuss the GSC support instrument in more detail in Section 3.2.2. However, net metering and self-consumption were also substantial. After 2012, when the GSC level dropped considerably, net metering and self-consumption of electricity became the major shielding instruments for small residential and large industrial systems.

### 3.2.2. The GSC support instrument

The introduction of GSC certificates has been highly significant for the Flemish PV market. The support instrument is a hybrid support scheme combining a feed-in-tariff and a Renewable Portfolio Standard (RPS), as we will further elaborate below [7,46] and [47]. From 2006 onwards, for every MWh of renewable energy produced (also non-PV), a premium was granted, which was guaranteed for a period of twenty years, thereby functioning as a feed-in-tariff for PV producers [44,48,49]. In order to apply for a GSC, safety standards have to be met and a special permit has to be obtained before the installation can become operational [50]. For PV producers it is important to deal with this timely, in order to meet the deadline for the current GSC compensation level and thus avoid lower compensation. VREG is responsible for assigning the GSCs [31] and [48]. It also announces adaptations to the GSC level on its website and via its newsletter [51,52]. The timing of such announcements used to vary and sometimes entrepreneurs had to adapt their organizations quickly (see Section 3.3). However, from 2013 onwards, the GSC instrument is evaluated every six months to one year and adaptations are reported shortly after the evaluation [53]. Residents with systems smaller than 10 kWp have to report their production to VREG (i.e. a production meter is installed) [44]. For larger systems, the DSO reports to VREG. The DSO pays the GSC compensation to the PV electricity producer (both for small or large scale systems) [54].

Energy suppliers are obliged by the Flemish government to meet a quotum in renewable energy production [47]. In order to meet this quotum, they have to produce renewable energy themselves or buy certificates from others. If they cannot comply with the set targets, they have to pay a fine, which was €125 per certificate until March 2012, €118 until March 2013 and €100 thereafter [47,55]. The prices on the certificate market were somewhat below these fines, varying between €109 (average price 1 april 2006 – 31 march 2007) and €100 (average price 1 april 2012 – 31 march 2013) [56]. Thus, for systems installed in most of our period of study it was more favorable for PV producers to sell their certificates to the DSO, rather than trading them on the certificate market. This resulted in financial losses for the DSOs who had to buy certificates for prices they could not recuperate when trading them on the certificate market. Only when GSC levels dropped to €90 per certificate and below (see Fig. 3 below), it became attractive to sell them on the certificate market. However, some producers still decided to sell their certificates to the DSO [57]. The loss the DSOs made was compensated by increasing the net tariff for their customers, in particular residents (low voltage), who pay 80% of the total costs [47]. Additionally, suppliers charged their customers for the GSC transaction costs by adding a fee to the existing electricity price [47,58]. Thus, GSC compensation was not paid by the Flemish government from taxes, but financed via the energy bills. Also electricity suppliers spread the GSC costs they made unevenly over customers; large industrial customers got a discount [47]. For 2010, green certificate compensation was not paid for about 10% of all electricity supply. The Flemish PV trade association estimated that 75% of all GSC

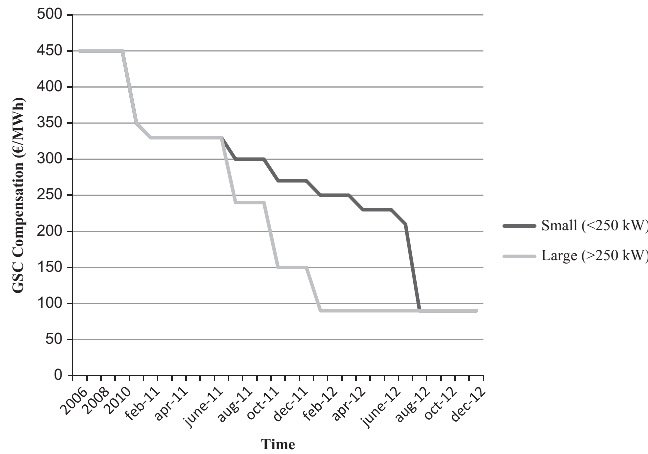


**Fig. 3.** Development of green certificate (GSC) compensation for both households and large installations (Light gray: > 250 kW) from 2006 till January 2013 (adapted from [49]). Note that from August 2012, the duration of GSC compensation was reduced from 20 to 10 years.

costs from PV were allocated to low voltage end users like residents and SMEs in 2012 [59]. Thus, those benefitting from the GSC compensation instrument were not equally carrying the load.

Furthermore, total costs related to GSCs for the period 2006–2013 were estimated at €1.5 billion[2]. These costs will remain high since GSCs are assigned for a period of 10 to 20 years. Costs related to GSCs assigned in the period 2006–2013 are estimated to be €6.7 billion for the period 2014-2031 (€5.1 billion if corrected for the time value of money). For 2012, this corresponded to €35 for an average household using 3500 kWh per year [59]. We expect this number to rise in future years because of increased installed capacity numbers and the ongoing costs of already assigned GSC certificates.

Finally, while *prosumers*[3] do profit from GSC compensation, they contribute less to the GSC instrument since the costs are calculated per kWh consumed from the grid [47]. In order to compensate for this, from January 2013 onwards, all PV owners of systems smaller than 10 kWp were charged for use of the network (i.e. per kWp) [60]. However, PV Vlaanderen fought the implementation of the network tariff and won the case in November 2013 [61]. Their main argument was the inequality with large scale electricity producers who paid much less for using the same electricity network [62]. This indicates that the PV niche has gained momentum, having triggered a broader discussion on existing mainstream energy rules and regulations and the allocation of costs and benefits.

*3.2.2.1. Level of GSC compensation for PV producers.* From its start in 2006, a distinction was made between compensation per GSC for systems smaller and larger than 250 kWp (Fig. 3). From 2006 until 2009, GSC compensation was very high, with 450 Euros granted to every GSC. But after August 2012, there was a sharp decline for small systems. From then on, GSC compensation was only assured for a period of 10 years, both for small and large scale systems [49]. Interestingly, GSC compensation for small and large systems was

[2] PV Vlaanderen, personal communication. PV Vlaanderen estimates total costs at €1.8 billion, supporting that we are conservative in our estimates. The difference can be attributed to the fact that we used assigned GSCs published by VREG as input instead of installed capacity numbers (indirect calculation method). We also took system degradation into account. The data file with calculations is available from the authors upon request.

[3] A prosumer is a consumer who also produces electricity. Prosumer is a conflation of the terms consumer and producer.

**Table 6**
Banding factors for small ( < 10 kWp), medium (10–250 kWp) and large systems ( > 250- ≤ 750 kWp) installed in 2013. The lower the banding factor, the more kWh correspond to one GSC, which is worth €93 ([63] and [64]). The number of kWh needed per GSC is indicated in parentheses and thus shifts over time (GSCs are assigned for 15 years).

| System size | Banding factor *Jan 1-July 31 2013* | Banding factor *Aug 1- Feb 16 2014* |
|---|---|---|
| ≤ 10 kWp | 0.23(4348) | 0.28(3571) |
| > 10- ≤ 250 kWp | 0.63(1587) | 0.72(1389) |
| > 250- ≤ 750 kWp | 0.49(2041) | 0.57(1754) |

equal in the period 2006 till July 2011. Thereafter, however, GSC compensation for large systems decreased faster (Fig. 3).

In January 2013, a new GSC compensation instrument covered three categories: ≤ 10 kWp, > 10- ≤ 250 kWp and > 250- ≤ 750 kWp, for which different banding factors were assigned [63]. The lower the banding factor, the more kWhs correspond to one GSC (Table 6), which is worth €93 [64].

VEA calculates the banding factors for both new and existing systems every six months to one year, taking into account PV system prices, inverter replacement costs (i.e. main maintenance cost), and electricity prices [35] and [53]. In case the banding factor deviates more than 2% from the actual banding factor it is adapted [53]. The new banding factors are enacted one month after publication of the evaluation report of the VEA [65]. The new GSC support instrument can thus be considered as a feed-in-premium co-evolving with electricity prices rather than a fixed feed-in-tariff [7]. From 2013 onwards banding factors for systems installed will be updated every six months. It is therefore impossible to calculate the expected overall support from GSC for systems installed after this date since this requires all future banding factors to be included. However, as Table 6 shows, levels of support are expected to be lower than the previous level of €90 per GSC in 2012, at least for 2013 [49,63] and [64].

### 3.3. *The effect of support instruments on firm activities and performance*

Our interviews revealed how the different support instruments in place over time affected firm level activities and performance. Fueled by high levels of governmental support, mainly in the form of GSC, the residential and commercial market in Flanders showed exponential growth from 2006 onwards (see Fig. 1). Relatively high levels of support compensated for the low electricity prices paid by commercial customers, thereby creating financially attractive business cases. Some companies started to provide financing solutions to their customers. One company offered a rent-a-roof solution from 2009 until July 2012, the period with relatively high GSC compensation for medium sized systems ( < 250 kW; Fig. 3). However, when GSC compensation was lowered, the business proposition had to be abandoned:

> *"At some point, renting a roof became impossible. You had to spread your margins over too many players and you just could not do it without the subsidy"*

(Interview with Solar Company A)

Moreover, with decreasing support levels, entrepreneurs needed to shift to other customer segments with relatively high electricity prices and support in place. For example, one company reoriented to the 10–250 kWp segment in 2013, since this had the highest level of support:

> "Suddenly the situation has totally changed, much faster than we expected. You have to adapt your business to these circumstances, you have to focus on other segments….We had to reorient to 10–250 kWp…we need to continually adapt." (Interview with Solar Company C)

This shift in targeted customer segment also matched the installed capacity numbers for small, medium and large systems (Fig. 1), showing how medium sized systems continued to be installed in 2012, unlike large systems with low levels of support from January 2012. The above quote also shows the need for a flexible organization, especially in times of decreasing support, for example by hiring temporary staff only. Furthermore, as can be seen in Fig. 3, from July 2011, GSC compensation was reduced every few months. Since customers wanted to benefit from the higher tariff rates, deadlines became stricter, requiring fast adaptation of the firm:

> "This peak changed from once per year, to once every ten months, to once every three months….In order to handle those peaks, you need to better organize and coordinate the purchasing. The internal dynamics have to change drastically in order to finish the projects on time."

(Interview with Solar Company C)

Entrepreneurs also made smart adaptations in order to obtain maximum benefit from the support available. For example, by spreading an invoice over two years, residents could avoid the maximum cap for tax reduction, thereby profiting from higher tax discounts. In a public-private PV project, an extra firm had to be started up in order to apply for the ecology premium. In another case, this was done via selling one share to another company. However, this also led to discussions on regulations related to the support instrument, sometimes even via a court case. An energy cooperative applied for an ecology premium for installing PV, and had to go to court to obtain it since the support instrument was originally meant for companies only [66].

Finally, implemented support instruments might have been counterproductive. Since VAT reductions only applied to houses more than five years old, this delayed rather than supported investments in PV. However, such anticipation of future support (i.e. a more profitable value proposition for the customer) may have had negative consequences:

> *"There are examples of new houses that were built ready to install PV panels (cabling, roof mounting) but waited five years for actual installation…. When GSC began to drop, some regretted that and decided not to wait five years, but other people were too late"*

(Interview with the PV trade association)

The above discussion shows how the different support instruments in place have shaped firm activities and may even have been counterproductive. Moreover, costs for complying with market regulations may actually counteract the available support instruments in place. This is in line with Hoogma showing that niche shielding is always partial in nature [67]. For example, a bank explained why they did not provide a lease offer for residential customers:

> *"There is extra protection for private persons (for lease), strict regulations. It is possible, but the costs don't match the benefits because of the enormous amount of paperwork. Also, a special permit is needed."*

(Interview with a bank)

One interviewee reported how a large scale project was stopped by energy and building market regulations:

> *"Regulation was implemented to stop it…It has a very volatile production profile, which is difficult to integrate in the net…no*

*permission was granted unless there was local use. Also building permits were not granted."*

(Interview with Business Developer X)

The above examples show how mainstream regulations also affect firm performance and the effectiveness of support instruments. Regulations can even hinder or block particular firm activities despite sufficient levels of governmental financial support in place [68] and [69]. Related 'soft costs' include access to the grid and balancing, spatial planning and permission, and can counteract governmental support instruments [46] and [70]. Morris considers grid access an essential 'layer of access' for implementing a variety of local renewable energy frameworks [71, p20]. Regulations may thus be related to non-energy areas like building, demonstrating how multiple mainstream systems can affect a single niche innovation. This becomes even more evident with Building Integrated PV solutions, where the building sector strongly affects niche development [72].

Governments thus play a dual role in shaping solar PV markets. First, available support instruments provide entrepreneurial opportunities to the firm. Second, mainstream regulations force entrepreneurs to adapt their firms which may even lead to blocking of particular business propositions, despite sufficient levels of support.

## 4. Discussion

Triggered by high levels of governmental support, the Flemish PV market has shown extensive growth over recent years, in particular between 2006 and 2012. This study provides insight into which aspects of the Flanders region of Belgium' support instruments fueled this growth. From the entrepreneurship literature perspective, governmental policies represent a particular source of entrepreneurial opportunity [9]. Similarly, institutional theorists argue that institutional processes (rules, norms, beliefs) influence economic systems [10]. Indeed we found a range of support instruments to affect the Flemish market and firm activities and performance over time, with the GSC scheme as the main market shaping instrument. Additionally, our review shows how conflicting regulations, originating from mainstream systems like building or finance may unintentionally limit the effectiveness of support policies in place (i.e. in line with [46] and [70]).

The provisions at the higher, more aggregated energy system level directly influenced the opportunities for cost and benefit allocation and financial attractiveness of more locally embedded PV entrepreneurial activities. Active shielding of the Flemish PV niche became highly dynamic, with financial support available at various governmental levels [6]. Entrepreneurs exploited such opportunities by adapting their organizations. Sometimes this has led to working in the 'gray areas' of regulations related to support instruments. The high GSC compensation was significant, making PV attractive even for large scale projects with relatively low electricity prices. Additionally, external investors got involved in providing finance for residential and commercial applications. However, when GSC compensation was reduced, the market proved to be still highly dependent on support and stagnated. A similar situation occurred in Italy in 2013, where cuts in financial support for PV deployment resulted in severe market decline [2]. Flemish businesses shifted towards smaller systems where PV was still competitive thanks to higher electricity prices and higher GSC compensation. A new regulation in January 2014 enforces the use of renewable energy in new houses and office buildings [73]. This shows that the market is still dependent on active shielding in some form; however this is a quantity driven instrument rather than direct economic support and, as such, does not directly affect governmental budgets [7].

Additionally, the cost and benefit allocation over different stakeholders at the higher energy system level should be carefully managed by policy makers. The regional government of Flanders definitely succeeded in substantially increasing the installed capacity for PV, mainly through GSC. The unique characteristic of GSC is that it has never been part of the governmental budget, representing therefore a relatively safe support strategy with no evident need for an exit strategy on the policy side [47]. However, the down side is that the cost of the GSC support instrument, which had no cap in terms of installed capacity, has rocketed. As support is granted for a period of up to twenty years, declining support levels will only be felt after many years and will not change the big picture in the short run. GSC also provides investors with lower investment risks compared to net metering, which can be altered or even exited at any time by the government [46]. However, the sudden changes in the level of GSC support created many difficulties for companies and led to a low level of certainty for investors. Our analyses further revealed that the costs of the GSC support instrument have been distributed unevenly, with residents paying the most via their electricity bill. Similar to other countries, it was the business sector and the large-scale electricity users that benefited relatively more from governmental support. This indicates that design of policy instruments is not only about who receives support, but also who pays for it (policy equity) [8]. These are political choices, whereby attractiveness not only depends on the level of support, but also on the regulated electricity prices for the particular segment along with the system installation costs. In the case of Flanders, those benefitting were not equally carrying the load, which caused friction. This has already led to broader discussions on cost and benefit allocation in the current mainstream energy production and consumption system, a recent example being the tariff for PV owners using the grid. In response to the new tariff, the 'Organisatie voor Duurzame Energie' (ODE; Organization for renewable energy) appealed in December 2012:

> *"We plea for a thorough debate, including all stakeholders, where all elements - costs and benefits- will be taken into account for calculating a legitimate network tariff."* [74]

Such debates could also open up existing system structures, thereby paving the way for further PV market growth and the building of an electricity system that deviates from the status quo [6]. We also see how removing support instruments from a government's national budget can become problematic over time, thus necessitating new interventions that disturb market development.

Finally, our focus was deliberately not on how the support instruments and mainstream regulations came into place (e.g. via lobbying processes and power struggles), although this could be an interesting complementary line of research related to the institutional theory stream of literature [10]. In this respect, the cost-benefit allocation over the various players in the world of energy systems could provide valuable insights. Schaltegger and Wagner (2011) consider such activities of institutional entrepreneurship to be at the heart of sustainable entrepreneurship, which does not only focus on individual firm success, but rather on creating favorable market conditions and wider social change [75]. Thompson et al. (2014) were the first to explore *how* sustainable entrepreneurs engage in institutional entrepreneurship, for example by introduction of new symbols and quantifying measures [76]. However, more research on these processes is needed, including different contexts and differentiating between individual and collective efforts.

## 5. Conclusion

This paper has shown how governmental support instruments like the GSC shape the business environment and the opportunities for companies. We approached this issue from a socio-technical perspective and analyzed the impact of support instruments for solar PV in the Flanders region of Belgium from 2006–2013. Niche entrepreneurs actively build their companies based on available support schemes. A range of production, investment and financing support instruments was available. However, some of these were counteracted by financial, building and energy market regulations in place. The GSC support instrument was found to be the most important for market development. Related costs proved to be extremely high and unevenly distributed over different stakeholders, indicating the need for a careful assessment of cost-benefit allocation over the energy system.

## Acknowledgments

The authors are grateful to the insightful feedback of the participants of the EU PVSEC conference in Amsterdam (2014) and the Solar Day of the Eindhoven University of Technology (2014) on the previous versions of the paper. Any remaining errors are the responsibility of the authors. This research is funded by the Ministry of Economic Affairs, Agriculture and Innovation of the Netherlands (EOS-LT subsidy, HR-NANO project, Project number EOSLT10031).

## Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.rser.2016.04.058.

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