Environmental Science and Policy 119 (2021) 66–71

Contents lists available at ScienceDirect

Environmental Science and Policy

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

Early European experience with tradable green certificates neglected by EU ETS architects

Aviel Verbruggen [a], Erik Laes [b,c,*]

[a] University of Antwerp, Prinsstraat 13, BE-2000, Antwerp, Belgium
[b] University of Eindhoven, De Rondom 70, 5612 AP, Eindhoven, the Netherlands
[c] VITO Transition Platform, Boeretang 200, 2400 Mol, Belgium

ARTICLE INFO

Keywords:
EU emissions trading scheme
Tradable green certificates
Market segmentation
Excessive 'windfall' profits
Target fetishism
Technological innovation

ABSTRACT

Tradable Green-power Certificates (TGC) systems resemble greenhouse Emission-permits Trading Systems (ETS). In Europe they both emerged in the period 1999-2001, based on similar beliefs in 'constructed markets solve public policy problems'. In 2001 TGC were launched under impulse of the European Commission (EC). The systems' design, attributes and performance were known in 2005 (start ETS phase 1) and more documented in 2008 (start ETS phase 2). Detailed year-by-year follow-up of the Flanders (Belgium) TGC system, revealed major flaws of the experiment, such as: neglect of proper market segmentation, excessive financial transfers from small electricity consumers to renewable electricity generators, lacking innovation incentives, target fetishism. Instead of evolving to a workable market, the TGC system metamorphosed in assignment of certificates case-by-case, mainly to large-scale RE generation projects set up by influential project promoters. The EU ETS exposes similar flaws. There is no evidence the EC has taken advantage of prolific comparative analysis and advanced comprehension of the TGC market construction trials and failures. The EC – deliberately or unconcernedly – skipped the opportunity of learning.

1. Introduction

The U.S. cap-and-trade system for reducing sulfur dioxide emissions by coal power plants is recognized as the guiding star of Europe's greenhouse gas emissions trading scheme (Ellerman et al., 2000; Carlson et al., 2000; Burtraw and Szambelan, 2009). Mostly overlooked are Europe's early experiments in market creation for trading green-power certificates (TGC), starting in 2002 when the design phase of the emissions trading scheme (ETS) was ongoing. Careful attending of the TGC experiments delivers important insights for the construction of emissions trading systems. This article describes the functioning of a TGC experiment during the period 2001–2007, as a learning source for officials then elaborating EU's ETS. Most lessons are still highly relevant today.

Market prevalence is a common vision in the European Commission (EC) directorate for competition. It is strongly rooted in the directorate striving for a competitive internal electricity market (EC, 1997). After UNFCCC COP3 in Kyoto (December 1997), it also permeated the directorate for the environment. This directorate changed camps in accepting emission permits trading as a valid instrument for pursuing climate policy goals (Ellerman et al., 2000; Skjaerseth and Wettestad, 2010; Meckling, 2011), Soon, EC's environmental directorate became a firm believer and missionary for the application of artificial market constructs (EC, 1999, 2000; Christiansen and Wettestad, 2003; Ellerman and Buchner, 2007). Voss and Simons (2014) attribute the success of the ETS as a policy instrument mainly to the fact that an entire 'instrument constituency' (composed of members of academia, consultancy, public policy, business and civil society) could be enrolled in its support. In turn, this enrollment depended in part on the promised "…*elegance of an almost self-governing policy instrument that could be operated light-handedly by adjusting an emission cap and leaving the rest to the market*" (Voss and Simons, 2014: 745). The ETS followed the more general model of emission trading, which was already mathematically established in environmental economics textbooks by the mid-eighties. The more mundane observation that ETS design and implementation would create a big demand for consultancy and advisory services explains the other part of its success.

By the end of the 1990s, the European Commission (EC) was editing a Directive for the promotion of renewable energy (RE) in the EU, and mulled the possibility of supporting RE development and deployment –

* Corresponding author.
E-mail address: e.j.w.laes@tue.nl (E. Laes).

https://doi.org/10.1016/j.envsci.2021.02.013
Received 13 June 2019; Received in revised form 26 January 2021; Accepted 17 February 2021
Available online 25 February 2021
1462-9011/

mainly of renewable electricity – by applying an artificial market as policy instrument (EC, 1999).

At first sight, instruments for reducing greenhouse gas (GHG) emissions have little in common with instruments for increasing renewable electricity generation. However, at the turn of the century, constructing the path of GHG emissions reductions and the path of developing renewable electricity generation faced comparable conditions. Both endeavors were receptive to novel policy ideas and instruments to incentivize non-governmental decision-makers. Fulfilling the decarbonization missions requested technological innovations and their broad deployment; in addition to R&D pushes, market-pull initiatives had to play a significant role (Fri, 2003; Kemp and Pontoglio, 2011; Rogge et al., 2011). For stimulating and measuring the market-pull initiatives, quantitative targets for emissions reductions and for generated renewable electricity in future years were defined. Minimum targets were – and still are – set in EU's policy-making processes. The EC and the member states (MS) administrations had to construct the respective regimes of incentives, control and enforcement to attain country specific targets that should sum up to the EU-wide targets.

In preparing the first directive on RE, the EC (1999) advocated a pan-European market for tradable green-power certificates (TGC). "On paper" such certificates as trading instruments for the promotion of renewable energy "offer clear theoretical advantages (…) when compared with command-and-control and targeted subsidies" (Baron and Serret, 2002: 105). However, the EC was not capable to submit a clear architecture on how a tradable green certificates system would work in practice. Among the EU Member States (MS), mainly Germany opposed the EC proposals. Germany already had implemented its own policy and support mechanism (Lauber and Mez, 2006). Also the European Parliament delivered a documented, critical report (Turmes, 2000). The European Parliament report clearly states that of the three existing types of support system, the feed-in system has proved to be most effective (p. 7), and leads to dynamic market development and considerable reductions of environmental burdens (p. 8).

The EC lacked sufficient influence to impose a TGC market regime on all MS. The majority of MS followed Germany in developing a RE technology specific support mechanism, mostly a feed-in tariffs (FIT) system, or a technology specific premium (Meyer, 2003; Haas et al., 2004). Following the EC-1999 ideas and proposals, Denmark was elaborating a TGC system (Morthorst, 2000), but immediately turned back to FIT support when the RE Directive (EC, 2001) allowed freedom of choice. A few MS opted for TGC systems, starting their deployment in 2002.

The significance of RE policies for the EU ETS has only been discussed in terms of the interaction between both policy instruments, which was labeled' perverse' (Schmalensee and Stavins, 2017). A thorough study of the TGC market architecture and experiments providing valuable insights for the elaboration of the EU ETS is not available. The architects of the EU ETS ignored the early lessons available from the TGC experiments.

Our argumentation unfolds in five sections. In 2001 the EU adopted a directive on the promotion of electricity produced from renewable energy sources (Section 2). The directive let the MS select their preferred policy instruments to realize their indicative quantitative targets on generated renewable electricity by 2010. A few MS adopted a TGC system. Flanders is an exemplary experiment to learn from (Section 3) because it fully followed the certificate market construction theory. Also, the Flemish region geographically encircles Brussels, and its officials maintained good contacts with EC staff that was designing EU's emissions trading scheme, i.e., there were no barriers for learning. Section 4 reports about salient results delivered by the TGC system, for example, huge money transfers across participating constituencies in the regulatory system. The excessive and unfair transfers are largely due to flawed design, mainly due to a lack of RE source, technology and related market segmentation and to a poor understanding of the policy matter at hand. Flawed design also impedes technological innovation and environmental effectiveness. Notwithstanding the clear lessons, discussed in scientific reports (Held et al., 2006), the European Commission (EC, 2005) adheres to artificially set-up markets (section 5). Conclusions are presented in section 6.

2. Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market

After the EC launched the liberalization of the electricity sector in 1997 (EC, 1997), the realization of the competitive pan-European power market faced considerable defects and delays. Some cures were expected from additional electricity and gas market regulations and updated internal energy market directives (2003, 2009), and via supplementary directives for the promotion of renewable electricity (2001) and of combined heat & power activities (2004).

The prior debates (Turmes, 2000) and the compromise in the RE directive of 2001 accentuated important conditions to respect during implementation, e.g., article 2 defines a catalogue of energy sources considered as renewable[1]. Article 4§2 states that the framework (for support) should "be compatible with the principles of the internal electricity market" and should "take into account the characteristics of different sources of renewable energy, together with the different technologies, and geographical differences", and should be "as efficient as possible, particularly in terms of cost" (EC, 2001). The RE directive holds a list of the RE generation targets for every MS (then 15 countries), to be met by the year 2010. The indicative targets were expressed as percentages of the electricity consumption in the MS.

The renewables directive (EC, 2001) was a compromise: every MS could choose its preferred support system for the development of renewable electricity supplies, and an evaluation of the various systems by 2005 was announced. A few MS (Belgium, Italy, Poland, Sweden and United Kingdom (EC, 2005)), countries with none or only embryonic RE policies in place, opted for the construction of a TGC market. They were influenced by the EC working paper (EC, 1999), and by officials' talk about trading permits and certificates being novel, promising policy instruments. Implementing the RE directive was urgent for the MS in order to meet the country specific RE targets by 2010. As such, one could observe how artificial market regimes were quickly designed and implemented, and how they performed. Section 3 presents observations on Flanders' TGC system. Since it started per January 1, 2002, this experiment could provide instructive experience for the preparation of the EU ETS.

3. Flanders market construct for tradable green certificates (TGC)

Belgium's regions (Flanders, Wallonia, and Brussels), in their territories exert exclusive authority over renewable energy, while the federal government has maintained authority over the Belgian North-Sea area. The regions' authority implies responsibility to transpose the RE directives on related matters. Belgium installed four different RE support systems: 3 regional + 1 federal. Federal support is related to offshore wind in the North Sea. The Belgian patchwork of authorities in energy policy contributes to deleterious deficiency in capability and capacity at all four regulatory offices. Poor coordination among the regions and with the federal level precludes agreement on elementary common standards and rules. The lack of know-how and experience made the Belgian politicians and regulators receptive to premature ideas as brought up by the EC on setting up TGC systems. For discussing how the emerging EU ETS could learn from artificial market constructs, the Flanders TGC case is highlighted, based on earlier analysis (Verbruggen, 2004, 2009).

In 1997 domestic RE generation in Belgium was but a slight 1.1 percent share of electricity consumption (the lowest percentage of all 15 MS of the EU at that time). Inexperienced in RE policy-making, Flanders embraced the brand-new market creation approach, promoted by the EC and by many academics as superior – sometimes qualified as superior "on paper" (Baron and Serret, 2002) – to all previous policy instruments. Belief in simple, assumed superior solutions empowers a freshmen administration. Implementation of the new approach was pursued according the purest blend market creation. The story (and the regulation built on it) went as follows: First, the regulator assigns to generators one certificate per generated MWh of 'green' electricity, when the output comes from one of the sources labeled as renewable by article 2 of the RE directive; this creates the supply of certificates in hands of RE generators. Second, sellers of electricity to end-users are mandated to submit yearly to the regulator the number of certificates sufficient to meet the RE% targeted in the coming years (0.8 % in 2012; 1.2 % in 2013; 2% in 2004; etc.) to meet Belgium's goal of 6% in 2010 (EC, 2001); this creates the demand for certificates. Naturally, electricity sellers charge the TGC purchase expenses on the bills of their customers, with small, captive customers more vulnerable than large customers which command more alternatives for obtaining electricity (for example self-generation in combined heat and power units). When a supplier falls short in submitting the mandated number certificates, a penalty is applied per missing unit (starting at €75 per certificate in 2002, €100 in 2003, and €125 since 2004). Third, the market mechanisms will function automatically: demand for and supply of certificates will settle their equilibrium price, day-by-day and year-by-year. The regulator only has to fix the yearly quota, monitor and enforce implementation by electricity suppliers, and impose penalties when needed.

The assumed merits of the TGC system were broadcasted, summarized in one-liners, such as: '*set targets guarantee effectiveness in raising the market shares of domestic RE generation*'; '*the TGC market guarantees cost-effectiveness, because least-cost producers come first*'; '*the market, not the bureaucrats, picks the winners and creates stimuli for technological innovation*'; '*the financial expenses of TGC support are paid by 'brown' electricity end-users, in accordance with the 'polluter pays' principle*'; …

Deliberately, Flanders TGC system amalgamated all RE supplies, i.e., all categories of RE supplies were placed on a single playing field and treated uniformly. This is contradicting art. 4§2(c) of the directive, telling that any proposal for a (support scheme) framework should take into account the differences in RE sources, technologies and geography. On the one hand, uniform treatment of participating actors in a given market is the theoretical standard, as prescribed by economics textbooks. On the other hand, uniform treatment has been the source of major flaws of the TGC system (Section 4).

The reckless start of the Flanders TGC system per January 1, 2002, caused several shortfalls. There was no deliberation over the goal(s) of the RE support system. Economic theory learns that financial support, i.e. subsidies, are an instrument to correct market failures, such as compensating inventors for free riding by copyists. At the beginning of the 21st century, valid RE policy goals were supporting the invention and development of RE technologies, and growth of related industrial activities. R&D money delivers technology push support. When new technology is promising to deliver low-cost RE in the future, financial support for market pull by pioneer investors is justified. For market pull public authorities count on private investors to install and run novel RE apparatus and equipment forthcoming from the invention-innovation shops. Reaching quantity targets in yearly green kWh generated should not be the primary goal of RE support policies. In the initial phase of technology development targets and quota are just means for pulling innovation. A narrow focus on nearby target fulfillment (also called 'target fetishism') works as a barrier to strategic vision on how a growing RE industry and equipment markets may develop and come to mature, robust functioning, outperforming fossil fueled electricity supplies.

4. Flanders TGC experiment holds important lessons

As a prototype artificial market, Flanders TGC experiment exposed typical attributes of artificial market construction, of direct relevance for the EU ETS conception in the period 2000–2005.

The early TGC systems in a few MS of the EU deliberately neglected segmentation of problems and markets (DTI, 2000: 25–26). Neoclassical economists prescribe this neglect. However, it turns problematic because it scorns physical and institutional realities. Physically, RE supplies are obviously forthcoming from a variety of sources, harvested with different, tailored technologies (for example, a wind turbine is a mechanics device, related to fluid dynamics, new materials, etc.; photovoltaic power is related to electronics, light flows, etc.). The EU directive (EC, 2001) adopts more than ten names to label the various RE supplies. The Renewable Energy and Climate Change special report, edited by IPCC (2012) holds six chapters of classified RE supplies, with additional sub-cataloguing in most chapters, especially in the bioenergy chapter. Institutionally, policy problems are organized by problem category in order to come up with proper solutions. For every public pricing, taxing or subsidizing policy, the devil is in the details. Generic approaches, applied on divergent realities, are superficial and a source of flawed outcomes. Here, three factors are documented: (1) excess profits related to unfair cash transfers, (2) target fetishism, and (3) technological innovation.

(1) Excess profits from unfair cash transfers

TGC's deliberate neglect of actual physical and institutional diversities leads to unjustified excess profits and unfair cash transfers. Fig. 1 illustrates the composition of financial flows resulting from a policy installing a uniform price for regulating a diverse reality of different 'bands' of RE sources ('band' is a term introduced in the UK when they experienced the drawbacks of amalgamating all RE sources under one umbrella). Fig. 1 shows three different bands of RE sources A, B, C. The marginal cost of the available A-sources is constant and lowest (for example: A may represent incineration of the biomass shares processed in established domestic refuse plants). B and C show increasing marginal costs (for example: B may represent the bundle of other biomass conversion processes, and C wind power in the first decade of this century). The area under the three marginal cost curves represents the amount of euros sufficient for covering the real costs[2] in producing the RE quota. The payment for the RE quota by electricity users is the full rectangle (quota multiplied by uniform 'market' price per certificate).

The financial flows corresponding to the dashed areas are money transfers from consumers to RE generators on top of cost coverage. The transfers consist of two components: Ricardo rents and excess profits. Ricardo rents realized within a particular RE source band may result from graduation in natural endowments, from proficiency of the producer, or from other band specific characteristics. The perspective of

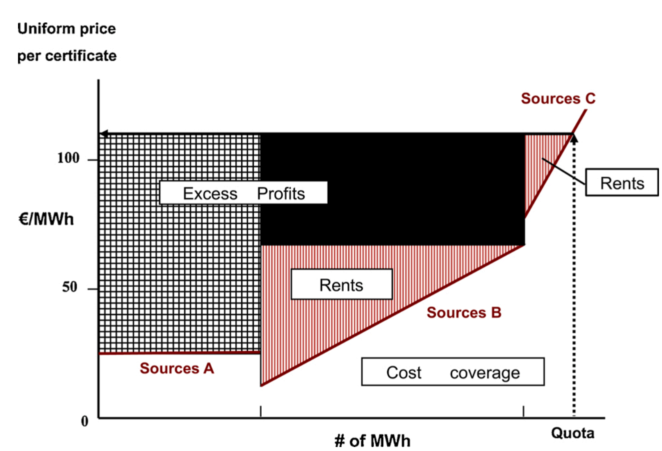

Fig. 1. Cost coverage, rents and excess profits, when three disparate technologies, mostly also of unequal maturity, are amalgamated in a TGC regulation imposing a uniform certificate price.

earning such rents may stimulate innovation and entrepreneurship, and therefore these rents are mostly considered as reasonable earnings. Excess profits (usually named 'windfalls', an euphemistic name when regulatory failure is the cause of it), however, result from excessive power of the resource owners, from flawed regulations, or from other unjustifiable factors. Transfers related to excess profits are unjustifiable and a bitter fruit of failing public policy.

The inbuilt occurrence of excess profits in Flanders non-segmented TGC market was exposed in 2003, with the warning: "The payments by end-users would grow so high that the system would implode under its own weight" (Verbruggen, 2004: 175). The extent of the excess profits during the first six years [2002–2007] functioning of Flanders TGC system was numerically assessed in 2008. The actual 838 million euro bill paid for the green certificates in Flanders, compared to the 301 million euro bill when these RE flows would have been remunerated at the rates of the German FIT system, gave an estimate of 537 million euro excess profits. The capture of excess profits was estimated as 57 % by bioenergy in waste processing, 30 % by other bioenergy plants and 13 % by new wind-on-land projects (Verbruggen, 2009: 1393). Incumbent companies picked up the predominant share of the excess profits. The independent wind project developers were happy to receive a small piece of the cake, after many years of parsimonious pioneering. Almost all stakeholders at the generators side defended the TGC system, although from the very beginning the inherent flaws started to manifest pernicious effects.

Excess profits transferred from electricity consumers' wallets to RE generators, were lavish and distributional regressive (small, less well-of consumers carried relatively the highest financial burdens). The high returns gained by electric power from bioenergy waste processing corrupted the polluter pays principle and the proper environmental policies with respect to waste management (prevention, re-use, recycling, processing with energy and materials recovery).

(2) Target fetishism

In addition to the structural flaw of negating source and technology diversity, came the myopic focus on the RE quota targets. Target fetishism directs all attention on meeting politically agreed numeric targets. Because attainment of a numeric target is easy to measure and reveal, a shortfall exposes politicians in office. It makes that highest priority is adhered to increase in the short run RE output from whatever source or quality. Obsolete and non-sustainable supplies, mostly from bioenergy sources, received extra stimuli in this way. Notwithstanding lax quality standards on what was called domestic RE generation, the numbers of TGC deposited were too low for the targets fulfillment, even with high TGC prices, allowing significant money transfers from electricity consumers to RE generators.

RE plants installed before 2002 could obtain certificates, making the regulation instrumental in registering most of the pre-2002 active RE capacities in the region. During the three start-up years [2002–2004], about half of the TGCs were allocated to outputs by pre-2002 plants and by more biomass co-firing in old coal plants. The total RE output did not suffice to meet the year targets. In June 2004, Flanders entitled waste incineration technology for receiving TGC (see art.2 of the RE directive), neutralizing earlier opposition by green politicians. The fastest expansion came from biomass co-firing, converting old coal plants in biomass only plants, or building new medium-scale biomass power plants. Because Flanders' biomass supply is limited, shiploads from overseas (forestry residues from North-America, palm oil from South-East Asia) helped to fill the gaps towards the targets. Some companies, which were specialized in recycling wood waste for manufacturing chipboards, did complain about highly subsidized power generation emptying the supplies of wood material for recycling in useful material.

Target fetishism had a high price in environmental costs and in higher bills for electricity consumers. Target fetishism also turns the numeric quota into ceilings on performance and stimulates stop-go policy processes (efforts stop once a nearby target is realized). In Germany, RE development and deployment by yearly adapted FIT support per specific technology, were far more successful and the country surpassed its target set in the RE directive.

(3) Technological innovation

Innovation requires strategic vision on the state and future of the renewable energy sector, with separate chapters for each major technology group. A strategic vision is more than the transposition of a EU directive, and is inter alia related with science & technology policy and industrial policy of the MS and of the EU. The neglect of innovation imperatives retards the benefits of better technology and causes higher environmental costs. In Flanders, the innovation goal was not noteworthy. Implicitly was assumed that the TGC market would automatically care for innovation. However, Flanders TGC had no positive impulse on innovation of RE technologies, neither on the growth of an industrial cluster fostering RE future markets. The poor performance in market pull of innovative technologies is a logical consequence of the amalgamated TGC market construction. It choked the development of promising RE technology by the run to the bottom for mature, cheap (some obsolete and environmental dubious or even negative) RE sources and technologies.

Disruptive technologies were crowded out by easy money on 'mature' options. Fixing the penalty height (= the certificate ceiling price) faces an innate contradiction. On the one hand, a high penalty pulls the uniform certificate price upwards[3], further amassing the excess profits on 'mature' options. On the other hand, reasonably low penalty levels exclude high-end new technologies, for example photovoltaic processes (PV) at that time. In 2002, solar power via PV was an immature technology, in need of market deployment. The costing price of PV generation in central Europe was about €600/MWh, far above the penalty levels of €75-€125/MWh applied in Flanders TGC market. When the costing price of a technology is higher than the penalty, mandated electricity suppliers will not buy from the technology because it is cheaper to pay the penalty, and charge this on their customers. Hence, PV got support by assigned premiums on top of the sales value of generated power. In 2006, the Flemish premium for PV was set at the same value of the then applied German FIT level (€450/MWh). Because at the time, household electricity prices were around €150/MWh in Flanders, the Flemish premium was too generous. Flemish politicians and regulators did not react appropriately to the spectacular 2008 price drop of solar panels (IPCC, 2012; IRENA, 2018). The sales of solar panels in Flanders boomed in the following years. So did also the cash drain from small consumers (lacking opportunities to invest in solar panels) to their more wealthy co-citizens (obtaining safe, high-return investment deals). This experience emphasizes the importance of continuous regulatory follow-up of every support mechanism. Alertness is the more relevant, the more dynamic occur technological evolutions. Also Germany was overwhelmed by the success of PV cost reductions. The yearly review and FIT adaptation proved insufficient by the rapid pace of PV cost falls since 2008; quarterly reviews and adaptations cured the follow-up, until PV prices became competitive with the electricity tariffs charged by standard suppliers (called 'grid parity').

4.1. *Epilogue*

The major lesson of Flanders TGC experiment is that lack of source and technology segmentation leads to ineffective, inefficient, and unfair outcomes. In reaction to the poor outcomes, politicians turned to ready-fix measures to stop the blooding. The idea of market creation was shelved and replaced by ad-hoc rulings per band of RE supplies. The reversal, however, took place without assessment of the failing TGC system. The new practices went on, missing an agreed framework. The support dissolved in project-by-project subsidizing of larger projects, far too generous compared to all standards, e.g., in 2018 new large-scale PV projects still receive subsidies. The onerous financial burdens on the small electricity consumers are relabeled from time to time, but charging continues.

The once announced and lauded TGC market system has metamorphosed in its opposite: case-by-case allotment of (excessive) financial premiums to large-scale RE generation projects set up by influential project promoters. In Flanders, not all regulatory failures were directly related to the artificial TGC market trials. The many and persistent failures magnify the dangers of a wrongly designed and implemented artificial market system, when outstanding and alert regulatory and political capability are lacking, as is the case in the Belgian institutional and political patchworks.

5. The EC's formal evaluation of RE support instruments (EC, 2005)

Article 4 of the RE directive (EC, 2001) states: "not later than 27 October 2005, the Commission shall present a well documented report on experience gained with the application and coexistence of the different mechanisms". Before the formal report came out, scholars had published evaluations, showing the superior performance of well-designed, properly segmented FIT support and the peculiar functioning of TGC systems (Held et al., 2006; Haas et al., 2004).

The EC report does not clearly specify the criteria[4] and their weights in the evaluation. At occasions the evaluation is circumstanced, referring to complexities and little experience with TGC mechanisms. The report observes: "The generation cost of renewable energies varies widely. National, regional, and agricultural resources are rather different in Member States. Any assessment of support schemes should therefore look at each individual sector" (EC, 2005: 5). Apparently, this observation is not thought through the inherent properties of the support schemes: specificity of FIT and amalgamation of TGC. Given the known facts in 2005, the EC report reluctantly acknowledges the better performance of FIT, mainly in developing and deploying wind power and in pursuing solar PV. The report insufficiently discussed the biomass issues.

The field facts delivered no arguments to the EC for imposing TGC markets on the Member States, when the 2001 directive was amended and the 2009 directive (EC, 2009) adopted. Contrarily, because of the failures in the TGC concept the few MS that had engaged in TGC systems shifted to FIT or premium systems openly, e.g., UK (DTI, 2007) or via covert metamorphosis like in Flanders, ending in a deplorable state of the regulation.

However, linkages between RE support systems and the EU ETS remained. They were apparent when CEOs of incumbent European energy companies claimed three main points for EU's energy policy: *(1) preference for mature renewables in the regular market; (2) priority to the utilization of existing competitive power capacity rather than subsidizing new constructions; (3) restore the ETS as a flagship climate and energy policy* (Magritte Group Press Conference, March 19, 2014; http://www.gdfsuez.com).

On April 9, 2014, the then European commissioner J. Almunia served the energy corporations, as they liked it. New state aid guidelines significantly constrained the renewable support mechanisms of the MS (EC, 2014). On October 8, 2014, competition commissioner J. Almunia approved UK's financial support package for the planned nuclear station Hinkley Point C. Critics of the German RE successes joined forces to facilitate the revision of the German Renewable Energy Act to rein in 'excessively' rapid renewable power deployment (Verbruggen et al., 2015). Since the policy break in 2014, the EU lost momentum in RE development, and leadership on the global RE scene.

6. Conclusions

Observing real-live experiments in artificial market building offers important insights, not easily detectable at the moment of market design (Smith, 2002; Wettestad and Gulbrandsen, 2018). By timely and close observation one may obtain early warnings on flaws and their ensuing impacts.

The EC (1999) proposals pushed early experiments in the set-up of artificial markets in green certificates. The actual experiments were highly instructive about, e.g., the importance of problem (hence policy and 'market') segmentation, the dangers of target fetishism, the missing focus on technological innovation, and the huge financial transfers from small electricity consumers to excess profits cashed by RE generators. The salient failures were evident from analyzing the performance of one particular European TGC experiment (Flanders, Belgium). Rather than learning from the facts, the EC kept holding up the myth of 'markets solve the problems', illustrating the ideological conversion of means into ends (Bryner, 1999).

Due to its failures and to the bursting financial transfers from low-voltage electricity customers to RE generators, Flanders TGC 'market' requested continuous policy interventions, for fixing design failures, e.g., its neglect of problem segmentation. The poor repairs, like crude banding of some RE technologies, did not suffice. Overall the Flemish TGC quota driven system metamorphosed in direct price support 'à la tête du client', case-by-case for particular projects of particular investors.

Opposite to the failing TGC experiments, technology specific FIT support (e.g., in Denmark and Germany) delivered the diligent development of two most crucial RE power technologies: wind and PV. Economists (Frondel et al., 2009) commented this success story unfavorably, subordinated it to the 'holy grail' of uniform carbon pricing (Wagner et al., 2015), or considered it as "perverse interactions" for emissions trading (Schmalensee and Stavins, 2017).

Problematic attributes of TGC systems are also present in the EU ETS, for example: lack of problem and market segmentation, huge financial transfers, and metamorphose from quota to price control (Point Carbon, 2008; De Cendra De Larragán, 2008; Marcu et al., 2017). A clear example of ETS weakness is the actual building of new coal-fired power stations by incumbent power companies (RWE, E.ON, GDF-SUEZ) in Germany and the Netherlands, commissioned after 2015 (Agora Energiewende, Sandbag, 2018).

There is no evidence the EC has taken advantage of prolific comparative analysis and advanced comprehension of artificially constructed markets, as tested by the TGC predecessors, promoted by the EC (EC, 1999). The EC – deliberately or unconcernedly – skipped the opportunity of learning for the ETS design. This attitude announces a repetition of flaws and failures that could have been avoided. Poor application of economic textbook propositions is disparaging rather than helpful in finding fast (given the urgency to mitigate climate change) roads to a low-carbon economy and society.

Notes

1 (a) '*renewable energy sources*' shall mean renewable non-fossil energy sources (wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogases); (b) '*biomass*' shall mean the biodegradable fraction of products, waste and residues form agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste; (EC, 2001)

2 'Cost coverage' includes a normal return on invested capital.

3 The yearly average certificate 'prices observed'/'penalty levels imposed' in Flanders were [in € per MWh/€ per MWh]: 74.48/75 in 2002, 94.67/100 in 2003, and 112.77/125 in 2004. The hanging of certificate prices nearby the penalty or ceiling price continued during later years (Verbruggen, 2009).

4 For example: "effectiveness refers to the ability of a support scheme to deliver green electricity", without considering the effectiveness in RE technological innovation; equity aspects are neglected.

CRediT authorship contribution statement

Aviel Verbruggen: Conceptualization, Methodology, Formal analysis, Writing - original draft. **Erik Laes:** Conceptualization, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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