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Market Liberalization and Innovation in the Energy Sector: The Case of Belgium and the Netherlands

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Abstract

Electricity markets in Europe have gone through several rounds of liberalization reforms since the 1950s and 1960s. In recent decades these reforms have also been justified with non-optimal levels of innovation and research and development (R&D) in the energy sector. This article examines the effect electricity-market liberalization has on innovation in the sector and argues that market structure has an influence on the outcomes of these reforms when R&D and innovation diffusion are considered. This is usually not discussed during policy deliberations concerning electricity-market reforms. The case studies of Belgium and the Netherlands are used to exemplify the argument. The findings of the paper are relevant to policy discussions regarding innovation diffusion in the energy sector and the spread of renewable energy technologies. Furthermore, the new market context should be taken into account when designing energy-technology policies.

Keywords: electricity-market liberalization, renewable-energy policy, innovation diffusion, Belgium, the Netherlands

1. Introduction

Historically electricity-market liberalization[3] in Europe started in the 1950s and 1960s. Its main goal was to diminish restrictions on in- and out-flows of electricity from national boundaries (De Jong 2006). Thus, policies during the first round of liberalization developed though the help of technology push as large electricity

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[3] In this article the concept "electricity market" is used interchangeably with the "energy market" – if the latter is used in a broader sense (including the heating and the gas market) it will be specified in the text.

capacities (via outsized nuclear power plants) were built and their output surpluses had to be absorbed and transmitted. Nevertheless, cost-efficiency decisions were still made in national states, as the interconnected energy systems only provided safety valves for seasonal flows of energy for the utility grids, but did not have any measures to stimulate energy production at the lowest (including environmental) cost (COM(88)238). Affordability, reliability and security of energy systems in Europe took precedence (e.g. Surrey 1992). After 1985, the liberalization process has been concentrated on opening energy networks to third parties, unbundling the system and increasing competition across borders (Jamasb and Pollitt 2005; 2008; Serrallés 2006; Lagendijk 2011). Thus, from the 1980s onwards, the European Commission has promoted reforms to increase trade in electricity across Europe using the pillar of the free movement of goods to gradually expand regulation on electricity markets (Padgett 1992). Common investment in energy infrastructure and a smaller number of internationalized electricity companies with a better competitive positions were deemed more efficient (Clifton et al. 2010).[4] In 1996, the policy momentum culminated in the directive on the internal market for electricity (96/92/EC) which called for the opening of electricity markets starting with bulk consumers (Eising 2002; see also Jamasb et al. 2014).

Consequently, in the second round of liberalization reforms, the efficiency arguments became more important and started to include research-and-development (R&D) efforts. The reasoning was that R&D expenditures in publicly owned companies were not transparent: they were considered ill-directed (over-engagement with fundamental science with little connection to the market) and not geared towards profit maximization (see, e.g., Chesshire 1996; Mulder et al. 2006). Furthermore, it was argued that there was a myopic bias in R&D funding in state-owned companies: e.g. more than half of public R&D funding in all OECD countries after the oil crisis went to nuclear energy in the 1970s (Grubler and Riahi 2010). While the debate regarding the inefficiency of state owned enterprises has been rather one-sided, the activities of state-owned energy companies are dependent on the role the government has assigned to public enterprises (Tõnurist 2015).Thus, also the productivity and innovativeness of state-owned energy companies can vary considerably across countries (Tõnurist and Karo 2015).

Nevertheless, in the midst of rising electricity demand, the governments had to socialize the risks associated with R&D in thermal and nuclear power production. Thus, the effects of electricity-market liberalization were seen as very positive (e.g. IEA 2005), and after the liberalization R&D levels were also expected to increase (Erdogdu 2013). However, since the mid-1990s work on the unintended effects of market reforms on R&D, patents and renewable energy (RE) started to surface about the US with other research following (GAO 1996; Dooley 1998). Hence, the previous debate on the effects of market liberalization and increase in competitiveness

[4] The interests of France and Germany have been seen as instrumental in promoting the idea of an internal market in the union and arriving at the "buyer model" (i.e. all energy generators will sell energy to a singular party that distributes electricity imports and exports; Lagendijk 2011). During this period Belgium and the Netherlands (among others) opposed the idea of third-party access to energy systems (Eising and Jabko 2001); however, later the Dutch government became a strong advocate of ownership unbundling (Torriti 2010, 1066).

was found to be dependent on a static understanding of the technological environments (Porter and Van der Linde 1995). There are still gaps in this academic debate, and one of them relates to the effectiveness of market mechanisms – here liberalization – in the context of different market structures and hence also technological mixes and the influence it has on innovation in the energy sector.

This article discusses how energy-market liberalization has influenced R&D and innovation in the energy sector and the development of renewable technologies. A short review of previous research is presented in the theoretical part of the paper. We argue that these effects are at least partially dependent on energy-market structures prior to liberalization. To exemplify this argument and propose new research avenues, we compare the electricity markets in Belgium and the Netherlands prior to and after liberalization and the effect of reforms on incumbent energy producers' R&D and strategic goals. Belgium and the Netherlands were chosen for case studies, because both countries opened up their electricity markets at a relatively similar time, meaning that the effects of economic fluctuations can be minimized. Furthermore, while both countries have distinct energy-sector structures, they still belong to the same general energy and environmental policy context as part of the older EU member states. After an outline of the empirical cases, we will also discuss the need for hierarchical and network-based policy measures in different settings, and we conclude with the theoretical and policy relevance of our study.

2. Theoretical considerations

Public policy has been found to play an important role in innovation transitions in the energy sector (e.g. Lewis 2011; Ru et al. 2012). In any policy field there are different policy mixes and coordination measures to choose from – most broadly speaking these can involve the use of market mechanisms, hierarchies and networks (Wollmann and Bouckaert 2006; in the context of innovation policies Karo and Kattel 2010). However, ambiguity on what is desired from the policy mix and the instrument interactions has, thus far, not been studied very well (Rogge and Reichardt 2013). Therefore, policy measures can be inconsistent, counter-productive and work against each other (Kern and Howlett 2009, 396). Here we concentrate on the use of market mechanisms and market liberalization in particular in these policy mixes.

As outlined above, at first, energy-market liberalization was not tied to the R&D and innovativeness of the sector, but the risks and uncertainties characterizing the process were soon found to influence also the innovativeness in liberalized electricity markets (Markard and Truffer 2006; Künneke 2008). It became clear that policies which at first glance did not seem to be technology- and R&D-oriented presented a complex relationship between innovative activities and desired goals in the energy sector (e.g. Jørgensen 2005). Parallel to liberalization, the sector was also confronted with societal challenges coming from the climate-change debate and thus, policy (incl. market-based measures) was increasingly put into the context of technological change and innovation (Tõnurist and Valdmaa 2015).

Consequently, the main idea in the energy sector (besides the increased use of market mechanisms) is to raise competition levels through which selective efficiency could be enhanced (Gaffard and Quéré 2006). Hence, in this context market mecha-

nisms – in addition to other governance forms – should be aimed at creating the desirable growth conditions. This can be done through (1) deepening of the market (enhancement of existing product functions), (2) widening of the market (adding new functions to the product), (3) drifting (change of product usage) and (4) emerging of markets (solutions for new problems) (Moore et al. 2007). However, when we are talking about the nature of electricity production – non-unique, interchangeable and infrastructure-dependent product – some of the former market-development models become more difficult to achieve. There are studies about the relationship between liberalization and technological capabilities (Basant and Chandra 2002; Pamukcu 2003; Figueiredo 2007) but little consensus over the direction of the effect. Consequently, free trade does not automatically enhance the accumulation of knowledge and R&D (Cimoli et al. 2007). Therefore, no automatic positive response regarding the growth of innovation should be expected following the liberalization of the energy market.

What is known is that electricity-market restructuring influenced the overall R&D expenditure levels within the industry and affects the levels of technological innovation (Jamasb et al. 2008). R&D investment levels in general have been wavering over the last two decades in the energy sector. This has been ascribed – at least in part – to the process of privatization and liberalization in the energy sector (Sterlacchini 2012). Consequently, also the creation of a wholesale market for electricity is associated with the drop of R&D spending (Kim et al. 2012). As such, between 1990 and 2004 investments in electricity-utilities R&D fell by 62% (45.5% directly relating to electricity research) in Europe, as companies have been abandoning long-term research projects with fundamental and general-purpose technology concerns (Sterlacchini 2012). The same trend holds for the US, especially after the liberalization reforms carried out in 1993 (Sanyal and Cohen 2009). Moreover, going through the unbundling process, the size of the electricity-utility companies and the overall R&D budgets have decreased, meaning a loss in the ability to scale up projects (Jamasb and Pollitt 2008). This points to an overall push towards decentralization in open market conditions, which is also expected to create the momentum for the prevailing technological regime change (e.g. Jacobsson and Bergek 2004). However, Bell and Schneider (1999) describe this process as the "Balkanization" of R&D, in which deregulation is undermining collective research efforts and leads to duplications, which publicly funded technology programmes cannot compensate for. Furthermore, liberalization, unbundling and privatization in the energy markets all contribute to the increased importance of the financial performance of energy companies searching for cost-saving and efficiency gains (e.g. Markiewicz et al. 2004). Consequently, Sanyal and Cohen (2009) found a deep decline in R&D expenditures after restructuring in the electricity markets. The decrease is cyclical: meaning that companies reduce their expenditures very early in the stages of restructuring, followed by a recovery phase and another dip after the market regulation is enacted. This has been tied to the decline in R&D intensity and the suboptimal investment levels in the electricity industry (Jamasb and Pollitt 2006). This also means that R&D budgets in general can decrease through market-based measures in the energy sector, and the configuration and mixes of technologies in the market have a tendency to stabilize after reforms (Munari and Sobrero 2003; Sanyal and Cohen 2009; Jamasb and Pollitt 2008; 2011; Gugler et al. 2013; Cominato Boer et al. 2014).

On a more technical-organizational note, the existing spot markets do not allow hedging based on spot-prices and forward prices – this complicates investment decisions because hardly any informational quality is currently attributed to the aforementioned (Defeuilley and Meunier 2006; also Finon 2008). Moreover, due to the homogeneity of electricity the free-rider problem raises its head when electricity production is a competitive activity, but R&D investments become an "optional" spending for the firm (Grubb 2004; Thomas 2007). On the whole, this means that it is difficult to create high levels of innovative competition in a uniform product markets through market-based measures alone, and the effects of market liberalization policies can be unforeseen (see further on the effects of low competition in energy markets in Schimitt and Kucsera 2014). Thus, in liberalized market conditions regulatory quality – re-regulation – is assumed to be key in inducing adequate investment levels from private players (Joskow 2008). At the same time, regulators in Europe are found to be rather ineffective: for example Ugur (2009) shows that there is no correlation between *ex-ante* regulatory quality and *ex-post* performance indicators in liberalized EU-15 network industries.

Consequently, when we just look at research funding then R&D budgets for RE technology have increased substantially in the 1970s and the early 1980s, but from then on remained broadly constant in OECD countries (Jacobsson and Bergek 2004). The stagnation of R&D funds is in conflict with the increased attention on environmental goals (Johnstone et al. 2010; da Graça Carvalho 2012; Tõnurist and Valdmaa 2015). Various government policies (e.g. tradable renewable energy certificates, feed-in tariffs, production quotas and tax credits) have been introduced in an effort to reduce costs and accelerate market penetration, but also further investment in R&D is needed. Hence, the advisory group of the European Commission has urged to increase the levels of investment in the energy technologies to a level similar to the proportions of 25 years ago (Advisory Group on Energy 2005).[5]

At the same time, R&D expenditures cannot be recovered in the same magnitude from customers anymore (Sterlacchini 2012; Moreno et al. 2012): stable income from the markets to recover costs from guaranteeing a reliable electricity supply has disappeared, and profit margins have become limited due to increased competition.[6] As a result, companies see possibilities for dividends at the expense of advancement in technology (see e.g. Salies 2010; Clifton et al. 2010), especially after the decline of state funding (Schimitt and Kucsera 2014). Some examples of technology fields that are found to require more investment than is currently available are tidal turbine systems, biomass gasification, carbon capture and storage, fuel cell batteries and photovoltaic technologies (Salies 2010). This means that business-oriented goals start to dominate with very little long-term strategic perspective (see also Tõnurist and Valdmaa 2015).

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[5] For example, while 6.5 billion Euros of the Horizon 2020 are set aside for research and innovation under "secure, clean and efficient energy" the new version of the programme "Intelligent Energy – Europe" was initially not included in the aforementioned, and only later the programme "Market uptake of energy innovation" was added to it (see Climate Allegiance 2012; the opinion of the Committee of the Regions on the Horizon 2020 (2012/C 277/14)).

[6] Thus, many larger electricity-utility companies (especially from larger economies) have selected an aggressive strategy towards cross-border acquisitions and internationalization to increase their size in the market that is characterized by monopolistic competition (e.g. the emerging dominance of EDF, ENI, E-ON, Vattenfall in the European energy markets) (Clifton et al. 2010).

Furthermore, electricity companies are not in general terms R&D-intensive companies (Nemet and Kammen 2007; Jamasb and Pollitt 2011). However, the intensity and quality of R&D (measured by patent data) has also declined in the connected industries (e.g. Sanyal and Ghosh 2013). Nevertheless, it does not mean that all innovative activities have stopped. Markard and Truffer (2006) found, after studying the effect of liberalization on the 4th-generation energy technologies (nuclear energy, fuels cells, wind power etc.), that while prior innovations were incremental, "slow" and technology-oriented, after structural changes in the market, companies tended to switch to more customer-oriented, organizational and more rapidly executed innovative activities. That means that energy companies have put the weight of innovative activities on the customer end of the value chain dealing with intelligent networks, smart grids etc. (Jamasb and Pollitt 2008). Therefore, through the process of liberalization in a network-bound system customers are re-involved with the service through the changing strategic actions of power utilities (e.g Vliet 2012). Consequently, re-shuffling of the energy market and creating institutional discontinuity affects both basic and applied activities of energy firms – the first seems to decrease and the second to increase (Calderini and Garrone 2002). Thus, innovation has moved in the energy sector more towards how electricity is consumed rather than how it is produced.

Consequently, in the context of the adoption of renewable energy sources there are considerable "system failures" that are outlined also in connection to market structures, infrastructure and institutions (Negro et al. 2012). While Johnston et al. (2010) show that public policy and especially the environmental restrictions and the passage of the Kyoto Protocol spurred on patent applications in the field of renewable energy, large-scale criteria, the dominance of incumbents and incremental/near-to-market innovations still play a role. High sunk costs become large barriers to market reconfigurations (Paulun 2008; Grubler 2012), and if surpassed too fast, technological up-scaling can lead to inferior technology choices (Kamp 2008; Verbong and Geels 2007). Hence, uncertainties created through market restructuring may affect investment in general, investment in R&D in particular and thus also the technological direction in energy sectors (Sanyal and Cohen 2009; Sirin and Erdogan 2013). Consequently, spurring competition through the liberalization of energy markets might increase the possibility of technological breakthroughs and their diffusion (Szabó and Jäger-Waldau 2008), but without substantial initial public stimulus and stability of investment it is difficult for RE companies to break through (Jacobsson and Bergek 2004; Nemet 2010; Jamasb and Pollitt 2008). Furthermore, the smaller the energy suppliers are in the electricity market (as is the case for the UK and the US) the more difficult is the task to support collaborative R&D projects (Sterlacchini 2012). Consequently, a U-shaped relationship between innovation and completion has been previously discussed (Aghion et al. 2005). However, there is no direct and uniform connection between the two: Tishler and Milstein (2009) argue that it depends on the sector/technology, strategic choices of firms and differences in existing competition. In the infrastructure-bound system of electricity generation this seems to become even more important.

Thus, more competition to the energy sector may create market failures in the electricity system or uncover them, but based on current evaluations it is difficult to

see the full extent of the former. As mentioned above the market structures and technological mixes become important factors in the ongoing R&D and innovation dynamics. Thus, market structure may strongly influence technology penetration (Moore et al. 2007). Tsoutsos and Stamboulis (2005), furthermore, argue that different players in the market should be made to participate in R&D activity or at least contribute to it, because knowledge creation needs to be sustained throughout the evolution of the system. For this reason, even the initial degree of decentralization (with existing linkages, networks and possibilities for technology spill-overs; Dantas et al. 2007) in energy markets prior to the introduction of market measures can become very important: previous experience in integrating decentralized sources of energy to the network helps collaboration (Lehtonen and Nye 2009). Consequently, Jamasb et al. (2005) argue that the initial sector structure predetermines the reform trajectory and following key decisions. Furthermore, the distance from the technological frontier becomes a factor in how companies deal with increased competition (Aghion et al. 2002; Carlin et al. 2004). This, however, is more postulated in single-case-study approaches, rather than empirically analyzed. As argued above, prior analyses have been more static and have not accounted for the dynamic and developing nature of markets. This is the topic where the current article tries to make a contribution: we will compare the market structures and market incumbents' strategies over time in Belgium and the Netherlands in the following sections to explore the significance of market structures on innovation and R&D through the process of electricity-market liberalization.

3. Market liberalization and innovation: the case of Belgium and the Netherlands

The paper adopts a comparative research design juxtaposing the energy sectors in Belgium and the Netherlands throughout the process of market liberalization. While the countries are different in their policy-implementation structures (federalism, centralism) and policy measures to promote R&D in the energy sector (see, e.g., Table 2 in the Appendix), the countries were chosen due to their relatively similar timing of reforms, similar size and dependence on (albeit different) non-renewable energy sources. Both countries belong to the same regional wholesale market, and they have relatively strong, single-sector national regulatory agencies (at the time of the analysis; the Netherlands has integrated national regulators into a multi-sector regulator since 2013) (Glachant 2014). While it is impossible to minimize all challenges that comparative research designs present – causality issues, identification of net effects and confounding factors – triangulating evidence gives us the possibility to study the effects of market structures and the liberalization of electricity markets on innovation in the sector and propose new research avenues. However, we have to note that the relative overall time span of 20 years of market liberalization is too short for an in-depth analysis of the success or failure of radical innovations and their connection to market reforms.

In the following sections we will outline the structures of the energy sectors in Belgium and the Netherlands, analyze the reform trajectories towards market liberalization and the effects the former had and look at the change in R&D investments during this period. To get a better picture of the actions of the electricity-production companies in Belgium and the Netherlands and illustrate the effect of market struc-

tures on innovative activities, we will look at the changing strategic positions of significant incumbents in the markets (> 1% market share). This is based on the qualitative analysis of the authors based on annual company reports (from 2001 to 2011) from the database Amadeus. Not to be influenced by the diverging availability levels of recent data, we cap the year of analysis with 2011. Following that we will proceed with two chapters to describe the context of electricity-market reforms in Belgium and the Netherlands and the policies applied to make the energy sectors "greener" before proceeding to the discussion of changes in R&D and innovation levels within the two markets throughout the process of liberalization.

3.1 Electricity market reforms in Belgium and the Netherlands

The starting points of the electricity-market reforms in Belgium and the Netherlands have been arguably different in terms of sources of energy for electricity production. While the increase in electricity-production capacity and the total production levels of electricity in these two countries have been historically quite comparable (despite the Netherlands having an understandable size advantage; see Figure 1 below), the composition of the electricity production structures have been relatively different (see Figures 2 and 3 below). Since the mid-1970s the dependence on oil and coal for electricity production has diminished in Belgium due to the introduction of nuclear energy. Currently (according to the data from 2010 from the World Bank), the biggest energy resources for electricity production are nuclear energy (50%), natural gas (32%), coal (8%) and renewable energy (6%). In the Netherlands, the electricity production since the late 1960s has been dependent on natural gas. At the moment, natural gas constitutes 62% of the total electricity production, followed by coal (22%), renewable resources (10%), nuclear energy (4%) and oil (1%). Further differences in the market structures and the potential impact on R&D and innovation within the sectors are discussed below.

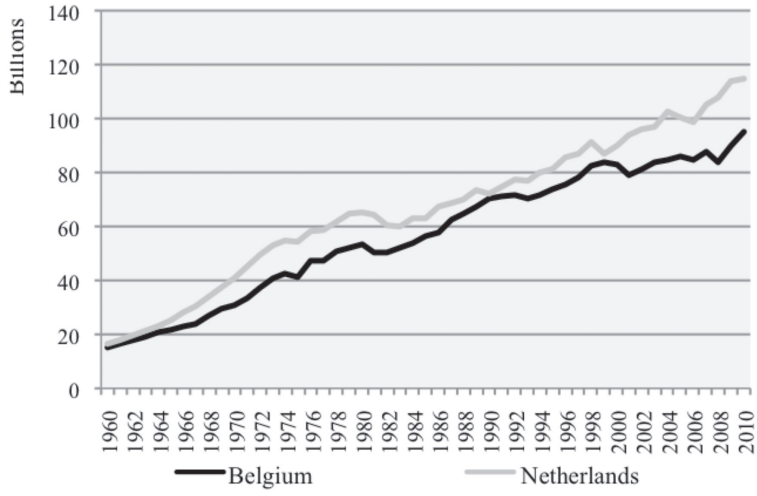


Figure 1. **Electricity production (kWh) in Belgium and in the Netherlands**
Source: Authors. World Bank Development Indicators.

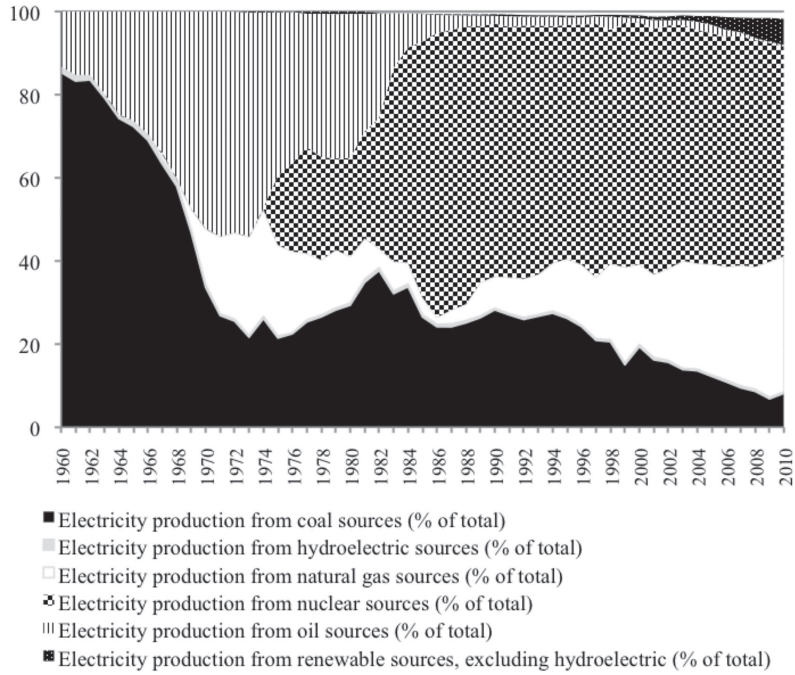


Figure 2. **Electricity production structure in Belgium by source of energy 1960-2010**

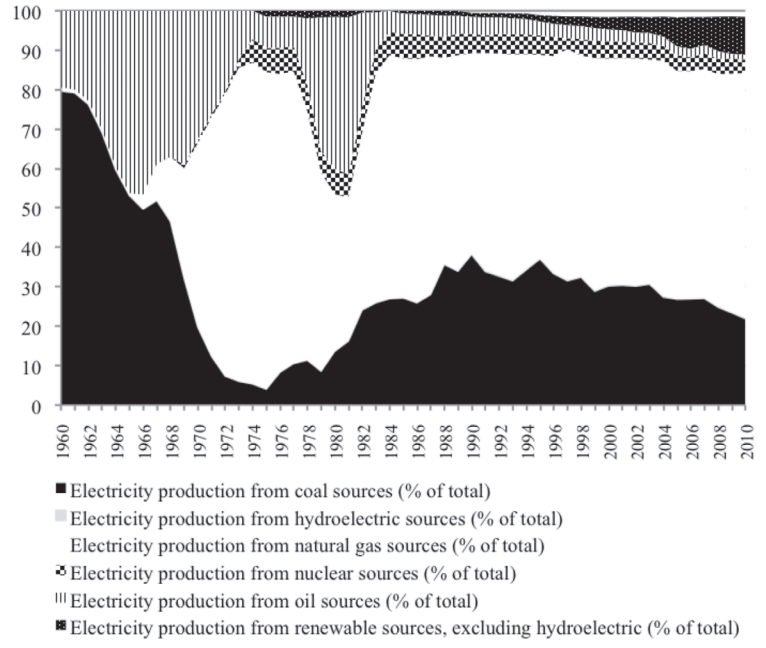


Figure 3. **Electricity production structure in the Netherlands by source of energy 1960-2010**
Source: Authors. World Bank Development Indicators.

3.1.1Market structure and reforms in Belgium

The previously mentioned EU directive (96/92/EC) was the first impulse to start the liberalization of the Belgian energy market (Deconinck and Gillard 2004), and the Electricity Act was introduced in 1999. Before the process of the liberalization, the Belgian market structure was highly concentrated, especially in the production or generation segment and the transmission segment (De Jong 2006). At the end of the 1970s, only three large private companies remained: Ebes, Unerg and Intercom. These private generators merged into Electrabel in 1990 and gained a market share of 91%. The other market shares belong to CPE, a fusion of small public generators, and some diminutive autonomous producers (Verbruggen and Verstappen 1999). In 1995, Electrabel and CPE formed the Coordination of Production and Transport of Electricity (CPTE),[7] which served as a participative company for the coordination and the management of their activities in the generation and transmission segment (Verhoest and Sys 2006). Since then, CPTE has dominated the transmission segment of the market (Huveneers 2005). The distribution and supply segments were in the hands of the municipalities. The first segment was controlled by both municipal and inter-municipal companies. Some inter-municipal companies joined forces with private partners in order to have a better organization of their activities. By the end of 1995, Electrabel was the private partner of 33 "mixed inter-municipal companies" and served 87% of the municipalities (IEA 1997). Therefore, it is easy to conclude that Electrabel dominated the whole Belgian energy market (see Table 1 below).

Table 1. **The Belgian and Dutch energy market: before and after the process of liberalization**

	Before the process of liberalization		After the process of liberalization	
	Belgium	**Netherlands**	**Belgium**	**Netherlands**
Supply/sales	*Concentrated*: Domination by Electrabel (91% market share) and nuclear energy – publicly owned (encompassing generation, transmission, distribution and supply) SPE (6.5% market share; public) – company in public hands (generation, transmission and supply)	*Less concentrated*, but controlled by large-scale producers: Electrabel (33% generation capacity in 1999; of which 85% was gas-fired), Reliant, Essent, E.ON; EPZ	*Concentrated*: Generation and supply: market control of Electrabel + SPE (98% in 2006) Electrabel private for profit company – bought by Suez (France) RWE and EDF emerge	Acquisitions, *concentration* in the market: RWE, E-On etc. sold to MNCs; Essent buys up CHP companies and concentrates production
Distribution	*Centralized*: CPTE created by Electrabel and SPE (public-private elements)	*Centralized control*: SEP – transmission company owned by main producing companies	*Centralized, public control increased.* CPTE►Elia (transmission systems operator public (30%), Electrabel (ca 27%) and SPE (6%); rest stock market.	*Centralized, public control.* SEP►Tennet Nationalized and in public ownership
Transmission	Public and partially private: municipal and inter-municipal companies + Electrabel (obligation to buy electricity from company)	Distribution-grids-regulated local monopolies (Nuon, Eneco Energie and Essent biggest owners)	Same + Elia, BIAC Public and partially private (Electrabel ca 30% in 2006 mixed-municipal companies)	Some consolidation and emergence of new distribution companies (incl. Enexis)
Generation	Electrabel + SPE (38%), municipal (1%) and pure (12%) and mixed inter-municipal companies (with Electrabel 49%)	Large number of municipal and local energy sellers and suppliers; however, dependence on main electricity suppliers (Nuon, Essent, Electrabel, Eneco Energy)	Increase in the number of smaller companies in the Belgian market: including E.ON Belgium, Luminus, RWE, Essent Belgium, Wase Wind etc. (however, entrance to the market through purchase of regional utilities)	Rapid acquisition processes, number of suppliers decreases (when looking at subsidiaries) (e.g. under Essent)

Source: Authors based on the overviews by Verhoest and Sys (2006) for Belgium and De Jong (2006) for the Netherlands.

[7] Electrabel holds 91.5% of the shares, the remaining 8.5% of the shares are property of CPE.

The Electricity Act of 1999 served as the translation of the EU directive 96/92 at a federal level. This law would have initiated the opening of the market by legally unbundling the distribution and transmission segments from the generation and supply segments. This unbundling was realized by creating a legal monopoly for the former segments (Gusbin and Kegels 2003). CPTE accommodated their high-voltage transmission infrastructure in their subsidiary Elia, which was established in 2001. This operator was chosen in 2002 by the Belgian government as the national Transmission System Operator and gained a market share of 94% in the transmission segment. The municipal and inter-municipal companies were also obligated to exit the supply segment to fulfil the regulations of the Electricity Act (Huveneers 2005). Several measures were taken by the government to breach the monopoly of Electrabel in the supply segment, and the process was speeded up by the Royal Decree of 11 October 2000. This decree stated that all large industrial consumers are free to choose their suppliers. The full market opening for all other consumers had to take place from July 2004 onwards. Furthermore, the dissociation of CPTE and the auctioning of parts of the generation capacity of Electrabel have intensified competition (De Meulemeester et al. 2006).

It took several years after the Energy Act of 1999 to see some limited changes in the Belgian market structure (see Table 1 for the situation in 2006). Only two new players, RWE and EDF, entered the generation market, but they made no impact on the dominant position of Electrabel. The transmission segment stayed under the control of one company. The distribution segment stayed more or less as before the liberalization process. Municipalities retained their legal monopoly, and only two new players entered: Elia and BIAC. The biggest changes took place in the supply segment, where over 40 new companies entered the market. This seems very impressive, but the impact was rather limited with their combined market share of 14.2% (Verhoest and Sys 2006). The legal unbundling separated the distribution and supply activities, and municipalities had to leave the supply segment. The new law created a monopoly again for Electrabel with an 85.8% market share.

On the whole, the Belgian liberalization process was characterized by two different stages and the speed of the market opening. The energy-market opening was officially completed by July 2003. The energy market of the Walloon and Brussels region opened at a slower pace. According to the directive of the European Commision (2003/54/EC), these markets opened completely for industrial customers in July 2004 and for household customers on 1 July 2007. Thus, in Belgium a defensive strategy was at work: by delaying the market opening in different regions, Electrabel pursued an ambitious internationalization programme between 1999 and 2006 (Clifton et al. 2010, 1001). The fears of the government were proven correct, but the delayed strategy failed, and the company was bought by Suez and later merged with Gaz de France to form one of Europe's largest multi utilities (for an overview on the evolution of the French electricity policy in this regard see Bauby and Varone 2007). It is a general conclusion that the liberalization of the Belgian energy market was not successful either in promoting cost-efficiency or in diminishing the almost oligarchic control of one energy company (or the legislators' preference for the latter) in the market.

3.1.2 Market structure and reforms in the Netherlands

The opening of the Netherlands energy market took place also after 1996, when the direction of the EU policies changed and the Energy White Paper was introduced for the liberalization of Dutch energy markets. However, the electricity-market structure in the Netherlands is at its core different from the market structure in Belgium. Where the former was very concentrated, the Dutch electricity market had decentralized suppliers and less state regulation (Larsen et al. 2006, 2865). Thus, during the 1990s, the Dutch energy sector faced a different set of problems (for an overview see De Jong 2006). First, there were numerous players in the energy market. In reaction, the Dutch government decided to limit the number of suppliers to 50 within ten years in 1996 and integrate electricity with gas distribution to achieve more economies of scale (ibid.). Secondly, another set of problems (perceived by the policy maker) was the failure of the Electricity Act of 1989, which was mainly concerned with pricing and planning of electricity. It was responsible for the creation of a network of four power generators controlled by one institution SEP (now Tennet – see also the overview in Table 1 above). It was owned by the producing companies and was in charge of the capacity decisions in the Dutch electricity market. In 1999, 69% of the electricity-production capacity was in the hands of the large-scale producers of electricity: Electrabel had 4.7GW (33%) with 85% gas-fired, Reliant 3.7GW (26%) with 80% gas-fired, Essent 3.3GW (23%) with 60% gas-fired, E.ON 1.7 GW (12%) with 65% coal-fired, and EPZ had 0.85GW (6%), this includes a nuclear station of 450MW and the rest was in the hands of the industry (combined heat and power (CHP) units) (da Silva and Soares 2008, 342). The lack of completion created by the structure was a major concern for consumers and suppliers of electricity (ibid.). Thus, prior to market reforms, energy distributers in the Netherlands were looking for a way to become less dependent on the main electricity suppliers (Eising 2002).

The reform of the energy sector was greatly influenced by the Electricity Act of 1998, which gave the consumers the right to choose their own energy company (a large part of the consumers of electricity would be able to choose suppliers by 2002, other commercial users would get this possibility by 2004 and households in 2008). The rights were, at first, reserved for green-energy providers only, but the possibility was quickly expanded (Vliet 2012, 271). The unbundling of the electricity sector followed the EU electricity directive (2003/54/EC), and the separation of the transmission and distribution of electricity from production, trade, metering and sales started. The main goal of the reform was to diminish market power and to remove market entry barriers for new electricity producers that would bring new technologies and energy sources to the electricity sector. However, electricity companies Delta, Eneco, Essent, Nuon and Rendo were quickly bought up in the market. What now is Tennet was nationalized and made into a system operator and manager for the establishment of the national grid (Van Damme 2005). Next to that, network oversight was established, which is carried out by a regulatory authority DTe (Association of Electricity Producing Companies). Since the 2000s, intermediary companies have come to the market selling energy in “green”, “grey” or “cheap” packages from various national and international energy producers (Vliet 2012). In 2007, the state required energy companies to separate the distribution and

production of energy into separate companies by 2011. This has led to shares of regional energy companies being sold to multinational enterprises (RWE, E-ON) and to the creation of new distribution network companies (e.g. Enexis; this already started in 2005-2006; De Jong 2006). Consequently, unbundling in the Netherlands created a situation where transmission networks remained in public ownership, but all other commercial activities privatized and concentrated (Künneke and Fens 2007). Table 1 above describes the processes succinctly: showing the concentration in both electricity generation and sales, however, as the starting point was much more decentralized compared to Belgium, the consolidation process was less centred on single companies.

3.2 R&D and innovative activity after market liberalization

How does the above-described market-reform and market-structure analysis tie in with R&D and innovation in the electricity sector? As shown in the theoretical framework liberalization can produce adverse effects for R&D expenditures and innovation in the energy sector. While it is deemed important how the reforms are implemented in the context of different market structures, there are few studies that concentrate on the former. This is so because, in general, R&D investment data for the electricity sector is very scarce. Only the country-level data submitted to the International Energy Agency (IEA) is available and thus can be comparatively analyzed. Data on corporate R&D expenditure, especially for the technology field, is very difficult to obtain – in this article available annual company reports (2001-2011) were analyzed to evaluate the commitment of electricity producers to RE technologies and R&D before and after the market liberalization in the Dutch and Belgian markets. Additionally, as indicative proxy for research activity, data from the Research Framework Programmes (CORDIS database and SET projects; ending 2011) was analyzed to identify R&D partners and especially direction of research of incumbent firms.

Our analysis shows that the variations in the starting conditions prior to the reforms have led to slightly dissimilar outcomes in Belgium and the Netherlands. The differences can be found both in terms of the technology base used in the dominant electricity-producing industries and also in terms of incumbents' power in the electricity market. The production and supply of energy was far more concentrated in Belgium with one dominating firm, while in the Netherlands, the market power was shared among several companies, and the local supply system was decentralized. This means that also in the Netherlands, the technology base was wider, and there were smaller companies in different RE technology fields and more interconnected networks. Thus, R&D was more diversified compared to Belgium. In Belgium nuclear energy dominates when it comes to R&D. Between 1989 and 2007 only R&D in solar energy and bio-fuels showed a slight increase in R&D-spending in Belgium, while in all other RE technology fields, R&D has remained relatively the same with no noticeable difference since 1970 (see Figure 4 below). Thus, despite the slight increase in R&D-spending in solar energy – demand of which was highly subsidized in the last decade – the energy-liberalization reforms in Belgium have not produced a significant diversification of R&D in the direction of RE technologies.

The prior momentum from the nuclear-energy orientation is still in place and is mostly funded by public sources. Nevertheless, there are R&D projects connected to RE technologies and diffusions in Belgium: for example, the construction of wind farms in the Belgian part of the North Sea (De Mulder 2008). However, funding for R&D in wind energy is so miniscule in Belgium that usually in international comparisons it cannot be displayed on graphs of the same scale graphs as other better performing EU countries (incl. the UK, Germany, the Netherlands, Denmark etc., but also the Czech Republic, Portugal, Hungary; see Technology Map 2009).

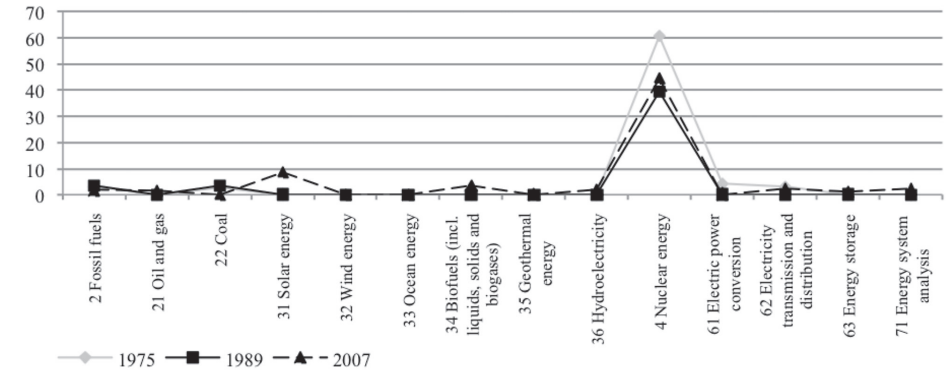


Figure 4. **Total RD&D in Million NC (nominal) in Belgium**[8]
Source: Authors based on IEA data (2012 edition)

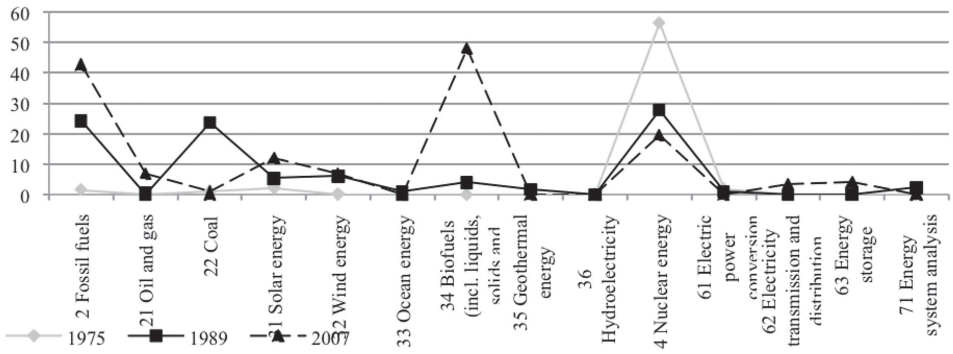


Figure 5. **Total RD&D in Million NC (nominal) in the Netherlands**
Source: Authors based on IEA data (2012 edition)

Consequently, in Belgium, only low-technology-based RE technologies have diffused. The biomass and biogas technologies in addition to PV solutions are not produced in the country itself. Here we cannot assign all of the changes in technology to market-liberalization processes alone, although the former was the single process

[8] For Belgium, data for the years 2000-2006 and 2008-2010 is missing.

which affected the incumbent companies the most. An overview of the policies and processes outside of the market liberalization is presented in Table 2 in the Appendix. However, in the 20-year-old solar thermal industry in Belgium, not many companies have survived the liberalization – at the moment only 4 to 5 companies have survived the competition with the largest supplier of equipment, HVAC (Verbunt 2011).

In the Netherlands R&D spending has shown some indication of diversification: from 2005 onwards, non-governmental R&D spending has increased from a basically non-existent position (see Table 3 in the appendix). However, private spending has been highly irregular, and the most noticeable increase has been in the field of bio-fuels. Governmental spending in the field has risen considerably since 1996. Resources for wind energy are higher now, but during the last decade, they have been wavering in the Netherlands (remaining on a level comparable to the period 29 years ago; see Figure 5 above). During recent years, the non-governmental part in the R&D expenses has increased (see Table 3 in the appendix). In the last decade, the total R&D resources allocated to the research of solar energy have improved. Fossil fuels have slightly improved (see Figure 2 above). However, as many projects started prior to market liberalization, it is hard to make a causal link between the two. Having transmission rights under public control may have led to smaller decentralized companies having access to a larger market base.

As such, there has not been a large shift in the direction of R&D spending in either Belgium or the Netherlands after the opening of the market and the unbundling of production, transmission and supply services. However, as there has been an increase in the proportion of electricity production from renewable energy sources in both Belgium and the Netherlands, the companies' commitment to using RE technologies for the production of electricity after liberalization processes is worth considering. The authors of this paper examined annual company reports and websites for companies having more than 1% market share in Belgium and the Netherlands for electricity production for this purpose. The subsequent list of the 6 energy producers in Belgium and the 5 energy producers in the Netherlands is presented in Table 4 in the appendix. While electricity-producing companies actively use the existence of RE sources in their production portfolios in marketing, the commitment towards RE sources and R&D, however, was not apparent in their annual reports. In line with the R&D spending overview presented above, use of RE technologies and investment in R&D are rarely presented in these company reports, meaning that for the largest incumbents in the Dutch and Belgian market at the moment, sustainable energy production is not a considerable factor for prospective investors (for it to be included in the reports) or a large-scale commitment for the firms themselves.

Nevertheless, there were some notable aberrations. First, Essent in the Netherlands, the largest energy producer in the Dutch market after Electrabel Netherlands, E.ON, Essent NV and Nuon NV, reported to have produced 17.9% of the energy generated from sustainable sources (accounting for 23% of the total RE produced in the Netherlands). In 2010, Essent was acquired by the leading electricity and gas company, RWE Group (German), which has tried to expand its portfolio towards RE sources in recent years. The main RE fields in Netherlands are biomass and wind energy. However, Essent did not become the biggest player in the Dutch cogeneration market (biomass) through building up capacities from the ground up,

but through a merger between two CHP production companies and several distribution companies (Hekkert et al. 2007, 4685). Furthermore, E.ON, EPZ, Electrabel and Vattenfall-NUON own co-firing biomass capacities (see also report on bio-energy by Schwarz et al. 2011). As such, the second exception, based on company reports, is Nuon Belgium N.V. It is a fully renewable energy producer (large electricity-production capacity from a wind farm in the Antwerp dockland area) with a market share of 5.1% in 2011. Nevertheless, this company (as well as the previously mentioned Essent) has been subjected to larger multinationals expanding their production portfolios: from 2011 onwards the company operates as the subsidiary of Eni S.p.A., an Italy-based energy firm engaged in exploration, production, marketing, distribution and sale of oil and natural gas (see Deloitte 2011). Thus, multinational companies have bought market shares in RE production in Belgium and the Netherlands rather than entering the market as new entrants. Looking at the incumbents, this means that in both countries, through the process of liberalization and opening-up of markets a small group of large multi-nationals has emerged. Their activities cover North-Western Europe, which makes their R&D activities hard to distinguish and dependent on the groups' interest. For the largest incumbent in the Belgian energy market, it was noted in the annual reports since 2004 that the Belgian subsidiary of Electrabel (acquired shortly after the market liberalization by the French GDF Suez) has no considerable R&D commitments in RE technologies or else. In line with the conclusions from Markard and Truffer (2006) discussed in chapter 2, a direction towards customer-oriented innovations was chosen in Electrabel in 2006, after the opening of the market. This is also true for Luminus, which has participated in two projects of intelligent networks since 2009 with KU Leuven (Electa, CUO) and others (SET projects data; CORDIS 2012). Established companies in the Netherlands, as well, are further along with the "smart metering" than other R&D projects (Technology Map 2011).

This does not mean that energy technologies are not developed outside of the electricity-production sector. As mentioned before, most of the R&D in the energy sector is carried out outside of the companies producing energy. For this, the authors mapped the SETIS projects in the EU: for example, in Belgium there is a world-class wind-turbine producer, Hansen Transmissions International, that makes equipment for a German manufacturer, ZF Friedrichshafen AG, and 4Energy Invest NV, which invests in biomass-related projects (however, neither is a major electricity producer, the former has a capacity of 503MW and the latter has 18MW; Deloitte 2011).[9] In the Netherlands, there is a large R&D project in wind energy, INNWIND (the counterpart of the famous UpWind research). It has a technology-oriented electricity producer with the involvement of ECN (SET projects data; CORDIS 2012). But again, the established companies in the market (see Table 3 in the appendix) were rarely represented in these joint R&D projects (SETIS), apart from the above-mentioned "smart" solutions for energy networks and also in projects not directly connected to RE technologies, but prior to production capabilities. For example, E.ON

[9] Estimated installed generation capacity in Belgium is around 19,627MW (in mid-2011) (GREG 2011), of which according to VREG data CHP constitutes 1491MW, hydropower 1MW, solar energy (PV) 977 MW, onshore wind 264MW and other (including biogas and -mass) 623MW.

Benelux Netherlands/Belgium and Electrabel Netherlands are involved with several projects connected to CO_2 capture and storage, and Nuon is involved with low-emission gas-turbine technology (SET projects data; CORDIS 2012). Thus, in line with the theoretical considerations, in the exemplifying cases we did not see considerable changes in commitments of electricity producers themselves. What happened is that the incumbents started to support low-technology-based RE-technology solutions and customer-oriented innovation. This is especially true for the Netherlands (Raven 2006; Negro et al. 2008), because the market was already considered to be highly mature (with high levels of decentralization to begin with), and since 1998 larger capacity developments were made by mostly national and foreign energy companies who built CHP plants for their own supply and had large surplus of electricity to sell on the market (Finon 2008, 155).

4. Discussion and conclusions

The focus of this paper has been on the market structure of energy markets and its influence on innovative activities in the process of liberalization. In addition to the theoretical overview, we used two cases – Belgium and the Netherlands – to exemplify the arguments made. From the review of previous research and the exemplifying cases we can conclude that market-based measures are not enough for transformative innovations in the energy sector to emerge. In both countries, the market opening has led to restructuring, and a small group of large multi-nationals has emerged whose activities span across North-Western Europe, which makes their R&D activities hard to be distinguished and dependent on the groups' interest. As there is demand for green energy from the government side, larger multinational companies have chosen to acquire market shares within these countries from the existing incumbents and their RE projects (e.g. Essent and RWE in the Netherlands) rather than to establish themselves as "new" entrants in the market. For the incumbents, RE or other larger technology commitments are hard to find, while customer-oriented innovations have soared. This is not wholly problematic because most R&D and innovations in the electricity sector are conducted outside of the production companies themselves, although large sunk costs of existing infrastructure can become a large market-entry barrier. However, it is very difficult to ascertain causality between policies and outcomes – liberalization and R&D increase/decrease – because the policy mixes are widely different and complex and furthermore, there are very varied market mechanisms in use (see also Jaffe et al. 2002; 2004). This makes not only the analysis complicated, but also the policy context; hence, it is not surprising that in the overall goals R&D and innovation diffusion policies in the energy sector have failed.

When R&D-related rhetoric is brought into the market-liberalization reforms it seems to, furthermore, simplify the debate. It is not always clear if the governments understand that deregulation and liberalization reforms alone do not have the desired effect on R&D in the energy sector. At the same time, prior research has shown that regulators are largely ineffective in influencing the performance and investments of market incumbents throughout liberalization reforms (e.g. Ugur 2009). As such, there are barriers created by policy and regulatory frameworks that stand in the way

of regime shifts: unclear messages about the need for new technologies and their role in the energy system result in uncertainty about the future of market development and regulatory barriers to the deployment of new technologies. There is also risk aversion at play from the side of the public sector: governments do not risk change in the face of the political cost of vested interests (Tsoutsos and Stamboulis 2005). At the same time, it is highly unlikely that a process away from the market-based mechanisms (back towards more hierarchical measures) will be taken in the EU in the near future to regulate the sector. This means that the policy options regarding the increase of R&D and innovation in the electricity sector (especially towards renewable and clean energy sources and away from the use of fossil fuels) should first take into account the market dynamics which by now characterize the sector (for a similar argument see Jamasb and Pollitt 2008) and also the need of investment outside of the production firms hinting at the increased importance of network-based solutions between R&D organizations and the industry.

The main policy challenge here is the slow diffusion of RE technologies within the sector. The construction of the electricity sector plays an important role for the introduction of RE technologies, and the effect of the market structure should be addressed in liberalized market conditions. Hence, different policy approaches should be constructed depending on how fragmented or concentrated the market is (see the differences for Belgium and the Netherlands) and based on ownership structures (foremost, public or private, but also multinational ownership). Nevertheless, increase in funding alone will not guarantee innovation in electricity production, nor will automatic incentives such as tax breaks. It may require more specific measures depending on the technology field and the number of competitors present in the market. Consequently, the actual technology push in the liberalized energy market needs to be reconsidered, as relying primary on market demand may not be the most beneficial direction towards the diffusion of RE technology. Thus, not only are public subsidies to RE development needed, but there is also a need to deal with the diffusion of clean technologies among private market participants.

The main contribution of the paper is to highlight the importance of factors in large-scale reform processes and their indirect effects. The latter seem to disappear in the overall rhetoric of high-level policy making. This is dire in the context of the need to have high levels of private-sector involvement to employ renewables, CO_2 capture and storage and other green technologies on a massive scale in the upcoming years due to the climate challenge. Compared to the scale of the issue, the cases of Belgium and the Netherlands presented in the article were, at most, illustrative, but hopefully they will exemplify the need to analyze market structures, incumbents and network partners in the energy sector in more detail when also planning market-based measures.

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Appendix.

Table 2. **Greening of energy in Belgium and the Netherlands – overview of parallel activities to liberalization**

Belgium	The Netherlands
In 1997 Belgium was at the bottom of the EU15 with the production of only 1.1% RES-E (Renewable Electricity Standard for Europe) of gross electricity consumption. Together with the Energy Act of 1999, the government has since been promoting the use of renewable energy sources and energy efficiency. For the promotion of "green" energy, mainly market mechanisms have been used, while the public spending in the R&D field of 3rd nuclear-energy reactors still dominate over all other research fields (including outside of the energy sector). The facility is scheduled to be completed in 2014, and the total construction cost over the period 2010-2013 is budgeted at approximately €960 million (see SETIS 2012). For the ESNII-2 MYRRHA project 40% come from the national funding (15% from other European countries, 5% from non-EU countries and 30-35% from EU grants and incentives and 5-20% (open) from an EIB loan (Baetan 2011). This also means that the nuclear research reactor (MYRRHA nuclear fission research infrastructure) in Belgium is considered part of the new EU research infrastructure for wind, solar and nuclear energy within SETIS.	In the Dutch electricity sector natural gas still plays a substantial role. The country has large domestic natural gas reserves that contribute to the countries' energy security. Thus, the promotion of the adoption of RE technologies could have been hindered from the start; however, the feed-in tariffs were introduced to the electricity sector already with the 1989 Electricity Act. Nevertheless, the high generation costs of RE and the tariffs on their own made it hard to have a market for the technologies, although wind-energy technologies received the largest share of R&D contribution for RE from the government at the beginning of the 1990s (Agnolucci 2007, 870). The adoption of RE goals into the Dutch policy framework can be dated back to the White paper of 1996, which introduced the goal of a 10% share of renewable energy of the energy production of the Netherlands and the promotion of increase in energy efficiency (see De Jong 2006; Junginger et al. 2008). Green electricity was specifically defined in regulations as energy from biomass, hydro-electric solar-cells and windmills (Reijnders 2002; Agnolucci 2007) – the latter was already mentioned in the 1989 Electricity Act.
This in an unusual situation where a conditional agreement has been made by the government to close three nuclear reactors by 2015 and phase out nuclear energy altogether (Deloitte 2011). Here, it is good to note that in Belgium, nuclear-related R&D (fusion and fission) is under federal responsibility, namely through the DG Energy by the FPS Economy, while administration of non-nuclear-related R&D activities is the main responsibility of the regional governments and coordinated through regional authorities (Technology map 2009). This means that all other "greening" measures (also the electricity certificates discussed shortly) are under the control of three different regions (Walloon region, Flanders and Brussels), all of which have slightly different targets and implement their own regional market measures.	Indirect measures, such as the regulatory energy tax (eco-tax) (Van Rooijen and Van Wees 2006; Junginger et al. 2008), were used to subsidize green energy use in the Netherlands (Agnolucci 2007). Within a few years, the number of green-energy users increased substantially (by the end of 2002, it amounted to 1.4 million), and the demand for green energy outnumbered the national supply, mea¬ning that it had to be imported from other countries (Van Sambeek and Van Thuijl 2003; De Jong 2006). This resulted in a situation where Dutch tax money was used to buy green-energy certificates from neighbouring countries and the actual exchange of RE did not take place (Van Rooijen and Van Wees 2006). In 2003 the policy changed, however, from demand subsidy to supply promotion: while smaller tax breaks for consumers remained, producers of green energy in the Netherlands now had a guaranteed subsidy for 10 years (Van Damme and Zwart 2003). As the criteria within the eco-tax law were not well specified, it was modified in 2012 to include physical imports of green electricity from countries with a liberalized energy market to receive the tax break (Reijnders 2002).
The main tool to stimulate the "greening" of the electricity production in Belgium is a system of so-called tradable green-electricity certificates or TGC's, combined with penalty-enforced quotas on electricity-supply companies (VREG 2012ab). A second governmental tool is used to stimulate energy efficiency with a similar system of cogeneration certificates. The system of cogeneration certificates works with same type of penalty-enforced quotas (Deconinck and Gillard 2004). As such, in Flanders, since the mid-2000s, the number of green certificates has increased substantially, mostly from the technologies linked to the use of biomass and slightly from biogas (VREG 2012ab).	Throughout the mentioned measures offshore wind technology and biomass technology were clearly favoured (Dinica and Arentsen 2003; Jacbosson and Bergek 2004; Van Damme and Zwart 2003), while several other green industries were not able to survive in liberalized circumstances (an example of the latter is the Dutch CHP market; Hekkert et al. 2007).

At the same time, the number of certificates given out to wind energy has increased since 2005, but has remained relatively the same since. Also, after 2009, the number of certificates issued to solar energy has started to rise. This can be seen in parallel to the deployment of solar-energy subsidies, and the latter has decreased in recent years. Thus, stimulated by TGC's, green-energy diffusion has been led on the company level by larger industrial enterprises installing some green-energy- and electricity-producing measures to their production process. The Antwerp Port Authority and the Left Bank Corporation, for example, have decided to invest in up to 100 wind turbines to be constructed in 2013 (Deloitte 2011). With the latest market-based measures, the Flemish government guaranteed a fixed price for 10 years for tradable green certificate for wave/tidal energy (Technology map 2009).	Thus, the development of different RE fields – incl. the favoured wind energy – were fought with several system failures (see, e.g., Junginger et al. 2004; Negro et al. 2012) and also resistance from larger electricity companies (Bergek and Jacobsson 2003). Even though there were several market-stimulation instruments introduced, such as investment subsidies and taxation on electricity, the difficulty in obtaining buildings permits or public support slowed down the diffusion rate of the technology, and the new RE technologies did not diffuse quickly in practise (e.g. Kamp 2008; Negro et al. 2008).

Source: composed by authors.

Table 3. **Energy R&D spending in the Netherlands: government (G) and non-government (NG) resources compared (Million NC (nominal))**[10]

	1996		1997		1998		1999		2000		2001		2002		2003		2005		2006		2007		2008		2009		2010	
	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG
2 Fossil fuels	10.9	0	11.5	0	9.4	0	8.1	0	8.6	0	7.8	0	18.3	0	13.1	0	8.6	4.9	10.8	1.8	11.0	31.7	13.1	1.1	16.4	2.7	21.2	10
21 Oil and gas	7.9	0	8.9	0	7.6	0	7.4	0	8.4	0	7.7	0	15.9	0	10.9	0	3.5	0.2	5.7	1.1	6.4	0.4	7.1	0.7	5.9	0.6	2.7	0
22 Coal	3.0	0	2.5	0	1.8	0	0.7	0	0.1	0	0.1	0	2.3	0	2.2	0	1.7	0.3	2.5	0.3	0.3	0.5	0.5	0	0.0	0	0.0	0
31 Solar energy	13.7	0	19.0	0	20.8	0	17.4	0	11.9	0	15.9	0	17.5	0	15.0	0	12.3	0.8	10.4	0.6	11.3	0.7	14.2	0.6	25.6	2.3	26.3	3.2
32 Wind energy	4.9	0	7.1	0	6.3	0	8.4	0	7.8	0	12.4	0	11.8	0	10.0	0	4.4	0.4	4.2	0.9	5.5	1.2	4.7	1.6	9.4	0	21.4	9.8
33 Ocean energy	0.0	0	0.1	0	0.1	0	0.0	0	0.2	0	0.2	0	0.0	0	0.0	0	0.0	0	0.0	0	..	0	..	0	0.3	0	0.1	0.8
34 Biofuels (incl. liquids. solids and biogases)	5.9	0	6.6	0	9.3	0	12.1	0	10.6	0	12.4	0	11.6	0	23.5	0	9.7	12.3	14.5	16	20.1	27.8	22.0	3.9	18.5	4.1	49.5	16
35 Geother-mal energy	0.0	0	0.3	0	0.5	0	1.0	0	0.0	0	0.0	0	3.0	0	0.0	0	0.0	0	0.0	0	..	0	..	0	0.1	0	1.0	0
36 Hydro-electricity	0.0	0	0.0	0	0.0	0	0.1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	..	0	..	0	..	0	0.0	0
4 Nuclear energy	14.6	0	17.8	0	13.4	0	14.7	0	22.5	0	21.5	0	18.0	0	18.5	0	13.8	0.9	14.6	0.9	18.7	0.9	15.2	1.6	12.4	0	17.9	0
61 Electric power conversion	10.0	0	10.8	0	8.1	0	7.3	0	8.1	0	7.3	0	5.8	0	6.0	0	0.0	0	0.0	0	0.1	0	0.0	0	0.0	0.8	0.1	0
62 Electricity transmission and distribution	5.0	0	3.9	0	2.5	0	1.9	0	0.3	0	0.5	0	3.4	0	4.6	0	4.0	0.1	5.9	0.1	2.8	0.7	6.7	0.3	9.9	0	2.6	0
63 Energy storage	0.3	0	1.2	0	0.5	0	0.3	0	0.8	0	0.9	0	0.5	0	0.0	0	0.2	0	0.5	0	2.9	1.1	1.7	0.4	0.4	0.6	0.5	0
71 Energy system analysis	5.4	0	7.12	0	7.12	0	5.4	0	1.2	0	4.1	0	0.2	0	0.36	0	0.4	0	0.9	0	0.6	0	1	0.1	0.7	0	4.2	0

Source: Calculated by the authors based on IEA data (2012)

[10] Similar data from IEA for Belgium is not available as the country stopped giving data in 2000 to the organization on R&D (with the exception of 2007)

Table 4. **Overview of energy production companies in Belgium and the Netherlands (>1% market share)**

BELGIUM												
		2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Essent Belgium (RWE before 2006, private)	R&D exp.				0	0	0	0	0	0	0	0
	Firm size	NA	NA	NA	18,169,000	29,512,000	36,455,057	55,404,387	83,974,218	56,486,078	76,709,690	83,691,427
	Profits (EBIT)	NA	NA	NA	-8,123,000	-6,603,000	-22,058,746	-16,995,791	-3,965,761	-16,132,289	-2,796,459	-6,123,281
	Market share (%)	NA	NA	NA	2.9	1.7	<2	2.3	2.3	2.1	1.8	2.1
E.ON Belgium (private)	R&D exp.	NA	NA	NA	0	0	0	0	0	0	0	0
	Firm size	NA	NA	NA	5,156,000	6,609,000	14,089,058	75,944,471	128,985,161	170,437,578	67,525,346	104,927,712
	Profits	NA	NA	NA	459	366	468,274	766,396	-1,002,614	-9,704,435	-5,669,299	298,547
	Market share (%)[11]											
Nuon Belgium[12] (private)	Firm size	NA	NA	NA	92,996,000	115,291,000	118,182,897	167,948,604	213,727,220	257,872,995	240,053,796	214,426,785
	Profits	NA	NA	NA	25,024,000	243	-24,349,013	89,703	12,744,054	16,153,107	17,073,687	16,484,975
	Market share (%)	NA	NA	NA	2	2.8	3.2	3.2	3.3	3.7	4.6	5.1
EDF Luminus[13] (from 2006 private, before SPE=public)												
	Firm size	NA	NA	NA	1,001,347,000	1,104,593,000	1,315,478,642	1,290,439,792	1,272,110,152	1,635,805,616	1,791,772,006	1,810,287,764
	Profits	NA	NA	NA	26,645,000	-29,024,000	-1,294,446	34,902,283	69,712,921	118,412,713	174,898,650	226,103,589
	Market share (%)	NA	NA	NA	9	13.7	13.1	12.6	12.2	13.7	15.2	17.5

[11] Only available for N.ON Benelux – see further in the table.
[12] From 2011, Eni S.p.A., the listed Italy-based energy firm has agreed to acquire Nuon Belgium N.V. (Deloitte 2011).
[13] SPE NV before 2011; SPE+Luminus+ EDF Belgium before 2006.

Electrabel (private)	R&D						R&D for better performance			R&D through subsidiaries; goal: better performance and non-polluting technologies		
	Firm size	NA	NA	NA	18,874,757,000	19,597,061,000	20,241,074,976	37,448,710,475	41,975,019,160	45,454,904,414	47,650,593,578	46,244,721,771
	Profits	NA	NA	NA	727,887,000	784,075,000	725,456,567	855,316,663	772,702,741	1,141,551,654	1,009,512,497	1,122,780,762
	% RE of product.	NA	NA	NA						2.77		
	Changes in strategy	NA	NA	NA			Emphasis on customer service			Stronger emphasis on sustainable development		
	Market share (%)	NA	NA	NA	34.8	33.6	31.5	31.8	30.1	27	28.8	28.1
Electrabel Costumer Solutions (private)	R&D exp.											
	Firm size	NA	NA	NA	1,899,992,000	2,237,528,000	1,925,951,461	2,824,434,935	3,608,517,757	2,766,479,610	2,898,485,052	3,017,071,868
	Profits	NA	NA	NA	74,121,000	126,061,000	100,215,947	104,667,138	67,560,642	27,621,746	141,453,143	106,461,003
	Market share (%)	NA	NA	NA	31	32.3	33.3	42.9	42.5	43.6	40.4	38.3
NETHER-LANDS[14]												
Elsta (private)[15]	Firm size	NA	NA	NA	230,342,000	265,810,000	251,061,000	226,336,000	212,374,000	191,910,000	178,506,000	
	Profits	NA	NA	NA	36,454,000	34,059,000	32,850,000	35,018,000	32,337,000	31,641,000	28,392,000	

[14] Capacity shares instead of market shares are calculated due to lack of data using available electricity production capacity of the company (in MW). The total installed generating capacity of electricity in The Netherlands is used as a basis. Source: Energie in Nederland 2011.

[15] Owned by AES (50%), DELTA Nutsbedrijven (25%) en Essent (25%)

	New strategic direc.	NA	NA	NA	CHP							
	Capacity share (%)	NA	NA	NA	NA	NA	NA	NA	NA	NA	6.07%	6.07%
Essent (since 2010 part of RWE)												
	Firm size	8,680,000,000	8,975,000,000	8,525,100,000	8,580,300,000	6,507,500,000	6,558,600,000	8,204,000,000	7,829,600,000	12,377,000,000	10,605,400,000	
	Profits	414,000,000	311,000,000	389,000,000	417,000,000	526,000,000	761,000,000	935,000,000	1,069,000,000	4,400,300,000	763,100,000	
	% RE of product.											11%
	Cap. (%)	NA	NA	NA	23%	23%	23%	23%	23%	23%	23%	23%
EPZ [16] (public)												
	Firm size	518,936,000	480,670,000	510,855,000	468,007,000	491,510,000	521,417,000	495,618,000	490,129,000	565,913,000	556,443,000	595,963,000
	Profits	6,263,000	32,209,000	26,770,000	20,686,000	15,666,000	28,873,000	29,625,000	23,895,000	46,728,000	33,556,000	33,438,000
	Capacity (%)	NA	NA	NA	NA	NA	NA	NA	3.75%	3.75%	3.75%	3.75%
Intergen N.V. [17] (public)												
	Firm size	5,711,695,000	6,680,839,000	6,630,172,000	4,920,974,000	4,596,219,000	3,957,201,000	3,137,884,000	3,391,806,000	3,394,673,000	3,541,369,000	
	Profits	-49,440,000	-197,222,000	-18,762,000	-598,385,000	492,939,000	118,226,000	-47,557,000	149,512,000	98,205,000	137,913,000	
	Capacity share (%)	NA	NA	NA	3.2%	3.2%	3.2%	3.2%	3,2%	3.2%	3.2%	3.2%
Electrabel Inter. Holdings												
	Firm size	NA	NA	NA	1,277,983,000	1,343,501,000	NA	1,332,679,000	1,520,436,000	1,704,902,000		
	Profits	NA	NA	NA								
	Market share (%)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	19.7%
EON Benelux [18]												

[16] 2008 production: Nuclear energy 515MW, Coal and bio-energy 427MW, Wind energy 12MW. In 2012 in total 7 wind turbines 55.000 (MWh) green energy per year. DELTA Energy B.V. en Energy; Resources Holding B.V. have 70% and 30% of shares since October 2011.

[17] Owner of Rijnmond Energie.

[18] EON Benelux has annual reports available for the EON Group, information on Belgium and The Netherlands separately is not available.

	Firm size	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Profits	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Capacity share (%)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	7,3%
NUON (Nether-lands)												
	Firm size	NA	NA	10,553,000,000	10,225,000,000	11,183,000,000	10,875,000,000	11,601,000,000	9,478,000,000	7,816,000,000	8,685,000,000	6,848,000,000
	Profits	NA	NA	536,000,000	532,000,000	1,098,000,000	849,000,000	1,114,000,000	399,000,000	196,000,000	721,000,000	554,000,000
	Market share (%)	NA	NA	NA	NA	NA	14.6%	14.6%	14.6%	14.6%	14.6%	14.6%

Source: Comprised by authors based on annual company reports and database Amadeus.

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