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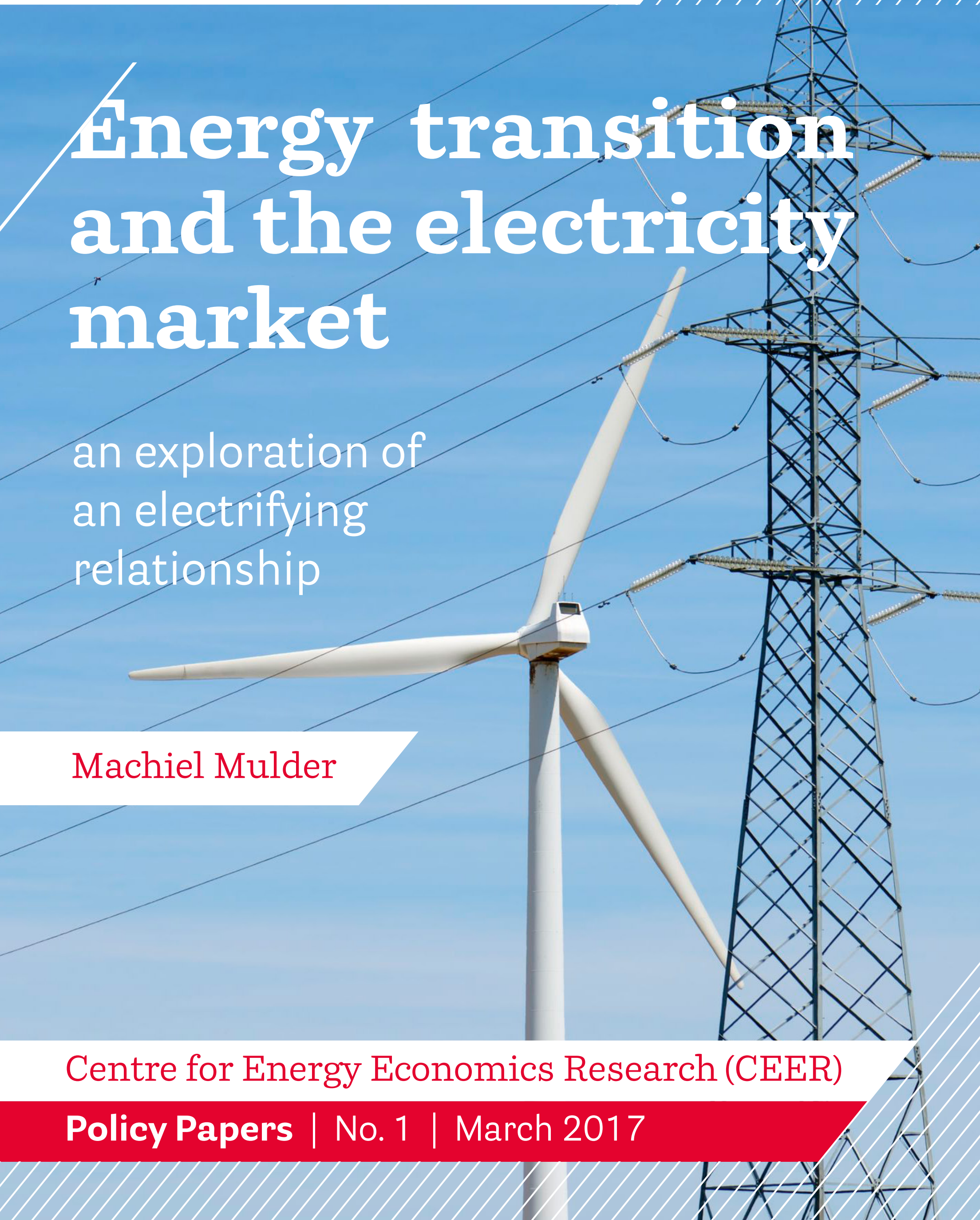

Energy transition and the electricity market

an exploration of an electrifying relationship

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Centre for Energy Economics Research (CEER)

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1. Introduction

The political ambition to significantly increase the role of renewable energy within the electricity market brings two policy fields together - competition policy and climate policy - which have a tense relationship.[1] The promotion of market forces in the electricity sector focuses on efficiency: producing electricity as cost-effectively as possible (productive efficiency), ensuring that consumers don't pay a higher price than is necessary (allocative efficiency) and promoting innovation (dynamic efficiency). The goal of climate policy is to reduce greenhouse gas emissions. The electricity sector aims to achieve this by promoting the use of technologies for power generation from renewable sources instead of technologies based on the use of fossil sources and, besides that, by attempting to consume - or waste - less energy per installation. Therefore, this specific climate policy is also called energy transition. Since energy transition focusses on encouraging businesses and consumers to make alternative choices, i.e., less energy and more renewable energy, it is in itself at odds with the basic principles of a free market in which all players decide for themselves what they use and how much. Furthermore, market participants are encouraged to install renewable technologies, the characteristics of which are different from those of the conventional technologies, such as increased dependency on weather and fewer possibilities to control production. It is often argued that because of these different characteristics energy transition should lead to an adjustment of the electricity market design (EC, 2015). The question is, though, to what extent the contemplated energy transition will negatively affect the way in which the

[1] Government energy aims usually comprise three components: affordability (efficiency), sustainability and reliability (EZ, 2016). These aims may be subject to various exchange relationships (Mulder, 2014). This publication mainly deals with the relationship between market forces and sustainability.

electricity market operates. If it has an impact, what measures will be required to safeguard the energy transition on the one hand and put into practice the objectives of a properly functioning electricity market on the other?

To answer these questions, we will discuss first how the electricity market is operating, what energy transition is and what is special about renewable energy from an economic point of view (§2). We shall subsequently examine how an increase in renewable energy supply can affect the operation of the electricity market and to what extent specific additional or corrective policy actions will be required to remedy unwelcome effects. Successively, we will explore how renewable energy is promoted (§3), what impact the increasing share of renewable energy in the energy market has on pricing and on the investments in generation capacity in the wholesale market and what effects it will have on the consumer market (§4), what effects it will have on the operation of the electricity grids (§5), what consequences it will have for the roles played by the government, the network operator and market participants (§6) and, finally, what implications an energy transition put in place by a national government will have at an international and cross-border level (§7).

This publication will be concluded by policy recommendations to the governmental authorities about which governmental interventions are required and, also, are not advisable if we want to put the energy transition objectives into practice without losing sight of the significance of a properly functioning electricity market (§8).

2. Introduction to the electricity market and energy transition

2.1 Structure of the electricity market

The term 'electricity market' represents a complex system in which electricity producers, network operators, traders and agents play their part for the purpose of providing consumers with electricity. This system was centrally coordinated until the roll-out of competition - about 20 years ago. Investments in and the deployment of traditional power plants were coordinated at a national level and electricity prices were collectively determined based on the costs of the entire production, transport and distribution system (EC, 2015). Connections with neighbouring countries were created to arrive at a more efficient deployment of, in particular, coal and hydro-electric power stations in various European countries and to support each other in securing the net frequency (UCTE, 2010).

The structure of the electricity market has changed drastically with the introduction of market principles. Central management and coordination were replaced by decentralised decision-making about investments in and deployment of power plants.[2] Uncoordinated decentralised decision-making is an important precondition for efficient markets, because only then can competition develop. Therefore, coordination between companies which jointly constitute a significant part of the market is not allowed under the Competition law. [3]

[2] Decentralised decision-making must not be confused with the decentralisation of the electricity system. The latter concept means that power is more frequently generated within the distribution networks, whereas decentralised decision-making implies that decisions on investments, among other things, are no longer coordinated, but are made by a number of decision- making units (companies, households) independently of each other.

[3] Therefore, according to the Netherlands Authority for Consumers & Markets (ACM), the intention set out in the Energy Agreement concluded between the large Dutch

The coordination of the decisions which have been made in a decentralised manner takes place with the help of the market. The market determines electricity prices based on the resultant of the entire power supply and the entire power consumption. What is special about the electricity market and what makes it different from other commodity markets, such as the markets for potatoes or natural gas, is that electric power cannot be delivered until it is consumed. When alternating current is used, the network frequency must be kept constant and, therefore, the total of power injection into and withdrawal from the grid must be in balance all the time. That is why the electricity market mainly comprises forward markets, in which trading takes place before the electricity is physically delivered and consumed. Some contracts are traded a long time (a few years) in advance; others are made more and more sophisticated as the delivery of the electricity comes closer: either at every hour of the following day (day-ahead market) or, on the same day, hours - or less - in advance (intraday market).[4] In this way, market participants can adjust their positions up to real time.

It depends on the extent to which future electricity demand can be foreseen, the flexibility which is required to adjust buying volumes at the last moment and the need to hedge price risks in advance whether buyers want to buy electricity a longer or a shorter time prior to delivery. Similar considerations apply to sellers, who also have to be aware of the characteristics of their power plant portfolio, such as the speed at which production levels can be adjusted and the commercial need to operate as many hours as possible in order to cover the plant's fixed costs.

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electricity companies to close down one or more coal-fired power stations was subject to the Dutch Competition Act. Since the anticipated environmental benefits for consumers were less than the anticipated costs, ACM decided to deliver a negative opinion (Kloosterhuis et al., 2015).

[4]The day-ahead and the intraday markets are often referred to as spot markets but, strictly speaking, they are also forward markets.

The various types of forward products enable buyers and sellers to make arrangements. This process of making arrangements can take place in various ways, such as through bilateral trade, with the help of a broker (OTC; over-the-counter) and on an exchange, such as EPEX and Nordpool. Exchanges set themselves apart because they make use of standardised products, members trade anonymously and the financial risks are taken on by the market participants' exchange.

This trade system generates a series of forward prices for each moment at which electric power is actually produced and consumed. The prices in the forward markets are correlated with market participant expectations relating to the market situation in the following forward markets, including the situation at the time of physical delivery. At that time, the degree to which the grid is balanced is indicative of the market situation. In such cases, some countries, including the Netherlands, make use of a market - the imbalance market; other countries intervene in the imbalanced market centrally and charge by means of fixed rates. These imbalance systems determine the imbalance based on a period of, for example, 15 minutes and offset it with the market participants. Within that period and from second to second, the national network operator bears the costs of the imbalance and settles the imbalance costs with those who caused it. In the end, the imbalance bill is channelled through to all energy consumers through the suppliers.

The way in which the power prices are established is important for how these wholesale market operations are evaluated. As long as there is sufficient generating capacity in a properly functioning market, the electricity prices in a certain forward market are based on the marginal generation costs plus the so-called opportunity costs which arise from being without the revenues due to not selling in a next forward market[5] as well as the costs which are

[5] When a power company sells electricity which has been generated in a certain power station in the day-ahead market, this electricity can no longer be sold in the intraday

associated with the risk of not being able to meet delivery commitments due to, for example, technical problems at a power plant. In the event of capacity shortage, scarcity prices emerge, i.e., prices which are required in order to reduce demand until it equals the generating capacity. In these situations, therefore, prices are not based on the marginal costs, but on buyers' willingness to pay. At the same time, these scarcity prices are incentives to invest in generating capacity: an investment is cost-effective when the anticipated revenues during production hours are at least equal to the investment costs.[6] This pricing, based on marginal costs (including the above opportunity costs) and on capacity shortage thus ensures that the fixed costs of investments in generating capacity are covered.[7] In this way, the market ensures that, generally, there is sufficient generating capacity at all times. The supply security which is taken care of by the market is not complete, though. In the event of a fully utilised generating capacity and an inelastic demand, the market cannot achieve a balance: the demand continues to exceed the available supply, which could lead to an interruption of the supply. Thus, situations like these require an intervention, for example, load shedding. In theory, electricity consumers must be disconnected when the market price has reached VoLL (Value of Lost Load). If electricity prices exceed this amount, consumers will prefer having no electricity power to paying a higher price. Such a maximum price must apply at least a couple of hours before an

market. As a result, this company will miss out on benefitting from higher prices in the *intraday* market, where applicable. Similar opportunity costs exist with regard to electricity generated from hydro-electric power plants: in those periods in which the water supply in the reservoirs is limited, any consumption of water will lead to the opportunity cost that this amount of water cannot be consumed at a later time.

[6] The anticipated revenues per unit of electric power depend on the height and frequency of the expected peak prices.

[7] In case of capacity shortage not only the total available capacity, but also the capacity which is available in each type of power station, with certain marginal costs, are relevant. For example, infra-marginal power stations will yield revenues when there is no capacity shortage at sector level in order to cover their fixed costs.

investment in peak capacity is cost-effective (Cramton, et al., 2013)[8]. Because of the maximum value which consumers set to having electricity, the best thing to do is not to have so much capacity that there will never be too little capacity - expectedly - and an interruption of the supply will never happen. In practice, the load is shed automatically and in stages as soon as frequency values become very low (less than 49 Hz). The aim is to prevent a total electricity blackout from happening.

The capacity shortage hours, which lead to load shedding, are necessary to have a number of hours during which power prices are very high, which enables all power plants to generate sufficient revenues to cover their fixed costs. Consequently, an energy-only market with VoLL-based prices prevents a missing-money problem from occurring: when power firms want the optimum design for their generation parks, they all see to it that investment costs are adequately covered.[9] Therefore, in theory, a properly functioning electricity market with efficient pricing creates a generating capacity which is optimally compiled and sized. This market requires intervention, though, by way of implementing maximum prices based on VoLL and organising involuntary partial load shedding. The latter is usually the case, however, the former is not. While the imbalance market in the Netherlands has no price cap, the EPEX *day ahead* market has set its maximum price at 3,000 euros/MWh. The choice which consumers will be disconnected is made by the network operator at network segment level, without considering specific preferences of individual consumers. Certain key provisions will be spared,

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[8] When, for example, the amount which electricity consumers are willing to pay in order to prevent a power failure from happening (VoLL) is 20,000 euros/MWh and the total costs (fixed as well as variable) per peak plant unit amount to 80,000 euros/MWh , the anticipated number of power failure hours will be 4 (80,000/20,000) if the power station portfolio is optimal. If the anticipated number of hours is less, too much has been invested from an economic point of view, if the number of hours is greater, investing in additional capacity will be worthwhile.

[9] This is not just theory; it has been proven in practice. The European electricity markets show an abundance of overcapacity (Redl, 2015).

however. Due to the advent of smart meters this may change, though, in the sense that the maximum power supply may be reduced at some point at the level of individual consumers. For that matter, load shedding due to scarcity in generating capacity in the Netherlands is so rare that it is not worth the trouble for consumers to invest in emergency facilities or to take out insurance for that reason. [10]

Another crucial part of a power system is that all parties involved must be connected with a network for transport and distribution of electricity. This network must have a standard frequency range at all times, which means that the total of injected and withdrawn power needs to be kept in balance permanently. While market forces can play a role in keeping the network in balance because, in principle, all power producers and consumers can help them achieve this, this is not the case when it comes to network operation. A decentralised organisation is not feasible here due to the natural monopoly nature of the electricity networks and the public good nature of grid quality. Because of the high fixed costs, creating a number of neighbouring networks which compete for grid usage demand is not cost-effective. That is why a monopoly-like organisational structure of the networks is the best solution, because it keeps costs low. Besides that, it is almost impossible for the networks operator to differentiate the quality of the services provided by networks based on the wishes of different consumers, which is an additional obstacle to achieving the best possible results. Because of these two types of market failure, government regulation of the networks is advisable, even more so now that these networks take up a key position in the electricity market. After all, both generating companies and customers depend on the quality of

[10] 2006 was the last year in which load was involuntarily shed. It should be noted, though, that key services, such as those provided by hospitals, are excluded from load shedding. The network operator will not proceed to load shedding until it has deployed all strategic reserves of its own. There is a considerably greater risk of load shedding when the network is suffering from a physical problem - although it is still small at an international level - than when there is a generating capacity shortage.

the grid connections and the operation of the entire network. This makes the networks a key facility which none of the market participants can ignore.

An independent operator is crucial if there is to be a level playing field for access to the networks for all participants. European rules and regulations have translated this into an obligation which they impose on Member States to unbundle network operations from other, commercial activities, at least in an administrative sense. The Netherlands has gone a step further by introducing full ownership unbundling with regard to both the transmission system and the distribution networks. This means that network operators are not permitted to be part of a group which is active in the generation or trade in electricity and that their full focus must be on managing the networks well.

The core tasks of network operation include the maintenance of the physical quality of the networks (asset management), the management of the physical properties (load, frequency, voltage)[11] and the facilitating of the market by creating connections with new network users, creating and maintaining cross-border connections, providing access to these connections and using them as efficiently as possible (allocation of cross-border capacity, e.g., via an auction; congestion management). In carrying out all these activities, the network operators are subjected to national regulation. Regulators regulate, among other things, the grid tariffs and the network quality (including investments in capacity) and introduce technical codes with regard to how the network operator must operate as and when necessary. Besides that, the European Commission imposes an obligation on the network companies to make adequate investments in the European electricity transmission network as efficiently as possible. Therefore, the joint TSOs are

[11]While the high-voltage network operator(s) manage the frequency, that is to say, the balance in the entire grid, the low-voltage and medium-voltage network operators secure the voltage in their network parts only.

under an obligation to periodically present a programme for the development of the European grid in the next 10 years. [12]

Not only the network operators are under legal obligations, all other players in the wholesale market have been set a task, which is to ensure that their power injection and withdrawal programme is in balance before electricity supply and consumption actually start. This task is called programme responsibility. Strictly speaking, this task applies to all those who are connected with the network, therefore, including consumers. Suppliers are obliged to take over this programme responsibility from the consumers, though. In the Netherlands, this system implies that all these so-called 'balance responsible parties' have an incentive to make sure that they cope with anticipated load fluctuations for which they are responsible by contracting demand flexibility, for instance.

All the parties are running an imbalance risk, though, which means that they run the risk that the actual injections and withdrawals are different from what had been expected. Power producers, for instance, may be confronted with an unanticipated power plant failure. Suppliers are uncertain about consumer power consumption. They sell their electric power to consumers under the premise of a profile, i.e., standardised time patterns in consumer power consumption. Because they take over consumer programme responsibility, suppliers need to ensure that their customer group's actual consumption is in balance with what they bought in the wholesale market and/or generate themselves and inject into the system. As a result, the consequences of changes in power consumption by consumers, for instance, when they are generating electric power themselves, are initially borne by their suppliers.

[12] See http://tyndp.entsoe.eu/.

These suppliers have an incentive to deal with these consequences as efficiently as possible; after all, they have to operate in a competitive market which allows competitors to gain access and consumers may switch to another supplier. Suppliers can also distinguish themselves by offering, for instance, different types of contracts, including ones which provide a fixed electricity price during one or more years or electricity generated from a renewable source. The green energy products in the consumer market are modelled on a European certification scheme for renewable energy (the so-called Guarantees of Origin of Electricity Produced from Renewable Sources). In all Member States, producers of renewable energy receive an EU-certificate for each MWh which they produce. These certificates may be traded, both nationally and internationally. Therefore, there is a green energy certificate market in addition to the power market. It is considerably less liquid and transparent, though. Due to the large supply of certificates in proportion to demand, the prices of those certificates are low, which means that suppliers can provide green power at low additional costs (Mulder et al., 2016).[13] The import of these certificates is playing a large role in the Dutch consumer market, given that 2/3 of all green power sales in the Netherlands are based on this import.

2.2 Energy transition as a social challenge

Part of the policy pursued by governments to reduce greenhouse gas emissions is their aim to substitute fossil energy consumption by renewable energy consumption. This switch to an energy system which is based on renewable energy is called energy transition. Energy transition is a more

[13] It should be noted that market prices for certificates issued for power generation by, for example, Dutch wind turbines, are considerably higher. This is a result of relatively limited supply and large demand. Apparently, a significant number of citizens and companies prefer buying power which is generated with the help of wind energy in the Netherlands.

comprehensive concept than just a change in energy consumption composition. Energy systems are in a constant state of flux, often as a result of changing relative prices (Hölsgens, 2016). Energy transition is a change in the composition of energy consumption which is intentionally pursued by means of all sorts of government interventions. Energy transition in the framework of the above-mentioned decentralised electricity market means that governments aim to influence the decisions made by the decentralised units in such a way that, on balance, electricity generated by renewable means will represent a greater portion of the national electricity consumption.

The energy transition ambitions are high (EC, 2015; ECN et al., 2016). The aim at EU level is a 20% share of renewable energy in the total energy consumption in 2020 and a 27% share in 2030. At present, the percentage of renewable energy in the EU is approximately 13. The current rate of renewable energy in the Netherlands is nearly 6%, while the aim for 2020 is 14% and for 2023 16% (ECN et al., 2016). As electricity offers greater opportunities for renewable energy than, for example, fuels, these high ambitions imply that, in 2030, the share of renewably generated electricity in the total power consumption in the EU must be approximately 50%. It has been calculated that the portion of renewably generated electricity in the total domestic power consumption in the Netherlands will have to rise from approximately 14% today to over 60% in 2030 (ECN et al., 2016). This increased portion of renewably generated electricity will have to be created whilst total power consumption will also increase further, among other things because of electrification of transport and house heating.

In order to induce market participants to make other decisions than they would usually do, governments are taking numerous measures to make renewable energy more appealing or even, in some cases, mandatory. These measures include more subsidies for renewable energy, taxes on the use of fossil energy, mandatory closure of coal-fired power stations, a trade system for CO_2 emissions, a system of guarantees of origin for renewably generated power, supplier obligations to offer a fixed percentage of renewable energy and network operator obligations to give priority to the supply of renewable power (regardless of network congestions). Besides that, governments in a number of countries are taking measures for the purpose of increasing the flexibility of the power system, such as promoting investments in storage, in order to be able to cope with any perceived consequences of a more fluctuating supply of renewable energy.

Because of the measures being taken in many countries, the portion of renewably generated electricity will significantly increase. It is often said that such a strong growth in renewable energy will a have major impact on the operation of the electricity market (EC, 2015a). How come the advent of a greater renewable energy supply in the electricity market must be held to be different from the way in which the market has developed so far? To assess whether this is indeed true, we will have to study the special characteristics of renewable energy.

2.3 Special characteristics of renewably generated electricity

Power which is generated using energy from the wind or the sun differs in a number of ways from conventionally generated power.[14] Its supply is weather-dependent, which implies that the maximum production not only depends on the installed capacity, but also on external conditions. Therefore, it is less controllable. By the way, this does not mean that the supply of renewable energy is unpredictable. It has more variability in time, however, it is not necessarily much more uncertain. Due to improved meteorological analysis

[14] Renewable power is also generated from hydro-electric power and biomass. Energy transition, though, focusses on electricity generated from wind and solar energy in particular.

methods, short-term weather forecasts will be increasingly accurate (Ummels et al., 2006; Martinot, 2015;).

Another characteristic of renewable power is that its generation hardly involves any marginal costs. Power generation from wind and solar does not involve additional costs once the windmills and solar cells have been installed. Obviously, installing this capacity is not free, which means that the fixed capital costs of renewable power need to be covered, just in the case of conventional power. Although the actual capital costs per installation (windmill, solar panel) are usually considerably lower than in common conventional installations, that does not mean that renewable energy has no scale effects. While building a modern coal-fired power station can easily cost 1 billion euros, an onshore windmill can be built at the cost of 1 million euros and solar panels can be installed on the roof of a house for a few thousand euros. There are small-scale conventional installations too, though, such as gas turbines, CCGT units and micro-cogeneration, with capacities varying from approx. 15 kW up to several hundred MW. [15] The fact that the number of small-scale renewable energy installations has significantly increased during the past few years is most likely associated with the existence of financial support schemes, the limited pressure on space because solar panels can be installed on the roof of a house and people's desire to contribute directly to energy transition. This does not alter the fact that investments in renewable energy are also made in large-scale projects. The costs of investing in a windfarm offshore comprising, for example, 35 windmills, amount to half a billion euros (*Natuur en Milieu*, a Dutch environmental organisation, 2016). In part, economies of scale are found in the network connections and, somewhat less, in the size of a windfarm.[16] As far as solar parks are concerned,

[15] See for example: www.centraleinfo.net and www.blockheizkraftwerk.org/.
[16] Although the argument of achieving economies of scale is often used in defence of a large-scale rollout of windfarms, empirical research shows no evidence of these benefits (Dismukes et al., 2015). The costs involved in offshore windfarms is mainly associated

the average costs of a park with a capacity from 1 MW prove to be 30% lower than those of installations with less capacity than 2 kW (Barbose et al., 2010). Among other things. the economic benefits of a solar farm compared with on-roof solar panels arise from the fact that the panels in a solar farm can be orientated more easily towards the sun and, besides that, are able to turn with the sun.

Partly due to the financial support schemes, the advent of renewable energy is being accompanied by a decentralisation of the electricity generation. There are more decision units, including businesses and households, which are generating power; besides that, power generation is increasingly taking place in the distribution part of the electricity networks. Decentralisation of generation also means that more adjustments to the network will be required. Particularly when renewable energy represents a significant portion of the network, renewable energy may involve considerable system costs (Hirth et al., 2016).

Furthermore, it is obvious that renewable power generation does not involve CO_2 emissions.[17] While in a situation without environmental policy this would lead to a lack of external costs in that area; in a situation with emissions trading, though, as is the case in Europe, it means that the providers of renewable energy do not incur costs when spending emission allowances. However, the total (fixed and variable) costs per renewably generated energy unit are, for the time being, significantly higher at most locations than the costs involved in conventionally generated power. This means that another characteristic of renewable energy is that it is put on the market with the help of government policies.

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with the distance from the coast and the depth of the sea, not with the size of the installed capacity.

[17] The construction, transport and installation of facilities do involve CO_2 emissions.

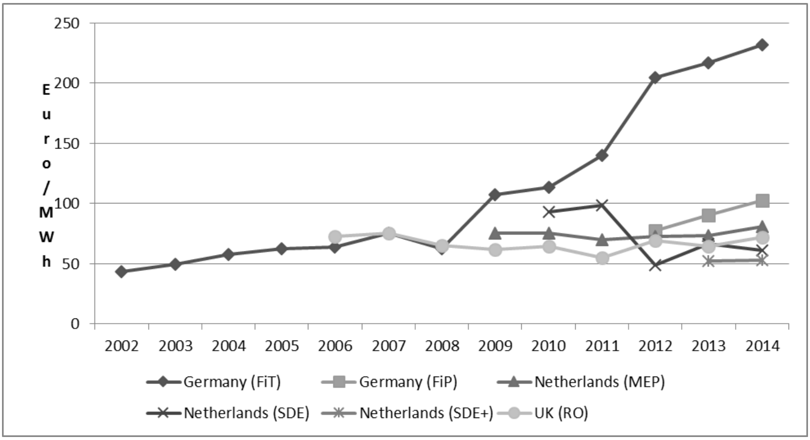
Summarising, renewable energy distinguishes itself from conventional electricity because of its greater variability and poorer controllability of production levels over time, not a much greater deal of uncertainty, though; because of marginal costs being virtually absent, which means that the costs involved largely comprise fixed costs; the possibility of generating renewable energy on a small scale, which means that the decentralisation of the electricity sector can receive a boost; and the absence of CO_2 costs while total costs per production unit are significantly higher, which means that, for now, renewable energy cannot be put on the market unless it is supported by the government.

3. Efficiency with regard to fostering renewable electricity

Despite the benefits associated with the lack of CO_2 costs, investment costs per unit of generated electric power are so high that these technologies still cannot usually compete with conventional generating technologies. Consequently, government measures are required to persuade companies and households to invest in renewable energy. Generally, the challenge which governments are facing when they try to make changes in the choices which companies and households make is to make these changes financially attractive to them (effectiveness) without society paying too much (efficiency). While in the past the focus was on the first aspect when renewable energy was promoted, efficiency is gradually receiving more and more attention (Haas et al., 2010).

In Germany, guaranteed prices were paid for each unit of renewably generated power - the so-called Feed-in-Tariffs (FiT) - until 2012. Renewable energy producers had no financial incentive to work as efficiently as possible, but to produce as much as possible. Thus, the premiums per unit of generated renewable power paid by society were high (Figure 1). The costs - the implicit premiums - comprise the difference between the subsidy which has been paid and the electricity price. In the past few years, these FiT scheme costs have significantly increased due to the increase in subsidies granted for solar energy. While solar power represents only a quarter of the total renewable production in Germany, it was paid half of the total amount in subsidy granted in 2014. Although solar power premiums have come down considerably, 300 euros/MWh in premiums were still paid under the FiT scheme in 2014. This amount was about 75 euros for onshore wind energy and about 150 euros for offshore wind energy (Rook et al., 2016). These costs still apply, because guarantees have been issued for the duration of the investments. In 2012, Germany introduced the Feed-in-Premium (FiP) system for new applications, in which the producer is supposed to sell its power on the market itself and receives a subsidy for the difference between the average annual power price and the investment costs. The underlying idea is to encourage electricity producers to conform to market requirements. The average subsidy amounts in this scheme are considerably lower than in the FiT scheme, however, the main reason for that is that solar panels are excluded from the FiP scheme.

Figure 1 Implicit premium paid for renewable energy per country and type of incentive, 2002-2014



Source: Rook et al. (2016)

Subsidy schemes in the Netherlands have changed several times over the years. In 2010, the MEP scheme was replaced by the SDE scheme and, in 2013, by the SDE+ scheme. Each change caused financial incentives to increase, which has helped to reduce the average premium paid per MWh of generated renewable power. While the MEP made a subsidy amount available for each separate technology, the SDE+ requires the individual technologies to compete for the subsidy budget which is available. As a result, the premium per unit of generated renewable energy has gone down and there were fewer surplus profits than in the case of the MEP scheme (Korteland et al., 2007). In this system, the subsidy amount gradually increases, so only the most efficient technologies will apply for a subsidy at the beginning of the subsidy period. In the course of the subsidy period, when the subsidy amount gets higher, the subsidy scheme starts to become appealing to economically less efficient technologies as well. Due to the limits set to the total subsidy amount which is available, though, the applicants run the risk that there is less subsidy left. Partly as a result of this change made to the scheme, the costs per unit of generated renewable power decreased compared to the old scheme (ECN, 2016).

In addition to these subsidy schemes, the Netherlands has two systems which differ from each other regarding the incentives they contain to work in the most efficient way: the consumer net-metering scheme and the auction of subsidy contracts regarding offshore wind farms.

The net-metering scheme is giving consumers the option to offset their power production (i.e., the feed-in of power into the network) with regard to taxation of their power consumption and the supply tariff against their power consumption on an annual basis.[18] While all forward products in the electricity market are related to the anticipated situation regarding real total production and consumption at some points in the future, the net-metering scheme pretends these actual market situations do not exist. A net position on an annual basis is not a relevant quantity in the wholesale market; the

[18]The net-metering scheme only applies to network users with a low-volume connection - i.e., with a maximum of 3x80 Ampère - and, in principle, to electric power which is consumed and delivered via the same connection. The so-called postcode rose scheme (*postcoderoosregeling*) provides an exception to this rule, though. The amount of electricity generated by the consumer which can be offset is subjected to the so-called offset limit, which is determined by the amount of own consumption. A feed-in tariff to be determined by the supplier applies to generation which exceeds this limit. The net-metering scheme not only applies to renewable energy generation, which means that own generation with the help of a small gas engine is eligible too, in principle.

focus is on the actual position regarding each time unit (one hour or 15 minutes). Because of this offset fiction, consumers do not receive the producer price for their power production, but the consumer price, including energy taxes, renewable energy surcharge and VAT. This means that their price for power supply is about 150 euros/MWh higher than the price paid to regular power producers (Rook et al., 2016; EZ, 2017)[19] This high payment is directly associated with the relatively high rates in the consumer energy taxes. Since the prices of solar panels are gradually going down and the compensations are not based on those prices but, among other things, on the increasing taxes on energy consumption[20], making use of this scheme is becoming increasingly appealing to consumers. This has the additional effect that consumers who generate electric power themselves are paying less energy tax and, consequently, are contributing less to the financing of public-sector spending, including expenditure to encourage the use of renewable energy.[21] While the net-metering scheme may increase support for energy transition among consumers who make use of the scheme, it may decrease support among other

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[19] Since power consumption by bulk consumers and, possibly, also by low-volume users when they have smart meters is generally measured over a measurement period of 15 minutes, this mechanism also exists within this time period, apart from the net-metering scheme.

[20] In 2008, households spent 8.65 eurocents per kWh on energy tax; in 2017, this rate has risen to 12.26 eurocents. The renewable energy surcharge in 2017 is 0.90 eurocents/kWh. For comparison: users whose power consumption is between 10,000 and 50,000 kWh will pay 5.93 eurocents/kWh in energy tax and 1.49 eurocents/kWh in renewable energy surcharge in 2017. Therefore, the energy tax exemption for households which generate electric power themselves represents a significantly greater share in the own production revenues than the electricity price, which is not more than approx. 5 eurocents/kWh. See https://www.gaslicht.com/energie-informatie/energiebelasting.

[21] The design of the energy taxes is such that they encourage energy consumers to use energy more economically without paying, on balance, more tax. It has been arranged that the energy tax revenues are channelled back by means of a reduction in payroll and income tax and, as a result, this levy is budget-neutral for the government. Consequently, power-generating households are benefitting from both lower energy taxes and from the generic payroll and income tax cuts.

consumers who do not benefit from it but, as a matter of fact, are faced with higher taxes.

In short: the net-metering scheme contains few incentives to making efficient investments in renewable energy, while the risk of supranormal profits is increasingly growing. Besides that, consumers are not stimulated to take the actual conditions in the wholesale market into account when they generate power, because the revenues are based on the balance of their annual consumption and production. Should the net-metering scheme be replaced by a system which settles use and delivery separately and pays a subsidy amount which is based on efficient costs, the efficiency of this incentive scheme would increase (EZ, 2017; NVDE, 2017).

By contrast, auctions of subsidy contracts regarding offshore wind farms provide strong efficiency incentives. Participants interested in building an offshore wind farm compete for the lowest subsidy fee. When they draw up their bids, the parties not only have to assess the costs of building a wind farm but also the future electricity prices. These incentives have reduced the premium which society has to pay for offshore wind from approx. 100 euro/MWh under the MEP scheme to approx. 50 euros now.

A system for curbing green energy costs which was adopted in the United Kingdom in 2005 also provides strong incentives. Energy suppliers in this so-called renewable obligation (RO) or quota system undertake to buy a fixed percentage of renewable energy. They must buy certificates from renewable energy producers, who receive these certificates for the electricity which they produce. In this system, the different technologies are treated the same and, as a result, the less efficient technologies are hardly used and the average premium for renewable energy is low. Consequently, the share of solar energy in the UK energy mix is extraordinary low (1%), whereas Germany has a 25% share of solar energy.

These experiences show that the cost of stimulating green energy can be reduced when market participants are given more freedom of choice, as in a quota system, and when the parties are allowed to compete for not readily available subsidy amounts, as in the SDE+ scheme and in auctions of subsidy contracts for offshore wind. Where there is no competition for scarce subsidy resources and the compensation level is more or less guaranteed, as in the net-metering scheme, there is a significant risk that less efficient technologies will be promoted and society will pay more for renewable energy than is necessary. Besides that, an additional effect of the net-metering scheme is that the basis for taxing energy is being eroded and the relative contribution of households which do not generate power to the financing of public expenditure is growing.

4. Renewable energy effects on the wholesale and consumer markets

4.1 Wholesale market pricing

Since investments in small-scale installations for renewable energy generation, such as solar panels and wind turbines, are also promoted, the energy transition leads to decentralisation of the electricity sector. Investment and production decisions are thus being made at a much smaller scale than they were in the past and the number of decision-making units (i.e. companies, households) is significantly increasing. While the electricity market used to be characterised by an oligopoly-like market structure in which several large companies dominated the market and managed to secure high margins (Van Damme, 2005), the energy transition is a source of increased competition between the electricity producers. Due to the large number of producers, who jointly own an increasingly growing installed capacity, it is becoming more and more difficult for the individual large companies to influence market outcomes. From an economic perspective, the total installed capacity which falls outside the large electricity companies constitutes the fringe supply, which implies that the so-called residual demand for these companies decreases. A smaller residual demand combined with a constant number of companies reduces market power. This reinforced competition may cause greater pressure on the electricity price and, thus, lead to stronger incentives to reduce electricity generation costs. It should be noted that the electricity market in the Netherlands has become significantly more competitive already, mainly because of the more efficient use of connections with its neighbouring countries (Mulder, 2015).

Due to the fact that marginal costs in renewable energy are virtually absent, electricity prices are under even greater pressure. This decrease is caused by the merit order effect. The merit order is the classification of all generation units from low to high marginal costs. Since green energy has virtually no marginal costs, this capacity is below on the left in this classification.[22] This means that, in a properly functioning market, green energy capacity will be deployed sooner than capacity with higher marginal costs. Therefore, a greater renewable energy supply implies that the merit order moves to the right and crosses the demand curve at a lower equilibrium price. This is not just theory, as is evidenced by the experiences gained in, for instance, Germany. This effect sharply reduced electricity prices in that country. In some cases, the electricity prices are even negative. The reason for this is that, at some points in time, producers which have less flexible power stations are willing to pay money to avoid incurring costs involved in interrupting their production, while green-energy producers continue production because their compensation is based on a flat rate.

The price-lowering effect of renewable energy is not detrimental to the producers of conventional electricity only, it also affects the producers of renewable energy. The profile effect is playing a part in this. The average price which green-energy producers achieve is lower than the average electricity price since, because of the correlation between weather conditions, there is a high power supply at the times when wind and solar power is offered, as a result of which this electricity is mainly supplied when prices are low. This so-called profile effect increases as the share of green energy increases (Hirth, 2015). It should be noted that some subsidy schemes, e.g., the *Feed-in-Tariff* scheme, can more or less alleviate this effect for producers of renewable energy, though.

In addition to this effect on the average electricity price, the price variation over time is also affected. The greater the amount of solar power, the higher

[22] The opportunity costs also apply to the sales of wind and solar power: when the electricity is sold in the day-ahead market, the seller cannot benefit from potentially higher prices in the imbalance market. In addition, there are costs related to the risk of plant outage.

the production levels are during the hours when demand is high, i.e., by day, which reduces peak hour prices. Thus, the hourly variation in prices on the same day decreases. Since wind and solar power supply strongly depends on the weather conditions, their merit order effect also depends on these conditions. This leads to additional price variation from day to day and from week to week (Rintamäki et al., 2017).

Summarising, more renewable energy means lower profit margins for producers due to increased competition and, besides that, it leads to a further decrease in electricity prices because of the merit order effect. Renewable energy producers suffer from the profile effect because, due to this effect, their average electricity price is lower than the average prices paid for conventionally generated power. While price volatility decreases from hour to hour, it increases from day to day. It should be noted, though, that lower electricity prices are essentially beneficial to consumers. While more price variation over time means that there is more uncertainty about future prices, the wholesale market provides various options to cope with this uncertainty. For instance, market participants can buy or sell in advance for longer or shorter periods of time in order to hedge themselves against the risk of price fluctuations.

4.2 Consequences for consumers

As compared to the lower wholesale prices, there are higher levies for the financing of the energy transition subsidies and higher grid costs because of the investments in network enlargements. While all electricity consumers are paying for these grid costs, in most countries only the residential users are footing the bill for the levies. In the Netherlands, consumers are paying a renewable energy surcharge of 0.90 eurocents/kWh in 2017. Although medium-sized consumers with a power consumption of 10,000 to 50,000 kWh have to pay 5.93 eurocent/kWh in 2017, bulk consumers do not have to pay this surcharge. In Germany, consumers are paying approx. 6 eurocents/kWh to cover the renewable energy subsidies. Therefore, despite the drop in wholesale prices, more green energy means a higher energy bill for consumers.

By making use of the consumer net metering scheme, consumers can generate electric power themselves and, thus, considerably reduce their energy bill (see §3) at the expense of other consumers. When they sell their electricity, consumers have no free choice of buyer for the time being because they are bound to one supplier that assumes the programme responsibility and, thus, bears the imbalance risk. Consumers may switch to another supplier, though, which means that these suppliers have an incentive to keep the costs of bearing this programme responsibility as low as possible. Besides that, the advent of smart energy meters has enabled suppliers to sell even more and different products to consumers, for instance, contracts with prices which are linked to the *day-ahead* or imbalance prices. It should be noted that the fact that this type of contract involving hourly varying prices is a possibility does not imply that many consumers will opt for it, as experiences in other countries have taught us (Littlechild, 2014).

4.3 Investments in power stations

The advent of renewable energy will obviously have implications for the profitability of existing power stations. Not only the remuneration which they receive for their products is going down due to the decrease in the average electricity price, their production levels are also on the decline. After all, the increasing supply of renewable energy is reducing the residual demand for these stations and, thus, their joint production size will go down. Their merit order rank determines which power stations in particular will produce less. The question which remains is to what extent this will have implications for the issue of achieving the optimum production portfolio. In other words: are adequate investments made in power stations which will be needed when our wind turbines and solar panels are not generating electricity?

In theory, an energy-only market with VoLL-based scarcity prices leads to the best possible compilation and size of the generation park. This means that this market also generates the highest possible supply adequacy level, i.e.: maintaining the exact number of power stations which ensure that a further reduction in the risk of shortages by making additional investments in generating capacity is no longer profitable. The fact that the increase in green-energy generation has a price-lowering effect is not relevant for the degree to which the energy-only market is able to ensure sufficient investments in capacity. The principle of scarcity prices with a VoLL-based maximum remains the same, while the portion of renewable energy does not affect VoLL either (Cramton, et al., 2013). It is conceivable, though, that an increase in the portion of renewable energy brings on an increase in residual demand variation for conventional power plants, which may result in longer periods of minor or considerable shortages around the same LoLE (Loss-of-Load-Expectation). After all, the residual demand is at its peak when wind turbines and solar panels do not generate power and at its lowest level when these installations operate at full capacity. Greater variation in residual demand would result in relatively many hours of power shortage in certain years and, thus, in more - and more frequent - load shedding. This may lead to an increased risk of political interventions in the electricity market, for instance, by not allowing high wholesale prices, which puts pressure on the expected return of investments in power stations. Furthermore, the anticipated (average) residual demand in the future is also subject to the degree to which governments will be successful in promoting renewable energy investments. Consequently, energy transition can be a source of reduced investments in conventional power stations and, thus, lead to a suboptimal production portfolio (Giesbertz et al., 2016).

Besides that, the speed of energy transition may lead to a less than optimal generation park. When investments in renewable energy are promoted within a short period of time, as is happening in many countries now, the conventional generation park cannot adjust rapidly enough. The share of base-load stations will then be greater than in an optimal situation, but these stations will continue to be operational as long as the electricity price covers their marginal costs and thus force other flexible plants with higher marginal costs out of the market (Redl, 2016). If these flexible power stations have fewer CO_2 emissions, this may lead to an increase in total emissions by the electricity sector (CEPS, 2015). Exactly this happened recently in Germany and the Netherlands, for instance, where coal-fired power stations were in full operation whereas gas-fired stations were mothballed. This created an increase in the total of CO_2 emissions caused by the electricity sector in both Germany and the Netherlands.[23] It should be noted that not only the increase in renewable energy supply, but also the way in which the relative fuel prices have developed as well as the low CO_2 prices have contributed to this course of events (Pangan et al., 2016).

In practice, all kinds of factors may be responsible for a situation in which the energy-only market does not achieve the best possible generation park mix, so that specific interventions are required to secure supply (Stoft, 2002). For example, the theoretically calculable optimal duration of a capacity shortage is based on the average expected situation during the lifetime of the assets. In practice, however, the dispersion around the number of capacity shortage hours in a year may be considerable, so certain investments may be confronted with (many) more or less hours in which VoLL is achieved. This uncertainty gives rise to a risk premium and thus causes less than optimal investments. Furthermore, prices are in practice often not based on the VoLL.

[23] See www.emissieautoriteit.nl (in respect of the Netherlands) and the German Statistisches Bundesambt www.destatis.de).

Instead, the wholesale market, whether day-ahead or intraday, sets price ceilings, which means that the expected yields of the investments and, thus, the size of the investments will be less than they would have been in an optimum situation.

Because of these practical obstacles, many countries have taken specific measures to separately reward generating capacity. Examples are: strategic reserves, capacity requirements, capacity auctions, reliability options and capacity payments (ACER, 2013; Giesbertz et al., 2016). [24]

In general, the risk of implementing capacity mechanisms is that it leads to a so-called *crowding out* of investments which would have been made otherwise. Since a capacity mechanism may ensure more installed capacity, scarcity prices will occur less frequently, so the energy-only market leads to fewer investments in power stations. On balance, the introduction of a capacity mechanism thus need not lead to (many) more investments.

A capacity mechanism also involves the risk of overinvestment, which means that, from a social perspective, the costs incurred in generating capacity are higher than the benefits to society which ensue from preventing involuntary load shedding.

Capacity mechanisms may also lead to undue distributional effects when they create higher profits for power stations which would have been there without this mechanism anyway.

In short, capacity mechanisms can affect electricity market efficiency both adversely and beneficially. Given that the increase in renewable energy in itself does not make many changes to the potential of the energy-only market

[24] A strategic reserve refers to a specific amount of capacity which is kept in reserve. By contrast, making capacity payments means that a certain amount of money is made available for furnishing capacity. The resulting capacity is thus an outcome of this process, whereas in the first option the costs of the reserve constitute the resultant. All three other options (capacity requirements, capacity auctions and reliability options) are volume measures which are being implemented market-wide.

to create an efficient generation park, the introduction of capacity mechanisms for this reason is not self-evident.

5. Renewable energy effects on electricity networks

5.1 Power balance

In order to determine the extent to which an increased share of renewable energy can impact the grid's power balance, we will need to have a clear picture of how it is monitored. Securing the frequency of the electricity network is one of the core tasks of the national transmission system operator.[25] This frequency is kept constant by maintaining the so-called active power balance, which means that the input to the network must be permanently equal to the output (Nobel, 2016). While network balancing is still mainly based on (sub-) national balancing zones, the nature of these zones will be more international in the future, which should improve the flexibility and efficiency of the system (TenneT et al., 2016). There are differences in the way in which system operators in the various zones (countries) involve market participants in the safeguarding of the network frequency.

Anyone who is connected to the network in the Netherlands has programme responsibility, which means that they have an incentive to secure that their input and output programme is in equilibrium before the start of each 15-minute period - the so-called *Imbalance Settlement Period*. Whenever there is a deviation in the frequency during the ISP, there will be a financial settlement. If the deviation caused by a market participant takes the same direction as the imbalance in the entire network, they must pay a penalty

[25] This applies to AC (Alternating Current)-networks. The AC-network frequency in Europe is 50 Hz; in the US, for instance, it is 60 Hz. Since the AC-networks in Europe constitute a meshed network, the responsibility for monitoring the frequency lies with the joint network operators. Each single operator of a high voltage network, such as TenneT, is responsible for securing its power balance. This entails that, at any point in time, the total domestic injection plus import must be equal to the total domestic withdrawal plus export. This power balance (in MW) must be monitored permanently, that is why it is also referred to as the energy balance (in MWh).

which is established based on the market price in the imbalance market. If the deviation takes the opposite direction, they will receive a reward which is depending on that market price. The Dutch imbalance system design, though, is such that market participants have an incentive to prevent imbalance from happening (Nobel, 2016).

To rectify an imbalance, the Dutch imbalance market has two types of market participants: on the one hand, the market participants which have concluded contracts with the network operator to the effect that they will furnish balancing power and, on the other, the other market participants.[26] The first-mentioned group is given a reward for furnishing power as well as for the points in time at which they are actually requested to make power available to rectify an imbalance. Based on the bids made by these market participants for the deployment of power and the size of the imbalance, an imbalance price is determined. These and all the other market participants may respond to the expected imbalance price by regulating their production or demand, resp., up or down.[27] The system operator will solve the remaining imbalance during the ISP using own reserve power.

Now, the question remains to what extent the operation of the imbalance systems is affected when there is a considerable increase in renewable energy. Such an increase means that power supply will be defined by weather conditions to a greater degree. This is all the more so because of the subsidy schemes which provide a refund per unit of generated electricity without regard to the actual market price. All these factors can lead to considerable

[26] All market participants with a minimum generating capacity of 60 MW are required to make capacity available in advance to the system operator which may be used in case of an imbalance (Tanrisever et al., 2015).

[27] The imbalance prices are published from minute to minute: see http://www.tennet.org/bedrijfsvoering/Systeemgegevens_afhandeling/verrekenprijzen/index.aspx. The highest price value in a 15-minute period constitutes the final imbalance price.

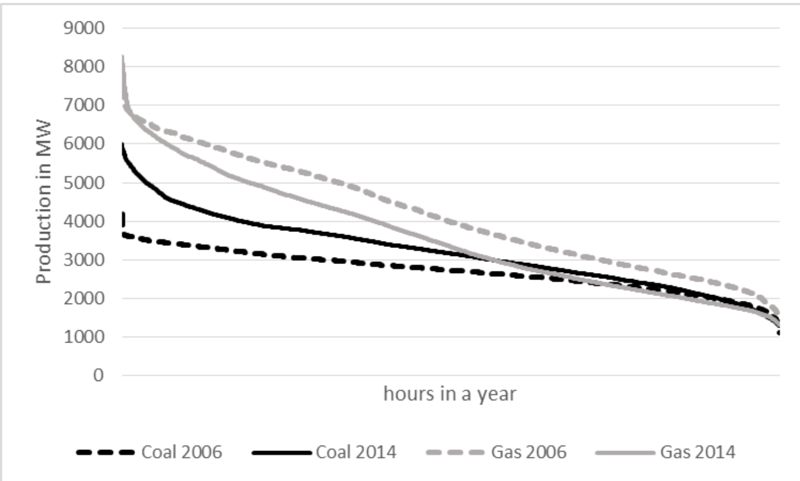
daily or weekly variations in the supply of renewable energy - from very low levels to almost total utilisation of the installed capacity.

Weather condition fluctuations within a quarter of an hour are limited, which means that the system operator doesn't need more reserve power to secure the network balance within an ISP. Unanticipated changes in weather conditions which may lead to a 15-minute-based imbalance in market participants are solved within the imbalance market. For that purpose, the system operator uses the balancing power furnished by market participants, while the market participants themselves may also react to the imbalance prices. The extent to which the imbalance market facilitates these reactions depends on the design of the imbalance market. The German imbalance market, for instance, provides ample options for market reactions since it allows more market participants to participate actively and, besides that, provides room for demand response. Also, the very liquid intraday market in Germany, which is open up to the moment of delivery, enables market participants to efficiently cope with deviations in the anticipated production (Bader et al., 2016)

Weather conditions can be forecast increasingly accurately, though, which means that participants in the *day-ahead* or the *intraday* markets can adjust their portfolios to changing expected conditions. For instance, in the *intraday* market in the Netherlands participants can trade up to 5 minutes before physical delivery, which enables them to cope with an anticipated imbalance in their own portfolio up to the very last moment. Because of the advent of more green energy, therefore, the demand in these markets for products which supply or consume more or less electricity in the short term is increasing. These products can be provided by conventional power stations as well. It appears that German coal-fired power stations are significantly contributing to meeting the increased need for flexibility which has arisen as a result of the strong growth in green-energy supply (Martinot, 2015). In the

Netherlands, coal-fired power stations are progressively deployed for short-term flexibility as well, which is reflected in the fact that the difference between the highest and the lowest hourly production levels in 2014 was considerably greater than in the previous years (see figure 2). More options for deploying coal-fired power stations in a more flexible way have been created by making updates in the plants, including in the operating software, so they can be dispatched up and down rapidly.

Figure 2. Duration curves of total hour-to-hour production of coal- and gas-fired stations, 2006, 2010 and 2014



Source: Mulder (2016)

While the advent of the smart meters has facilitated the mobilisation of household demand response potential, the anticipated size of the hour-to-hour response is limited, though (Ma, 2016). It appears that by exposing consumers to hourly fluctuating prices, their savings on electricity expenses are only 1 to 2 percent on an annual basis (Allcot, 2011). On a somewhat longer term, for instance, the time difference between day and night, the demand response potential obviously increases. The size of the demand response depends on three components: price sensitivity, the amount of power consumption and the fluctuations in prices. The short-term price elasticities in respect of a reduction in power consumption in a certain hour or in respect of a consumption shift to another hour are very low and are estimated in the order of -0.002. Possibly, the short-term price elasticity may be increased a little by using software which automates the demand response. Households mainly consume electric power by day, which is exactly when the generation by solar panels is reaches its peak (Madlener, 2015). The fluctuations in the wholesale prices flatten out by day, though: as a matter of fact, solar energy has the effect that the price profile flattens out from hour to hour within a day. Consequently, even when consumers are confronted with prevailing wholesale prices, not much can be expected from this type of demand response. Besides that, when consumers start to consume more electricity, for instance, for charging their electric cars, the hourly demand response will not increase much either as long as the price fluctuations are small. The good news is that, when there are only small fluctuations in the wholesale prices, producers and consumers apparently do not feel the need for greater short-term flexibility. In any event, retailers in the present system do have the opportunity to involve consumers in providing flexibility, both in the forward and in the imbalance markets.

5.2 Grid congestion

Since the increase in renewable energy for a significant part occurs in the distribution networks, there will be implications for their operation. It is the job of the operators of these networks to monitor the voltage levels and keep local congestions from occurring (Nobel, 2016). For these networks, the energy transition means that the traditional one-way transmission of power in the grids, from producer to consumer, will change into a two-way transmission system in which consumers also generate electricity. The direction of the transmission is changing from moment to moment, depending on the amount of own generation and own consumption. Furthermore, the energy transition leads to an increase in household power consumption, among other things, for charging electric vehicles. The consequences of the greater variation in the flows and the higher peaks in grid load are that network operators must do more to keep the voltage level in the grids up and to prevent grid parts from becoming overloaded.

Network operators have different options available to deal with these consequences. With the help of technical updates, for instance, generation by solar panels can be temporarily eliminated when overloading in local network parts is imminent (Martinot, 2015). Another option to make the grid smarter is to integrate production and demand locally in order to relieve higher-level network parts. Investments in increasing the local network capacity is yet another way to solve congestions. Technically, network operators are capable of temporarily storing electricity for the purpose of preventing network parts from overloading, however, in doing so network operators would interfere with market participants.

A more efficient solution would be if network operators make use of an incentive to stimulate network users to consider the grid situation when timing their electricity generation and demand (Fuse, 2017). They can do this by translating network overload into so-called shadow prices. These shadow prices indicate the costs which must be made to reduce a constraint caused by one unit (Jafarian, et al., 2016). If network users are confronted with these shadow prices, they can weigh the pros and cons of using the grid (production or consumption of power), postponing it to another point in time or not using it at all. A household which generates electricity using solar panels, for instance, may discontinue its production temporarily or make use of storage. In this way, efficient incentives are developed to stimulate network users to invest in a storage facility, or not. In some cases, this may give rise to a discontinuation of the green electricity generation because grid usage costs are too high; this can be an efficient solution (Doorman, 2015). Should network users' responses to these incentives be inadequate, network operators may contract storage capacity in the market; this is a more efficient solution than a situation in which network operators invest in it themselves. Besides that, interference between network operation activities and market participant activities is avoided in that case.

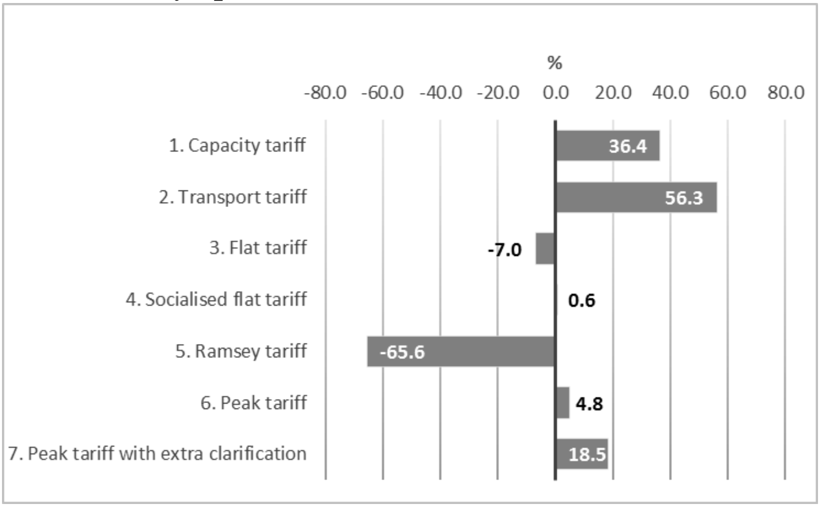
To confront consumers with these shadow prices, the prices must be translated into network tariffs. Currently, the network tariffs for households only consist of a capacity tariff, which means that households are paying a flat-rate amount per connection type per time unit. Thus, the actual volume that is used is not taken into account, let alone the timing. The bulk consumers which do pay a transmission tariff have no incentive either to adjust the timing of their grid usage to the network conditions. To make the network tariffs dynamic with regard to the grid load, the grid tariff may be divided into two parts: a flat capacity tariff per connection type per time unit, which serves to cover the fixed network costs, plus a variable tariff which varies over time with the grid load. This variable tariff is positively correlated with the congestion and ranges from zero (no congestion) to very high (in case of serious congestion). [28]

In order not to create a perverse incentive for the network operators to make a profit by increasing the chance of congestion, the revenues from the variable tariffs should be channelled back to the network users by reducing

[28] In practice, this system can be introduced by providing in advance several dynamic tariff options to the network users and by asking them how much capacity they would want to be able to use regarding the different tariffs.

the flat capacity tariff. This dynamic component in the network tariffs provides network users with an incentive to use the network efficiently and, at the same time, encourages the network operator to create efficient solutions to the congestion. Solutions are only efficient when the costs per unit are lower than the average expected future shadow prices. Since the revenues from the dynamic tariffs are channelled back to the network users, this system does not confront them with higher network costs than the costs incurred by network users in other distribution or transmission networks without dynamic network tariffs. Besides that, on balance, electricity producers in this system do not incur transmission costs, as is the case now.

Figure 3. Assessment of the fairness of various types of network tariffs made by a panel of Dutch consumers



Note: fairness score = % "(very) fair" - % "(very) unfair"
Source: Neuteleers et al. (2016)

Dynamic tariffs may be efficient in economic terms, the question is to what extent citizens perceive them as fair. A survey among a panel of Dutch consumers[29] has shown that, on average, people do not consider dynamic tariffs, which are depending on the congestion in the network, unfair (Neuteleers et al., 2016). The percentage of people considering dynamic tariffs as (very) unfair is about the same as the percentage considering these tariffs as (very) fair (Figure 3). In this respect, dynamic tariffs score significantly higher than a tariff system in which tariffs are entirely based on the network users' price sensitivity. By the way, this Ramsey pricing system is frequently used for all kinds of products, including aircraft seats; price-insensitive business travellers pay much more than others. Dutch households, though, appear to look upon a system in which tariffs are based on the connection capacity or the actual volume of the use as much fairer. Furthermore, when in a situation of dynamic tariffs households know in advance how high the tariffs will be and that the revenues will be used to solve the bottlenecks in the grid, acceptance will increase. The percentage of households which considers this system fair will be significantly greater in that case.

These conclusions are in line with the findings in behavioural economics and ethics literature (Neuteleers et al., 2016). Behavioural economics teaches us that people react negatively to price changes which are not based on changes in costs but on, in their view, arbitrary conditions, such as scarcity in the market. Ethics teaches us that fairness of prices depends on to what extent general principles have been complied with, such as equal treatment, meeting of basic needs and cost causation.

The general lesson learnt from this is that consumers do not have much sympathy for market incentives. This is another reason why the hour-to-hour demand response potential among consumers should not be estimated as

[29] The panel is the *Consumentenbond* consumer panel.

high. If incentives are provided, though, support levels will increase if predictable price incentives are opted for, or incentives comprising allowances and bonuses in respect of behaviour which is valued positively.

6. Division of roles between government agencies, network operators and the market

6.1 Government targets and market failure

Energy transition is the ambition which governments have to drastically change the nature of the energy system. Even though there are many in society who share these ambitions, at the end of the day, these targets have been set by the governments. These targets are ambitious, which implies that they are likely to be achieved less quickly than intended. If energy transition is not taking off rapidly enough, this means that government policies are not effective enough, not necessarily that the market is failing. The market only fails when there are flaws which prevent market participants from entering transactions which would be beneficial to either of them. Examples of flaws are market power - which makes prices too high; negative external effects - which makes prices too low; coordination issues - which causes uncertainty in investors about their revenues after they have made their investment; and information asymmetries - which means that consumers have less information about a product than suppliers have. Targeted public sector action may remedy these flaws or their consequences. When there are no flaws in the operation of a market (any more), it is nevertheless not uncommon for a product to have no market. This is simply because the costs of providing this product exceed the value allocated to it by customers. This situation may also occur with regard to products which are put on the market in the framework of energy transition, including energy-saving advice or devices for monitoring power consumption in real time. When households do not buy these products often enough to satisfy policymakers' targets, the costs which they will have to incur, including their efforts, apparently outweigh the advantages they would enjoy.

If the authorities do want these energy-transition products to be sold, they have basically a wide range of options available. It is not self-evident that government agencies themselves make these products available, as in that case the costs will be much higher due to a lack of competitive advantages. While subsidising certain products may be effective, it involves the risk of finding out in retrospect that the wrong products have been promoted. The same risk is involved in imposing measures on households or companies to take certain actions. Improving incentives for market participants is the most efficient solution. Much remains to be done in this respect. For instance, the implicit CO_2-price which households currently pay through the energy taxes on their energy consumption is approx. 250 euros/ton, which is significantly higher than the social costs of these emissions (EZ, 2017).[30] Partly because of this, a growing number of households have been motivated to invest in renewable energy installations, however, this does not apply to the majority of households. In the face of this relatively high price that must be paid for CO_2-emissions, the energy consumption by households continues to increase.[31] While this is not in line with the government targets, it cannot be considered a market failure. There is rather evidence of a regulatory failure: the implicit price to be paid in other parts of society is significantly lower than the price for households. As a result, relatively expensive technologies are promoted and cheaper emission reduction options remain unexploited.

[30] The social costs of an additional unit of CO_2-emissions depend on when this emission takes place and how many emissions will take place in the future; after all, the damage caused is associated with the cumulative CO_2-concentration in the atmosphere. As a result, estimates differ widely, however, most studies arrive at a figure of less than 100 euros/ton for current emissions (CE, 2010).

[31] In 2015, the total household electricity consumption was approx. 15% higher than in 2000, which is partly due to the increase in the size of the population. The per capita electricity consumption in 2015 was approx. 5% higher than in 2000. Total electricity consumption in the Netherlands in this period increased by approx. 10%. Source: Statistics Netherlands (CBS), Statline.

Hence, in order to identify the role of the government in achieving the energy transition, it is important to know why market participants fail to take the measures envisaged by the government. If it becomes apparent that the market cannot perform properly due to flaws such as information asymmetry or coordination issues, a societal cost-benefit analysis can be used to assess what government measures would be efficient.

6.2 Network operators and the market

The electricity grids occupy a key position in the electricity market. Gradually during the liberalisation of the market, the role played by the network operators has been confined with the help of regulation, structural interventions and public shareholding. The electricity grids constitute a natural monopoly which makes competition impossible. In order to stimulate the operators of these monopolies to work as efficiently as possible and to pass on the accompanying advantages to the network users while keeping the reliability of the networks high, the network tariffs are regulated and the quality of the networks is monitored. For the purpose of securing the same conditions for all market participants to make use of the networks as a critical infrastructure, the network operators are prohibited from acting as market participants themselves. Moreover, to guarantee that grid management does not focus on pursuing private interests, the networks in the Netherlands must remain in public hands.

The question now is whether the intended energy transition is a reason for adjusting the network operators' role. Should network operators be given the opportunity to carry out activities which are conducive to the energy transition and which could be conducted, in principle, by these market participants, but have not been undertaken swiftly enough so far by the latter in the eyes of the operators? Think of rolling out charging stations for electric cars and installing devices in households for reading out data stored in smart meters. Just as with identifying the role of the government, the question now is: what is the market failure? Installing devices for reading out data for smart meters is a relatively small investment without a great deal of fixed costs, which makes competition possible. Besides that, the advantages of this investment basically benefit the households, because they may be able to reduce their energy consumption costs. Hence, a natural monopoly or external effects do not exist. Furthermore, because of the competition on the consumer market, suppliers of energy have an incentive to keep costs for their customers as low as possible and to offer them new products. Consequently, there seems to be no reason for network operators to take on this task, even more so because this would create the risks of too little innovation and too high costs. After all, successful innovation can be achieved only when various options have been tried out and this cannot be done unless a number of participants are active. When a network operator takes on a task, there is only one operator and, probably, only one product, which means that there is a much higher risk of other, more successful, opportunities being missed.

The guaranteed revenues from tariffs and, thus, the network operators' relatively robust financial position must not be used to give them a stronger role in the development of other operations. When the tariff regulation works properly, the network operators will not achieve surplus profits, so no extra financial resources can be derived from them. The main argument for not allowing network operators to develop other activities is that it would allow them to discourage other market participants due to the advantages associated with their position as network operators, including scale and scope advantages and the advantages they have because of their brand awareness and positive image among customers.

7. National energy transitions in an international context

7.1. Cross-border effects

The ambitions for energy transition and competition policy for electricity are different in terms of spatial dimension. The objectives for energy transition are often nationally or even regionally oriented, whereas the integration of national markets into an international market is essential for the promotion of competition (EC, 2015). Growth and more efficient use of cross-border transmission capacity and facilitating activities in different countries (markets) for market participants should achieve the integration of markets.[32] Market integration may lead to lower production costs, more competition and more supply security (Giesbertz et al., 2008; ACER, 2013). The lower production costs result from deploying power stations as efficiently as possible on a larger geographical scale; less efficient power stations that are still needed for production in a national system may then be replaced by more efficient power ones in other, linked markets. Market integration may also have a positive effect on competition as there will be more market participants in a larger market, which makes separate producers less indispensable and makes it harder to collude. In addition, integration contributes to a higher degree of supply security because a larger system reduces the chance that supply and demand shocks occur simultaneously in a large part of the market, while at the same time there are more options for flexibility. The consequence of market integration is that the effects of national interventions are not limited to the national market, but spread over the entire integrated region.

[32] See the website of the European supervisor ACER for an overview of all types of measures: www.acer.europe.eu.

However, the energy transition policy is highly nationally oriented, although it emanates from European policy. Under the EU *Renewable Energy Directive* there are binding objectives for the portion of renewable energy both on an EU and on a Member State level. In the EU as a whole the portion of renewable energy in the total energy consumption must be 20% in 2020, with different objectives for the separate Member States[33]. The Netherlands is required to generate at least 14% renewable energy in 2020, but this percentage is between 30% and 49% for example for the Nordic countries (EU, 2015). These differences in obligations for each Member State are connected with their starting positions and their possibilities to promote renewable energy. For the rest, the Member States are free to choose how they translate these obligations both in terms of tightening the objectives and of their choice of policy instruments. With the Energy Agreement, the Netherlands tightened its own EU requirement for 2020 to accomplish a further increase of the portion of renewable energy to 16% in 2023. Numerous measures were taken to achieve these objectives, such as the promotion of the rollout of large-scale windfarms, promotion of decentralisation of renewable power generation and the closure of a number of coal-fired power stations (SER, 2016). Other Member States are taking similar measures and Germany is the most ambitious EU country in this respect. It has already formulated its objectives for 2050: in that year 60% of its total energy consumption and 80% of its total electricity consumption are to come from renewable sources. Pursuit of transition in the electricity sector mainly manifests itself in subsidies for renewable energy.

[33] For 2030 an agreement is concluded between the Member States to have the portion of renewable energy at EU level as high as 27%, but this ambition will not be allocated to the individual Member States to allow each Member State more flexibility in its implementation of the climate policy (EC, 2014).

Because the energy markets are integrated, all national measures to influence the composition of the electricity generation have cross-border effects. As the Dutch and German power markets are so closely linked, the German energy transition caused the power prices not only to fall in the German wholesale market, but also in the Dutch one (Mulder and Scholtens, 2016). This reduction of the Dutch power prices as a result of the German energy transition has made subsidising renewable energy in the Netherlands more expensive, as the subsidies cover the difference between the costs of renewable energy and the power prices. The decline in power prices also makes the net-metering scheme for private individuals somewhat less attractive, as the implicit compensation for investments in solar panels goes down. If, incidentally, the volume of the cross-border capacity is limited, the policy to stimulate renewable energy in a country may lead to larger price differentials between neighbouring countries, as occurred between Germany and France (Keppler et al., 2016).

Apart from this cross-border price effect, there is also a cross-border effect on the deployment of power stations. When German wind turbines generate more electricity, they replace the conventional production in Germany, but in the Netherlands this may, as a matter of fact, lead to more conventional production. This paradoxical outcome is the result of the fact that the power supplied by wind turbines in northern Germany must find its way through the network to the customers who are mostly located in the west and the south of the country and therefore, subject to physical laws, also draws on the electricity network in the Netherlands. The high wind energy generation in Germany thus adversely affects the cross-border capacity available for trading, which is why the Netherlands can import less (Pangan et al., 2016). However, this effect ceases to occur when the cross-border capacity is more voluminous and when Germany solves its internal congestions. A recent study shows that at many European borders the cross-border capacity available for the market is less than 50% of the technical capacity, leaving much to gain in terms of efficiency (ACER, 2015).

National measures to make the generation by coal-fired power stations more expensive (for example by levying a coal tax) or even impossible (by mandatory closure) may, as a matter of fact, stimulate production by coal-fired power stations in the neighbouring countries. Such national measures shift the merit order of the domestic production upward (in the case of coal tax) or to the left (in the case of closure), making other, foreign power plants more competitive. Therefore, a closure of power plants in the Netherlands will lead, *ceteris paribus*, to more generation with coal-fired power stations in the neighbouring countries and a consequent increase in CO_2 emissions (Zeng, et al., 2016; ABB, 2016). This does not only mean that the domestic environmental impact is partly undone, but also that the neighbouring countries will have to incur more costs to realise their energy transition objectives.

Closing coal-fired power stations is expensive for electricity consumers, but hardly beneficial for the environment due to the European system of emissions trading. If closure is realised within a short period of time, the electricity price will rise considerably. If a longer period is allowed for closure, the price effect will be limited, but even in that case consumers will be faced with the financial consequences. Shareholders will demand compensation, and this compensation will eventually have to be paid by electricity consumers or tax payers.

Given the international integrated electricity markets, these examples show that the energy transition policies must be coordinated to minimise the costs. The same applies to measures to improve the operation of the electricity market, including the introduction of a capacity mechanism (ACER, 2013). The introduction of a capacity mechanism in a country may lead to externalities in the neighbouring countries, such as lower electricity prices and, consequently, reduced investments in production capacity (Cramton et al., 2013).

The spillover effects to other regions also occur within countries. Empowered by the decentralised character of renewable energy in combination with financial support schemes (such as the net-metering scheme, SDE+), some local communities try to become independent from the electricity markets.[34] This preference for independent renewable energy systems is connected with a preference some have for physically realising the energy transition themselves without depending on the existing market system. Of course, this tendency to be independent affects all parts of the electricity system as it reduces the demand response potential in the market, the financial basis for maintaining the networks and the basis for taxing energy. All these effects imply a rise in the costs for other market participants. Such spillover effects to other parts of a market are normal phenomena really, and all market participants will continuously have to adjust to changing circumstances. The pursuit of local systems where all energy is renewably generated as much as possible in the own region raises the costs of the energy transition, though, while the volume of renewable energy generated nationally will not increase.[35] After all, the smaller the region that has to generate the renewable energy, the fewer its possibilities. The costs of local solutions, therefore, are contrary to the above-mentioned benefits of the international integration of markets. As local independent electricity systems serve no public interest, there is no reason for the government to support a tendency towards independence.

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[34] See for example https://www.noordelijklokaalduurzaam.nl/lokale-energie/. In 2016, there were 313 energy cooperatives in the Netherlands totalling a generated wind power of 115 MW and solar power of 23 MWP Source: http://www.hieropgewekt.nl/lokale-energie-monitor.
[35] See also *Vrijhandelsoptiek*, 13th volume, 6 February 2017.

7.2 Energy transition and emissions trading

In their energy transition policies, governments focus on bringing about a change in the composition of the energy sector, but energy transition is never a goal in itself. These policy ambitions originate in the wish to mitigate the risk of further climate change. The ultimate goal is to curb greenhouse gas emissions. Therefore, besides the renewable energy objectives, there are also objectives at EU level for the reduction of CO_2 emissions: - 20% in 2020 and -40% in 2030 relative to the 1990 level. These objectives were allocated to the sectors that are subject to the European emissions trading system (the ETS sectors) and the other sectors (the so-called non-ETS sectors). Subsequently, the objectives for both groups were allocated to the Member States, *inter alia* based on the relative level of economic development (measured by their GNP) (EC, 2014).

The distribution - also: primary allocation - of emission allowances is based on the national objectives for emission curbing in the ETS sectors. At first the allowances were allocated for free (so-called grandfathering [36]), but they are increasingly sold by auction. The manner of allocation makes no difference to the eventual price of CO_2, at least theoretically. Free allocation of emission allowances can be viewed as a lump sum subsidy (i.e. subsidy based on the total volume of emissions), but the incentive to curb emissions is determined by the marginal costs (i.e. the price of CO_2). This price is determined by the marginal costs to curb emissions up to the emissions ceiling, and these costs are the same in both forms of allocation. [37]

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[36] This term is understood to mean that the allowances are distributed on a historical performance basis.

[37] As both forms of allocation result in the same CO_2 price, selling the allowances by auction will not lead to a greater competitive disadvantage for internationally operating companies than *grandfathering*. However, in the latter option companies are granted a lump sum subsidy which enables them to absorb any adverse effects on their competitiveness. Such companies may then remain located in the ETS area, whereas in the case of an auction they might move their activities to other regions. If they do not move their activities, the demand for allowances will be higher than if they do. A higher

The electricity sector is one of the ETS sectors, which means mandatory participation in ETS for all electricity generation in power plants above a certain lower limit[38]. In the Netherlands, the electricity sector is responsible for approximately half of the ETS sector's total emissions. Recently, this portion has increased due to the increased generation by coal-fired power stations (see also figure 2), which led to a rise in the CO_2 intensity of the electricity sector (Mulder, 2016).[39]

The mandatory participation of the electricity sector in ETS has major implications for the effects of energy transition on the emissions of CO_2 in the electricity sector. Although an increase in the share of renewable energy or closure of coal-fired power stations affects the composition of the electricity generation, it does not affect the total CO_2 emissions. This is the so-called waterbed effect of the ETS. Reduction of CO_2 emissions, for example due to the closure of coal-fired power stations, results in a declining demand for or a growing supply of emission allowances. Both scenarios put pressure on the price of CO_2 emission allowances. After all, the ETS is a cap and trade system, which means that the environmental impact (i.e. the level of the total emissions) is determined by the ceiling and the costs incurred are determined by the price of the permits. Reduction of emissions due to the promotion of renewable energy has, *ceteris paribus,* no environmental impact, but only affects the costs incurred for the remaining emission curbing. Therefore, subsidising renewable electricity indirectly also means subsidising the other ETS participants.[40]

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demand leads to a higher CO_2 price and therefore to more curbing measures elsewhere in the ETS. These additional measures are necessary, too, because in the end each adjustment in the emissions trading system is a pay-out and claw-back solution.

[38] This lower limit is that the rated thermal input (i.e. capacity to combust fuels) must be at least 20 MW. Source: www.emissieautoriteit.nl.

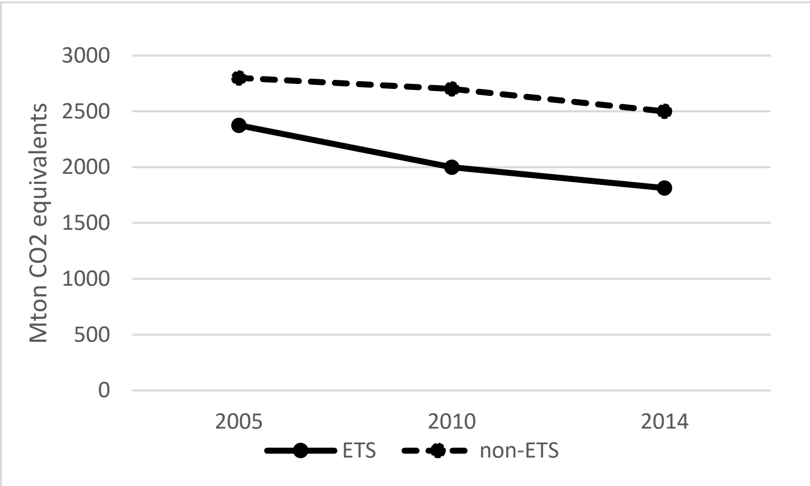
[39] Source: http://www.clo.nl/indicatoren/nl0584-ets-emissies-kooldioxide.

[40] Model studies show, incidentally, that a sharp increase of renewable energy can neutralise the waterbed (Zeng et al., 2016). If the share of renewable energy has

In discussions on ETS, its effectivity is often measured by the level of the CO_2 price (PBL, 2013). The fact that for many years this price has been considerably lower than expected is sometimes wrongly seen as an inadequacy of ETS. However, the performance of ETS must be judged by a) the degree of emission curbing and b) emission curbing being executed as efficiently as possible. Since the start of this system, emissions in ETS have been curbed by nearly 3% annually, more than necessary according to the ceiling (figure 4). In addition to that, the emissions in this sector have been curbed further than in the non-ETS sector, where the emissions of greenhouse gases fell by 1.25% per year in this period. Therefore, ETS is effective in reducing the greenhouse gas emissions. The fact that the price of CO_2 is low at the same time must, as a matter of fact, lead to the conclusion that the system is functioning well. The lower the price, the cheaper it is for society to achieve the intended emission curbing. It may be so that the low CO_2 price is no incentive for investing in renewable energy, but that is not a correct criterion to judge the success of ETS.

increased sharply, this may lower the price of CO_2 until it hits the floor price (0 euro/ton). Then, the waterbed effect can no longer occur, so that a further increase in the supply of renewable energy leads to a net CO_2 curbing. The strong growth in renewable energy in Europe and the lower CO_2 price, partly caused by it, already seem to have resulted in this situation.

Figure 4. Greenhouse gas emissions in ETS and in the non-ETS sector, 2005-2014



Source: EEA (2016)

Any measures to increase the price for emissions of CO2 by, for example, levying a CO_2 tax or by the introduction of a floor in the price will therefore yield no environmental impact.[41] Such measures may lead nationally to a curbing of CO_2 emissions, but due to the operation of ETS it will result in a lower price of the emission allowances, so that elsewhere in the system emissions will increase.

[41] A price floor at European level may have an environmental impact, but only if the floor is higher than the price resulting from the ETS game of supply and demand. In such a situation the trade system will rather have the nature of a tax on CO_2.

8. Conclusion: policy recommendations

While achieving the ambitious energy transition targets is important to society, it is also costly. To keep these costs as low as possible and, thus, increase the chances of successfully accomplishing the energy transition, upholding the basic principles of the organisation of the electricity market to the greatest possible extent is required. Experiences with the design of the electricity markets in the last few decades have shown how the efficiency in this market has gradually improved by applying several of these principles. To cope with the anticipated strong growth in the supply of renewably generated electricity, the market design of the electricity market hardly requires adjusting.

One basic principle of a well-organised market is that scarce resources must be allocated based on market prices to the greatest possible extent. Interventions in the electricity market, for instance, allowing network operators to invest in storage themselves, suppress the workings of the scarcity prices and, thus, the efficiency of investments made by market participants in storage and generating capacity. When scarce subsidy funds are distributed, the largest amount of renewable energy per subsidy unit is generated if the scheme is set up in a generic way, i.e., independent of the technology that is used and when participants have to compete for subsidy.

Another basic principle is that the responsibility for footing the bill must be taken by those who have caused the costs or can influence them. As far as electricity grids are concerned, this implies that programme responsibility for keeping own portfolios in balance is a vital component of the incentives required to stimulate participants to produce or consume, as the case may be, the electricity which they have sold or bought in the forward markets as well as that the market participants minimise the costs of creating imbalance.

Even though energy transition is looked upon as something which can only succeed when "government agencies, the energy sector, knowledge institutions and society cooperate in pursuing shared objectives" (EZ, 2016), if the costs and the risks are to be kept as low as possible it is of the utmost importance to embrace the principle of a decentralised organisation in which decisions are made by separate parties which operate as autonomously as possible. Market prices cannot fulfil their driving and informing role well unless they are the resultant of independent decentralised decisions made by suppliers and consumers and, besides that, all participants are exposed to these market prices. This increases the chance of successful innovations because, ultimately, the best initiatives will emerge from a multitude of more or less successful ones.

Cooperation or coordination between market participants when they determine their investments or disinvestments in generating capacity decreases the efficiency of the system. Cooperation can generate welfare gains only where there are coordination problems which the market cannot solve, for instance, when new infrastructures are built, such as heating networks, and others are phased out, such as gas networks.

Local and national governments should not take the place of market participants because they feel that the energy transition process is too slow. It may be that the market is less dynamic in taking the energy transition on board than governments would want them to, that doesn't mean that the market doesn't work. Usually, the reason for market participants to not proactively implement green-energy projects is that the costs exceed their private or commercial interests. When local or national governments want to stimulate these market participants to take action in this respect, something will have to be done about the market participants' costs or revenues; their role must not be taken over by governments.

Market participants can only be put to use for achieving social objectives where competition is possible. This is not the case with electricity grids. These networks constitute a vital component of the electricity supply which all market participants depend on. A completely independent operation of these networks is, therefore, of the utmost importance. That is why network operators should not add tasks to their job of network operator which can be carried out by market participants as well. While storage of electricity, for instance, may help prevent network congestions from occurring, this task can be carried out by market participants. To stimulate market participants to invest in storage where this is efficient, dynamic network tariffs may be helpful, with the principle in mind that scarce network capacity can be priced. Another option may be that network operators request market participants to provide flexible capacity in a certain part of the network.

Furthermore, international embeddedness is required for keeping energy transition costs as low as possible. Even though local renewable energy initiatives are appealing to some, local solutions are, by definition, more expensive than solutions which come to the fore in an international system. Therefore, government support for local initiatives is not a logical thing to do. International coordination of energy transition is also required because electricity markets are international markets, so that domestic interventions in the electricity system may have cross-border implications, which may lead to higher costs for bringing about the energy transition. This means that domestic environmental effects can leak away to other countries, even without emissions trading.

Finally, if the reduction of CO_2 emissions is to materialise effectively, taking measures for promoting the share of renewable energy within the electricity sector only is not sufficient. In a system with emissions trading these measures do not bring about fewer emissions, but cut the costs of emissions reduction within the trading system. Subsidies for renewable energy are thus subsidies for all participants in the trading system. As costs are cut for the participants in the trading system, it is more cost-effective for them to do more about emission reduction than is necessary in the framework of the current emissions cap. Therefore, energy transition can increase public support for further emissions reduction within the ETS. This reduction can be achieved in various ways.

At a European level, the ETS cap may be lowered further, as has been proposed by the European Commission.[42] The EU might also bring more sectors under the ETS in order to subject the emissions in these sectors to the total emissions cap as well. These measures may be made only at a European level, which means that all the Member States must give their approval.

Separate Member States, companies and citizens may take emissions-reducing measures themselves, though. One example is electrification, for instance, in transport or for domestic heating, so that energy consumption which was initially outside the ETS is brought into the ETS. Each petrol car which is replaced by an electric car and each gas-fired boiler replaced by a heat pump lead to a reduction in the CO_2 emissions. Even though the electricity is partly generated with the help of coal-fired power stations, total emissions cannot increase because of the ETS requirements. Therefore, electrification results in an increased demand for emission allowances, an increase in the CO_2 price and a reduction, somewhere, in the ETS sector.

An even simpler way of reducing CO_2 emissions is to buy emission allowances and, subsequently, cancel them without using them. This increases the scarcity in the emission allowances market, which leads to an increase in the CO_2 price and requires the ETS sector to do more about emission reduction.[43]

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[42] The European Commission has proposed to decrease the emissions cap by 2.25% each year from 2020 (EC, 2016).
[43] For instance, emission allowances can be purchased and cancelled by making use of the British think-tank Sandbag; see www.sandbag.org.uk.

Seen in this light, competition policy and climate policy do not need to have a tense relationship but can reinforce each other. In that event, electric power is generated in the cheapest possible way, electricity consumers do not pay more than is necessary, innovation takes place and, besides that, the CO_2 emissions go down.

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While achieving the ambitious energy transition targets is important to society, it is also costly. To keep these costs as low as possible and, thus, increase the chances of successfully accomplishing the energy transition, upholding the basic principles of the organisation of the electricity market to the greatest possible extent is required.
The author discusses these basic principles and the extent to which they must be adjusted because of the energy transition. The topics discussed include the wholesale market pricing, investments in power stations, the way in which the network operators keep the electricity network in balance, the opportunities which suppliers have to increase consumer involvement in the electricity market, citizens' desire for setting up local energy cooperatives, the increase in the degree to which the electricity markets in different countries are interconnected and the relationship with the European Union's emissions-trading system.

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