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European Power Struggles. Can EU's Decarbonisation Agenda Break the State-Company Axis in the Power Sector?

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Summary

Europe's power system is still marked by a distinct national component, and despite some regions with strongly integrated power systems, electricity supply today still has a largely national basis. Policies to decarbonise the power sector may fundamentally alter this situation, because power generation from renewable, carbon-neutral sources may require large, flexible, and heterogenic power pools as backdrop for efficient operation. Integration of little or non-integrated parts of the European power system is therefore a key element for the successful transition of the European power sector towards more renewables. But a development which fosters integration, growing transmission distances and bigger markets will likely lead to a reshuffling of allocation of power generation capacity in Europe. As with any fundamental policy change, decarbonisation of the power sector will create new winners and losers. Moreover, an integrated power system will probably cause new dependencies on the good-will of neighbouring countries. Europe is hence confronted with a 'catch-22': On the one hand, policy makers see the advantages of renewables and the exploitation of domestic energy resources, yet the necessary adaptations of power generation, distribution and consumption implies the risk of 'harming' the national power sector. EU policies to increase renewables and to create an internal energy market (IEM) thus aim at ameliorating this situation by e.g. both stimulating construction of renewable energy infrastructure and creating more interconnectors between member states. But due to various interests at the national level, member states' levels of ambitions in contributing to achieving these overarching targets vary a lot. The instruments the European Union has at her hands will therefore have to be refined if the reluctance of member states to integrate power systems is to be overcome.

Keywords: Decarbonisation, Electricity generation, Energy policy, European Union, Interconnectors, Member States, Political negotiations, Policy making, Power grid, Power transmission system, Power pools, Power system, Regulatory framework, Renewable energy

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European power struggles

Can EU's decarbonisation agenda break the state-company axis in the power sector?

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Contents

Abstract

Europe's power system is still marked by a distinct national component, and despite some regions with strongly integrated power systems, electricity supply today still has a largely national basis. Policies to decarbonise the power sector may fundamentally alter this situation, because power generation from renewable, carbon-neutral sources may require large, flexible, and heterogenic power pools as backdrop for efficient operation. Integration of little or non-integrated parts of the European power system is therefore a key element for the successful transition of the European power sector towards more renewables. But a development which fosters integration, growing transmission distances and bigger markets will likely lead to a reshuffling of allocation of power generation capacity in Europe. As with any fundamental policy change, decarbonisation of the power sector will create new winners and losers. Moreover, an integrated power system will probably cause new dependencies on the good-will of neighbouring countries. Europe is hence confronted with a 'catch-22': On the one hand, policy makers see the advantages of renewables and the exploitation of domestic energy resources, yet the necessary adaptations of power generation, distribution and consumption implies the risk of 'harming' the national power sector. EU policies to increase renewables and to create an internal energy market (IEM) thus aim at ameliorating this situation by e.g. both stimulating construction of renewable energy infrastructure and creating more interconnectors between member states. But due to various interests at the national level, member states' levels of ambitions in contributing to achieving these overarching targets vary a lot. The instruments the European Union has at her hands will therefore have to be refined if the reluctance of member states to integrate power systems is to be overcome.

1. EU's decarbonisation agenda: Past achievements, future constraints

Five years ago, in October 2009, the European heads of state and government agreed on an ambitious long-term climate policy objective in order to prevent dangerous anthropogenic interference with the climate system and to ensure the European Union (EU) plays its part in limiting global temperature increases to 2°C (European Council 2009). European policy makers therefore decided to bring the European Union on a demanding decarbonisation path, with the objective to develop instruments to reduce greenhouse gas (GHG) emissions by between 80 and 95 per cent by 2050 (European Commission 2011a), as compared to 1990 levels. National policies in many member states aim in the same direction, as the examples of Germany, Denmark and Sweden show (e.g. DEA 2014, MSD 2005, Sattich 2014).

Energy policy is one of the main fields in this regard (see IPCC 2014), as decarbonisation of the economy in only a few decades implies a major and swift transformation of the energy sector towards almost zero GHG emissions. In an attempt to define a common framework for the future evolution of the energy sector, the European Union therefore developed and implemented a diverse set of policies. Decarbonisation became part of these policies only recently, yet despite its short history, it is particularly important, as it provides an overarching narrative which focuses earlier elements of EU energy policy on the aim of limiting the use of fossil fuels to an absolute minimum. Decarbonisation can therefore be described as a strategic factor which guides EU energy policies towards the overarching goals of near to zero CO_2 emissions.

The power sector plays a fundamental role in this context, as it represented about 37 per cent of the total CO_2 emissions in Europe in 2012, and is believed to be one of the sectors where decarbonisation could take place in the quickest and most economical way (Roques 2014, p. 82). This requires a large-scale renewables expansion in order to substitute fossil fuels in electricity generation. Accordingly, large-scale use of carbon-neutral renewables is one of the key elements of EU's decarbonisation agenda. Different indicators show that the mix of energy sources that supply industry, transport and households with the necessary power, is indeed in transition. Renewable power has increased massively during the last decade in particular in Europe; the result is that the contribution of carbon-neutral renewable energy (RE) grew by about 64 per cent since 2004, so that renewables in 2012 already accounted for about 24 per cent of electricity

generation (EUROSTAT energy statistics). With expected faster electrification of other sectors, including industry, transport and buildings (Sugiyama 2012), the power sector's contribution to decarbonisation is likely to grow further.

Given the significant increase of renewables (as well as their positive prospects[1]), and the relative decline of carbon-based energy carriers (see Fig. 1), the European decarbonisation agenda hence seems be on track(see Fig. 2). If this trend continues, renewables will cover an ever more significant share of Europe's energy mix and relatively soon deliver a main part of the future energy supply (see also European Commission 2011a).

Yet today *conventional*[2] plants still largely define the *logic* of power systems. The latter are designed to provide a technical and economic environment that is adapted to the *needs* of these power stations. The adaptation of *conventional plant-dominated* power pools to the use of renewables will be one of the major impediments for the further increase of RE with today's technologies (see European Commission 2012, pp. 6-9), because a fundamental change in the economical and technical *logic* of power generation (such as the large scale integration of renewables) affects the existing system *as such*, and hence requires subsequent and more or less costly adaptations (for technical details see section 2). Thus, politicians, grid system operators, power companies and other relevant actors have to assess the trend towards more renewables with great caution.

In fact, a deeper analysis shows that the integration of renewables into the established power pools, and with it the transition of Europe's power system towards decarbonisation, is about to enter a new and critical phase. Renewables are about to reach a share in the power system significant enough to require fundamental adaptations of the established structures of power generation, transmission and consumption mentioned above, if new RE generating facilities are to operate at their full capacity. In some member states, e.g. Germany, where renewables are outcompeting gas and nuclear power stations, this point maybe reached (Bloomberg 2014; ISE 2015).

[1] The 2020 targets for the domestic use of renewables set out by the Renewables Directive (Directive 2009/28/EC), e.g. on average 20% by 2020 might very well be over fulfilled (see EEA 2014 and Commission 2014a).

[2] Carbon-based (e.g. coal, gas, oil) and low-carbon (e.g. hydro, nuclear), dispatchable and centralised power plants.

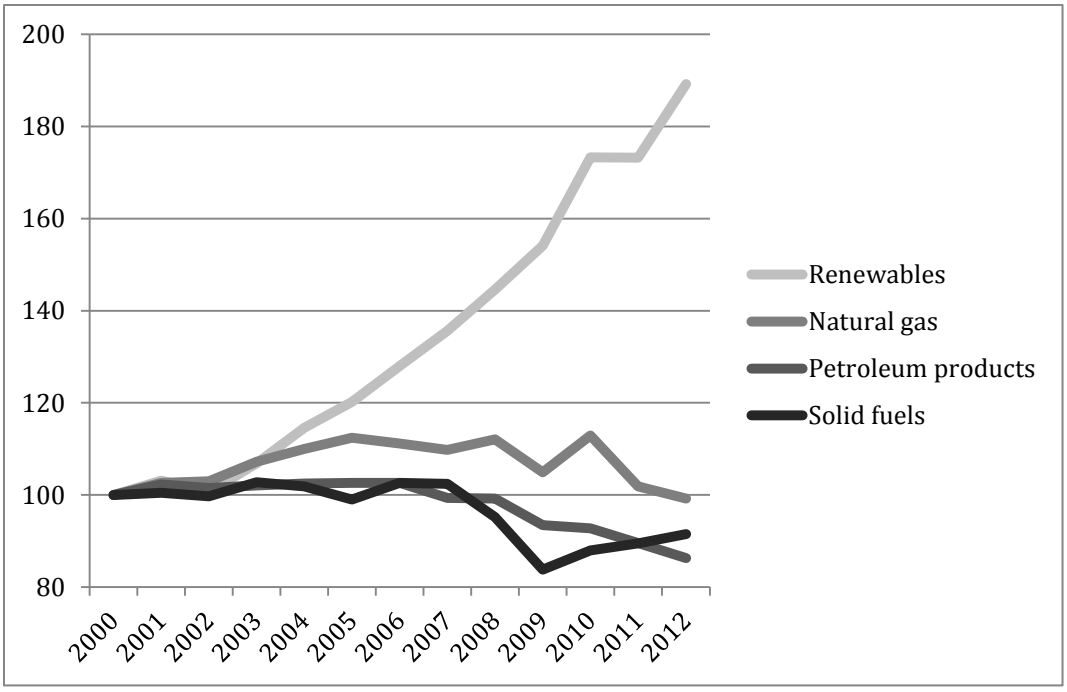

Figure 1: Development of different energy carriers in the EU-28 from 2000-2012 (EU gross inland energy consumption by fuel type (1000 tonnes of oil equivalent), 2000 = 100 per cent)

Source: EUROSTAT energy statistics

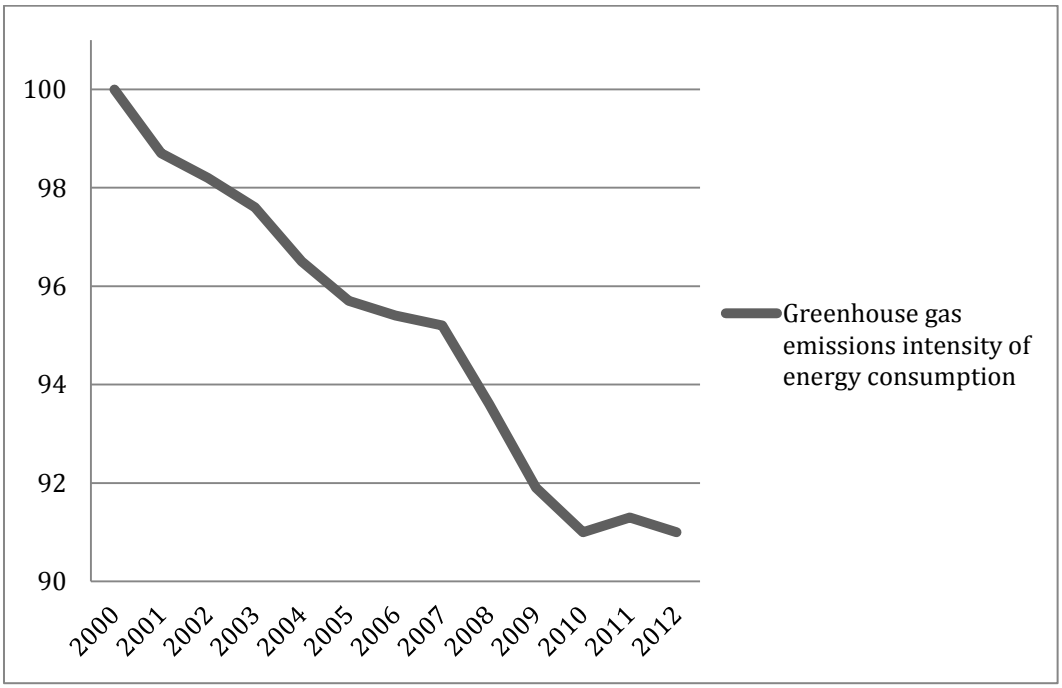

Fig. 2: Greenhouse gas emission intensity of energy consumption in the EU-28, 2000 = 100 per cent)

Source: EUROSTAT energy statistics.

Cross-border power transmission infrastructure plays an important role in this regard, because the low interconnector capacity rather isolates than integrates power pools in Europe. Many studies therefore point at the need for more exchange capacity in order to increase renewables, and indicate that efficient full decarbonisation of the power sector

implies the need for a Europe-wide power pool (e.g. ENTSO-E 2012). The question hence is, whether European decarbonisation policy at present has the right tools to overcome concerns about and opposition against the integration of national power systems in Europe into a European power pool. This working paper therefore asks:

> *Whether and to what extent do EUs decarbonisation policies provide the right means to overcome the fragmentation of the European power system?*

The following section therefore first examines the complex technical-economic relationship between renewables and the (cross-border) grid infrastructure in more depth (section 2). Based on this examination the working paper then reviews the EU policies which aim at integrating different parts of the European power system and adapt the power infrastructure to the technical and economical requirements of renewables (section 3). The paper concludes with a discussion whether EU decarbonisation policy has the right instruments at hand to overcome the *geo*-economic frictions that hinder the integration of power systems in Europe into a European *power pool*[3] (section 4), and a number of recommendations for a coherent and effective policy framework (section 5).

2. Power pools and their (potential) role in decarbonisation

Because storage of electricity with today's means is difficult and costly in most European countries, power generation generally has to follow changing load in real-time in order to keep main voltage and grid frequency stable. Power plants therefore operate as interacting components in integrated power pools where the different generation units *dispatch*[4] their power output to the momentary *load.*[5] The role of electricity grids in these power pools is to optimise this system, with interregional power lines providing power system operators with the flexibility needed to keep the network stable despite local load changes (ECF 2010, p. 70). The larger, the more flexible and diverse a power pool is, the better a network can be stabilised, and the closer to their optimal utilization factor (e.g. full capacity or optimal profit) individual plants can operate (Sattich 2014).

[3] A power pool consists of two or more facilities who combine their resources to better meet their individual needs. These resources can include generating facilities, transmission system access, emergency response capability and even accounting and billing databases. This pooling of resources allows utilities to keep costs low and insure higher reliability through "strength in numbers". Pooling is an accepted, desirable and often mandatory efficiency strategy in regulated energy markets, but in deregulated markets it is usually a voluntary activity (from EnergyVortex Energy Dictionary).
[4] The adjustment of power output to the system's varying demand.
[5] Moment-to-moment power requirement in the system.

Conventional plants still play a dominant role in these pools and thus exert a major influence on the structure and logic of the entire system. The technical features of intermittent renewables such as wind and solar divert, however, partly from those of conventional plants, and *disturb* their interactions. For older conventional plants it may be difficult and costly to balance the quick fluctuations of wind and solar (see e.g. Schaber, Steinke & Hamacher 2012, p. 123). Moreover, renewables[6] tend to outcompete conventional plants, but in many cases the latter are obliged by regulating authorities to stay online in order to ensure generation capacity in the times when there is little wind or sun. Decarbonisation of the power sector does thus not only consist of replacement of old power generation units with new, carbon-neutral ones, but also, generally requires the reorganisation of the power pools in which renewables operate (see e.g. Schaber et al. 2012).[7] Consequently, from a certain level on renewables either dictate the logic of those power pools they are integrated in (and the required reorganisation/adaptation), or cannot deliver their full potential.

Power grids play a fundamental role in this context, as they are the prerequisite for flexible, interactive operation of power plants, for the efficient allocation of generation units over a given territory, and for the interconnection between sites of generation and consumption. Several studies therefore point at the importance of the power transmission and distribution infrastructure for the switch to renewables. They conclude that European power grids need to be adapted, otherwise extensive decarbonisation will be much more difficult or expensive to achieve and/or delayed while waiting for other technological options such as storage (see for example Tröster, Kuwahata & Ackermann 2011). Intelligent systems to predict loads, smart grids (Capros et al. 2012, p. 96), smart meters and a densely intermeshed electricity transmission grid are widely believed to be key elements of the necessary adaptation (Fürsch et al. 2013, p. 642). Big data, analytics, cloud-based technology, and the internet of things are all making contributions to a smarter energy system, which is likely to revolutionise the energy sector (Bowden 2014).

For grid operators, calculating predicted needs for grid improvement in a longer time perspective has, however, become a hard task, as future grid demand depends on many

[6] Often RE power generation is subsidised/supported.
[7] Different forms of renewables differ, however, largely with regard to their dispatchability and centralisation, and thus in their impact on the power system.

factors that are difficult to estimate. Factors include the level of technical development and prices of renewables infrastructure, what neighbour countries will do in terms of connecting themselves the other neighbouring markets, weather conditions etc. In addition, some places, whole villages are deciding to go off the central electricity grid or reverse the traditional roles, such as in the German town Wildpoldsried, which produces five times more electricity than it consumes (Energytransition 2014). Moreover, grid development has to adapt to the trend where a growing proportion of consumers are becoming *prosumers*, which means that consumers are both producing their own electricity (from e.g. rooftop solar panels) and regulate their own demand more efficiently (e.g. Eid et al. 2014).

This poses several questions of technical, economic, legal and political nature: What kind of power generation units will and should be built, where, at what size, and when? What may be needed in terms of infrastructure upgrades? What sorts of drivers and barriers are in place? How are policy developments in the EU responding to such challenges? And how will the European power system develop under the framework of EU and national decarbonisation/energy policies? In order to answer some of these questions, the following sections aim to provide a better understanding of the organisation and operation of power pools, especially with regard to cross-border interactions (section 2.1), and to describe the complex relationship between the renewables in this environment (section 2.2), as well as the necessary reorganisation of the European grid (section 2.3).

2.1 From isolated electricity systems to a European super-grid?

At the very beginning of electrification at the end of the 19th century, power systems in Europe were locally organised and isolated. They consisted of a number of small plants in major cities such as Berlin or London, serving the illumination of individual streets or the electrification of small factories or workshops. Yet the new technology advanced quickly, and technical progress soon enabled transmission distances over hundreds of kilometres at relatively low losses and costs. Until the early 20th century the original power circuits therefore expanded from the city centres to the suburbs, and from plants closer to coal and hydro resources located far outside urban centres into the cities (Lagendijk and van der Vleuten 2013, pp. 64-66).

Moreover, technical standardisation enabled the interconnection of formerly isolated systems of independent plants (and companies) to more complex power pools. This step towards heterogenic power pools which integrated different plants in one system, resulted in a better economic mix, with greater security of supply and less generation capacity overcapacities (for details on this step in the early days of power systems, see: Hughes 1993). As a result the early power pools quickly expanded to include a growing number of interacting, complementary elements such as different plants (with varying characteristics, e.g. availability) and consumption centres (with different loads, e.g. peak demand).

But even though complex power pools turned out to be a big advantage compared to the earlier, isolated systems, they remained largely local/regional/sub-national in the first half of the 20th century. Where first cross-border electricity transmission lines emerged, they served local purposes only. But with the possible transmission distances becoming longer, the question arose, what the optimal dimension of the power system would be. The reflections of plans for the future power system therefore soon got a transnational, and even European dimension (Lagendijk 2008, p. 80). In this regard it is remarkable, that the added value of a European continental super-grid – coupling plants and major consumption centres all over Europe by means of large-scale grid expansion and the construction of an European overlay network – was already under discussion in the 1920s and 1930s (see Hughes 1983, and Lagendijk 2008, see also section 3.1).

The underlying reasoning of this early debate was threefold: technical (1), economic (2), and political (3):

1. Interconnection between different sorts of plants such as coal and hydro on the one hand, and different consumption centres on the other, has large advantages over simple circuits with only one or a limited number of plants with similar characteristics. Combination of different load factors with plants of complementary characteristics allows a more rational use of material, infrastructure and resources.
2. A European system was therefore regarded as the most economically rational solution, particularly during the Great Depression, with engineers discussing the potential of such a transnational electric power system.
3. Debated on different layers of the international system, for example in the League of Nations as an alternative to a purely national development, the early

deliberations of the future European power system and the potential of an overlay network had a distinct political aspect. It featured a clearly Europeanist undertone and was favoured by the young European movement that promoted the idea of supranational cooperation.

The respective arguments arguably largely resemble those of today's debates. Thus, even though debates about the added value of super-grids, interconnection, and the benefits of different forms of electricity generation appear to be of recent date, they actually date back to the first half of the 20th century.

The evolvement of state and sector interests after the Second World War brought these debates, however, to an end; instead of a European super-grid, an axis between power companies and the nation state emerged that became the most prominent feature of Europe's post-war power system (Van der Vleuten and Lagendijk 2010, see also below). The power system thus remained a national prerogative, and energy policy remained under strong influence (or even in the hands) of vertically integrated, in many cases state-owned power companies which had monopolies in power production and transmission on the national (or sub-national) level.

Even though power transmission infrastructure could have been a potential prime candidate for a common European policy following the Second World War, national thinking prevailed, and energy policy turned out to remain one of the policies where the nation states prioritized sovereignty to the largest extent.[8] Together the national perspective of policy makers on energy related issues, the tight ties between policy makers and power companies and their economic rationale, hence blocked new initiatives to Europeanise the power system. Consequently, the Rome Treaty of 1957, which established the European Economic Community (hereafter Community), did not include electricity (Meeus, Purchala & Belmans 2005, p. 26),[9] and the Community institutions merely remained an additional player in this context.

Moreover, the focus of the state-company axis rested on national markets and investments in the national power systems. Cross-border integration therefore not only evolved outside the framework of the emerging Community (Van der Vleuten and Lagendijk 2010), but had low prominence amongst policy makers and managers, and

[8] See for example the failure of the 1974 Council resolution concerning a new energy policy strategy for the community to produce results (European Council 1974).
[9] Electricity was considered a service.

was only a secondary aspect in the overall evolution of the European power system. Rather than being a key element in the emerging European power system, and despite the fact that interconnection of plants and consumption centres was possible over hundreds of kilometres without significant transmission losses, cross-border interconnectors were hence merely constructed gradually and on an ad-hoc basis.

As a result, interconnection capacities to import/export electricity between neighbouring countries generally remained very low. In other words: Despite some *pockets* along borders, where the national power systems of neighbouring countries have been interconnected and thus interacting with each other, each European country developed its own power system, with an infrastructure and sufficient generation capacity to supply its own economy and population with electricity (Van der Vleuten and Lagendijk 2010). The underlying political and economic conditions of this fragmented European system stayed largely unchallenged until the 1980s, and the European power system still reflects the strong role of the state-company axis on the one hand, and weak Community involvement on the other.

But even though the economic rationale of utilities and the national perspective of policy makers largely prevailed over the idea of a top-down implemented European power system (Van der Vleuten & Lagendijk 2010, p. 2045), the dualism between the state-company axis and the supranational approach to the development of power systems in Europe never fully disappeared and can be traced through the decades (Lagendijk 2008, pp. 80ff.; see also section 3.1). Moreover, some countries proceeded with international integration of power systems on their own initiative, resulting in international power pools such as Nordpool (the Nord Pool Spot stock exchange for the Swedish and Norwegian markets was established in 1996) in Scandinavia, which is the world's first international power market (Newbery et al. 2013, p. 12).

The generally low integration of power systems in Europe does hence not imply that there is no integration of national power systems today. Cross-border interconnections exist between most neighbouring countries, and in some regions the power transmission infrastructure has significant exchange capacity. Beyond the Scandinavian countries, the German-Dutch couple would be an example for such a high level of integration. But these regions/countries are selective exemptions, and only mark one extreme of the spectrum. Other regions/countries show low capacities for cross-border exchange of electricity relatively compared to the installed generation capacity. An

example for such a situation is be the French-Spanish border, where a significant increase of capacity for electricity exchange could be possible, but has not achieved the last decades[10]. This and other comparable cases hence mark the spectrum's opposite extreme.

In between of these extreme examples a heterogenic group of cases can be located with varying levels of (relatively low) interconnection. As an example for this group may serve the Central European case, where large cross-border flows of electricity occur at peak hours of wind power generated in Northern Germany, which threaten to overcharge Polish and Czech grids. In this particular case the power flows are not only erratic and unplanned, but also not welcome by the receiving side, which therefore is planning the construction of technical installation to block them (see Puka and Szulecki 2014).

In sum the power system in Europe can be described as a heterogenic patchwork of integrated and mostly not (so well) integrated components of still largely national power systems. In general the situation is hence such that cross-border interconnection is relatively low compared to the installed power generation capacities. More interconnection could be possible and has been subject to political discussions during the last decades, but large scale interconnection has not been achieved yet. Exchange between the different national systems therefore seemingly has stagnated at 7-10 per cent (ENTSO-E online electricity exchange data, see Fig. 3)[11]. With generally low Net Transfer Capacity values, today's power transmission infrastructure *in Europe* can therefore only partly be described as *European*, and hence rather prevents free flow of electricity in Europe than to promote it.

[10] This situation might be, at least, somewhat altered/ameliorated, with the ongoing land interconnector and the new planned interconnector under the ocean between Spain and France.
[11] This situation will likely be ameliorated with the gradual expansion of interconnections outlined in the list of the projects of common interest (PCIs) in the years to come.

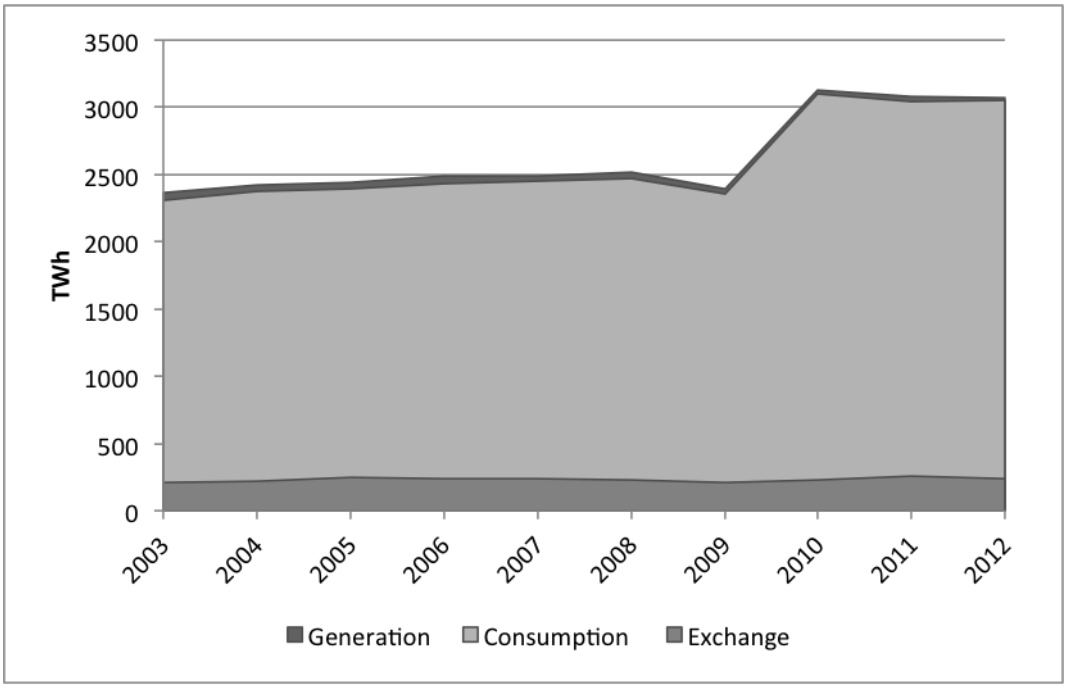

Fig. 3: Generation, consumption, and exchange of electricity across borders in Europe, 2003 – 2012

Source: ENTSO-E energy statistics

2.2 The power system and decarbonisation

In view of current trends in the power system it is estimated that about 80 per cent of the existing gaps and bottlenecks in the European power system relate to the integration of renewables (ENTSO-E 2012, p. 56). Many of the necessary projects have a cross-border dimension (ENTSO-E 2012, p. 91). Notwithstanding the underlying reasons for this situation, it compels the involved countries to maintain power supply on a national basis. In turn this leads to inefficiencies, larger reserve capacities than necessary, significant overcapacities, and – most importantly with regard to the topic under discussion here – key-holes between RES and load centres (ENTSO-E 2012, p. 56). In other words, the historical structure of power grids in Europe causes today's inefficient distribution of RE generation units and net welfare losses when compared to an *optimal situation* seen from a European point of view.

Without adaptations of the cross-border interconnection capacity even the bigger national systems may seem to be too *narrow* to serve as basis for the large-scale integration of renewables. Stronger integration on the other hand should – half by directly connecting RE, and half by accommodating inter-area imbalances triggered by RE (ENTSO-E 2012, p. 66) – avoid present congestion to worsen and new congestion to appear (ENTSO-E 2012, p. 56). It would thus lead to the more rapid phasing in of RE

power generation units close to their full capacity, improved security of supply and hence lower reserve and overcapacities. The EU's decarbonisation agenda thus involves initiatives to increase interconnectivity between national systems (see European Council 2014).

The pressure RE power generation puts on the established power pools varies, however, with the specific type and the location of generating capacity. Measures to adapt the grid infrastructure will therefore differ from region to region. Decarbonisation thus poses a double challenge for the European power transmission infrastructure:

1. The energy source co-determines the location of power plants. The switch to renewables will hence change the distribution of power plants and hence the *topography* of the grid.
2. The product of electricity generation changes with decarbonisation. In contrast to carbon-based systems, where standardised units of coal, oil or gas make the power system partially independent from meteorological effects, many RE plants depend on changing elemental forces such as wind and sun. Grid modernisation (e.g. smart grids and smart technologies such as the coupling of power transmission and telecommunication networks) may thus be required to stabilise power supply.

The changing topography of the European power grid

The relatively low energy density of many RE sources will require installations to be dispersed over large territories. Wind parks, for example, will have to be developed and interconnected. Second, these installations are likely to be further from the centres of consumption. As most renewables cannot rely on modern transport systems to bring the energy source to the plant, power transmission infrastructure will have to cover growing transmission distances in order to bring the electricity to the consumer. Other technologies such as small scale wind turbines, solar heaters and solar cells are, however, located close to or directly at the point of consumption and might thus reduce demand for increased grid capacity. These are contradictory trends, but as the distribution of renewable energy sources tend to be unequal,[12] decarbonisation is likely

[12] Load hours of solar- and wind power between the most and least favourable sites in Europe vary by factors up to 100 per cent (see Fürsch et al. 2013:650), but rapid cost degression of e.g. photovoltaic power will likely lead to instalments at sites which today seem uneconomical.

to result in a much more unequal distribution of generation sites than it is the case today, and thus to the need for new grid infrastructure.

Moreover, there are differences between the various forms of renewables. While wind, solar and tidal power tend to be highly concentrated in geographic areas that do not coincide with consumption centres, biomass can (partly) be transported to and used in the power generation infrastructure in place (such as in combined heat and power plants (CHP). The impact on the grid will thus vary largely between different regions and greatly depend on the regional energy mix. With the increasing use of electric vehicles to transport energy from one site to the next the picture will likely become further complicated. On the other hand, electrification of road transport may also make energy systems more flexible, because the car batteries can also serve as valuable battery capacity which are filled when the electricity prices are low and can refill electricity into the grid again when prices are high, thus contributing to stabilization of the electricity systems (Loisel, Pasaoglu & Thiel 2014).

The impact of intermittent renewables on the grid

Not only the changing location of generation sites, but also the changing product of power generation will have strong implications for the future shape of the European power grid. According to estimations of the International Energy Agency (IEA) and the European Commission, existing power pools are flexible enough to counterbalance five per cent of *intermittent* renewables such as wind and solar power in the system (European Commission 2012, p. 8). Where, however, intermittent RE exceeds this margin, additional measures, tools and technological innovations are required to provide the system with enough flexibility to absorb network fluctuations. 'The necessary measures depend largely on the given local configuration of electricity grids, the interaction between grid operators, the generation mix, the availability of backup generation capacities and the level of cross-border interconnection' (Faure-Schuyer 2014, p.1).[13]

In this regard, the European power system is close to a paradigm shift. In 2011, intermittent renewables already amounted to 35 per cent of RE-generated electricity in 2011 (nine per cent in 2002), and seven per cent of all electricity generated (Eurostat

[13] The larger, for example, the share of biogas, bio-liquids and biomass as energy carriers for electricity generation in a particular area, the better energy input and power output potentially can be controlled. More biomass hence may imply less infrastructure adaptation and expansion.

online data). It can be expected that this number will climb to 49.7 per cent of RE capacity by 2020 (ECN 2011b, p. 14, see Fig. 4 and 5);[14] if this trend continues *intermittent* RE will hence account for a total of 17-20 per cent of European electricity by 2020 (ECN 2011a). And, as most of today's conventional plants will be decommissioned in the next decades, much of this generating capacity needs to be replaced.

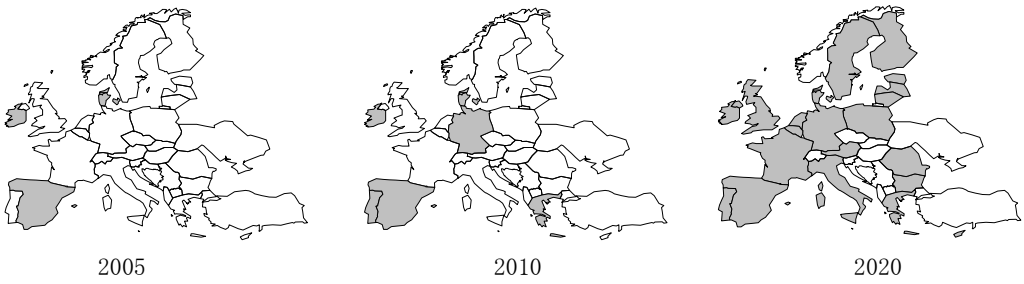

Fig. 4 EU members exceeding 5 per cent intermittent renewables in the power system in 2005, 2010, and 2020

Source: Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States (ECN 2011a)

The EU's power sector is thus headed towards an era where the characteristics of intermittent renewables will increasingly determine the logic of power generation, transmission and consumption. Increasing the flexibility of existing power pools and their transformation to a smart and flexible system is the key to the sector's further decarbonisation, and – in the long run – a complete switch to renewables. This situation will potentially pose a brilliant opportunity for political entrepreneurs who are trying to make governments decide on subsidizing particular technologies[15]. But with its capability to integrate otherwise isolated regions, and thereby to increase the capacity to keep growing network fluctuations under the control of systems operators, the power grid has a vital role to play in this adaptation. The need for more flexibility in particular areas depends, however, on the specific regional energy mix and how the energy carriers there operate together.

[14] The potential of hydropower, the most important non-intermittent form of renewables, is already to a large extent realised; this form of RES will therefore probably lose its relative share within the power mix in the future.

[15] This already seems to be the case for the companies lobbying for nuclear technology. Already, the governments in Finland (Olkiluoto 3) and in the UK (Hinkley Point C) have decided to expand their production capacity by subsidizing the construction of nuclear reactors which are much more costly than alternative sources of energy in terms of their levelized cost of production.

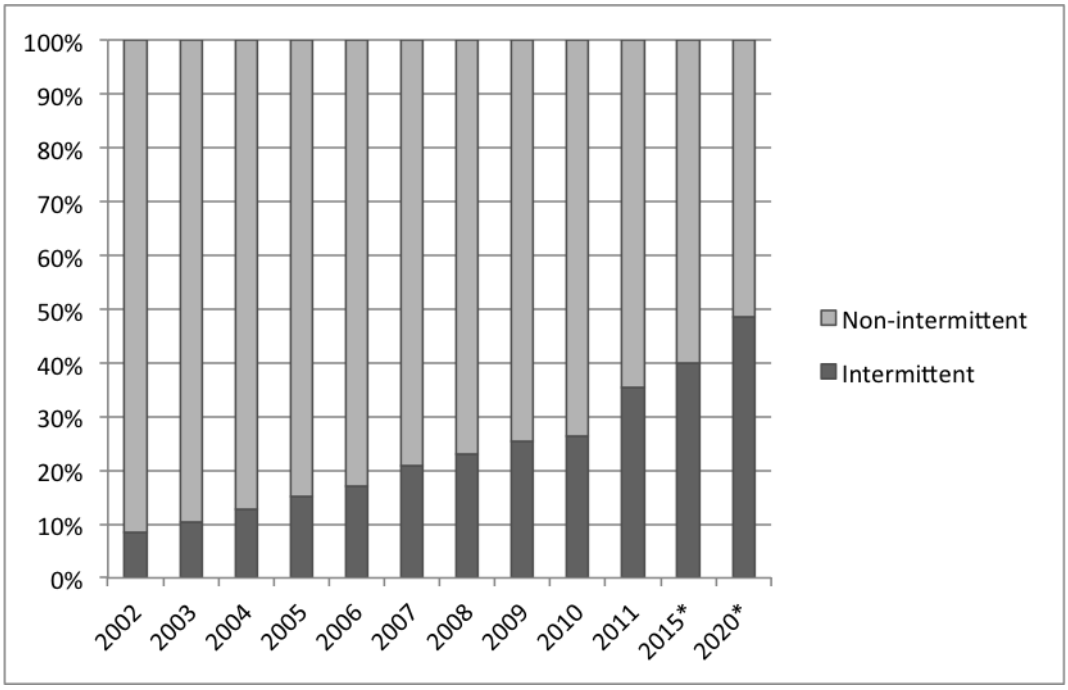

Figure 5: Share of intermittent and non-intermittent renewables in the EU-27 (per cent of all renewable-generated electricity).

Note: Data for 2015 and 2020 are estimates.

Source: EUROSTAT energy statistics; ECN 2011b, p. 14.

Another key element for the EU's decarbonisation policy is possibly the introduction of more modern gas fired power plants; these cause only low CO_2 emissions and are capable of reacting flexibly to the ups and downs caused by intermittent renewables. Even though there is quick progress in battery technology, flexible storage facilities will probably remain scarce for the time to come. Together with biomass, gas fired power plants might hence remain vital to balance network fluctuations and uphold security of supply. Their capacity in the system may possibly even have to be increased,[16] if near decarbonisation is to be reached with today's technologies.[17] New supply routes and probably altered entry points to the European energy system will be the result, making new infrastructure in the gas and electricity system necessary.

2.3 The reorganisation of the European power system

The European power grid has to be adapted to the requirements of renewable energies, if decarbonisation of the European power sector is to be continued. This need for grid

[16] Natural gas already contributed to 23 per cent of electricity generation in 2010 (9 per cent in 1990, data: EUROSTAT).
[17] With the unfolding crisis in Ukraine the future of natural gas and the respective transmission system in Europe is, however, very much unclear.

modernisation concerns different dimensions (see section 2.2), parts,[18] levels[19] and most geographical sections of the grid, and can thus be described as *universal*[20]. Ideas and plans for the reorganisation of the European grid are hence far-reaching, and potentially include the construction of regional (e.g. North Sea countries' North Sea Grid Initiative), continental (the super-grid) and even transcontinental networks (for example between North Africa and Europe). One of the options is a flexible and smart power pool of European size, where all power plants jointly balance the disturbance of one power station, regardless of its location (Battaglini et al. 2009).

The establishment of such a continental power pool has been regarded a convincing and economically viable possibility for better network stabilisation (Newbery et al. 2013, pp. 86-87). Filling the gaps in the European cross-border grid infrastructure can therefore be interpreted as largely untapped option (ibid.) for near complete decarbonisation at moderate costs (Haller, Ludig & Bauer 2012, p. 288). The varying characteristics of different RE technologies will, however, also pose *specific challenges* for particular, local and regional sections of the power grid. Thus, the question arises, where exactly grid development is required, what type is required, and where the necessary adaptations are most urgent.

Per area generation of intermittent electricity is helpful to understand where infrastructure adaptations are necessary (see Figure 5), as it reveals sharp differences between member states in their approach to renewables. While some countries show only a moderate density of intermittent renewables, and intend to keep their numbers limited, other countries decided to integrate large numbers of these plants into their national systems (ECN 2011a). This will result in largely varying need for interconnectors with neighbouring countries. Similarly, the need for gas as an energy carrier might increase where intermittent renewables demand balancing capacity; Altered gas supply routes, grids, and more LNG capacity at particular sites might thus be the result. Given that (cross-border) transmission distances and capacities will increase, this may lead to further shifts in generation capacity.

[18] Uptake, transmission, distribution, off-take, net metering etc.
[19] Regional, national and international.
[20] The advanced age of many parts of the European grid contributes to the necessity for universal grid modernisation.

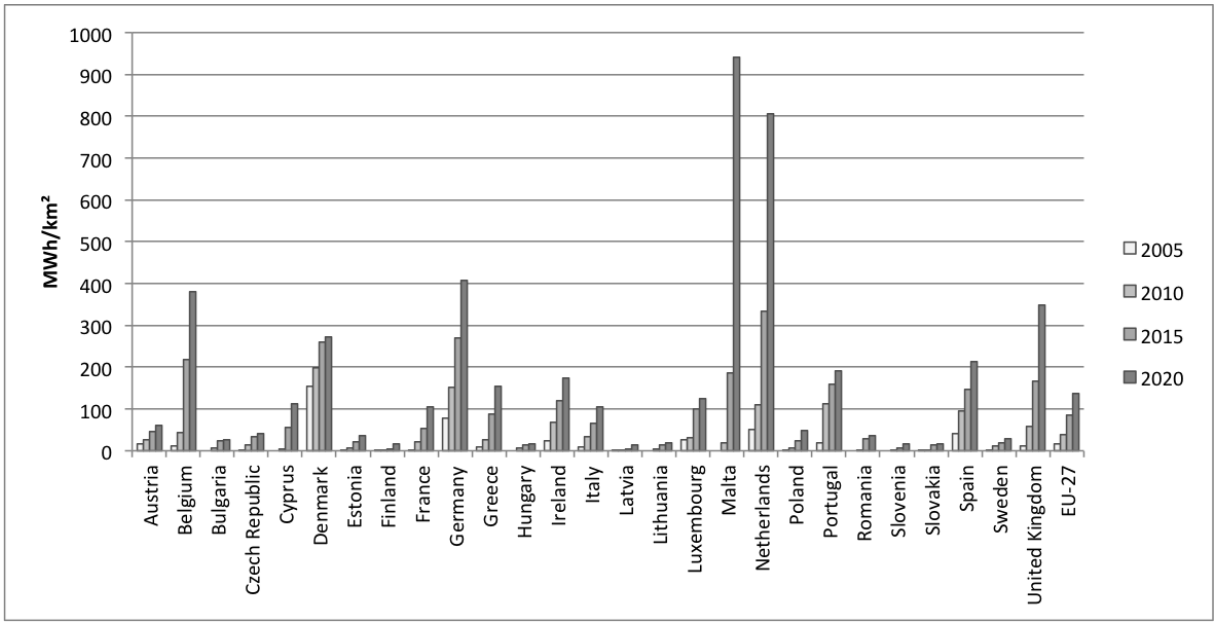

Figure 6: Calculated per area generation of intermittent electricity (solar, tidal, wind) (MWh/km^2).

Note: Data for 2015 and 2020 are estimates.

Source: ECN, 2011a , p. 124, 132, 142.

3. EU's decarbonisation policy and the integration of European power pools

The EU has several means at its disposal to affect the development of power systems in Europe. While member states remain the right to decide on their own energy mix,[21] Article 194 of the Lisbon Treaty (Treaty of the Functioning of the EU, TFEU), gives European policy makers four different competences to influence the future shape, organisation and working logic of power pools:

- Ensuring the functioning of the energy market
- Promoting the development of renewable forms of energy
- Ensuring security of supply
- Promoting the interconnection of networks

The adaptation of power pools to the requirements of decarbonisation rests on these competences. This section describes in more detail what policies the European Union developed over time on their basis (section 3.1). The integration of electricity transmission networks is a central element in this regard, as it is the basis for market

[21] The Court of Justice of the European Union recently confirmed this national prerogative in the Åland-case, 1 July 2014.

integration, the integration of renewables, and increased security of supply. The respective EU policy is therefore presented separately (section 3.2).

3.1 Market integration, renewables, supply diversification – a historical overview

The oil crises of the 1970s made energy security, supply diversification and integration of energy systems a highly topical issues; yet their stimulus for European energy policy was too limited to overcome the political framework that favoured development of power systems on a national basis. It took the European Community another decade and the Internal Market programme of the 1980s for the Community to take a more assertive stance on energy related issues and to specify a number of key elements necessary for the integration of energy markets. As energy markets are grid-based, the idea of a *common carrier system* for electricity was one of the outcomes of this early period of today's European energy policy (European Commission 1988, p. 72).

This *common carrier system* would have included a common transit system for national grid operators to purchase electricity across the European Community (Eikeland 2004, pp. 4-5), and was supposed to allow power consumers to purchase electricity from any supplier, regardless of the ownership of intermediary grids. Increasing cross-border electricity exchange capacity in specific network *bottlenecks*, and a limited *Europeanisation* of the existing networks were fundamental elements of this initiative (European Commission 1988). Yet due to the strong political opposition, the common carrier system never materialised. Instead, with the endorsement of a limited number of high priority trans-European projects (European Council 1994), a more limited approach became central to European policy on the power system, namely the common development of certain large-scale energy infrastructure projects such as interconnectors (and pipelines) categorised as being of *Community interest*.

The establishment of the Internal Market for Electricity (IEM) remained in the focus of EU energy policy throughout the 1990s. During the end of the 1990s and 2000s the focus of EU energy policy shifted, however, to sustainability. And with growing ambitions in climate policy, and growing numbers of renewables in the system, the question arose how to reconcile the EU's environmental policy with the goal of creating the Internal Electricity Market, and how the increase of renewables affects that market (Glachant et al. 2013, pp. 68-70). Towards the end of the 1990s, the Commission

addressed these questions in a number of papers (e.g. European Commission 1997, European Commission 1998). They concluded that power transmission capacity between member states was too limited for the integration of large numbers of renewable electricity into the power system (Eikeland 2011, p. 20).

Despite this growing understanding of the technical requirements of renewables, the promotion of renewables for policy makers at the EU-level was still mainly perceived as support for the increase of RE generation *capacity*. Despite some Commission papers pointing towards the importance of cross-border power system integration for the operation and integration of renewables, the *grid environment* was still largely neglected as an issue for RE promotion (see Fouquet & Johansson 2008). Only with regard to the most obvious cases, such as distant wind parks, the Commission papers point out the need for an adaptation of power systems to the particularities of renewables (European Commission 1997, p. 29).

The low penetration of intermittent renewables in the power system at that time, may explain the lack of deep technical analysis. Since the EU in 1997 set out the aspiration to obtain twelve per cent of electricity from renewable sources by 2010 (EWIS 2010, p. 146), the promotion of RE moved, however, gradually further up the European agenda (Nilson, Nilsson & Ericsson 2009, p. 4454). The gap between the importance of the surrounding power systems for the operation of renewables, and the focus on economic support mechanisms for new (renewable) generation capacity, started therefore to close (European Commission 2000, p. 48). Technology-specific support for renewables (Boasson & Wettestad 2010) became an important element of the discussions (Jansen & Uyterlinde 2004, p. 95).[22]

Questions concerning the electricity transmission infrastructure, conditions for grid access, grid reinforcement, and charges to RE generators for use of networks, thus received more attention (Jansen & Uyterlinde 2004, p. 93). Moreover, in 2006 a major blackout cascaded through several European countries and resulted in a renewed debate about security of power supply (Lagendijk & van der Vleuten 2013). With the Russia-Ukraine crises of 2006, 2009 and 2014, security of supply now is on top on the

[22] This was not the least the case during the discussions for the Renewables Directive, where there was very strong controversy regarding letting member states decide their own energy mix and keep their feed-in tariff systems versus implementing an EU wide system of green certificates to support renewable energy. In the end, the discussion/negotiations ended on the member states to decide on their own support mechanisms (Nilson, Nilsson & Ericsson 2009, Ydersbond 2014).

agenda for the national top politicians and the EU-elite (see e.g. European Commission 2014a, Ydersbond and Sveen 2014). The development of Europe's energy networks will therefore remain high on the EU's political agenda.

3.2 EU grid integration programmes

The development of the cross-border power transmission infrastructure turned out to be the central element for market integration, security of supply and the increase of renewables. The European Union hence developed a number of grid development programmes. These programmes can be placed in two broad categories: Policies to provide favourable framework conditions for grid development *as such*, and policies to develop specific parts of the system. Moreover, financing tools should be examined separately.

Framework conditions for grid development

Power companies in Europe are based on a power transmission infrastructure that converges with national boundaries. Unbundling – in other words breaking up the vertical-integration of power companies into supply and transmission – was thought to guarantee that investment decisions would be taken in the interest of the network infrastructure and not that of national/regional/local utilities (Eikeland 2011, p. 32). More cross-border interconnections and the integration of electricity markets are assumed to be one of the results (Von Koppenfels 2010, p. 84). Unbundling can therefore be interpreted as one of the main EU programmes to alter the framework conditions for grid evolution and to create a European environment for the development of power systems and markets (Eikeland 2011).

In order to guide the grid evolution process and to oversee and improve cross-border aspects of the European power system, the European Agency for the Coordination of Energy Regulators (ACER) and the European Network of Transmission Systems Operators (ENTSO-E) have been set up (Regulation 714/2009). This unbundling initiative is the most noted, but not the only European policy to develop framework conditions of the power grid. Several other EU programmes aim at the exploration of new energy technologies, their market-maturity, and the stimulation of their (potential) markets, including the gigantic prestige research programme *Horizon 2020* which allocates 20 per cent of its budget to climate and energy related research.

Development of specific parts of the power transmission infrastructure

Debates about the need for new cross-border electricity exchange capacity in specific bottlenecks of the European grid date back to policy papers from 1988 (European Commission 1988, p. 28), and the endorsement of a limited number of so called *high priority trans-European projects* for rapid implementation in 1994 (European Council 1994). At that time it remained, however, unclear how to stimulate private investments in these projects. Thus a debate began about the best lever for public intervention (see European Commission 1993, p. 79; and European Council 1994, p. 27). In 1996 member states agreed on a mix of horizontal and sector-specific measures for a number of infrastructure projects (Decision 1254/96/EC).[23]

This trans-European energy network programme (TEN-E) lists four Priority Electricity Corridors of *European interest* (Regulation No 347/2013, Annex I), for example the Northern Seas offshore grid or the North-South electricity interconnections in Central Eastern and Southern Europe. Particular projects within these corridors such as high-voltage overhead transmission lines are labelled as being of *common interest* are provided with priority status that entitles them for administrative and financial support. In sum 66 power infrastructure projects fall into this category, most of which are transmission infrastructure projects (European Commission 2013a).

With better financing towards decarbonisation?

The EU programmes described above do not yet seem powerful enough to stimulate the development of a power transmission system that is capable of integrating large numbers of renewables and suitable for the aims of decarbonisation; much remains hence to be done (Monti 2010, p. 48). Repeated focuses on specific projects on a bottom-up basis has been blamed for limited progress (Helm 2014), yet EU policy towards individual grid development projects changed in the second half of the 2000s, and seems to be on the way towards somewhat more of a top-down approach. TEN-E, for example, today is characterised by a distinct top-down approach (Agt 2011, pp. 28-29).

Moreover, grid development seems to suffer from the open question how to organise markets in a way investors can have confidence that costs will be recovered (Helm 2014, pp. 30-31). The European Commission therefore called for a new approach to the

[23] TEN-E has a strong focus on market integration, but cross-border power interconnection projects that contribute to the integration of renewables, are also included (see Regulation No 347/2013, Article 4 and Annex IV).

planning and construction of electricity transmission infrastructure projects (European Commission 2010). In this context it seems that the European Union is increasingly inclined to (co-) finance or guarantee the financing of infrastructure projects of *European interest* (Agt 2011, p. 29). With the European Energy Programme for Recovery, for example, the EU channelled financial resources from its budget directly to selected energy infrastructure projects (European Commission 2013b).[24]

Increasing certainty for investment and innovation (in grids) is one of the key elements of this new focus on financial support (European Commission 2011b). The Connecting Europe Facility (CEF) is the latest result of this approach (Regulation 1316/2013). With a multiannual budget of 5.85 billion EUR this new institution supports implementation of energy infrastructure projects defined as *common interest* (Regulation 1316/2013, Article 5). This support will mostly be granted in form of so called risk sharing instruments for project companies which are supposed to make loans to interconnection projects cheaper by alleviating some of the risk for the lenders by giving loan guarantees (Annex I, Part 2). In fall 2014, for example, the European Commission has allocated 647 million Euros for this purpose.

The Connecting Europe Facility hence aims at reducing the financial risks for certain infrastructure projects. According to the assessment of the European Commission, this latest trend in EU infrastructure policy resulted in progress towards an integrated internal energy market, but additional infrastructure needs to be built (European Commission 2014b). A part of the Commission's infrastructure investment package from autumn 2014 is intended to function in the same direction: to help building transmission infrastructure through giving access to cheap loans and guarantees.

Lately, grid infrastructure has crept up the EU agenda. Free flow of energy is mentioned as a fifth freedom in the press release on the Energy Union (European Commission 2015b). Moreover, in the communication the same day connected to the Energy Union, energy infrastructure is highlighted as a vital part of the Energy Union: 'There are **missing interconnection links between several countries. Building these interconnections will require the mobilisation of all efforts at all levels, as a matter of urgency, to achieve the common objective of a fully functioning and connected internal energy market**' (European Commission 2015a, 2).

[24] With a financial framework of 904 million EUR for grid interconnection measures and 565 million EUR for offshore wind energy[24], the integration of invested sums are considerable compared to the financial resources of the TEN-E programme, which has only a limited financial component.

4. Exploring the geo-economic consequences of EU decarbonisation policy

Despite their 25 years of history, their diversity and considerable financial means, the European policies and programmes described above have not yet stimulated the development of an integrated European power system that could serve as the technical basis for a decarbonised power sector sufficiently. The question is, why? Given that EU decarbonisation policy and the underlying policies to adapt the European power system will put pressure on the geographic allocation of electricity generation, transmission and storage infrastructure capacity in Europe, the difficulties become clearer: If fully implemented, EU decarbonisation policy may put energy assets (conventional as well as renewable) of individual member states 'at risk'.

Europe's decarbonisation agenda is thus likely to have considerable *geo-economical* long-term implications such as the following:

- With increasing market integration come larger transmission distances, new markets with new competitors, and hence new competition between utilities and other producers
- Traditional coal, nuclear and gas power plants face new competition from renewables in their home markets and from abroad
- New renewable based electricity generation capacity will be located differently than fossil and nuclear plants
- With the changing location the question arises what the suitable interconnection and storage services are
- Diversification towards new supplier countries and energy sources brings new trade routes and infrastructure such as LNG harbours, and with them new electricity and potentially also gas grids

Electricity generation capacity in Europe will therefore see a profound *reshuffling* in the coming decades as a result of the EU decarbonisation agenda. The following sections explore in more detail the *geo*-economical frictions that might follow the implementation of those policies the European decarbonisation agenda is based on, and what political concerns may be expected to arise between EU member states in the future. The question is: What are the potential EU specific *geo*-economical implications

of the combined effect of market integration, the transition to renewable energy, and supply diversification on the structure of electricity transmission and – as a result – the allocation of generation capacity in the EU?

4.1 Market integration

From a national perspective market integration implies that the interconnection capacity (shortage) along borders will cease to protect domestic markets from foreign competition; new competitors to domestic producers will emerge, and electricity companies which are not efficient enough at adapting to competition on a European market will get into trouble, while other producers/utilities (including foreign) will be able to strengthen their market position. Moreover, a successful EU market integration policy will increase the likelihood for countries to let their electricity be produced elsewhere, thus letting generation capacity to 'migrate' beyond national borders.

The variety of regulatory frameworks in the states in Europe does, however, hinder a more European development. It is very likely that one reason behind this situation is, that EU member states are more than aware that European network and market optimization will produce winners and losers on the member state level. Countries, industries and regions expecting to lose production capacity will thus be satisfied with the lack of progress to increase cross-border power exchange capacity. If every country has some winners and losers (companies, industries, or regions) it matters little. But what if, in an extreme case, a substantial part of energy production moves from one part of Europe to another?

4.2 Renewable transition

The promotion and integration of renewables implies three important changes to the European power system:

First, every country or region has access to at least some form and amount of renewable sources of energy; yet some countries are better qualified to become competitive producers than others, because renewable energy sources are denser at certain locations, and the technological and economical capabilities for their exploitation differ. Production will therefore shift to those countries that have access to better and more sources of renewable energy, offer better incentives for expanding capacity, and can exploit them more cost-efficiently. As a result, countries which decide to exploit their

own renewable sources to cover their consumption will (potentially) become (more) self-reliant, with the need for cross-border energy trade (potentially) becoming smaller. Other countries might prefer to import energy, i.e. to buy from EU energy and power markets. As a consequence, their strategic focus will shift from the access on overseas fossil fuel resources towards the ownership, management, and protection of grids (and other supply routes for renewables) in order to secure electricity imports.

Second, renewable generation such as wind and solar is of an intermittent nature. Large scale adaptation of the power transmission infrastructure are necessary to harness renewable energy sources such as wind and solar. Increasing the use of this form of power generation in one part of Europe therefore implies also growing balancing costs elsewhere. Moreover, countries that feature cheap balancing services (e.g. dispatchable hydropower or other storage means), standing reserves, interconnector capacity, or renewables that can deliver in times of peak demand, will potentially gain influence over neighbouring countries. Without a clear regulatory framework that clarifies costs and benefits of renewable electricity generation and transport, conflicts may arise. This will potentially be an interesting case for EU legal scholars, legal experts in the Commission and in the member states to discuss in the years to come.

Third, renewable electricity implies distributed generation in so called *combined power stations.* Contrary to today's big, centralized fossil fuel or nuclear power plants, this form of power generation hence allows for a business model that brings together a larger number of smaller generation units dispersed over larger territories. Where the option of distributed generation is chosen, energy markets become rather locally oriented, and are likely to involve a mix of private and communal companies. Regions/countries with a focus on this business model would hence be less present on the integrated EU market. Decentralised power systems could therefore be an interesting way to protect particular industries from the competitive pressures of European markets.

4.3 Supply diversification

The transition to a more renewable energy system, has already been discussed in depth. Thus, we will focus on two other issues:

First, external relations between supplier and transit countries outside the EU. Diversification away from Russian and Middle Eastern gas dependence towards other regions and suppliers will potentially lead to altered entry points to the European

energy system, for example new LNG capacity; gas grid capacity in those regions will hence have to be increased. Given that the integration of European energy markets proceeds, power generation and transmission capacity might follow these changes. Member states in risk of losing power generation to regions closer to new entry points are thus likely to oppose further steps in such a direction. Another example would be potential solar PV imports from North Africa which would necessitate new HVDC and interconnector capacity at the Southern European border; however member states which are located too far away to benefit from potentially lower electricity tariffs in the Southern regions might feel inclined to oppose the use of European funds to stimulate the construction of the necessary power transmission infrastructure.

Second, stimulating the construction of inter-member state transmission infrastructure is main part of EU's policy on supply diversification. Common grid planning and Projects of Common Interest for electricity and gas grids are two important instruments in this regard. Yet more interconnection capacity would not only increase the ability to secure and stabilise power supply, but (as in the case of market integration) also contribute to shifts in power generation capacity. Supply diversification through more cross-border interconnection capacity hence implies increased dependency on the will and the capability of (power and grid companies in) neighbouring countries to uphold and stabilize electricity supply. Moreover, the stimulation of interconnectors is currently pursued without a single clear legal framework for such an integrated market. Potentially the EU's internal approach to supply diversification therefore opens the door to continuous fears about the reliability of neighbouring countries. Clear agreements and regulations are therefore necessary to avoid mistrust among member states. Otherwise solidarity on this field will remain a somewhat 'unfirm' concept.

5. Breaking the state-company axis with refined instruments?

Decarbonisation with today's technologies equals a massive increase of carbon-neutral renewables. Given the technological and economic dynamics in the power system caused by these renewables, decarbonisation goes beyond the mere replacement of old power generation units with new ones, but depends largely on the adaptation and integration of yet largely isolated or semi-integrated power pools in Europe. Despite some first positive results, the European decarbonisation agenda will therefore soon

reach a crucial point, where the growing numbers of renewables demand a fundamental adaptation of the power system to their technical and economic needs.

5.1 Synopsis

The EU has implemented policies to adapt the power system to growing numbers of renewables, yet as seen in the sections above, this agenda largely relies on older competencies, policies, programmes and instruments (market integration, increase of renewables, supply diversification, stimulation of cross-border integration of power grids). The attempt to focus these on the goal of a near-to-carbon neutral power sector can be considered to be incomplete, because it avoids answers to the inconvenient truth that EU's decarbonisation agenda and its underlying elements contribute to changes in the *topography* of the power system: Better integrated markets and new transmission and supply lines allow new (renewable) power generation capacity to *migrate* to, and cluster together at sites where conditions are more favourable. And these are not necessarily located where power generation is located today.

Historically the relocation of power generation to new places, and dependency on neighbouring regions is of course nothing out of the ordinary. But while today's electricity systems have been built around consumption centres, with a limited number of central generation plants in a given region, benefits of European integration become more significant when new generation is less well located for demand (Newbery et al. 2013, p. 12). In other words: If European policies succeed to increase interconnection capacity between the different elements of the European system, proximity of power generation to consumption centres will be increasingly less important, dependency on other regions will therefore much more often include a cross-border context than it is the case today.

The North Sea region, for example, is in the process of becoming a hotspot for power generation from renewable sources, and the better integrated the European system is, the more power generation sites can operate there; other regions with less promising RE sources (and/or in member states without the will or means to exploit them) will lose this generation capacity, and be dependent in their power supply. Decarbonisation policy hence involves substantial *geo*-economical frictions, as member states have some reasons to worry about their relative position in the emerging European power system (see section 3.3). Europe's decarbonisation agenda thus implies the acceptance of the

involved actors to generate conditions which might lead to the migration of power generation capacity away from today's sites and beyond the borders of national control.

5.2 The state-company axis and decarbonisation

Today's power systems in Europe have been determined by an axis between power companies and the state which evolved in the second half of the 20th century. If Europe's power sector is to be decarbonised by 2050, a policy framework is needed which allows the evolution of the power transmission system to follow changes in power generation. Given the lack of progress with regard to the integration of power pools necessary for decarbonisation, it would seem that the state-company axis is still intact at many places. Where, on the other hand, high levels of power system integration already exist, one can infer not only high levels of mutual *trust* between the involved nations (as in Scandinavia), but also a distinctive political will to implement a policy that will ultimately increase dependency on others (as in the case of Germany and The Netherlands). Strong integration, moreover, indicates an orientation at the generally beneficial role of market forces, as interconnection opens the door to more competition between power companies.

But while EU policies are aiming at the modernisation of Europe's power system, member states have enough reasons to worry about their relative position in the emerging European energy system: Bigger markets, growing transmission capacities, new (renewable) energy carriers, and new supply routes represent greatly altered framework conditions for the future evolution of the power system. The *geo*-economical frictions resulting from EU's decarbonisation policies would probably be negligible if the balance between winners and losers were approximately equal in all EU member states, and if the regulatory framework established a level playing field for all market players which promises an overall net gain. Yet, not every country is likely to benefit equally from changes involved with a European power system such as the relocation of power generation capacity and the accompanying infrastructure effects.

In short, the EU policies discussed above will cause increased economic activity in some countries, whereas others will lose parts of their power industry, and hence produce winners and losers. To us, it therefore seems likely that member states will consider increased participation in the EU power market as a matter of strategic choice: Even though large parts of the electricity generated in Europe might one day be transmitted

through a truly European grid system, governments will attempt to keep self-provision for areas of vital state interests and economic reasons, while local communities may desire to become self-sufficient in their power supply.

5.3 Recommendations

As the paper shows, an integrated European power system would be strongly beneficial to reach the goals of the decarbonisation agenda. But even though diverse EU programmes indicate that an increasing number of actors are orientated at a European development, others appear to remain reluctant to either face competition on a European market or losing control over national energy assets. The question thus is, whether those instruments the EU has at hands are capable of fully bridging and overcoming those concerns on the national level which counteract such a European development.

EU policies to develop the European power system towards the large-scale integration of renewables have to take this into account: Integration of power systems will only occur if European policies are designed to balance the *geo*-economical frictions caused by the European energy transition towards more renewables. To make it from policy papers to reality, decarbonisation by means power system integration therefore requires:

- Generally high levels of *mutual trust*, and of the *political will* to overcome the *economic antagonisms* that might constitute an impediment for more integration and shifting generation capacities.

Thus, clear agreements to cover the commodity and monetary flows seem a prerequisite in order to avoid opportunistic behaviour and conflicts. One vital element for Europe's decarbonisation agenda to be successful therefore is:

- A regulatory framework that eases *geo*-economical concerns of member states through governance structures such as co-ownership of grid assets or co-decision making of grid operations, whether at the company level, between two countries, several countries or countries or on the EU level.

Such a framework needs to find answers to the following questions:

- What are country obligations to deliver?

- Who finances projects and where are production and storage facilities to be located?
- Who is going to be the main responsible for operations and disturbance response?
- How to manage the intermittency of power generation in cross-border networks?
- How will damages in one area incurred by fluctuating power in another area be resolved?
- What new modes of operating these systems may be required?

If the policies, programmes, and instruments described above do not provide such a framework, EU's decarbonisation policy will not be capable of merging power pools in Europe into a system that can sustain significant numbers of renewables. The overall picture suggests, however, a rather chaotic development of the European decarbonisation agenda, and not as much coherence between its underlying policies as could possibly be achieved. With decarbonisation climbing upwards on the European agenda, the existing programmes and policies have merely been adapted to include another end. Synergies are visible, yet a common working framework which successfully focuses the different policies on the end of a truly *European* power system, is still largely missing. Without it, the national state-company axis will remain in place at many places, thus making Europe's decarbonisation goals more difficult to achieve. Of course, state-owned companies can also contribute to successful decarbonisation, so, given their importance in the current energy systems, much will depend on what positions they will take on the issues at stake.

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