Polskie Sieci Elektroenergetyczne

European electricity market – diagnosis

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Dear Readers

I am happy to share with you this report prepared by PSE experts under leadership of Prof. Leszek Jesień and Ph.D. Piotr Koryś. It is a concise diagnosis of the European electricity market from a perspective of the transmission system operator.

There is a debate in Europe about the electricity market design. It is the most important dispute concerning the electricity industry, though it remains in the shadow of other issues, e.g. share of high-emission sources in the capacity remuneration mechanisms, or dispatch prioritization of renewables. The main dividing line between parties arguing over the Europe's electricity market project remains geographical extent of the bidding zones, or areas, within which prices of electricity, reserves and ancillary services are determined.

Proponents of large bidding zones argue that the larger bidding zones spanning over large geographical areas with more diverse generation mix and equally diverse demand side, the higher electricity market liquidity within them.

Supporters of locational marginal prices calculated in the smallest possible zones, thus individual grid nodes, point to substantially strengthened pricing signals that reflect needs of the power system. Prices calculated for each location allow to correctly set the value of electricity for end consumers, which is going to facilitate investors' decisions.

Both sides of the debate believe that it is necessary to bring markets closer to system physics. It means to make sure that demand curves represent the real load in the system, while supply curves reflect actual available generation. And there is no oversimplification of both. Because 'everything should be as simple as it can be, but not simpler', as Albert Einstein would say. Hence, for both sides the essence of the dispute remains in the level of necessary and acceptable simplifications of physical side of electricity systems in the market rules.

The need for market reforms, as well as the technological changes that electricity markets are going to face in the near future, require that the decision-makers and the market players respond to challenges of the evolving conditions in a quick, flexible and effective manner. Liberalized electricity markets are naturally based in market rules, therefore their effective functioning depends on economic incentives effective for all entities active in those markets.

Another highly important aspect of this debate is the need to provide an efficient organization of cross-border trade across the whole EU area, which naturally includes transmission capacity calculation method. It is of particular importance, that all market participants have got an equal access to all generation and transmission resources, while the unscheduled flows (or loopflows) resulting from incorrectly defined bidding zones are substantially reduced. Thus, the security of energy supply for European consumers, and economic effectiveness should determine which model proves better.

This paper deals with the key problems of power system and electricity markets in Europe, and their roots. It has been drawn upon analysis made by the Polish transmission system operator, an entity responsible for secure operation of the electricity system and for reliable energy supply.

With this diagnosis, we would like to share our reasoning with a general audience on where we are and where we are heading to in the world of electricity. I do hope it will be a valuable contribution to further discussions on future architecture of the European energy market.

Eryk Kłossowski
President of the Management Board and CEO, Polskie Sieci Elektroenergetyczne

List of abbreviations used in the text

CACM

Guideline on capacity allocation and congestion management Commission Regulation (EU) 2015/1222 of 24 July 2015

CEP

Clean Energy for All Europeans package

ICT

information and communication technologies

IEA

International Energy Agency

CO_2

carbon dioxide

DSO

distribution system operator

TSO

transmission system operator

RES

renewable energy sources

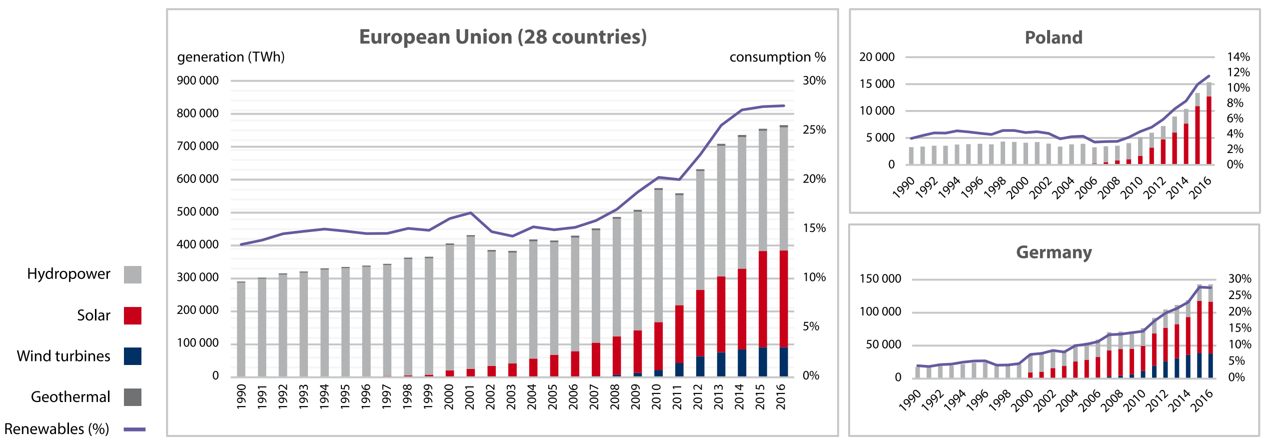
CONTENTS

Introduction

The recent decades have shown the emergence of an integrated European energy market which has contributed to the European economic integration. However, over the past years, stability of this market has been a growing challenge, which is due to revolutionary technological changes (both in energy generation and storage), and increasing regulatory challenges.

New competition-based conditions for the organization of the power sector have coincided with a period of a rapid technological development. In the same time, the EU climate policy, fostered by Germany's energy transformation (Energiewende), has translated into generous subsidies and regulatory support for RES technologies, resulting in a significant decrease in the cost of those technologies. Consequently, the share of renewables in the EU's present energy mix is becoming more significant. Small distributed energy resources, those based on solar power, biogas, biomass, etc. as well as storage technologies, have shown rapid development in the recent years (see Fig. 1). Despite investment costs still being relatively high and technological constraints yet to be addressed, these new technologies will affect the formation of the energy market and its future structure (Sioshansi 2018). This is particularily important, as widespread development of RES technologies in order to limit fossil fuel dependancy requires well developed storage to better allign the RES supply with the needs of consumers. Progress in ICT techniques opens up new opportunities for customers' participation in the electricity market and development of new business models, not only those directly involved in generation and distribution, but also those built around the sector, e.g. new transport models emerging around e-mobility. The sector, once focused on providing electricity to customers under any conditions, is now looking for new solutions, including demand-side flexibility technologies. It means a departure from a traditionally understood security of electricity supply. Yet changes in the generation structure, both in terms of technology mix, as well as geographical distribution of resources, are not accompanied by sufficient growth dynamics of the transmission and distribution networks inherited from the past. Today it poses an obstacle to the efficient absorption of new generation sources in the system.

Fig. 1 **Quantity of electricity generated from renewables in Europe, 1990-2016 (in tWh)**



Source: *Own compilation*
Data: *Eurostat, GUS.*

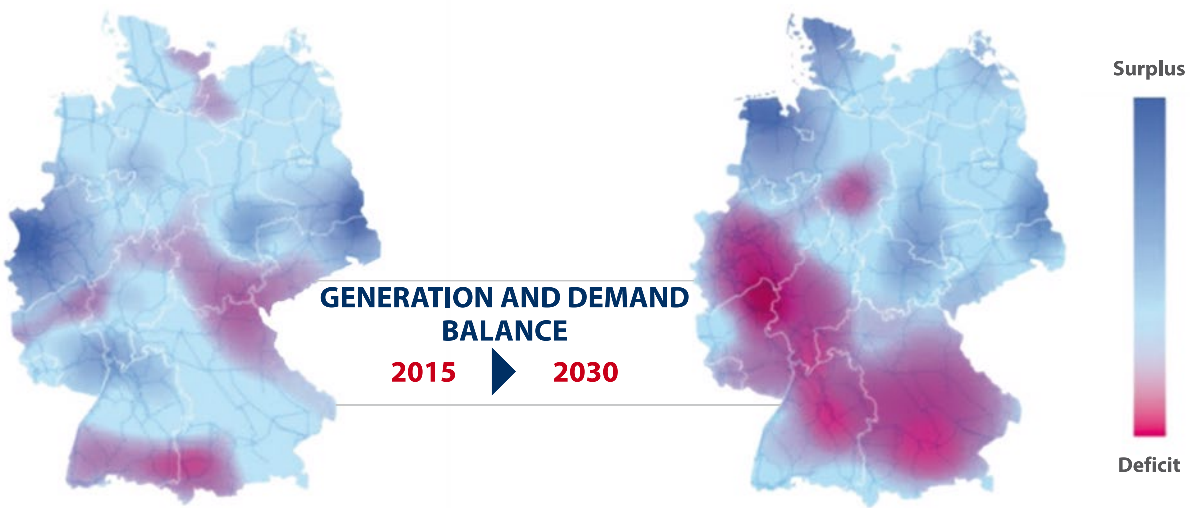
As the concept of the European energy market gained shape before the current technological breakthrough (on history, see Karan, Kazdagli 2011), many solutions that form the electricity market model in Europe fail to respond to today's and future challenges of energy transformation. This gives rise to concerns about further market integration in Europe, in particular whether the current market solutions are able to facilitate innovation in the sector and offer social welfare benefits to the consumers. This is connected, among other, with the system architecture and adopted solutions such as the zonal system based on large bidding zones, energy-only market, or excessive scope of RES subsidies. Mismatch between system physics and market design (PSE 2018) causes technical challenges. Consequently, inability to efficiently tackle the future challenges by existing market solutions might lead to increased overall energy supply costs, rendering them hard to accept socially and politically in one or more countries (it will be impossible to socialize costs generated by external costs of an inadequate market architecture; inefficient in Pareto's sense), which may lead to disintegration of the market.

This paper is an attempt at identifying key challenges of the power system and the energy market in Europe, and their sources (see Fig. 2) from the viewpoint of the transmission system operator. There is an ongoing discussion on the consequences in the near future of a simultaneous pursuit of the goals related to further market integration: consistently implemented and supplemented zonal model, development of the generation sector mainly based on the expansion of subsidized RES, and ensuring security of supply for Europeans. It is argued that pursuit of simultaneous implementation of these goals may pose a threat of instability throughout the system due to the scale of socialization of costs they generate.

This paper is organized into two parts. The first one presents the technological, institutional, political and regulatory framework of the European energy market, and the second one analyses their consequences.

Spacial distribution of generation and demand balance, Germany 2015-2030 (forecast)

Fig. 2



Source: *Appunn 2018.*

1 Paradigm of the European electricity market

In recent years, the European electricity market integration processes have advanced considerably. This has brought numerous benefits to the participating countries, old and new players in the energy market, as well as the consumers. Moreover, the establishment of a common market has provided conditions for building solutions that support continent-wide energy security.

The European Union countries, through a series of regulations shaping the electricity market, have tried to provide, as far as possible, an even playing field for all. This opened up the market – until recently closed due to entry costs and limited access to grid infrastructure – to new electricity generation and distribution players. Market participants, in particular consumers, have been given a special protection by the European regulators. Among other things, they have gained the freedom of easy and cost-free change of the electricity supplier.

However, despite unquestionable successes in building a common electricity market, a number of problems, related to the regulations adopted, have emerged over time. They took little account of the growing dynamics of technological changes in the sector, the development of power infrastructure and the physical requirements of the integration of power systems. This was influenced by the provisions that did not reflect the actual market conditions and the physical constraints of system operation, as well as the speed of changes implemented often with good intentions. As a result, in the face of the technological change affecting the rules of the game in the sector, with the current rate of change of the regulatory environment, participants of the market process often fail to keep up with adjustments (technical/organizational, etc.).

What is more, despite increasingly visible new challenges resulting from ongoing energy transition in Europe, new regulations such as CEP Package still aim at addressing the yesterday's problems. As a result, it is likely that even the post-CEP European market design will still be inadequate to ensure efficient power system management.

1.1 Technological considerations

It must be noted that the market framework in the energy sector (as in the case of other resources using dedicated transmission networks) is determined not only by regulations, but also by technical (physical) constraints of networks. Moreover, the electricity market recognizes the need to keep generation and load equilibrium at any point in time to ensure the operational security of the network.

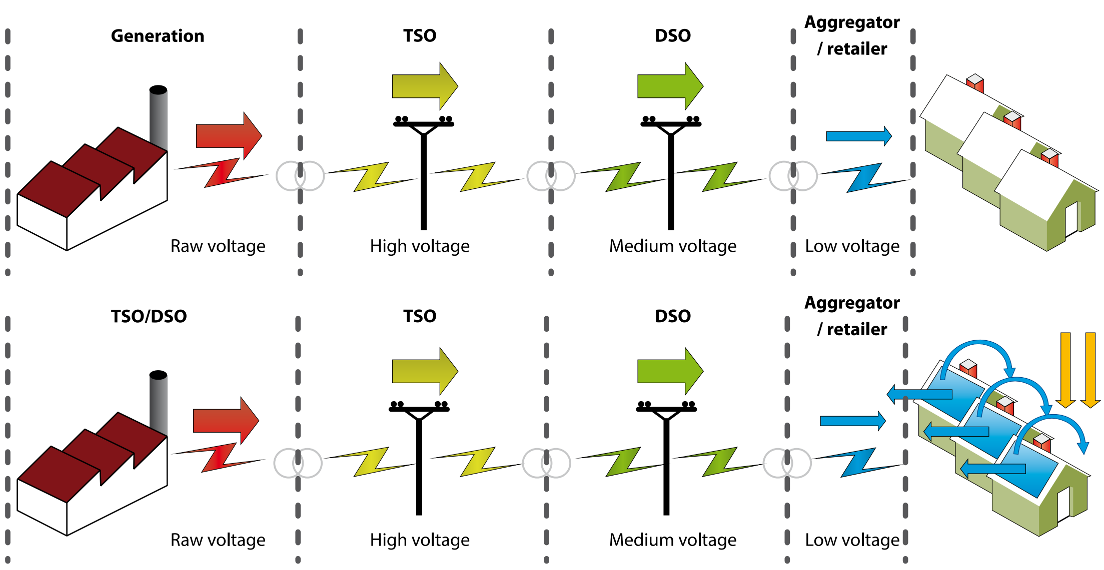
Taking into account the existing state of infrastructure, the market model under the current or anticipated by market participants regulatory framework may lead to optimal or sub-optimal allocation of resources. The regulatory framework – the zonal model of the market, preference for cross-zonal over intra-zonal exchange, etc. – also determines the allocation of resources (often suboptimal as explained in Part 2 of this diagnosis), and therefore, has an impact on short- and longterm system stability within the assumed security limits.

1.1.1 Legacy infrastructure vs. new technologies in transmission and distribution

For years, the power system has remained unchanged. Its backbone was a transmission network connecting power plants with demand centres. The distribution network connecting the transmission network with customers was passive, and the operational management of the system was centralized. More recently, the establishment of the electricity market and its subsequent liberalization led to separation, in terms of ownership and competence, of system management from generating units and distribution network operators. Along with the growing penetration of distributed sources, the operational specificities of the transmission network and, perhaps even more so, of the distribution network, have started to change. Distribution networks have become increasingly active, with power flowing not only from the transmission network to the distribution network, but also within the distribution network, as it were, from bottom to top (see Figure 3).

Transmission and distribution network including and excluding prosumers

Fig. 3



Source: *https://www.researchgate.net*

At the same time, demand-side management technologies have been developing, such as smart grid, smart metering and demand side response. An increasing role is played by networking solutions that aggregate active users – prosumers (such as clouds, energy sharing, prosumer energy markets) (Sioshansi 2018) – the business model in the sector is changing, and the market power of the existing main players has been decreasing at a high rate.

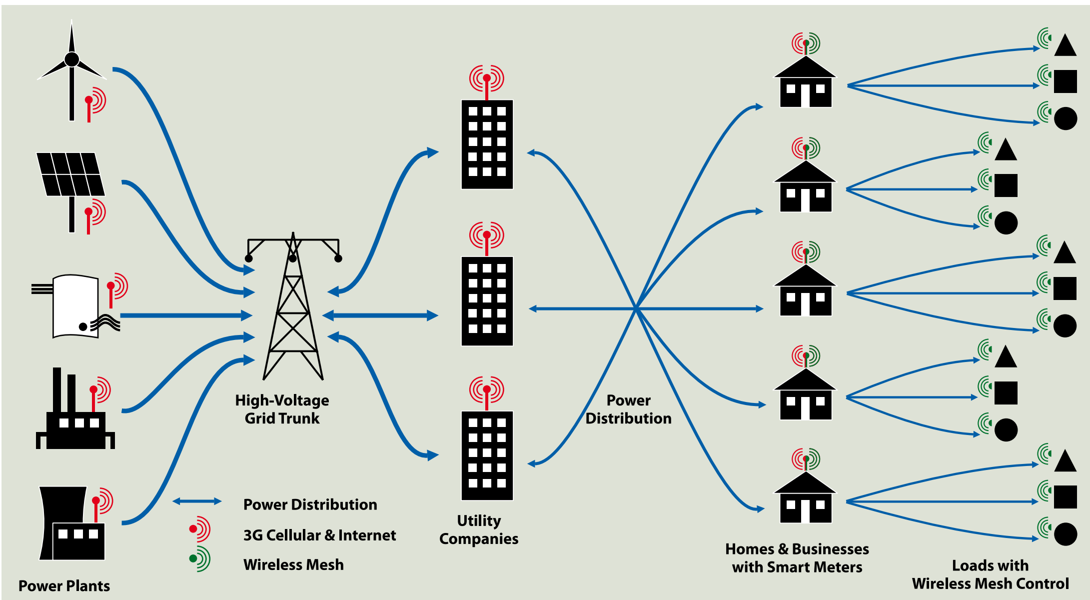
This is accompanied by a dynamic change in the demand structure. On the one hand, we can notice the increasing energy efficiency of the economy and, on the other hand, the new technologies that determine this different structure of demand e-mobility (power demand at a specific location and time), development of ICT services, including big data management (increased unpredictability of demand), air-conditioning in shopping centres (summer peak demand). Simultaneously, information and communication technologies are developing at fast pace. New technological solutions in transmission are also becoming widespread. Consequently, it is possible to make an increasingly effective use of network resources, mainly the distribution network.

The legacy power network structure is not always adjusted to the changing energy supply and changes in demand structure. Moreover, evolution of network structure necessary for the efficient integration of RES generation and distributed generation proceed slower than the technological change in generation. Incentives for network development within large bidding zones are not always aligned with the actual market needs (see below for discussion of the impact of the "copper plate" assumption on such incentives). In particular, system-related difficulties in building extra high voltage overhead transmission lines are witnessed in many countries. This is associated with environmental and social difficulties manifested by the reluctance of local communities to accept a planned way of overhead lines. As a consequence, the adjustment of transmission network structure to the unfolding technological change in generation is clearly slowed down, which leads to growing problems in the operation of the European market. (Appunn 2018)

European power system is confronted by an unprecedented fluctuations of operation conditions, increasingly dependent on weather conditions on the one hand and on a variation

Fig. 4

Smart grid structure



Source: *https://www.homepower.com* of demand (now still hard to forecast) on the other hand. At the same time, the intelligence of the power system has been increasing, driven by the capability to collect and process huge volumes of data. Therefore, the system management becomes an increasingly complex process. Few decades ago, the system management was still based on telephone communication between employees of the load dispatch centre and those based at electrical substations. Today's variation of operating conditions necessitates the automation of processes, often backed by advanced intelligent systems supporting dispatchers' work (see Fig. 4). (Richter et al. 2012) Consequently, technological revolution unfolding in power generation, transmission and distribution brings about serious challenges in terms of maintaining operational stability of power systems, especially if interconnected into large geographic areas.

1.1.2 Growing role of RES in the energy system

From the 1970s energy crisis, research on renewable generation technologies attracted interest in pursuit of the ability to acquire electricity at a near zero marginal cost. However, it was the global (UN) and European (EU) climate policy that became a true catalyst for the development and promotion of RES-based energy production. The EU climate policy and the associated programmes encouraging subsidies to wind and solar generation have provided additional strong economic incentives for the development of generation from renewables. This contributed to fast development of technologies, which additionally accelerates the implementation of the EU energy and climate policy goals. The EU's ambitious climate targets are also reflected by indicators of the share of renewable generation in the energy mix. Therefore, the Member States have deployed various support mechanisms for RES technologies, in order to achieve the targets represented by the indicators. Unfortunately, the scale of these subsidies distorted the market mechanism, changing (improving) the relative competitiveness of RES vis a vis other technologies through regulation. These support mechanisms often proved to be oversized, putting stable conventional sources at a competitive disadvantage.
The depreciation period and distribution of long-term costs is structurally different for energy based on renewables than for conventional energy. In the case of RES, the depreciation period is much shorter, and a large part of costs is incurred in the investment phase on a one-off basis. In the generation period, variable and marginal costs are very low, often going down to 0, so that it is possible to periodically offer energy at a price close to 0 or even negative such is the case with ill-defined subsidies. Consequently, rapid development of subsidized generation from renewable sources distorts price signals in the electricity market, affecting the entire market for both unconventional and conventional sources. Significant imbalance of the operating conditions of conventional energy sectors, where revenues depend mainly on electricity prices, compared with renewable energy which enjoys comfortable operating conditions due to high subsidies and faster-than-expected technological progress, translates into a significant deterioration of the financial position of the conventional energy sector, mainly into weaker investment incentives.

However, despite the advantages of RES in terms of low costs and energy sustainability, the energy sources are yet unable to guarantee the security and stability of energy supply. Consequently, increasing problems of conventional sources lead to generation adequacy and security of supply issues for all consumers.

Efficient use of RES in power systems is currently hindered by an insufficient technological development of electricity storage. Changes in this sector are highly dynamic, but still insufficient to ensure secure system operation based solely on RES. Consequently, owing to the fact that renewables are unable to guarantee the continuity of energy supply required by business and households, poor condition of the conventional energy sector poses a potential threat to the operational security of interconnected power systems. This phenomenon can be seen not only in Europe but also in other developed markets where RES subsidies turned out to be too generous, disrupting the operation of market mechanisms.

1.1.3
Challenges of distributed generation

Along with the development of RES generation and community energy, distributed generation increasingly penetrates DSO networks, which affects the way they operate – passive networks supplying energy to consumers become active two-way networks. Unfortunately, usually DSO networks have not been designed for such operation, nor have they been adjusted to this kind of two-way activity. Consequently, the dissemination of community energy and distributed generation solutions in the short and medium term may lead, in the existing market model, to growing problems with network management. In particular, under conditions of growing generation from distributed sources, sticking to the fundamental for European power system "copper plate" assumption, within large bidding zones, will involve increasingly high costs.

To meet this assumption in the face of development of distributed sources, it will be necessary to make significant transmission grid investments. Given the fact that the needs for these investments would be driven by low-quality price signals from the zonal market, there is a material risk that these transmission investment might be excessive leading to unnecessary costs for consumers. In addition, due to the new energy generation structure, the supply side is more susceptible to weather variations, requiring stable and controllable backup generation to replace RES during unfavorable weather conditions. This backup generation is particularly important due to the absence of sufficient storage technologies allowing for utility-scale, seasonal storage. However, it is difficult to achieve based on market price signals given the changing energy mix and a growing role of climate regulations in energy policy.

1.1.4
Summary

Rapid technological changes affect the operation and stability of the system. In such a situation, an efficient market design, consistent with the laws of physics, should strengthen the transformation of the energy system. Regulations governing the development of the market are of key significance to arriving at a short and long-term economic balance. Unfortunately, this is not the case with the EU electricity market. Contrary to expectations and favourable attitude of the lawmakers, the lawmaking process yields regulations that may fail to support the transformation of the energy sector. Just the opposite – an unstable and unpredictable regulatory environment may slow it down.

1.2 European energy policy and its objectives

The nature of the energy market is related both to the network infrastructure and to the features of the exchanged product. As with some fossil fuels (natural gas or crude oil), infrastructure can be used only to transmit one product – electricity. However, two commodities are actually exchanged in the market: energy and capacity, i.e. the readiness to supply an appropriate quantity of energy when it is needed. The trade can take place under energy-only market formula, where energy and capacity are traded in a single market process or an energy-plus-capacity market, where the market processes for energy and capacity are separated.

Fundamental feature of the energy market and power system operation is that the supply and demand equilibrium must be maintained at all times. Any deeper imbalances might affect power system stability and cause blackout disrupting supply for large group of consumers. In addition, unlike fossil fuel markets, there are currently no efficient solutions in place for utility-scale storage. An incorrect organization of the market poses not only the risk of distortion of the price mechanism or local energy deficits, but also loss of operational continuity or instability of the power system.

European energy policy defines the regulatory and institutional framework within which the power system functions and market mechanisms operate – both those of a technical nature (technical balancing of demand and supply) and the economic ones (setting the level of supply and demand in the market at any point in time, and consequently market prices; entering into forward transactions, etc.). In the European energy market, regulators are not only tasked with overseeing the execution of energy law, but to some extent they are also involved in shaping the law by means of approving various detailed methodologies necessary for implementation of European Network Codes. The regulatory arrangements adopted have thus a significant impact on the distribution of revenues of market players, investment structure, or price incentives.

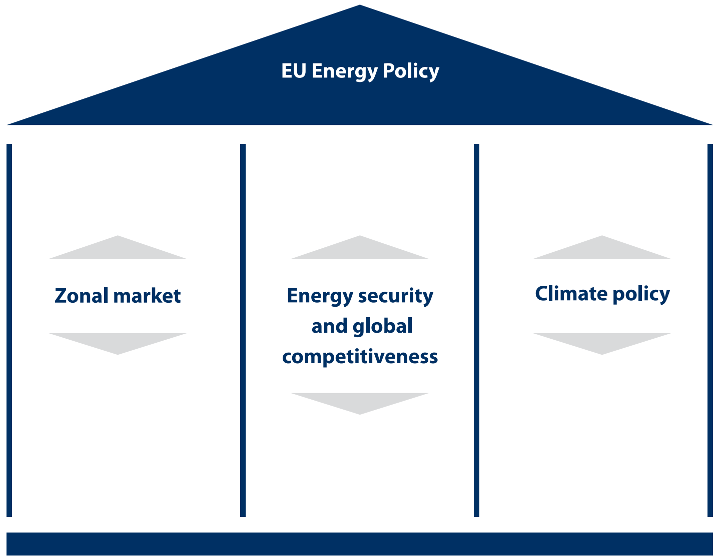
Key regulatory areas concern not only the definition of the nature of the market itself, which affects the price formation and the efficiency of utilization of system resources (e.g. zonal vs. nodal market; energy-only vs. energy-plus-capacity market, etc.); but also regulations external to the market as well as strategic objectives of energy policy that may affect its operation. Such regulations include, in particular, long-term economic and climate policy and, if wrongly executed, may lead to the selection of suboptimal technological and regulatory solutions. In the case of the European Union, formation of the market framework is significantly affected by the assumption that secure energy supply is indispensable for the EU business and citizens to ensure economic development, and, in the long run, to achieve energy self-sufficiency; and the belief that the power sector is the one where quick progress in decarbonization can be achieved.

1.2.1 Energy market

What have become foundations of European energy policy are zonal architecture of the common energy market, commitment to the energy only market, and the climate policy (see Fig. 5).

(1) The market model is zonal. The deployment of an integrated European energy market is treated as a part of the process of economic integration, classical liberalization, through national markets merge into a single EU-wide market. Today, the tool for the integration of power systems is a zonal market model, and European regulations in the recent decades have served the creation of such a pan-European, zonal electricity market. The zonal market concept was adopted in many regions of the world. It is based on the concept of bidding zones (market areas with the same price) operating on the assumption – made ex ante at the time of their initial delimitation – of unlimited transmission capacities and trading possibilities within each bidding zone ("copper plate" assumption). However, the actual delimitation of zones was made by taking into account mainly the existing administrative boundaries (coinciding with state boundaries, with a few exceptions), and not an analysis of transmission capacity within them. The individual zones are linked by interconnectors which, due to their specific

Fig. 5 **Pillars of the EU energy policy**



Source: *Own compilation*

transmission capacity, should determine the scale of transactions between them. The zonal market concept was supplemented in European regulations by a mechanism of possible dynamic zone revision (e.g. the option for change of zone borders). It is, however, difficult or impossible to achieve in practice due to political considerations.

(2) The market is an energy-only market – possibly supplemented in the short term with capacity mechanisms supporting generation adequacy. Unlike the energy-plus-capacity market, the only commodity traded on the energy-only market is energy, packaged in products defined by quantity as well as time and zone of delivery. Customers in the wholesale markets pay for megawatt-hours of energy. In addition, the TSO of the concerned zone procures ancillary services which ensure the operational continuity, stability and supply quality of his control area. The wholesale price is set by the price offered by the last (most expensive) generator in the merit order. Consequently, prices are formed at the level of the short-term variable cost of the last generating unit, i.e. the day-to-day operation cost of such a unit. Capacity mechanisms, such as a strategic reserve or capacity market, intended to secure generation in the mid-term, are treated as public support under the EU regulations so that their implementation as an additional market segment to support short term energy market is not obvious. Admission of those mechanisms is accompanied by the assumption that they are a form of state aid and as such can be only of a transitional nature.

(3) The market is to support the pan-European integration of the sector, owing to which cross-zonal exchange is given regulatory preferences over intra-zonal exchange. An increasing pressure has been witnessed in the European regulations, in particular the Clean Energy Package, towards support to cross-zonal exchange, even at the expense of intra-zonal exchange. It is intended as a tool to enhance supra-national market integration. It seems, however, to be used at the expense of security of supply to the European consumer. This is illustrated by a draft regulation on the electricity market, which requires at least 75% of interconnection capacity to be offered for the purposes of cross-zonal exchange. This means that transmission capacity calculation would disregard the actual technological conditions of system operation. In theory, such solution is supposed to support price convergence and facilitate more efficient utilization of generating resources throughout Europe. However, price signals coming from such market would have little relevance for actual power system needs. Moreover, it would give rise to significant out-of-market corrective measures that would need to be executed by TSOs,

creating a new high-volume market for redispatching organized differently and priced as compared to the wholesale market.

Today, in the face of technological changes and the development of new business models in the energy market, those foundations - if embraced together - may pose a threat to the stability of the power system as a whole.

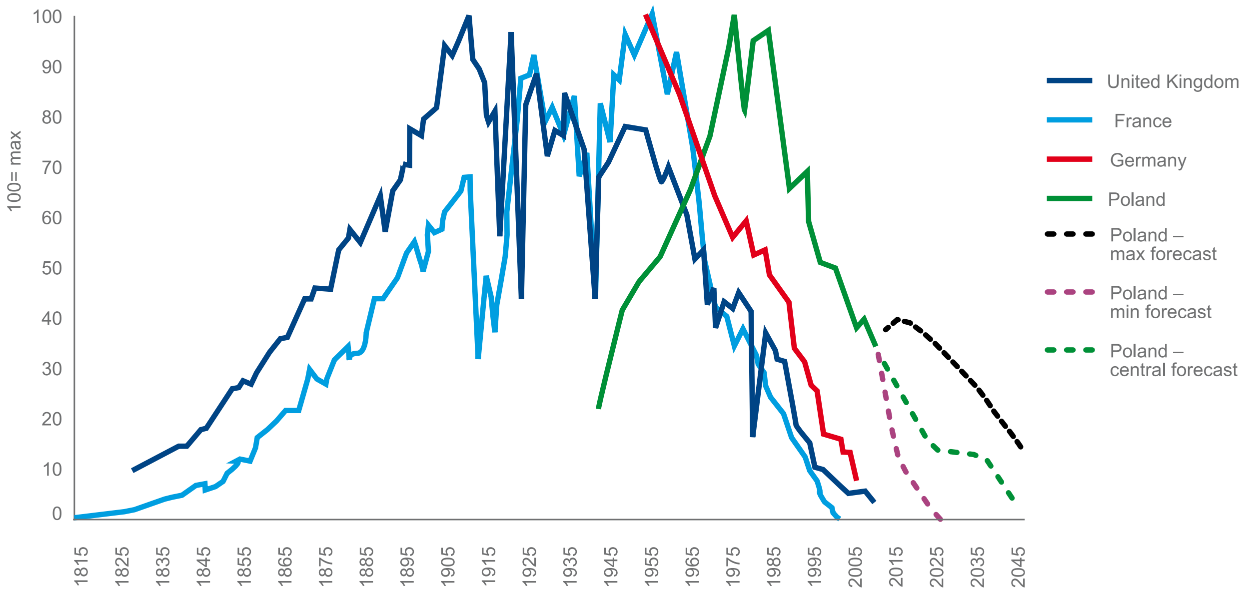
1.2.2
Security of electricity supply and global competitiveness of Europe

In historical terms, eliminating reliance on uncertain suppliers of energy resources was also an underlying assumption of the European energy policy. The foundations of the policy gained shape in the aftermath of the 1970s oil crisis. Therefore, in the face of depleting European coal resources (see Fig. 6), it was necessary to find new sustainable energy sources and limit energy dependency of Europe. In addition to ecological rationale, support to the development of RES generation and, to a certain extent, also natural gas energy, is also motivated by geopolitical considerations. However, its natural consequence is the risk of reliance on gas supply from Russia which was once – paradoxically from the Central European point of view – perceived as a stable supplier, especially as the European gas resources of the Atlantic Shelf are depleting. The promotion of RES was also intended to make energy prices in Europe independent of changes in the prices of non-renewable energy resources, providing access to "green" as well as secure energy. All this, however, remains in isolation from the electricity storage potential, which is still limited.

In the context of the existing economic conditions and, above all, long-term economic and geopolitical assumptions of energy policy defined this way, RES development has become even more important. In Europe, RES tends to be seen as a key to energy independence. Even more importantly, through the development of the associated industries (such as the wind turbine and EV panel manufacturing industries), the dissemination of RES was to improve Europe's competitive position in the global market by taking

Decreasing consumption of coal in European Union and Poland

Fig. 6



Source: *http://wise-europa.eu*

one of the most innovative and high-value-added niches in the industrial processing sector. This target has not been fully achieved, as European manufacturers of photovoltaic panels are displaced by their East Asian competitors, and in the field of energy storage Europe is dragging behind.

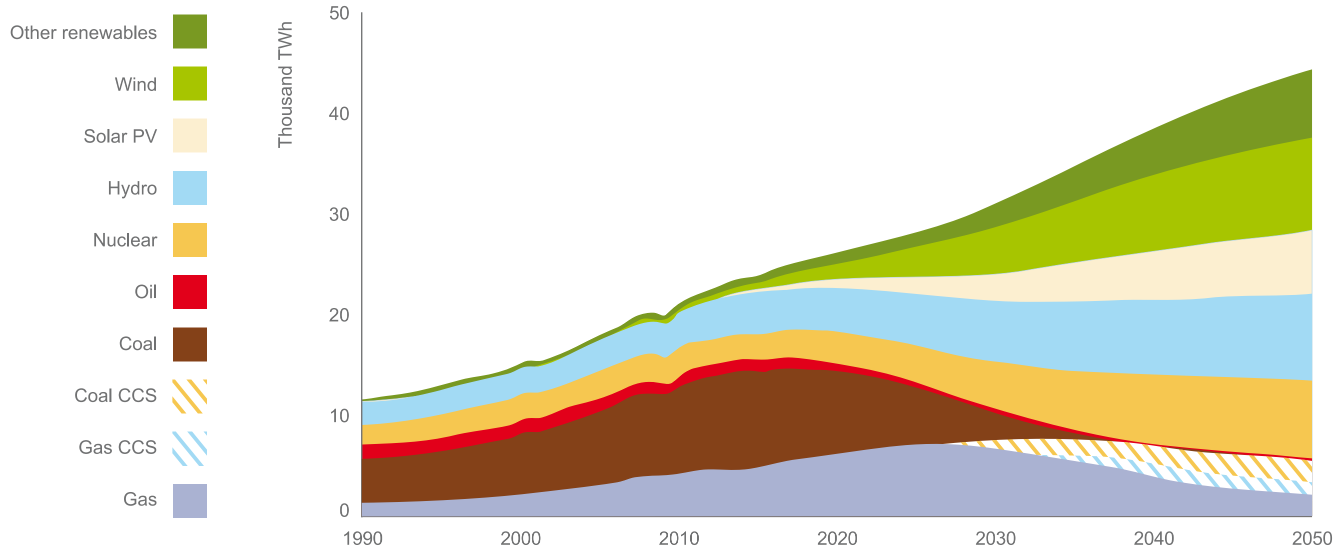
The choice of the market design and model of support to certain energy sectors may be considered in this context as a strategic choice for the EU. It seems, however, that it may lead to consequences opposite to what was intended – reliance on an unreliable monopolist for gas supply and uncertainty about sufficient generation (particularly acute under windless conditions and cloudy high pressure conditions in winter) and supply of electricity (which is also related to possible future problems in power network management).

1.2.3 Climate policy

The EU's engagement in climate policy and implementation of the goals of the Paris Climate Agreement significantly affects the European energy policy. The successive Energy Packages increasingly take into account the green component, which is also reflected in the title of the fourth Clean Energy Package (CEP). In particular, it is important to strive towards deep decarbonization of the European economy(ies), i.e. a dramatic reduction of the CO_2 emissions, mainly by eliminating the use of coal as an energy resource (see Fig. 7). The EU expects the Member States to extend the decarbonization process to conventional energy, so to a greater extent than provided for in the Paris Agreement, and therefore the emission targets are additionally supplemented by solutions concerning directly the power sector.

In particular, the objectives of European environmental policy are implemented directly in energy policy. Support to the development of the RES sector at the expense of other electricity generation subsectors is an important element of this approach. As a result, in addition to CO_2 reduction itself, the EU climate targets include a target share of electricity from renewables and elimination of emission sources specifically in the energy mix. To achieve those targets (or even more ambitious targets set previously by governments at the national level, as was the case e.g. with Germany), the Member States have implemented various support mechanisms, some of which turned out to be oversized, leading to the deterioration of competitive conditions for stable conventional sources which guarantee the security of electricity supply. Consequently problems

Fig. 7 **Deep decarbonization – scenario of changes in the energy market according to IEA (according to generation source)**



Source: *http://www.powermag.com*

with the power balance and availability of ancillary services are growing.

The transmission system operator is neutral to the power generation method, but it is of critical importance to any TSO whether the installed generation capacity is available for balancing the power system in each timeframe and with a degree of certainty necessary to ensure the operational stability of the power system at any moment and at any place in the system.

The climate policy pressure is accompanied by an additional rationale for cross-zonal exchange support at the expense of intra-zonal exchange: it is intended to enable Europeans to have access to green energy irrespective of its origin (i.e. irrespective of the energy mix of their country of residence). While the emission reduction target also in the power sector is reasonable, its hasty and inconsiderate implementation may result in a loss of energy self-sufficiency in the case of many countries, making them permanently reliant on supplies that may be periodically unavailable.

1.2.4 Summary

Europe's energy self-sufficiency achieved, among other things, through an effective climate policy in the power sector (which is to eliminate conventional generation sources using energy resources from uncertain suppliers), would not only improve the energy security and accelerate and deepen the decarbonization process, but also – by increasing interdependencies – deepen the political and economic integration of the European countries (e.g. through the above-mentioned preferences for cross-zonal flows at the expense of intra-zonal flows, so as to provide Europeans with access to "clean" energy). However, this target may prove impossible to achieve at the moment, not only due to the technological constraints described above (related mainly to transmission constraints and constraints of energy storage technologies), but also political and economic considerations of the integration process. The use of energy policy as a tool of environmental policy seems hard to reconcile with it being used at the same time as a way to deepen integration. This may aggravate the risk of failure to achieve the primary objectives of energy policy, such as security of electricity supply for Europeans, or ensuring the widespread availability of energy at socially acceptable prices. It should also be emphasized that growing technological complications that affect almost all TSOs in Europe are additionally aggravated by further regulations, tightening the integration under inefficient cross-border market model. While the TSOs are working on implementing existing regulations to improve markets, new and often contradictory regulations are being proposed colliding with solutions from the previous packages. As a result, despite the good intentions of the policy initiatives, they are not helpful to adjust the European market to the ongoing technological changes. This was for example the case with latest Clean Energy Package proposed by European Commission end of 2016, which in main part was addressing the yesterday's problems. Even the post-CEP European market design might still be inadequate to ensure efficient power system management.

The disorderly situation in the cross-border exchange market (loopflows) is an example that testified to an incomplete success of the European electricity market project. A lack of coordination in the process of capacity calculation and allocation translates into incorrect price signals, and consequently into inefficient use of the existing network and generating infrastructure.

2 Consequences of the European paradigm for market operation

2.1 Market

The present design and regulatory framework of the electricity market generate numerous problems at the interface of technologies, institutional considerations and organization of the market. In particular, implemented market solutions cause market processes to be performed in a framework of the zonal network model. It is a very far-fetched simplification in relation to the nodal reality resulting from the laws of physics. Electricity purchase and sale transactions are carried out by market participants disregarding transmission network constraints, which often results in technical infeasibility of such transactions and the need for TSOs to take costly remedial actions. Such actions obviously involve additional costs, which are not passed through to those whose decisions and transactions necessitate those actions, but they are passed through via the transmission tariff to all electricity consumers in the country (socialization of costs). In a non-distant past, such functioning of the market made sense: a widespread socialization of the costs of network operation allowed it to be developed and maintained also in those areas, where its existence cannot be justified in purely commercial terms, but where it was obviously necessary, e.g. in rural areas.

However, current experience of the operation of the zonal market shows that it fails to satisfy the efficiency criteria. Simply to maintain the stability of the system operating under conditions of such a market, it is already necessary for operators to take a large number of out-of-wholesale-market remedial actions aimed to ensure the secure operation of the system. This huge quantity, and the related high cost, of remedial actions currently arises mainly from the new phenomenon of a large and quickly growing volume of generation from intermittent sources.

The zonal model also does not provide for proper signals for market participants that would ensure the current operational efficiency of the system, or for long-term efficiency. This is associated with the inherent problem of the zonal market – the zone delimitation issue. The principle of initial determination of zones in Europe defined by state borders cannot guarantee that their areas are optimal. To improve the situation, it would be necessary to move the borders of the existing bidding zones so that commercial exchange within bidding zones has the smallest possible impact on flows between bidding zones, and consequently does not affect (to an unacceptable extent, as this phenomenon is unavoidable in the synchroneous meshed grid) the efficiency of cross-border capacity allocation.

This is increasingly difficult for two reasons. Firstly, the delimitation of borders of the majority of zones corresponding to the borders of EU Member States, creates a situation where changes in zone configuration will always be met with opposition which cannot be dismissed with the argument that it is merely a technical matter, because the network was built also in order to satisfy non-commercial needs, the needs of being member of society and participating in its development. Secondly, a change in the configuration of zones will always infringe interests of those market participants who have decided to enter into long-term, e.g. multi-annual transactions for electricity purchase/sale. They have done so, acting rationally on the basis of the current configuration of bidding zones with their suboptimalities which – obviously enough – could be conducive to the conclusion of such transactions. In an ideal zonal model, changes in the configuration of zones should be quick in order to adopt the zones to the needs of the system. However, any change of the zones is to an extent intrusive for the market and hence CACM prescribes that the bidding zones should be stable over time. Nonetheless, it also foresees a periodical review of bidding zone structure in case the existing zones are inefficient from market and technical perspective. In this context, given the fact that existing zones in Europe are defined by political borders and likely not ideal from technical point of view, the first exercise to redefine the zones is of utmost importance for efficient functioning of the European market.

Owing to the specificities of the European market and the political reality of the EU, changes of zone borders interfere with the sovereignty of the national states forming the European Union. The issue of bidding zone redefinition has been thus strongly politicized. Such a solution has been applied, to the benefit of the parties concerned, in Sweden and in Italy, in line with the intentions and with the consent of the governments of both countries. On the contrary, a split of the Austria-Germany common zone into two (along the state borders) is in the course of processing, under conditions of reluctant attitudes in both countries subject to the split. The experience so far shows that the bidding zone review process will be longer than planned within the existing regulatory framework, and difficult to implement. In addition, the regulations proposed in the CEP may render the process even more difficult. This is confirmed by the first edition of the review of bidding zones in the EU, which involved the TSOs from Austria, Belgium, the Czech Republic, Denmark, France, Germany, Hungary, Italy, Luxembourg, the Netherlands, Poland, Slovakia and Slovenia. The report stated that in view of the significant uncertainties of the analytical process concerning, among other things, the future network pattern, future generation structure, etc., the study has not privided unambiguous evidence of one configuration being superior to the other. Consequently it was recommended that the present configuration of bidding zones should be retained.

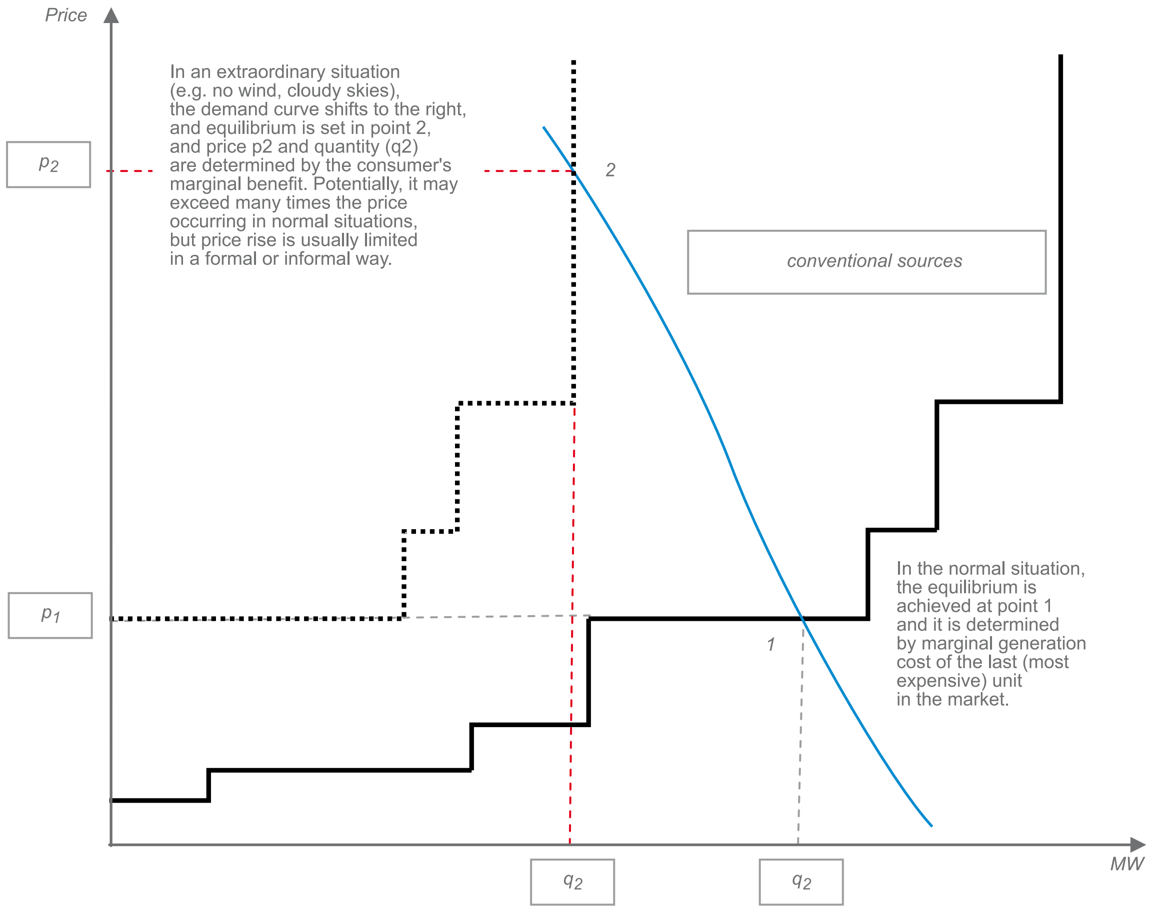
Thus, it seems that the present scheme for adjustment of the zone borders will not address the problems of the European electricity market. Potentially negative political consequences of zone border changes will be a natural incentive to avoid even if it could help improving price signals and ensuring coherence between market and physical reality. In particular, the emergence of zones covering the territories of many states will give rise to problems with the management of the security of supply, which operators will seek to avoid. While the experience of the operation of the bidding zone covering Germany and Austria shows such solutions are feasible, albeit with negative consequences for the neighbouring transmission systems (loopflows), the qualms about the adjustment of borders in the zone show how difficult it can be to adjust bidding zone borders.

2.1.1 Energy-only market

The price formed in the energy-only market under conditions of dynamic technological changes currently witnessed, poorly reflects the depreciation costs of generating units (or does not reflect them at all). What should be an investment incentive in the energy-only market are high demand periods (which is not the case), when energy is in short supply, i.e. it is priced very high – scarcity pricing (Fig. 8).

What becomes the foremost challenge under the changing operating conditions of the power sector is the need to restore a controllable production park in a situation where the share of variable renewable sources is steadily increasing. The experience of the recent years shows that the process will be very difficult, as revenues derived by the generation sector are not always sufficient to carry out necessary investments, characterized by multi-billion capital expenditure and a return period of several decades. The subject of development of generating sources is currently among the most important ones for the

Fig. 8 Market equilibrium determination process – normal and low supply (high demand) situation – scarcity pricing



Source: *Own compilation based on: CEEP 2018; Hachner, Hauteclocque i Sadowska 2015*

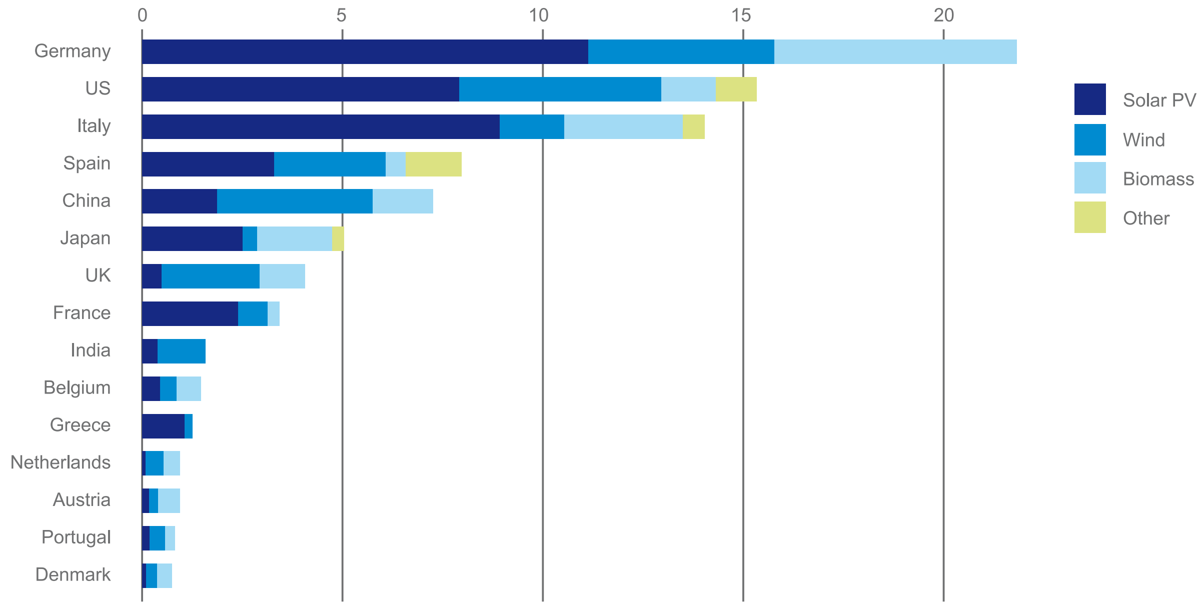
whole sector, and discussions on possible solutions are held in practically every EU Member State. Yet, it must be kept in mind that where it is necessary to implement mechanisms supporting the development of generating sources, they should be harmonized as far as possible at European level, which will allow the integrity of energy markets of the different EU countries to be maintained.

In the present situation, competition between the European electricity markets is significantly impeded due to the scale of grants and subsidies (RES subsidies in Europe represent a large proportion of such subsidies globally (see Fig. 9). Examples include the systems of Germany or Denmark, where a very low wholesale price is accompanied by Europe's highest price for customers, charged with very high RES grants . The RES levies imposed on the retail electricity tariff can be as high as twice the wholesale energy price. The scale of this phenomenon can be illustrated by a comparison of the value of energy consumed in Germany (approx. EUR 20 bn in 2013) relative to the amount of RES subsidies for the same period: approx. EUR 23 bn annually for RES energy, representing approx. 35% of the total German demand.

In addition, the zonal market model averages spatially diversified price signals without showing the value of electricity in a given location. In consequence, system users, in particular investors, do not know the real value of electricity in a given location (node), but only an average value of electricity in the bidding zone, which is not conducive to the correct location of new sources. The location of new investment projects under such conditions is based on the "copper plate" assumption guaranteed by regulations and TSOs' remedial actions. Consequently, the

Renewable energy subsidies. Europe and rest of the world (Billions of USD)

Fig. 9



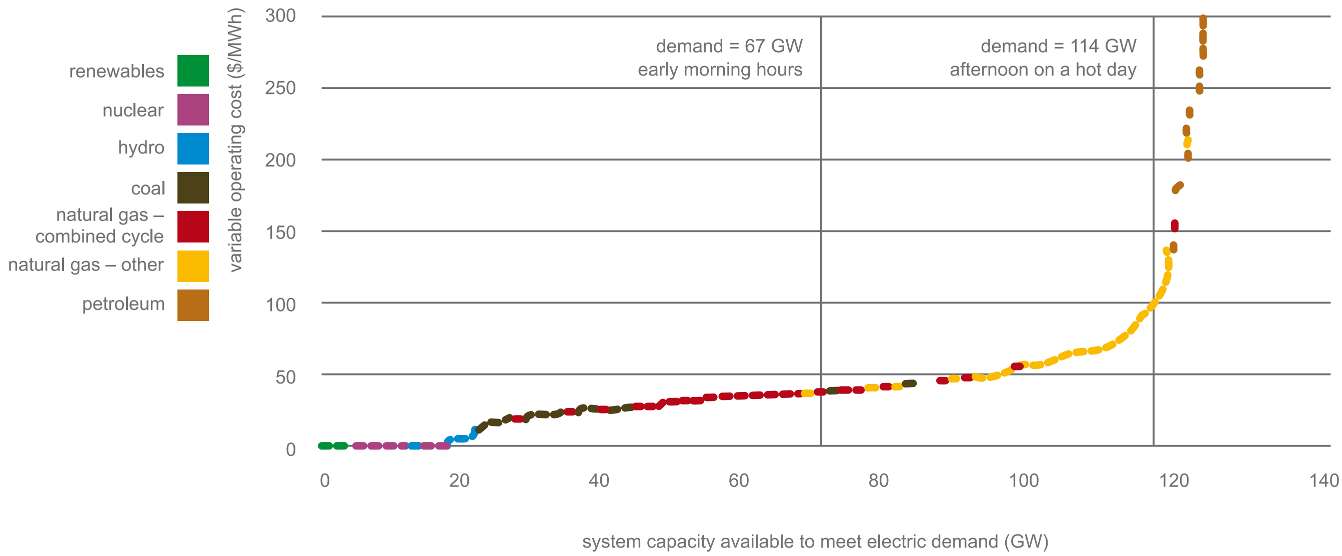
Source: *http://blogs.ft.com/the-world/files/2016/07/GR262Xcarbon_tax_modern_energy_SR_CHART.png*

attractiveness of location is assessed disregarding the state of network development and local demand. Low price variations averaged within a bidding zone will translate into weak price signals, which will not stimulate change of market participants behavior on both the supply and demand side. This in turn will imply potentially less efficient use of generating, load and network resources, preventing the achievement of the overarching objective to supply electricity to the customers at an optimal price. Under such conditions, scarcity pricing fostering prices to raise during high demand/low supply periods of electricity is bound to fail. Simply, scarcity is less likely to manifest itself in a large bidding zone where all transactions are assumed to be possible, even if they are technically infeasible due to grid limitations.

In the long term, price signals from a well-designed and efficiently operated energy-only market might be sufficient to stimulate generation investment decisions. However, this means that prices during scarcity periods should be sufficiently high to justify investing in sources even if it means that they would be used only for several hours a year. In reality, generation investments are quite lumpy and characterized by long payback times. In the sector suffering from an increasing problem of missing money, the investors are unlikely to take heavy financial commitments on the premise of high prices for limited period of time. Especially so knowing that high prices are politically and socially unacceptable. The assumption of sufficiency of price signals in scarcity pricing situations seems to be based on the belief that technological changes occurring in the electricity market take place at a slower rate than in reality (which would limit the risk of stranded costs), and of limited impact of political factors in the price mechanism. Those assumptions, as well as regulatory arrangements adopted inadequately on their basis pose a risk of growing problems to the operation of the European electricity market. In particular, the determination of the VOLL level as the maximum price, i.e. in accordance with the definition contained in the CEP (estimate of the maximum price of electricity that consumers are willing to pay to avoid a lack of supply) is not sufficient, especially where capacity mechanisms are treated as transitional measures. The assumption of electricity price increase in scarcity periods to the VOLL level will not be a sufficient tool for the deployment of new capacity for use in such periods. The experience so far shows that in a capacity shortfall situation extraordinary measures are taken to ensure the secure operation of the system, which limit the increase in prices. Consequently, investors are not willing to take investment risk based on hypothetical possibilities of electricity price increases, which are, as a rule, short-lived (see Fig. 10).
To sum up, the energy-only market is sufficient to provide long-term investment signals exclusively

Fig. 10

Hypothetical dispatch curve for the US



Source: *https://www.eia.gov*

from a theoretical point of view under idealized model assumptions. Unfortunately, the theoretical effectiveness of such a market architecture does not translate into practice, for reason including:

- administrative restrictions of electricity prices aimed to protect inflexible customers from sudden price hikes;
- non-market systems of support to RES, high-cost low-carbon technologies (e.g. differential contract for a nuclear power plant in the United Kingdom) which put them in a privileged position;
- long-term investment processes that require high capital expenditure, conducted under conditions of high uncertainty about long-term electricity prices and market operation rules (regulatory risk);
- insufficient remuneration of reserve capacity necessary to ensure operational security of the system;
- an (untrue) assumption of the existence of a copper plate within a bidding zone. Under this assumption, electricity is priced as if supplied at no cost to the supplier or the customer, and actual cost of transmission is incurred by all participants of the power system, which distorts price signals for network expansion and maintenance. (Aengenvoort, Sämisch 2016)

Based on the experience of the operation of the electricity market in Poland, it can be concluded that there is a risk that in future the energy-only market:

- will not ensure covering the costs of all stable generation sources necessary to ensure the operational security of the power system,
- will not create sufficient signals for investing in new stable generating capacity,
- will not provide correct signals for investing in network development, which may lead, in some cases, to oversizing investments which by nature have a very long timeframe spanning many decades.

What must be specifically emphasized is that the pricing mechanisms and the price signals currently witnessed fail to provide investment incentives. Generating capacity investments are capital-intensive, and therefore a mechanism is needed that will help to create more stable conditions for investing in new resources, and thereby to ensure security of electricity supply in a longer term.

2.1.2 Cross-border capacity calculation and allocation

European regulators have recently been placing focus on an increase of cross-zonal exchange at the expense of intra-zonal exchange. However, in an attempt at maximizing cross-border capacities available for the market, the proposed solutions are rather artificial, disregarding the physical network constraints. Given the existing market design based on bidding zones and energy-only products, increasing of cross-zonal capacities comes at a costs of ignoring power flows resulting from internal transactions and as a consequence having to apply corrective redispatching measures to bring the cross-border exchanges back to lower levels. Hence, it might be argued that artificial increase of capacities will create artificial exchanges, while in reality the physical cross-border exchanges will remain the same.

In the zonal market model, cross-zonal transmission capacity should be used to represent cross-border trade levels that guarantee the secure operation of the power system – in other words, an entity offering electricity transmission should offer only as much as it is able to physically handle without causing a threat to cross-zonal interconnection. If borders are determined on the basis of arbitrary target values, this means that a transmission capacity offered in cross-zonal exchange can exceed the physical transmission capacity available to the TSO.

An increase of the integration of power systems in Europe is a desired goal, albeit extremely difficult within the framework of the existing zonal market model, as market solutions directly translate into operating conditions of interconnected power systems. Along with the progressing integration of markets, leading to an increase in the volume of cross-border exchange and a growing share of renewable generation, correct regulation of the cross-border exchange market management is gaining a key significance.

2.1.3 Technological neutrality

The principle of technological neutrality in the electricity market involves a guarantee of equal conditions of participation in market processes for all generation technologies. Obviously, those conditions should take into account costs arising from other regulations, including regulations on the valuation of environmental costs of their use, such as the costs of emission allowances determined by the EU Emissions Trading System (ETS). Unfortunately, solutions that are currently in the pipeline clearly breach the principle of technological neutrality aimed to ensure stable generation, in particular to ensure the availability of generation capacity necessary for the secure operation of the power system. In the regulations proposed as part of the CEP, the admission of emission technologies in capacity mechanisms will probably be asymmetric – certain mechanisms will be preferred (such as strategic reserve), and other solutions (such as capacity market) will be discriminated through CO_2 emission restrictions. In that context, new regulations proposed in CEP clearly violate this principle of technology neutrality, since it will lead to some generation technologies being eliminated from capacity markets, while preserving the ability to use those technologies for other capacity remuneration schemes such as strategic reserve or network reserve (Frontier Economics 2017).

The solutions adopted may result in governance failure which makes it impossible to achieve an efficient market equilibrium (Orbach 2013). Efficient market mechanisms require technological neutrality. It is investors that should decide on an optimal method of generation that takes account of restraints related to the economy, technology and energy resources, as well as needs of the transmission system operator. Legal regulations should allow individual countries to freely use them, with due respect for internal market rules, as a competitive method of ensuring generation adequacy in the long term. Moreover, the regulations should neither infringe technological neutrality nor reduce the effectiveness of capacity markets, or else this will pose an obstacle to ensuring the security of electricity supply. Efforts towards reduction of CO_2 emissions should affect all technologies in proportion to the scale of emissions, so that political decisions do not diminish the efficiency of market mechanisms.

2.2 Network operation

The technological revolution taking place in the electricity generation and transmission area opens up highly promising prospects for the development of the sector. In the short term, however, it brings about serious challenges in terms of maintaining the operational stability of interconnected power systems. In particular, the dissemination of RES (with a generation level determined by weather conditions) in the energy mix is not associated by a sufficiently dynamic development of the utility-scale energy storage technology. Also the existing network structure inherited from the conventional, centralized power generation period, is not adjusted to the changing dynamics of supply and demand, generation and load. As a result, massive congestions build up, variable in time and space, within or between zones, which leads to an increase in system operation costs. Societies are facing growing costs of network management and development, in particular resulting from the needs of new transmission and distribution investments, depreciation of those already completed and, not less importantly, social costs of investment, which may fail to return the costs incurred (stranded costs). In addition, the full adjustment of energy systems to the new continuously changing technological reality is not only costly, but it proves to be extremely time-consuming in all countries.

Growing problems with network operation, which are experienced by European operators, are among the main challenges faced in Europe. They are influenced by incorrectly delimited bidding zones whose borders are hard to correct, cross-zonal unplanned flows (loopflows) and the related issue of a growing scale of redispatching.

2.2.1 Loopflows and unscheduled flows as an externality of the market model

Coordination of cross-border trade in Europe is not yet ensured. Flow-based allocation deemed as a solution to regulated cross-border exchanges in the continental part of Europe is still in an early stage, implemented among a small subset of countries. Large-scale deployment of flow-based is expected around 2020 when this mechanism is scheduled to be implemented in the CORE region covering 12 countries from CEE and CWE regions. For the time being, coordination of capacity allocation is rather limited. On top of this, bidding zones in Europe are defined based on political borders, rather than on the technical considerations. This results in physical aspects of operation of the interconnected transmission network being insufficiently taken into account when entering into market transactions. The resulting unscheduled flows pose a threat to the secure operation of the interconnected power system and prevent the achievement of intended goals with regard to the optimal use of the EU network and generating resources. In the Central and Eastern Europe (CEE) region, the phenomenon of unplanned flows has increased significantly in the recent years, posing a major problem for Poland and for other countries of the CEE region.

In the case of a transmission network structure such as that of Continental Europe, the loading on all lines, both domestic and interconnectors, is affected both by cross-zonal trade and domestic (intra-zonal) trade. Internal trade causes internal flows in the domestic grid, but also due to the meshed structure of synchronously interconnected grid, internal trade within bidding zones also causes power flows in the neighboring grids. These are traditionally referred to as "loopflows", or as draft Electricity Regulation puts it: "power flows leaving and re-entering the given bidding zone without being scheduled". Cross-border trade on the other hand can lead to transit flows through neighboring grids. If these transits are planned under coordinated trading mechanism, the concerned TSOs make sure that the exchanges are allowed only up to the maximal admissible levels without negative effect on system security. However, current reality of uncoordinated trade in Europe results in majority of transits being unscheduled, so that the TSOs hosting the transits is not aware of the transactions concluded outside of its market area. These transits are referred to as "unscheduled transits" and can pose a great security challenge to the affected TSOs. Both loopflows and "unscheduled transits" are commonly referred to as "unscheduled power flows".

While unscheduled transits will be managed by future continental Europe flow-based mechanism coordinating and scheduling all transits, loopflows cannot be managed by any zonal market mechanism. Loopflows are an inherent physical feature of power networks under the zonal market model. Although there is no doubt that they are an externality of the zonal market design, loopflows in zonal markets are inevitable. However, they should be minimized, since well-defined bidding zones should be characterized by very low loopflows.

Since loopflows are a natural part of every power system operated under zonal market design, handling them and related costs are also a natural task of every transmission system operator. As long as loopflows are small and constitute a small fraction of power flows in the meshed grid, the entailed costs of managing them can be considered as justified by the benefits derived from synchronously connected power systems operation. However, the increasing loopflows and hence also the increasing volume of necessary remedial actions, and consequently the growing costs of remedial actions, trigger the problem of who should bear the cost of remedial actions whose need exceeds the scale of loopholes naturally existing in interconnected networks.

The most common but dramatically inadequate approach is "requester pays", where the cost is incurred by the party requesting the use of remedial actions, i.e. by the operator who has been most affected by unscheduled flows.

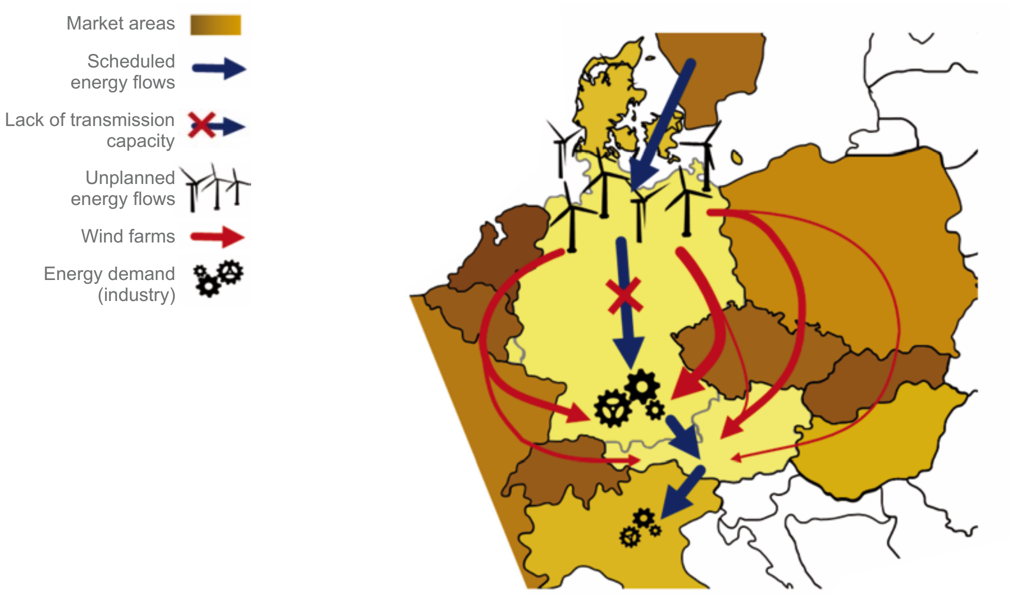
In other words, the cost is borne by the party that bears the burden of using remedial actions. This approach however fails to recognize the reasons being overloads, which is fundamental to implementing a mechanism with correct incentives. As long as it is not penalized to cause loopflows or unscheduled transits on neighboring system, there is no incentives to improve the situation. On the contrary, instead of expanding the grid to reduce loopflows burdening the neighboring systems, one is able to use foreign grid to supply domestic consumers without proper compensation or is able to use foreign grid for conducting commercial import or expert transactions. As a result, consumers on one country are subsidizing consumers in another country without obtaining any benefits. It is thus fundamental to implement a cost sharing regime, where parties causing externalities on foreign system in form of unscheduled power flows are obliged to cover the costs of dealing with these externalities, i.e. implement "polluter pays principle". This is also the line of action followed by the draft CEP.

2.2.2 Increase of the scale of redispatching

Under conditions of inadequately delimited zone borders and widespread unscheduled flows, a significant cost of handling congestion is generated by remedial measures, in particular redispatching and countertrading. As described above, the scale and costs of remedial actions go beyond the standard scope of activity of transmission network operators. Redispatching is a measure activated by one or more system operators when the generation or load pattern is changed in order to change physical flows within the transmission system and reduce congestions. It is needed when technical constraints of transmission capacity make the market result infeasible, forcing TSOs to use special operational remedial measures. This consists in restricting electricity generation in power plants "in the market" (cheaper) and related increase in generation in power plants "off the market" (more expensive), so as to reduce existing flow constraints. As the net financial result of redispatching is a cost, it is defined as a "costly remedial action". Another example of costly remedial measure is counter-trading. This is a cross-zonal exchange in the market initiated by system operators between two bidding zones in order to reduce congestions occurring on interconnectors. In contrast with redispatching, countertrading does not identify physical sources and sinks participating in the measure, but is rather a commercial trading transaction scheduled between zonal portfolios. Hence, in meshed grid redispatching is a much more efficient solution, because it allows TSOs to select the most effective generation resources for relieving a given congestion.

In recent years, redispatching amounts to an increasingly large scale, becoming an important segment of the market. Some of the newly proposed market integration solutions treat it as a normal element of operation of the European power system, which is quite difficult to understand from efficient market organization point of view.

Fig. 11 **Unscheduled flows in the Central and East European region**



Source: *https://wysokienapiecie.pl/1295-situation-on-polish-german-border-poses-threat-of-european-blackout/*

There are many highly important consequences of excessive redispatching. Extraordinary remedial actions are usually prepared to manage unexpected events, such as network failures, forced generation outages or weather forecast errors, and the ability to use them is technically limited by the availability of generating capacity. If the capacity is used for ex ante redispatching, aimed to boost cross-zonal capacity, it will not be available in the reserve in case additional measures prove necessary in real time, intended to ensure the secure operation of European interconnections (e.g. in case of a sudden interruption in the operation of a generator or a transmission element), posing a threat to the security of supply in Europe. Thus the concept of a massive use of redispatching, as a tool for the management of the power market, may lead to a serious reduction of the operational security margin of the transmission system.

A significant increase in remedial measures, if technically feasible for TSOs within the short time period between market closure and real time, causes additional extraordinary costs which is expected to be socialized by European consumers (redispatching costs are ultimately socialized by network users). This may be done directly – through an increase of network charges, which is a cost incurred by all or selected users (e.g. taken into account exclusively in tariffs for individual customers), or indirectly – through transfers/subsidies or other forms of public support. It is a transfer of costs from generation to the networks, and hence from the energy-only market to the transmission charge market. This allows for an apparent drop of electricity wholesale prices in the market, but at the expense of an increase of system risks and growth of transmission charges leading to high and untransparent energy supply costs paid by final consumers.

What may provide an illustration of potential risks arising from the depletion of additional resources for remedial actions, and consequently a warning from excessive reliance on such solutions in the daily management of the transmission system is the situation of 10-12 August 2015 in Poland. The TSO was then forced, due to a deficit of power caused by an insufficient supply of generating capacity, to impose power consumption restrictions. In those critical days of power deficit in the Polish system it was not possible to import electricity from Germany (the only country in the region that had a generation surplus at the time) due to the overload on the Germany-Poland interconnection, which necessitated extraordinary remedial measures in the form of multilateral redispatching. It should be noted that the low import capacity did not result from a lack of physical connections or from technical exchange capabilities, but directly from substantial unscheduled power flows through the Polish power system from the western to the southern border. Such large unplanned flows were attributable, among other things, to unlimited commercial electricity exchange between Germany and Austria.

While up to recently the problem concerned primarily the Poland-Germany border, in a longer run the secure system operation is at risk in all the countries of Continental Europe with a highly meshed grid. In case of an emergency shutdown of the Germany-Poland border, caused by overload on the individual power lines of the interconnection, an extensive system failure of a regional or even pan-European reach will be a highly probable consequence. The 2006 blackout should be kept in mind, when the European system split in the emergency situation into three parts. A possible shutdown of the Germany-Poland border caused by an overload will lead to severe overloads in the systems of Germany and Austria, which will have to transport their electricity without being able to use the networks of the neighbouring countries, which may consequently lead to the disconnection of the European system along the Baltic-Adriatic line. Financial effects of such a failure would be tremendous.

2.2.3 Stranded costs

The problem of missing money in the development of conventional generation is not the only investment problem. Stranded costs, i.e. costs invested in projects whose implementation has become commercially unjustified before full depreciation, are becoming an increasingly common phenomenon.

Stranded costs are related to the long depreciation period in the power sector, mainly its conventional part, a high level of investment costs, and technological transformation of the sector. It is also influenced by model of public support to some RES technologies.

Transformation of the power sector started at a time of a high oversupply of generating capacity, especially in Central and Eastern Europe. Many investments in new capacity had been initiated by enterprises that has a sense of responsibility for the security of supply. Time showed that under the new market conditions many of those investments proved to be a financial failure, e.g. gas power plants in Germany and the Netherlands, some of which were mothballed just after commissioning, and coal power plants which had difficulties in establishing their position in the light of an aggressive policy aimed to reduce CO_2 emissions.

In a zonal market, there is also a risk of stranded costs emerging in case of network investments. Meeting the "copper plate" assumption in large zones may necessitate network investments. Network development is subordinated in this situation to market model, and not to the actual technical and economic needs. In such a situation, a change of zone borders or market model will potentially reveal the unviability of some investments and lead to stranding further costs. An excessively extended network may additionally become a burden for the entire sector.

Conclusions

Creation of the European electricity market is an important and valuable undertaking story. It is quite remarkable to see 28 EU member states willing to significantly redesign the way electricity is provided, opening up their national markets to competition and removing barriers to cross-border trade. Simple, zonal, energy-only market model chosen at the beginning of liberalization has served the purpose of fostering early integration efforts. However, the same features are now becoming an obstacle to more efficient use of the grid. Prominent example is the quality of bidding zones, which is a decisive factor for the success of zonal markets and flow-based allocation. Network representation in the zonal model is highly simplified, causing detachment of market and system operations. European market outcome is thus often technically infeasible, requiring TSOs to take special measures outside of the wholesale market to correct market-based dispatch. Obviously, since market-based dispatch must be corrected, market prices are not reflective of the system needs, rendering them inadequate to provide price-based coordination of system operations. Given the ongoing technological transformation of the power system and the trend on smaller generation resources scattered over the power system with increased demand flexibility, it is quite evident that such price-based dispatch coordination will be fundamental. And we are speaking of the very near future.

Power system under large penetration of zero-marginal costs resources will be quite different from the existing one. Under current conditions, electricity-only market has already difficulties to provide long term generation investment signals, so it should not be expected to better serve its purpose in fundamentally more challenging future. Investment incentives in generation for both conventional and RES technologies based on solely energy-only market prices are simply insufficient, as proven over the recent years by European generation capacity withdrawals. Unconditional commitment to the present European market model without considering its fundamental improvements could prove a costly mistake. It is unfortunate, that new legislation, currently discussed in Europe, fails to address this issue and it is focusing on solving yesterday's problems. Instead of correcting price formation and ensuring coherence of incentives for all players throughout the market segments, policy makers focus on increasing cross-border capacities even beyond the physical grid capabilities. It would be much more efficient to treat the root causes of the problem, not the symptoms. Underutilization of cross-border infrastructure is mainly caused by loopflows and zonal market imperfections. More locational market design would allow for much better grid utilization without going beyond the secure boundaries of system operation. Liberalized markets outside of Europe have already understood this and are now able to benefit from increased economic efficiency. Perseverence of European policy makers to rigidly maintain the market design based on large bidding zones in pursuit of "enhanced market liquidity" is rather short sighted. The liquidity is treated like a "Holy Grail" of the European market, justifying any inefficiencies. Even the fact, that it may come from generation resources unavailable due to grid limitations does not seem to bother the proponents of large zones. It causes millions of euros of unnecessary costs for European consumers. Attempts at fixing these problems by massive grid investments might lead to even more unnecessary stranded costs given the clear trend towards more distributed energy resources and storage. Unfortunately, direction of legislative changes presently under consideration shows no indication of course correction.

Diagnosis of the European market included in this report aims at initiating a comprehensive discussion of the current market design inefficiencies. Such open discussion is indispensable. No topics should be considered as taboo. European electricity industry cannot be closed for new ideas, and should rather look across the oceans and draw inspirations from successful solutions applied throughout the world. Academic literature reviews show that locational market is the optimal market design solution. While the discussion between academics and businesses concerning the real-world applicability of economic theories will most likely not be solved in the near future. Closer interaction between these communities would definitely enrich the European energy sector. PSE is ready to facilitate this discussion. In Autumn 2018, PSE intends to publish its position paper on future market design, focusing on four fundamental pillars: economic efficiency, system security, incentive compatibility and market transparency. PSE is convinced that improved, more locational market design should better contribute to reaching all objectives of the European energy policy granting to higher social welfare for all Europeans.

List of Figures

Bibliography

Bloomberg .2018. Norwegian Gas Exporter Warns Europe May Be on Verge of Blackouts (A. Shiryaevskaya, M. Carr). 15.05. https://www.bloomberg.com/news/articles/2018-05-15/norwegian-gas-exporter-warns-europe-may-be-on-verge-of-blackouts

Hogan M. 2017. Follow the missing money: Ensuring reliability at least cost to consumers in the transition to a low-carbon power system. The Electricity Journal, Vol. 30, No 1.

Weibelzahl M.. 2017. Nodal, zonal, or uniform electricity pricing: how to deal with network congestion. Frontiers in Energy vol. 11.

Hancher L., A. de Hauteclocque, M. Sadowska. 2015. Capacity mechanisms in the Energy market. Oxford UP.

CEEP. 2018. Summary of the position of Polskie Sieci Elektroenergetyczne S.A. regarding the proposed new rules for applying capacity mechanisms set forth in the package "Clean Energy for all Europeans". CEEP. https://www.ceep.be/www/wp-content/uploads/2017/11/CAPACITY_MECHANISMS_PSE.pdf

Aengenvoort J., H. Sämisch. 2016. The illusion of the German copper plate power grid. Energy and carbon. http://energyandcarbon.com/the-illusion-of-the-german-copper-plate-power-grid/

Appunn K. 2018. Energiewende hinges on unblocking the power. Clean energy wire. https://www.cleanenergywire.org/dossiers/energy-transition-and-germanys-power-grid

ENTSOE. 2018. First Edition Bidding of Zone Review. Draft version. https://consultations.entsoe.eu/markets/first-edition-bidding-zone-review/supporting_documents/Final%20report%20for%20public%20consultation_090218.pdf

Frontier Economics. 2017. 550g-Rule as an Access Requirement to Capacity Markets. http://www.frontier-economics.com/documents/2017/08/co2-grenzwert_frontier-report.pdf

Karan M.B., H. Kazdagli 2011. The Development of Energy Markets in Europe, w: Dorsman et al. (eds.), Financial Aspects in Energy

Orbach B. 2013. What Is Government Failure? http://yalejreg.com/what-is-government-failure/

PSE. 2018. Worrying detachment of market and system operations. EUractiv, https://www.euractiv.com/section/electricity/opinion/worrying-detachment-of-market-and-system-operations/

Richter A., E. van der Laan, W. Ketter, K. Valogianni. 2012. Transitioning from the traditional to the smart grid: Lessons learned from closed-loop supply chains, International Conference on Smart Grid Technology (SG-TEP)

Sioshansi F. 2018. How aggregators will alter fundamentals of electricity business. Energy Post. http://energypost.eu/how-aggregators-will-alter-fundamentals-of-electricity-business/

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