Energiewende

And the Energy Security of the Czech Republic and Poland

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Summary

This study focuses on the impact of the Energiewende process, i.e. the German shift towards a decarbonized economy, and more specifically the large-scale deployment of renewable energy sources (RES), on the energy sectors of its eastern neighbors – the Czech Republic and Poland. Its main findings are as follows:

- The analysis of stakeholders' perceptions of Energiewende reveals that the grid stability is a key issue that both Czech and Polish stakeholders connect to Energiewende. The grid issue then affects the ways the stakeholders perceive also other issues including the very viability of the large-scale RES deployment or regional market setting. (Chapter 2)
- There are several pathways Energiewende could further develop along. The project's success would emerge as a result of either governmental policy designed to ensure the adequate development of a wide portfolio of renewable technologies, or a more spontaneous development of decentralized technologies driven by the consumers themselves. The less optimistic scenarios include a delay of the project due insufficient pace of the grid development, and a complete failure resulting from loss of the public support. (Chapter 3)
- With regards to the ways, in which the development of the German market affects also the markets of the surrounding countries, we identify two main impact mechanisms: the price signals, through which the price level and volatility converge among well connected markets, and the Europeanization process, through which some of the German policies get adopted as EU-wide policies and therefore directly affect the Czech and Polish regulatory framework in energy. (Chapter 4)
- As the Czech-German price convergence is much higher than the one between Germany and Poland, the Czech producers are fully exposed to the wholesale price decrease that has followed the RES development in Germany. The Polish producers are shielded off by limited interconnection and enjoy on average higher prices at which they sell their production. On the other hand, the Czech customers benefit from lower electricity prices, while the Polish ones cannot. (Chapters 5.1 and 5.2)
- The grid stability issue is expected to improve during the near future as the phase-shifting transformers, which are designed to reduce the magnitude of the unscheduled electricity flows from Germany, already run or are being installed at the borders between Germany and both its eastern neighbors. Furthermore, the German-Austrian common bidding zone is set to split by July 2018 and the

development of RES in Germany should more follow the grid development in the country. (Chapter 5.3)

- The recommendations are surprisingly similar for both countries. The policies they envisage suffer from similar issues, namely locking the energy sector in a system based on a single conventional technology that seems to be incompatible with the mainstream image of the energy system of the future. In the case of the Czech Republic it is the nuclear, which is considered as too expensive, too inflexible, and too risky given its lengthy approval and construction times, during which the market could change completely. In the case of Poland it is coal, which is environmentally unsustainable and which is becoming difficult to sustain economically as well. We therefore recommend the decision-makers of both countries to acknowledge the contemporary trends in the energy technology development and turn their focus from legacy technologies to truly diversified, flexibility-based systems. (Chapter 6)

1. Introduction

German Energiewende (EW) is arguably the most important phenomena in the current development of the energy industry. In times when the scientific consensus about climate change issues has been widely accepted amongst the World's leaders, as well as by the general public in individual national states, the Germans are spearheading the World's efforts to replace fossil fuels with renewable energy sources (RES) as a means of covering energy needs.

The specific features of RES, such as limited generation predictability and zero costs of production, make them substantively different from the conventional sources. Consequently, their integration into the existing market will trigger significant changes in the ways the market has traditionally operated.

This change will, however, not limit its range to the German market only. As Germany is to a significant extent interconnected with its neighbors (be it physically through the cross-border grid interconnections or through regulatory measures which facilitate cross-border trade), the development of the German market will influence the neighboring markets as well.

This study focuses on the impact of the Energiewende process, i.e. the German shift towards a decarbonized economy, and more specifically the large-scale deployment of RES, on the energy sectors of its eastern neighbors – the Czech Republic and Poland. The structure of the study develops as follows: firstly, we provide a brief reflection of the Energiewende process by the Czech and Polish grid operators and energy policy decision-makers, taking a closer look at the strengths and weaknesses of the current cross-border energy cooperation and pointing out what issues are in this sense considered crucial (chapter 2). Secondly, we introduce the possible pathways of Energiewende's future development, using the scenario analysis method and building on an analytical framework introduced by the 50Hertz company, one of the German TSOs (chapter 3). Thirdly, we provide a thorough explanation of the impact mechanisms through which the changes on the German electricity market are translated to changes to the ones of the Czech Republic and Poland. We primarily tackle the price signals, i.e. the price level itself and also the magnitude and pace of its changes; and the Europeanization of Energiewende, i.e. the ways in which the German energy policy is reflected by the European energy policy, which represents a significant input factor in articulation of energy policies of the individual Member States (chapter 4). Fourthly, we evaluate the impact itself. In this sense we combine the current development on the German as well as the regional market, their possible future developments and their likely impact on the Czech and Polish energy sectors, taking their specific features into the consideration. More specifically we focus on four types of actors within each country: producers, consumers, grid, and the decision-making bodies (chapter 5). Lastly, we provide a set of recommendations to both Czech and Polish decision-making bodies (chapter 6).

The study results from a six-month long research project awarded by the Czech and Polish Ministries of Foreign Affairs through the Czech-Polish Forum platform. The data collection phase took place between May and October 2016 in Prague and Warsaw. Preliminary results of the research were discussed with representatives of the Czech and Polish energy industry and decision-makers on a round table that took place in Prague on November 25, 2016.

2. The reflection of Energiewende by selected Czech and Polish stakeholders

After a decade in which natural gas market design, supply security and/or the Russian influence exerted through energy supply arrangements arguably ranked as the topmost concerns in the regional energy policy (see for example Ocelík and Osička 2011, Osička 2013, Ocelík and Osička 2014, Osička 2014, Vlček and Jirušek 2015, Vlček et al. 2015, Martanovič and Osička 2015, Osička et al. 2015, Osička et al. 2016, Vlček 2016, Osička and Ocelík 2017), the issues related to electricity supply, such as market design, generation adequacy and grid stability now seem to dominate the energy policy discourse in the region.

Renewable-focused generation structures in Germany changed electricity trade flows and caused congestion problems in the grids of neighboring states. Most fully the magnitude of these problems was outlined for the first time in a joint report of TSOs of four CEE countries in 2012 (ČEPS 2012) and aggravated since then. Prior to that, the EWIS report of 2010 predicted a significant congestion rate for Czech and Polish borders with Germany in the years to come (Winter 2016) (Winter 2010). In the broader regional context, Energiewende influences the market coupling between the CEE and CWE regions, which has been delayed since 2014, as well as, to a certain degree, it being a factor in shaping EU energy policy.

As a broad-scale concept with an ambitious agenda, Energiewende implies certain unpredictability in the outcomes. In the same vein, the ways in which it affects the neighboring states are evolving rather than static. For this reason, this chapter aims to map positions of the Czech Republic and Poland thereby seeking to capture similarities and divergence in the perceived implications. Perceptions about the Energiewende-related effects contribute to shaping the energy policies of these states and are therefore regarded as being worth closer attention. This knowledge is also deemed helpful to better comprehend the positions of the Czech Republic and Poland, as well as help reveal areas where there is no established common ground in place or where more intense cooperation may be needed.

The aim of this chapter is fulfilled by applying a method of stakeholder analysis. Within this method in-depth, face-to-face interviews were conducted with relevant stakeholders (Annex 8.1). These are mainly representatives of the transmission grid operators and ministries of energy in the Czech Republic and Poland. Altogether 8 interviews with 10 respondents were conducted. All respondents represent the official positions of their institutions and are ranked high enough to have a good grasp of the topic of Energiewende, understanding it in its entirety and complexity.

In this research setting, two levels of analysis are combined. These are state-level, revealing and comparing positions of stakeholder institutions where deemed necessary for the research purposes; and inter-governmental level, which allows exploration of the degree of similarity in perceptions, as well allowing for insights into areas where they are likely to diverge. The qualitative data were processed and analyzed using the qualitative analysis software PROSUITE – QDA Miner (Annex 8.2).

The analysis comprises two major parts. The first part reflects perceptions of the stakeholders on the pace of Energiewende in Germany through the prism of recent achievements and failures. The second part depicts perceptions of influences which Czech and Polish electricity markets encounter as a result of Energiewende.

2.1 The implications of Energiewende for Germany as reflected by the Czech and Polish stakeholders

This analysis is based on a combination of deductive and inductive approaches in developing an appropriate coding scheme to process interview data. Thematical statements are grouped into codes capturing a particular idea while codes are grouped into categories, as explained in Annex 8.2. Those categories and codes which appear to be the most relevant for the stakeholders receive more attention in our analysis.

In our analysis of findings, we use two major tools such as absolute coding frequency and coding co-occurrences. Absolute coding frequency shows the number of occurrences of the codes and enables us to capture the significance of various topics for stakeholders without having to go into depth about any interconnections between them. Coding co-occurrences reveals more complex interrelations between the codes. Co-occurring codes depict causal interrelations between various topics of concern and help explain the positions of the stakeholders in a more nuanced manner.

Prior to the detailed analysis, codes need to be explained (table 1). In this table, the left column displays a shorthand version for code names as they are used in the data analysis. But it is rather meaningless without the codebook which depicts the structure of each category and specifies codes which each category includes (see Annex 8.3).

Tab. 1. Code explanation. German context.

Code [short name]	Code [full name]
inc_sh_renew	increase_share_renewables
tech-adv	technological_advantage
ind_comp_suc	industrial_competitiveness_success
renew_lack_ec_feas	renewables_lack_economic_feasibility
del_grid_time	delay_grid_expansion_time
del_grid_opp	delay_grid_expansion_opposition
del_grid_sec	delay_grid_expansion_security
del_grid_pr	delay_grid_expansion_price
del_grid_neigh	delay_grid_expansion_neighbors
single_pr_z_opp	single_price_zone_opposition
reduc_CO2_em	Reduction of CO2 emissions

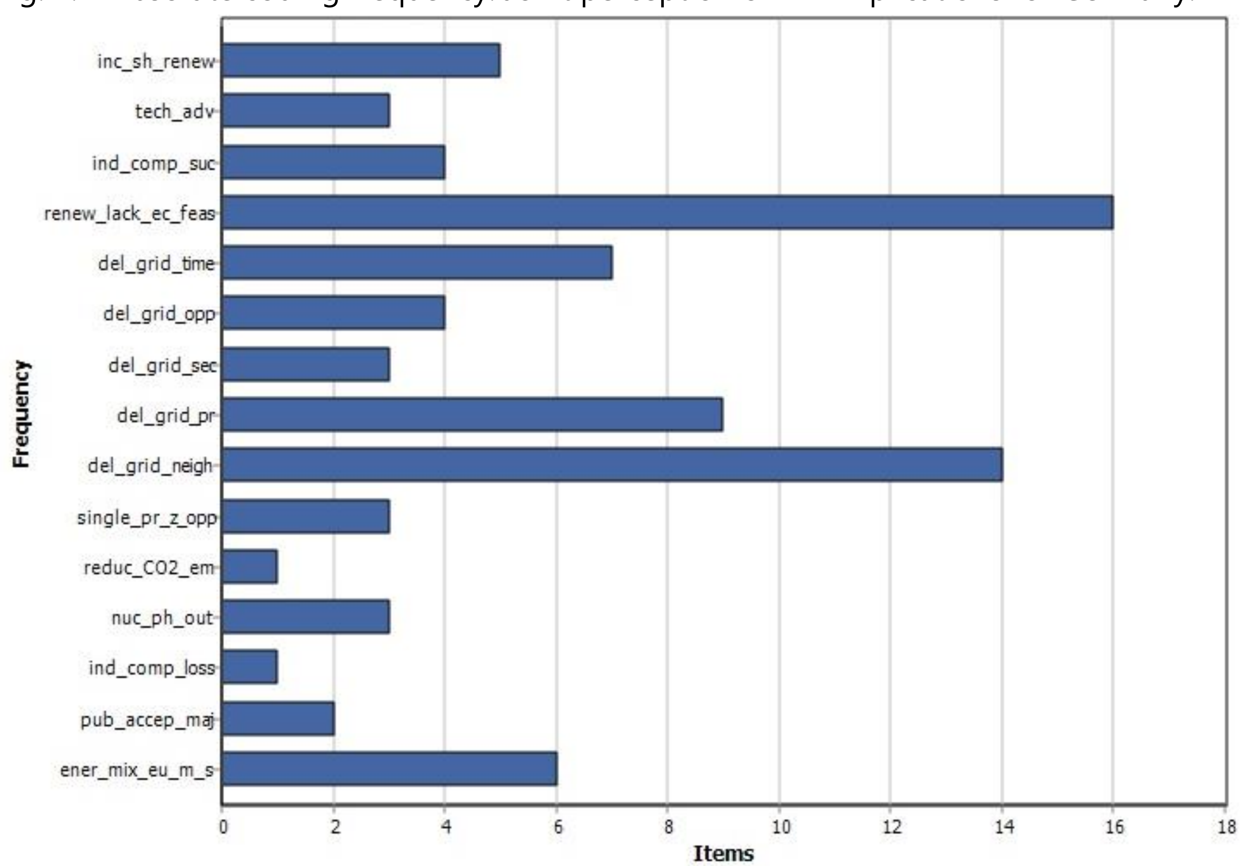
nuc_ph_out	nuclear_phase-out
indust_comp_loss	industrial_competitiveness_loss
pub_accep_maj	public_acceptance_majority
ener_mix_eu_m_s	energy_mix of_EU member_states

2.1.1 Absolute coding frequency

2.1.1.1 Category: Achievements

When addressing the achievements of Energiewende, the respondents generally see a growing share of renewable in the energy mix as an ultimate success of the German energy transition (Fig. 1.). Their evaluation of other achievements diverges quite significantly. Representatives of Polish ministries and TSO put, for example, greater emphasis on the technological leadership which Germany gained due to transformation of its energy system.

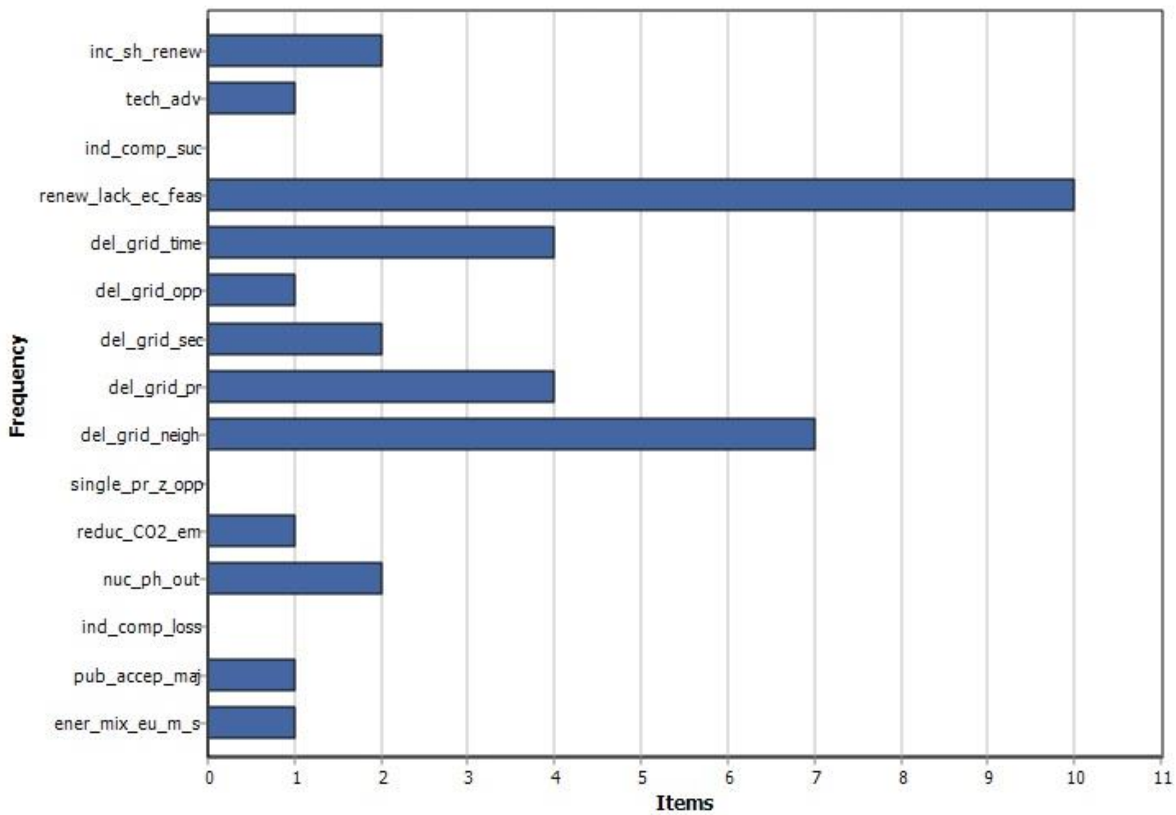
Fig. 1. Absolute coding frequency. Joint perception of EW implications for Germany.



Source: generated from PROSUITE – QDA Miner software (applies to the all Figures).

This is not a surprise taking into account for example that about 50% of all hydropower plants installed worldwide are based on German innovative technologies. (BEE 2015) With regard to the solar sector, the German export ratio exceeded 65% in 2014, according to the German Renewable Energy Federation. (Ibid.) Also the competitiveness of the German industry is named among achievements whereas this aspect was not mentioned in comments from their Czech colleagues (Fig. 2.).

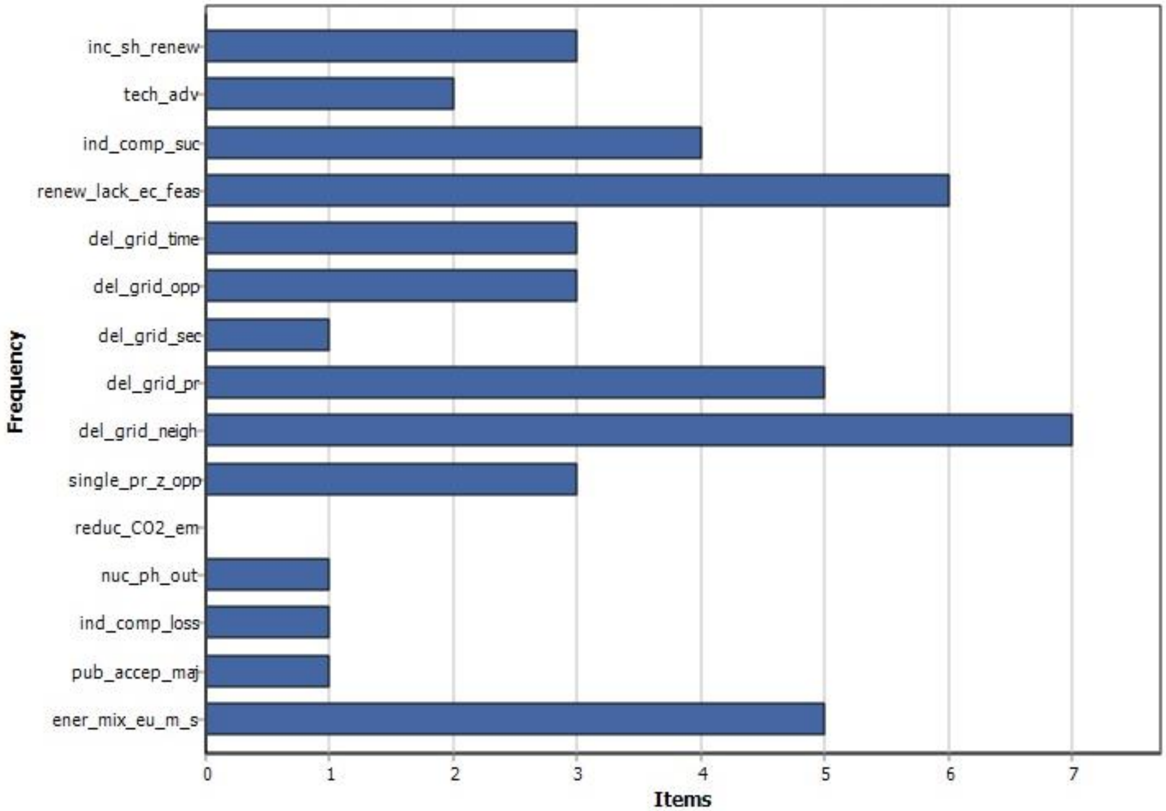
Fig. 2. Absolute coding frequency. Czech perception of EW implications for Germany.



2.1.1.2 Category: Challenges

When it comes to the category describing challenges, the coding frequency demonstrates agreement between stakeholders in considering renewable energy sources as economically unfeasible unless they are subsidized. The respondents share a common perception of the effect on the grids of neighboring states in the case of delayed grid expansion as one of the most pressing challenges Germany is faced with. Other, most frequently mentioned challenges concern price increases for end-consumers in the case of insufficient transmission infrastructure and time schedule delays in expanding the grids.

Fig. 3. Absolute coding frequency. Polish perception of EW implications for Germany



Country-based comparison demonstrates a striking difference in perceptions of challenges by Czech and Polish respondents. Czech stakeholders perceive lack of economic feasibility of renewables as a more relevant challenge for Germany than the destabilization of the grids of neighboring states. Conversely, the risk of electricity price increases is seen as more serious by the Polish side.

Qualitative findings provided ample information about pressure upon the grids of the neighboring states as a results of power overflows from Germany. Besides the Czech Republic and Poland, Polish TSO anticipated a greater influence upon the grids of Germany's western neighbors, such as the Netherlands and Belgium, once Czech and Polish Phase-shifters (PSTs) are commissioned, but this evidence is suggestive rather than conclusive.

In January 2016 the Federal Administrative Court declared the planning approval decision unlawful and requested greater importance be given to bird protection.

(50Herz 2016) It should be noted that public resistance is strong in Germany, not only against transmission lines, but also against new renewable installations. In the federal state of Brandenburg alone there are around 100 citizen initiatives protesting against planned new installations, according to some estimates. (Zummack 2016) Across Germany their number is estimated to reach 500. (Wetzel 2014)

Besides the categories tackling the perceived achievements and drawbacks of Energiewende, qualitative findings do not provide ample information about other topics such as high levels of public support for Energiewende or influence upon EU energy policy. In particular, the expansion of renewable energies is attributed to the high public support of Energiewende. This was explained through the prism of the identity issue and the high level of environmental awareness.

The coding frequency identifies a striking difference in positions towards influences which Germany is likely to exercise upon the energy policy of the EU. To be noted is that this topic was largely omitted during the interviews as it was regarded as sensitive. Whereas Czech respondents were silent about this issue, their Polish colleagues admitted to German influence on the energy policy of the EU. In particular, they are confident that Germany makes efforts at EU level to influence the energy mixes of other EU member states towards being more focused on renewables. Poland is seen to suffer from that due to its reliance on coal. The German economy is argued to profit from a rise of the share of renewables in the energy mixes of other states as they are seen as potential buyers of German equipment and technologies for the renewable sector.

2.1.2 Coding co-occurrences

2.1.2.1 Category: Achievements

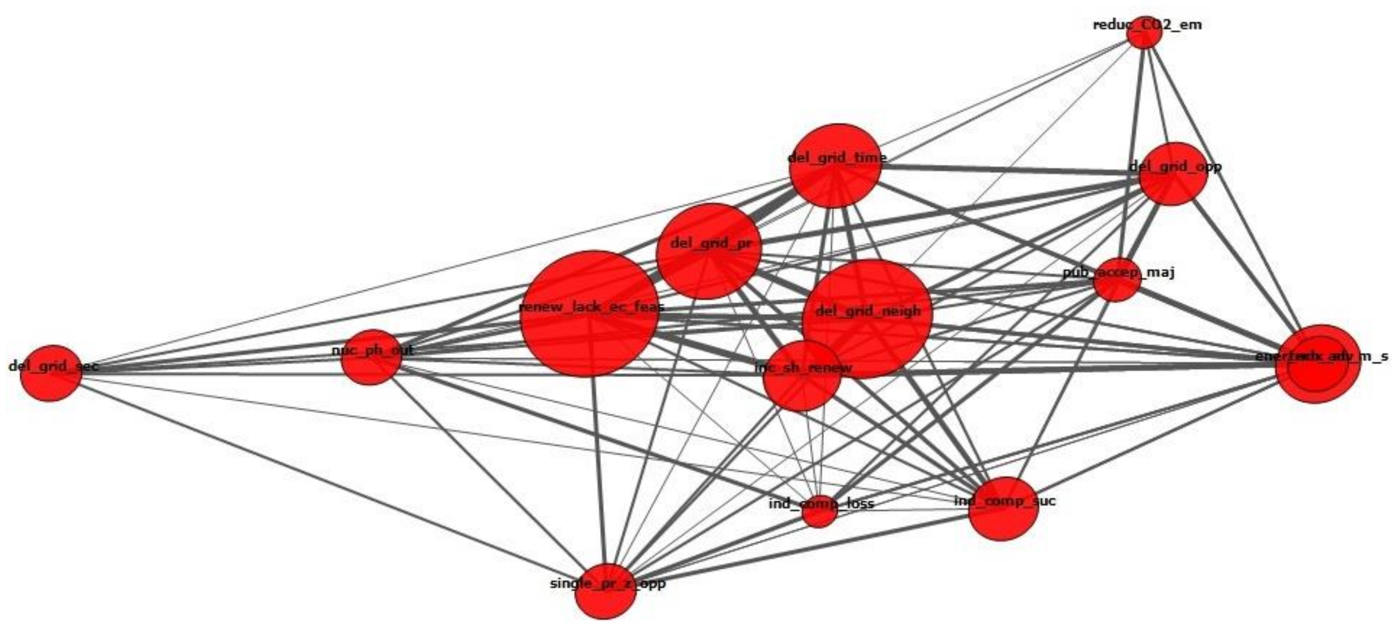
The code capturing growth of renewables in the energy mix is the most frequently co-occurring code among the indicated achievements. It is closely connected with lack of transmission capacity and grid congestion, perceived as mounting in Germany. The qualitative data detect several further topics which the respondents evaluated as achievements for Germany. One of them is technological progress which is incentivized by Energiewende though these observations are not numerous and confined to Poland. Renewables are recognized as an export engine for Germany. Code co-occurence exposes a link with public acceptance. This is not surprising as German people are widely seen to rely on "trust in renewable innovation" (Wittneben 2012, 2), believing that Germany is economically advanced enough to opt for a swift energy transformation.

2.1.2.2 Category: Challenges

The most frequent coding co-occurrences appear with regard to the category describing challenges in the course of Energiewende. Generally, the issue of a gradual deeper penetration of renewables is also closely interrelated (Fig. 4) with challenges depicting a lack of economic feasibility of renewables, risks for the stability of grids of the neighboring states and a risk for a rise of residential prices aggravated by delays in grid expansion.

The qualitative datasets tackling challenges delivered many observations on the lack of economic feasibility of renewable energy sources. This code intersects most frequently with the issue of price increase and delayed scheduling of grid expansion as well as destabilization of the grids of neighboring states.

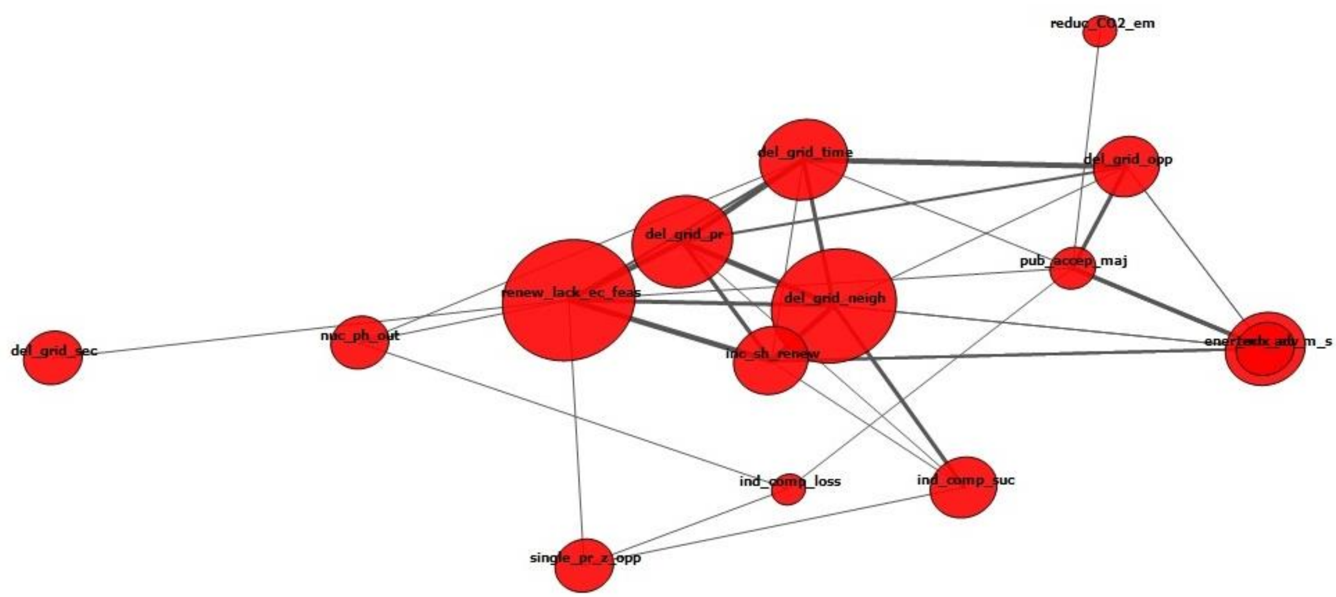
Fig. 4. Coding-co-occurrences. Joint perception of EW implications for Germany



Respondents, such as the Czech ministry responsible for energy (Ministry of Trade and Industry, here MoE) or Polish TSO, argue that renewables are still not sustainable on the market unless they are subsidized. Polish TSO depicts a long-term perspective attributing the non-sustainable nature of renewables to the need to support less and less economically feasible locations for renewable installations in the future, so as to meet ambitious targets of Energiewende. That is the context which interlinks a perceived lack of economic feasibility of renewables with the code of the growing share of renewables in the German energy mix, generally seen as a positive development (Fig. 5.).

Additionally, Polish respondents, both ministerial officials and TSO representatives, point to the burden of the Energiewende, which is borne by individual consumers and to the benefit for energy companies which have cheap green electricity.

Fig. 5. Coding co-occurrences. Joint perception of EW implications for Germany



Intermittency of renewables is another important feature articulated in this code in conjunction with strategic reserves in Germany. This topic was most often touched upon in an interview with the representatives of Czech TSO. The strategic reserve is seen as an instrument trying to compensate for the intermittency of renewables despite the fact it implies distortions to the electricity market.

This also reveals an interconnection with a code of price increase in the aftermath of grid expansion delay. More and more remedial measures are expected to be needed to mitigate the intermittency of renewables. Notably, the reserve's capacity is broadly seen in Germany as having a potential to assume some functions of the grid reserve and therefore help cover the need for re-dispatch in southern regions of Germany (BMWi 2015c) More than that, maintenance of reserve capacity is perceived as transitional and seen as becoming superfluous after the power grid is expanded. (BMWi 2014)

Costly remedial measures are seen as a major trigger for higher prices. The Polish MoE views the situation in retrospective saying that some years ago bilateral re-dispatch was a sufficient tool to cope with huge flows of electricity unlike it is today. The Czech MoE anticipates that Germany may arrive at a point where consumers will no longer be keen to pay high prices for electricity. Both Czech and Polish TSOs predict a growing need for re-dispatch, should the grid expansion plans be further delayed. Both of them mentioned increased spending by German TSOs (in the words of TSOs, about 1 billion euros) for re-dispatch in 2015.

With regard to the code describing timing in grid development, research findings revealed a widespread consensus among Czech and Polish respondents towards an idea that delay to grid expansion is a challenge for Germany. Admittedly, this delay is attributed to public resistance in Germany as co-occurring codes confirm. Except for general statements, Polish respondents exemplified it with the example of the delay in the building of PSTs on the cross border line Vierraden-Krajnik. They predicted a delay of 2-3 years until the case is settled in court.

When it comes to the code of a single price zone in Germany, the qualitative evidence was not sporadic which implied that if delays are not managed quickly, it may put the existence of the German single price zone into question. The respondents regard splitting of this price zone as a logical step, should grid expansion face a huge delay. Concurrently, they recognized this as a rather improbable scenario in the German context with the risk of undermining public support for Energiewende in the case of different residential prices.

To be noted, this position is widespread in Germany. If grid congestion is not overcome, in the long term it would be impossible to maintain a single price zone, according to the Bundesnetzagentur. (BMWi 2015a) In this case Germany may have two electricity prices and two EEG-surcharges. On top of rising electricity costs, this may deepen disparities between the German regions and bring serious disadvantages for the German economy.

Lastly, the decision to abandon nuclear energy by the end of 2022 was addressed as a snap decision without due consideration of possible consequences. German citizens reacted according to the norms which underpin their identity shaped, to a greater extent, by the anti-nuclear movement.

2.2 The implications of Energiewende for the Czech Republic and Poland as reflected by the Czech and Polish stakeholders

Before analysis of the implications for the Czech Republic and Poland, the codes are to be explained. The table below (Tab. 2) provides a shorthand categorization of the codes in the form they are used in the analysis of qualitative data.

Tab. 2. Code explanation. Czech and Polish context.

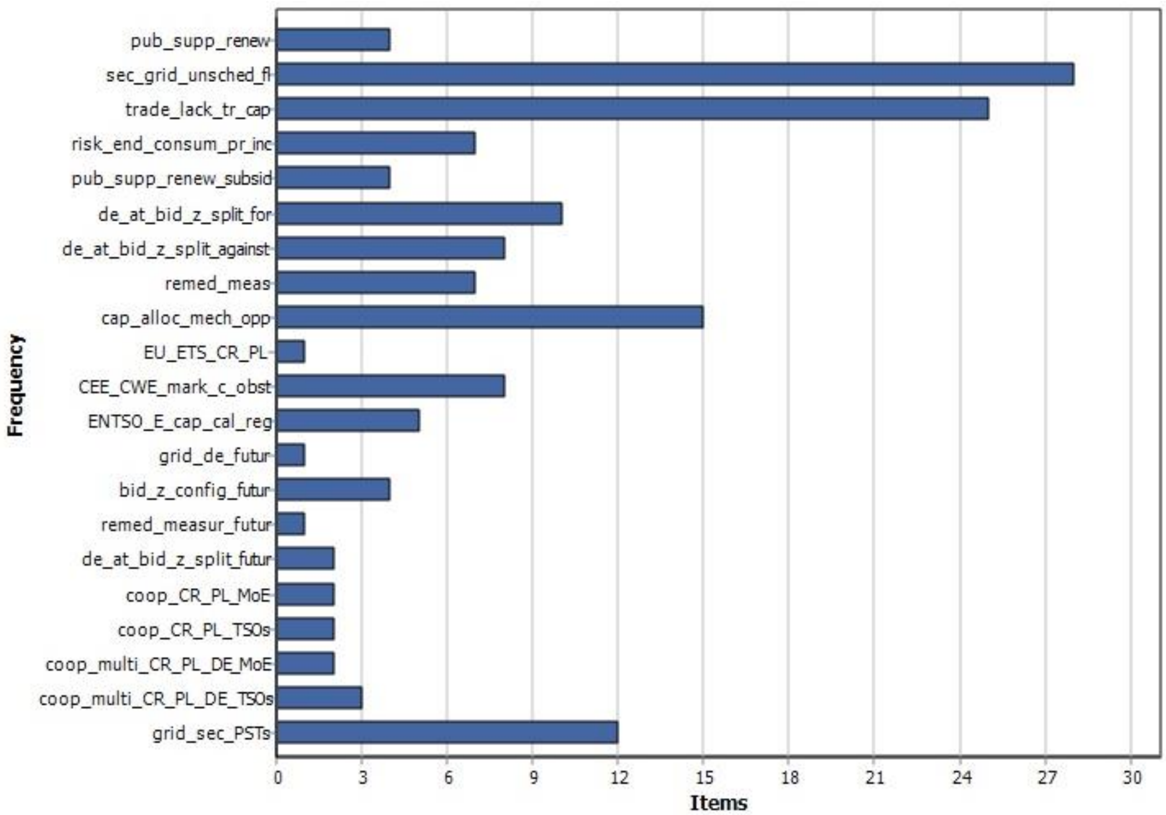
Code [short name]	Code [full name]
pub_supp_renew	public_support_renewables
sec_grid_unsched_fl	security_grid_unscheduled_flows
trade_lack_tr_cap	trade_limitations_lack_transmission_capacities
risk_end_consum_pr_inc	risk_end_consumer_price_increase
pub_supp_renew_subsid	public_support_renewables_subsidies
grid_sec_PSTs	grid_security_PSTs
de_at_bid_z_split_for	DE_AT_bidding_zone_splitting_for
de_at_bid_z_split_against	DE_AT_bidding_zone_splitting_against
remed_meas	remedial_measures
cap_alloc_mech_opp	capacity_allocation_mechanisms_opposition
EU_ETS_CR_PL	EU_ETS_position_CR_PL
CEE_CWE_mark_c_obst	CEE_CWE_market_coupling_obstacles
ENTSO_E_ cap_cal_reg	ENTSO-E_capacity_calculation_regions
coop_CR_PL_MoE	cooperation_CR_PL_MoE
coop_CR_PL_TSOs	cooperation_CR_PL_TSOs
coop_multi_CR_PL_MoE	cooperation_multilateral_CR_PL_ MoE
coop_multi_CR_PL_TSOs	cooperation_multilateral_CR_PL_ TSOs

grid_ de_futur	EW_implementation_grid_development_DE_future
remed_meas_futur	remedial_measures_future
de_at_bid_z_split_futur	DE_AT_bidding_zone_splitting_future
bid_z_config_futur	bidding_zones_configuration_future

2.2.1 Absolute coding frequency

Similar to the coding frequency situation in Germany, the codes concerning implications for the Czech Republic and Poland are not equally represented, with some of them being used more frequently. The explanation may lie in diverging perceptions of some issues as being more acute and relevant for the time being.

Fig. 6. Absolute coding frequency. Joint perception of EW implications for CR and PL



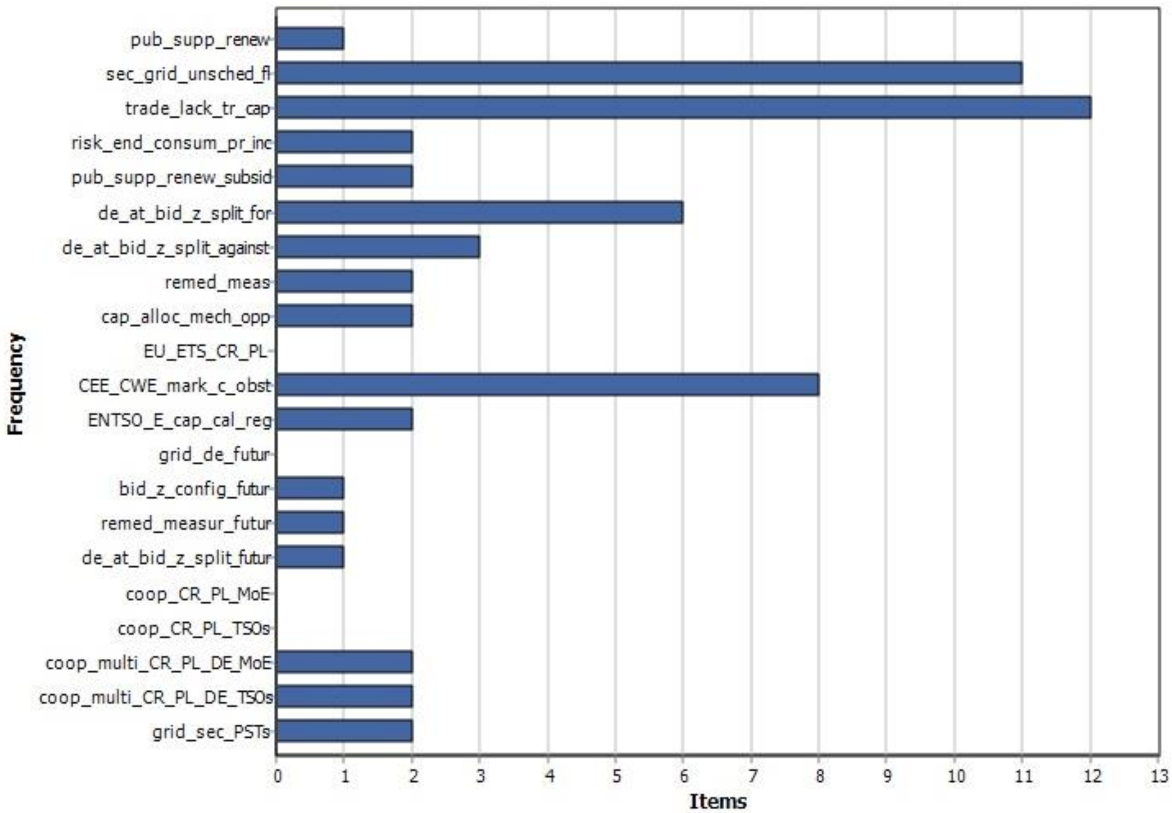
2.2.1.1 Category: Achievements

This category is limited to support of renewable energy sources which is perceived as growing in the Czech Republic and Poland. These observations are not numerous. Energiewende is named as a factor of influence of growing support towards renewables.

2.2.1.2 Category: Challenges

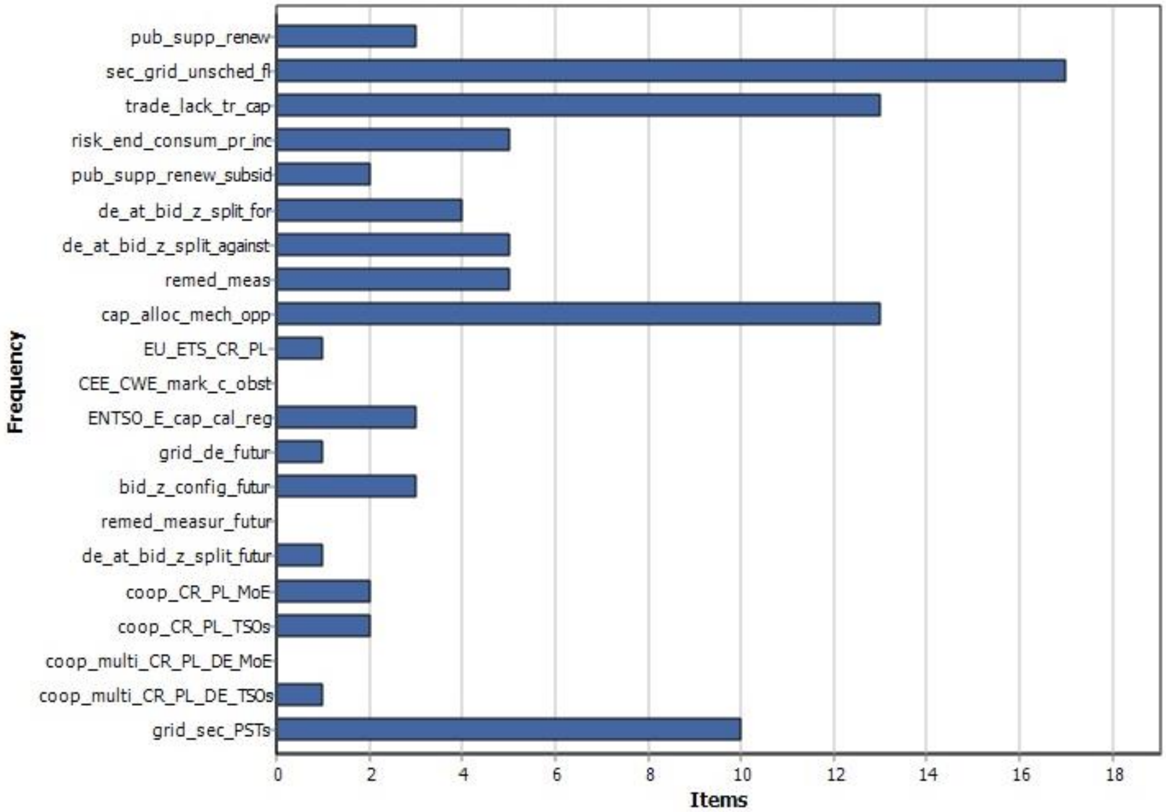
Given the amount of power overflows coming to the Czech Republic and Poland, it is not surprising that the issue of unscheduled flows stands out as by far the most frequently reiterated topic in the interviews when it comes to challenges Energiewende poses for the neighboring states (Fig. 6). This is a clear indication of the burning nature of the problem, which is frequently highlighted in respondents' statements. It terms of coding frequency, it is followed by the issue of lacking transmission capacity on the Czech-German and Polish-German borders due to transit flows from Germany to Austria through the territory of the Czech Republic and Poland, reducing trade opportunities in these countries.

Fig. 7. Absolute coding frequency. Czech perception of EW implications for CZ and PL



Coding frequency reveals an adjacent topic of capacity allocation mechanisms which is highly evident in respondents' statements. This issue is considered through the prism of the single price zone between Germany and Austria. One more adjacent topic frequently addressed is postponed market coupling between CEE and CWE regions. As a general pattern, respondents see the German-Austrian bidding zone responsible for this delay in market coupling as the coding co-occurrences explain in detail.

Fig. 8. Absolute coding frequency. Polish perception of implications for CZ and PL

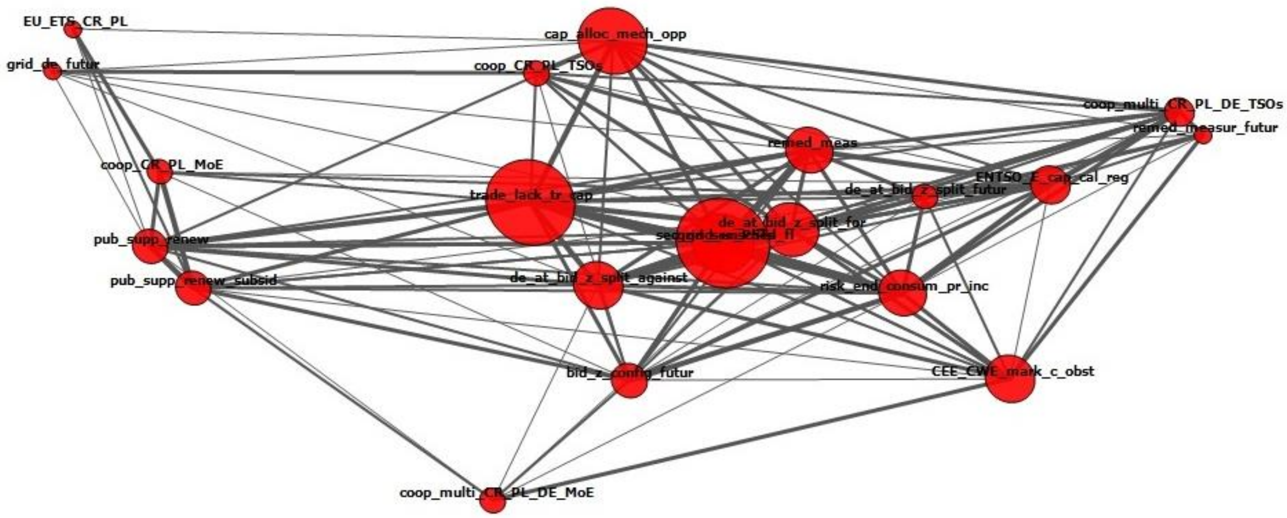


Code frequency from a country-perspective reveals a general consensus between Czech and Polish respondents in perceiving the challenges they are confronted with (Fig. 7 and 8). The only exception is a perceived risk of price increase for end-consumers fueled by costs of remedial measures which are ultimately passed on to the end-consumers. Polish respondents seem to be more concerned with the probability of price increase unlike their Czech counterparts.

2.2.2 Coding co-occurrences

This subchapter reveals many patterns of interconnections between the codes. Because many topics are complex in nature and interrelated, we have overlapping codes in our analysis. Figure 9 displays the full distribution of co-occurring codes. To better visualize interrelations among findings for our analysis, the figure 10 shows the most frequently co-occured codes.

Fig. 9. Coding co-occurrences. Joint perception of EW implications for CZ and PL



2.2.2.1 Category: Achievements

People in the Czech Republic and Poland were told, on the one hand, to support renewables more, being inspired by the German example. On the other hand, they are perceived as not being willing to subsidize renewable energy sources. Findings revealed a direct link between these two ends of the spectrum.

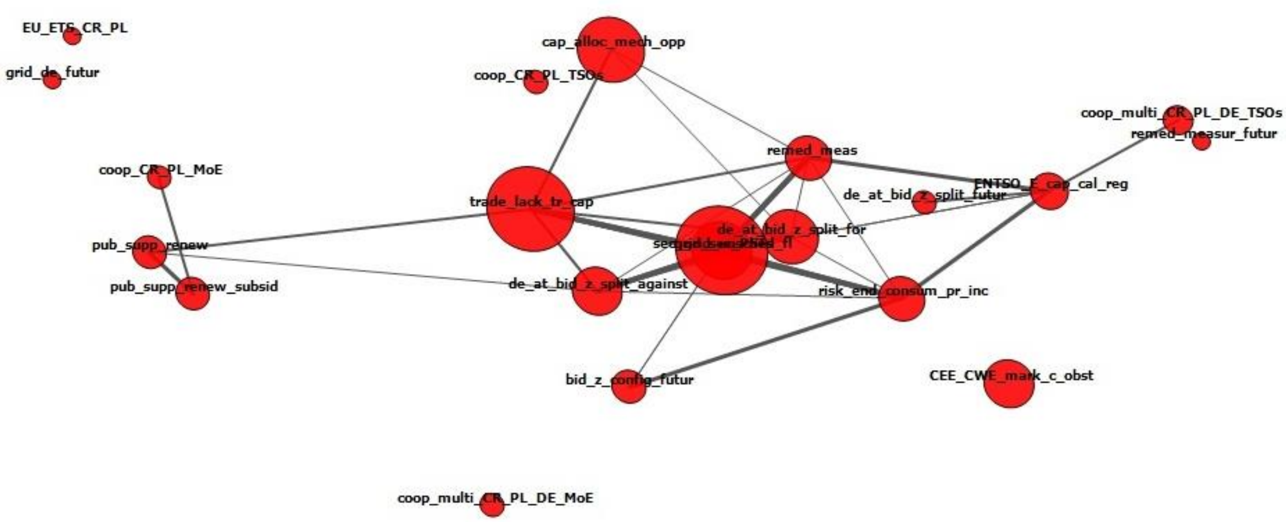
2.2.2.2 Category: Challenges

Analysis of the co-occurring codes demonstrates a great concern for the unscheduled flows which remain a predominant problem. Unlike any other topic, the topic of unscheduled flows is viewed unanimously by all respondents in the Czech Republic and Poland as a negative development. Both TSOs perceive the unscheduled flows as a growing problem.

This problem is perceived as increasingly affecting transmission capacity and trading opportunities in the Czech Republic and Poland. Although this was confirmed by a myriad of qualitative accounts among all respondents in these countries, we observe some variations in the discourse of the respondents. For example, the Czech MoE argues that the Czech Republic suffers more because of a significantly bigger commercial power exchange than Poland, whereas Polish counterparts emphasize physical flows which are coming to the Polish network due to geographical proximity with the German north.

When it comes to the risk of price increases for end-consumers, Polish respondents appear to be more active in articulating this potential problem. Generally, this code is most closely connected with the code describing use of remedial measures. This seems obvious as a more persistent need for remedial measures and in particular of re-dispatch was provided as a reason for price increase. This resembles the perception of the situation in Germany.

Fig. 10. Coding co-occurrences. Joint perception of EW implication for CZ and PL



Note: the strongest co-occurences are displayed only

2.2.2.3 Category: Disagreements

Among all issues in this category, the issue of the German-Austrian bidding zone appears to be the most actively discussed. It intersects dramatically with other serious challenges. This bidding zone exists since 2001 and allows for power to be traded across the two countries at a common wholesale price. With oversupply of fluctuating renewable power from Germany, infrastructure falls short of accommodating all traded electricity. Notably, in perceptions of the respondents, Austria and Germany have behaved until recently as if there has been no need to restrict electricity exchange activities between them by introducing a congestion management system.

Two codes are separated by presenting the views of proponents and opponents of this bidding zone. Austria and Germany are regarded as proponents although their positions differ in a quite significant manner. Poland and the Czech Republic call for the splitting of this bidding zone. In this case, it would be no longer be possible to exchange unlimited amounts of electricity between these two countries. Consequently, it could lead to different wholesale prices between Austria and Germany but improve power trading for the Czech Republic.

Poland plays a more active role in this process. The Polish regulator asked ACER in 2015 to provide an assessment of the impact on grids of neighboring countries. Representatives of Czech TSO reported they expected the Czech regulator to do the same and expressed its full support for the Polish regulator.

The perception of Czech TSO about the changing position of Germany in this regard coincides with the perceptions of Polish TSO. To be noted, the German regulatory authority, the Bundesnetzagentur, endorsed the ACER's opinion, while not being explicitly in favor of splitting. In other words, it showed a partial support for ACER's line of reasoning admitting however that ACER's opinion has put the splitting of the German-Austrian bidding zone on the political agenda. (Bundesnetzagentur 2015b) The Bundesnetzagentur does not exclude a scenario where a solution will be found "that better safeguards the interests of all those concerned than capacity allocation does" (Ibid.).

Apart from Austrian and German grid regulators, the respondents pointed to the market players who are against breaking up of this single price zone. Having stated this, the respondents were cautious about providing the details. This notwithstanding some assumptions can be made. It is to be noted that the energy exchange EEX and some German energy industry associations openly admitted they oppose this move. (Schlandt, Europe´s largest electricity market set to split 2015) These include the Association for Energy Market Innovators and the German Association for Energy and Water Industries. (Ibid.) From the Austrian side, the company Siemens took a similar stance arguing that this step would be detrimental to the competitiveness of Austrian industry. (Kischko 2015)

2.2.2.4 Category: Uncertainty and delays

The qualitative data shows contrasting views on issues within this category. Representatives of the Czech Republic and particularly Czech TSO put emphasis on obstacles in the market coupling between capacity calculation regions (CCRs) of CWE and CEE, whereas this is not touched upon by Polish representatives. Instead, Polish respondents (both MoE and TSO) are more active in tackling the closely connected issue of configuration of bidding zones within CCRs.

Recently ENTSO-E has become actively engaged in setting CCRs, i.e. the geographic areas in which coordinated capacity calculation is applied. (European Commission 2015, Article 2) They consist of a set of bidding zones and support coordination across the highly interdependent bidding zone borders. This is a huge stumbling block at the moment. In a proposal for Capacity Calculation Regions in 2015, ENTSO-E includes the German-Austrian bidding zone into CCR CEE. (ENTSO-E 2015a, 2)

This is a source of disagreement within CCR CEE as many interview statements in this analysis also reveal. The necessity to revise the bidding zone configurations is hence addressed by both TSOs and Polish MoE in rather general terms. To be mentioned here, in 2014 ACER recommended ENTSO-E to consider configurations of different bidding zones describing their geographical evolution and consider the influence they induce on transaction costs for market participants. Specifically, ACER recommended reviewing the extent to which bidding zone configurations induce an "undue discrimination" between internal and cross-zonal exchanges. (ACER 2014, 19) In so doing, ACER recognized this review "touches upon significantly diverging views and economic interests of different parties". (Ibid: 5) This is very close to what the respondents pointed to for explaining this delay.

2.2.2.5 Category: Solutions

Under this category PSTs are captured in a code which strongly dominates this category being closely interlinked with the issue of the unscheduled flows to Czech Republic and Poland. PSTs are perceived to reduce unwanted unscheduled flows and decrease the necessity of using costly remedial actions though the respondents note PSTs have a limited effect. In other words, the effectiveness of PSTs is said to be dependent upon the amount of flows.

Polish TSO anticipates a negative influence upon the Czech Republic as a consequence of commissioning the first PST at Mikułowa substation. In the final resort, pushed back to Germany, more power flows to the Czech border. Also admitted is that it entails a greater risk of internal congestion in Germany. Notably, the EWIS Study referred to PST as early as 2010 as not a sustainable solution, admitting that the installation of PSTs secures the borders of Germany's neighboring states, but simultaneously causes increased overloading in Germany. This results in massive re-dispatch and wind power generation curtailment in this country.

In the Polish case, the necessity of installing physical PSTs was agreed upon after an unsuccessful experience with a virtual PST. Once the problem with unscheduled flows exacerbated in 2012, PSE and 50Hertz agreed on launching a pilot project of virtual PST which was based on re-dispatching measures, though these measures turned out to be insufficient. (PSE and 50Herz 2014, 62) At its core, this confidential agreement determines cost sharing mechanisms for re-dispatching. Polish TSO assumed that because of this negative experience, 50Hertz was not willing to sign a similar agreement with ČEPS. Representatives of Czech TSO confirmed in an interview that they approached 50Hertz several times to test this approach in the German-Czech context, though unsuccessfully.

2.2.2.6 Category: Cooperation

When asked to assess cooperation with counterparts from the Czech Republic, Poland or Germany on mitigating the negative impacts of Energiewende, the respondents usually tended to give short answers. They were not willing to expand their answers to assess cooperation in either bilateral or multilateral settings. It appears, from the obtained findings, that the respondents generally assess their cooperation positively. For example, Czech TSO refers to it as being excellent. In contrast, Polish TSO considers cost sharing as a serious source of disagreement every time remedial measures are discussed.

Bilateral cooperation is argued to be more effective between Poland and Germany than between the Czech Republic and Germany. At least as perceived by the Polish MoE. The representative of MFA Poland assessed Czech-Polish cooperation positively except for lack of consensus with regard to EU Emission Trading System (EU ETS). The Czech Republic is perceived not to be against more stringent emission reduction rules, whereas the Polish side is in favor of a more flexible approach. Common understanding is not always in place as the Czech MoE pointed out in relation to cooperation with German counterparts, though German colleagues were said to be ready to negotiate.

2.2.2.7 Category: Suggestions

Qualitative accounts containing suggestions are not numerous. Overall, they concern grid expansion in Germany and agreement on optimal configuration of the bidding zones. The most relevant observation concerns the German position in the matter of the German-Austrian bidding zone. Germany is largely perceived as being in favor of compromise, unlike Austria, and assumingly a more suitable negotiation partner when it comes to finding a solution.

2.3 Summary

The purpose of this chapter was to explore perceptions of the Czech Republic and Poland to the effects induced by Energiewende upon these countries. Based on the stakeholder analysis, this chapter revealed a similarity in views between the respondents with regard to the most relevant topics.

In the context of Germany, both Czech and Polish respondents perceive delayed grid expansion as a main reason for pressure upon the grids of the neighboring states and as one of the main challenges which Germany is now confronted with.

Perceptions towards other pivotal challenges vary slightly. Comparing both countries, no significant difference is observed with respect to assessment of renewables in the power generation sector. The Czech Republic appears to view renewables as still economically unfeasible sources of power generation. This aspect gained less attention with Polish respondents. This is tied in with a difficulty to embed renewables into the grid without significant market distortions.

Views of Czech and Polish respondents mainly overlap when it comes to challenges both countries witness as a result of Energiewende. These are the unscheduled flows and limited transmission capacity as a result of overflow from Germany which were named as the central challenges needing to be dealt with. Being an export-oriented country, the Czech Republic seems to be more concerned with improving the free trade of power.

Both the Czech Republic and Poland share opinions on splitting the German-Austrian bidding zone, seen as a hurdle for market coupling between CCR CWE and CEE.

This analysis also discovered a visible interrelation between the respondents and topics they covered. Whereas TSOs were more prone to discuss the issues concerning the security and reliability of the girds, the MoE covered the Energiewende-related topics from a broader perspective, be it the issue of CO2 emission reduction and EU ETS format, German industrial policy and technological advantage or EU energy policy.

3. Energiewende - what to expect?

In this chapter we discuss possible future developments of the Energiewende process. As it lacks a clear pathway of development, extrapolations or predictions are extremely difficult to make and sustain. For this reason we use the scenario analysis – a method designed to structure highly complex and inestimable phenomena into a wide range of different future images, which are easier to evaluate and possibly to prepare for by the process' decision-makers and stakeholders. We build our analysis on scenarios introduced by the 50Hertz company together with E-Bridge Consulting, Prognos, RWTH Aachen Institut für Elektrische Anlagen und Energiewirtschaft and FGH (50Hertz 2016), and utilize them to outline the possible impact of different developments of Energiewende on the Czech and Polish energy industries.

We select the 50Hertz study for the analytical framework of this study for its focus on the issues that are at the core of Czech and Polish reflection on Energiewende – infrastructure capacity, trade flows and unscheduled flows. For scenarios more focused on resource deployment and related policies, see for example "Scenarios for an Energy Policy Concept of the German Government" (EWI 2010) or "Was kostet die Energiewende?" (Frauenhofer ISE 2015).

3.1 Energiewende 2035 – scenarios by 50Hertz

The scenarios by 50Hertz are derived from rather general input factors such as: the way the growing renewable portfolio is structured, severity of Energiewende's obstacles, and public support. The authors mix different settings of these input factors into five scenarios: the first three deal with incentives for renewables deployment, the fourth scenario stresses the obstacles and challenges, while the fifth is built on the possibility of a public support shift against Energiewende. A brief description of the scenarios can be found in table 3.

Tab. 3. 50Hertz Energiewende scenarios for 2035

Scenario	Description
Prosumer-oriented energy transition	High number of small storage units, often combined with PV installations.
Energy transition in accordance with the EEG model	Political targets are achieved through the combination of different technologies.
Competitive energy transition	Technology-neutral tender procedures that bring stronger support for installations at productive locations.
Delayed energy transition	Political objectives would only be reachable with a delay.
Incomplete energy transition	Lack of public acceptance prevents reaching the political targets.

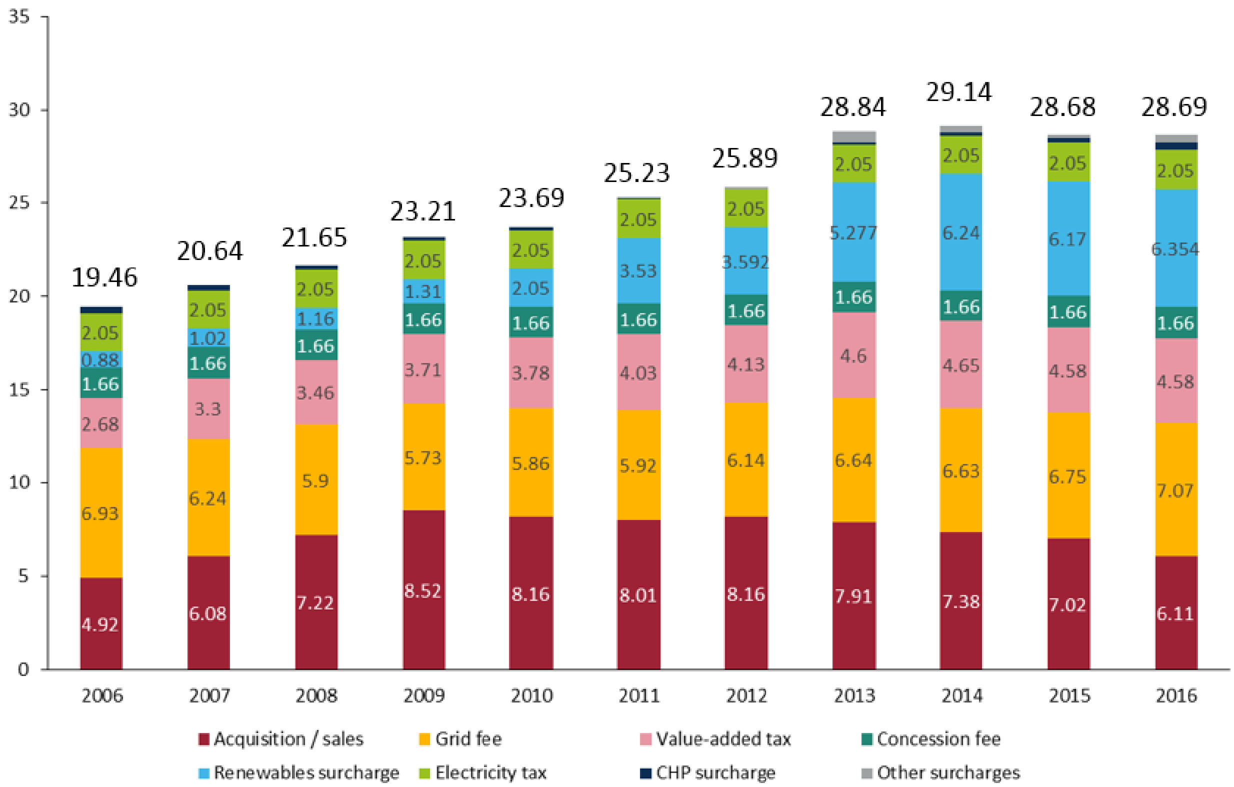
Source: (50Hertz 2016, 8)

3.1.1 Prosumer-oriented energy transition

This scenario focuses on decentralized power supply. In the scenario, intensive deployment of small-scale PV installation across Germany takes place. The RES deployment therefore occurs in a rather dispersed manner, bringing the production and consumption closer together. The main part of the electricity supply is transferred to the distribution networks, which become system services providers along the TSOs. Cross border trading is of secondary importance, and the transmission network serves primarily as a balancing tool for netting imbalances among the distribution networks. Rapid development of back-up solutions such as household level combined heat and power production from natural gas or battery storage is expected to contribute positively to the distribution of PV installations deployment. In line with this development, increased electro-mobility takes place as well. (50Hertz 2016, 14)

When evaluating the competitiveness of decentralized installations, it is important to acknowledge that they have substantially different prices to beat than those that are centralized and grid-connected. Whereas grid-connected RES compete with other energy sources at the wholesale level, the household-level decentralized power systems actually compete with the retail price, which is in the German case approximately ten times higher than the wholesale price (see fig. 11).[1]

Fig. 11. Composition of average power price in c/kWh for a household using 3,500 kWh per year



Source: (Clean Energy Wire 2016e)

Despite the costs of rooftop solar installations decreasing more slowly than those of mounted large scale installations (between 2006 and 2014, non-module costs for PV systems fell 11.5% p.a. for large scale projects and 7.7% p.a. for rooftop solar), they now lie well below the retail price of 28.69 c/kWh paid by an average household in 2016. In early 2016, the upper limit for the rooftop solar costs interval in Germany in general was 19.4 c/kWh. (Climate Policy Initiative 2016, III) For southern Germany, which displays more favorable weather conditions, the costs were estimated to have fallen into the interval of 9.8-14.2 c/kWh by Frauenhofer ISE already in 2013. (Frauenhofer ISE 2013, 2)

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[1] However, unless a household comes completely off the grid, it still needs to cover the fixed costs of connection. From this point of view, the real grid-parity of the decentralized RES lies below the actual retail price.

With regards to the small scale storage systems that are crucial for the concept of decentralized supply, the most widespread solution are batteries. Over the course of the past few years, battery back-up systems are becoming the solution of choice for most of the new rooftop PV systems currently installed in Germany. In fact, nearly as many as 60% of new installations were backed-up by batteries in Germany as of late 2015 (Staubiz 2016) and there were as many as 34,000 PV battery storage systems installed in Germany by January 2016 (Argus 2016). This can be attributed to the government subsidy program facilitated through the German KfW bank, which has made the battery systems accessible and effectively created a market for them. With regards to the costs, it is rather difficult to calculate them on the basis of levelized costs of electricity (LCOE), i.e. costs of each kWh withdrawn from the storage system throughout its lifespan. The systems are rapidly evolving and none of them has been around long enough to evaluate the crucial variables, namely number of usable cycles and long-term capacity loss. A paper by Lazard is one of the few on the topic. As of 2015 Lazard has estimated the LCOE of battery storage systems for residential use to fall within the interval of 67.4-154.8 c/kWh for lead acid batteries and of 96.7-149.1 c/kWh for Li-ion batteries. (Lazard 2015, 10) Unsubsidized battery back-up costs are therefore still one order of magnitude away from being competitive. However, two thirds of Lazard's LCOE are represented by capital costs (the rest is operation and maintenance, costs of charging and taxes), which have been decreasing at a rather fast pace throughout the past few years. Between 2013 and 2015, the costs per usable kWh decreased by 18% per annum (Staubiz 2016) and this trend is expected to continue. Lazard estimates the capital costs of Li-ion battery residential storage to drop by 47% by 2020. (Lazard 2015, 17)

3.1.2 Energy transition in accordance with the EEG model

In this scenario the RES development remains in line with the corridors set by EEG 2014. The deployment of individual RES technologies is steered by the government whose influence over the overall energy sector is the strongest in this scenario. The scenario expects the government to support all promising technologies to ensure that no development pathway is closed before its potential is thoroughly examined. In this scenario the RES generation therefore comes from farm-like as well as rooftop installations, from both onshore and offshore wind, solar as well as biomass, and support is also allocated to electro-mobility and combined heat and power generation. (50Hertz 2016, 14)

EEG 2014 was introduced to ensure more predictability and financial efficiency in the continuous rise of the share of renewables in the electricity sector. It also set ambitious mid-term targets: 40-45% of power consumption covered by renewables by 2025; 55-60% by 2035, together with annual capacity targets for each technology to make the roll-out of renewables more predictable. Feed-in tariffs are adjusted automatically depending on whether these technology-specific targets are met. (Pescia, Graichen and Jacobs 2015, 14)

Tab. 4. Technology-specific deployment corridors

Renewable energy technology	New capacity/year
Solar energy	2.5 GW
Onshore wind energy	2.5 GW
Biomass	0.1 MW
Offshore wind energy	by 2020: 6.5 GW by 2030: 15 GW

Source: (Clean Energy Wire 2014)

Apart from deployment corridors, EEG 2014 changes the way costs related to renewable energy development are distributed among different consumer groups. Prosumers are now obligated to pay a small portion of the EEG surcharge and exemptions for energy-intensive industries have been slightly reduced. The act also introduces several provisions to facilitate the market integration of new renewables installations: mandatory direct selling on the spot market; discontinuation of the feed-in support during periods of negative power prices (more than 6 consecutive hours); and a pilot phase for auctioning 400 MW of large-scale ground-mounted solar PV. (Pescia, Graichen and Jacobs 2015, 14) Furthermore, from 2017 onwards, the feed-in-tariffs were set to be provided only to successful bidders in auction systems. Under the system's provisions, the government announces how much new renewable capacity is to be built and investors offer a price at which they are prepared to sell electricity from their planned projects. The government will thus gain more control over the deployment of renewables and will have the chance to coordinate it more with the grid development. Apart from more coordination, auctions should also be more cost-effective as installations offering the cheapest electricity win the auction (Dinkloh 2015) Auctions should therefore bring more competition by allowing the participation of a variety of market players, manage the capacity expansion of renewables while staying on track with targets and lower the costs of Energiewende by supporting the least expensive projects. The only evaluation criterion for eligible bids is price and a ceiling price is set for each auction round. (Aures 2016, 16)

The initial results are positive. So far, five PV auction rounds took place and each was significantly oversubscribed, signalizing high interest among the potential producers. For example, for the August 2016 round, Bundesnetzagentur, which oversees the programme, initially tendered 125 MW and received 62 bids for a total volume of 311 MW. Throughout the course of the rounds, the average price of the successful bids decreased significantly: from 91.7 €/MWh in April 2015 to 72.3 €/MWh in August 2016, which represents a decrease of more than 21% within just 16 months. (Clean Energy Wire 2016c) What is yet to be evaluated is the effectivity of realization as the realization period is 18 months.

3.1.3 Competitive energy transition

In this scenario the RES deployment is expected to be driven by technology-neutral incentives that aim at cost efficiency. As it furthermore expects the decentralized supply to remain uncompetitive, it emphasizes large plants at high-yield sites in Germany and even in the near abroad. As a consequence, high voltage transmission and trading both within Germany and across national borders intensifies. (50Hertz 2016, 14-15)

The recent developments suggest that the government is willing to test the technology neutral pathway. Starting from 2018, the onshore wind and large scale PV projects will compete with each other in joint auctions of 400 MW per year. Currently, the costs of PV surpass those of onshore wind – the last PV auction saw average bids of 72.3 €/MWh, whereas the ceiling price for the first onshore wind auction scheduled for 2017 has been set to 70 €/MWh. (Knight 2016)

Despite their clear efficiency in deploying the cheapest RES technology that is available on the market at the given moment, a complete shift in favor of joint auctions is unlikely as it could ultimately lead to economically sub-optimal results. Weather conditions that are favorable for PV production are often unfavorable for onshore wind production and vice versa, which places them in an inverse proportion relationship. A well-chosen ration of onshore wind and PV installations could therefore stabilize the RES energy output, reduce the grid costs and consequently also the total costs of electricity even though the installation portfolio is more expensive than it would be should the most cost-effective technology dominate the auction results.

Furthermore, the idea of preferring high yield locations only seems to be rejected by the 2017 EEG amendment. For onshore wind auctions the revised act envisages that the level of support would vary according to the site quality. The better the conditions the lower the financial support and vice versa. (Bundesrat 2016, 81) This suggests that the government prefers spatially even development of the onshore wind installations (and therefore reduced grid costs) over the cost-effectiveness of the installations themselves.

3.1.4 Delayed energy transition

This scenario depicts a situation where the technological and political goals of Energiewende get delayed due to increased costs or acceptance problems in relation to infrastructure development. (50Hertz 2016, 15)

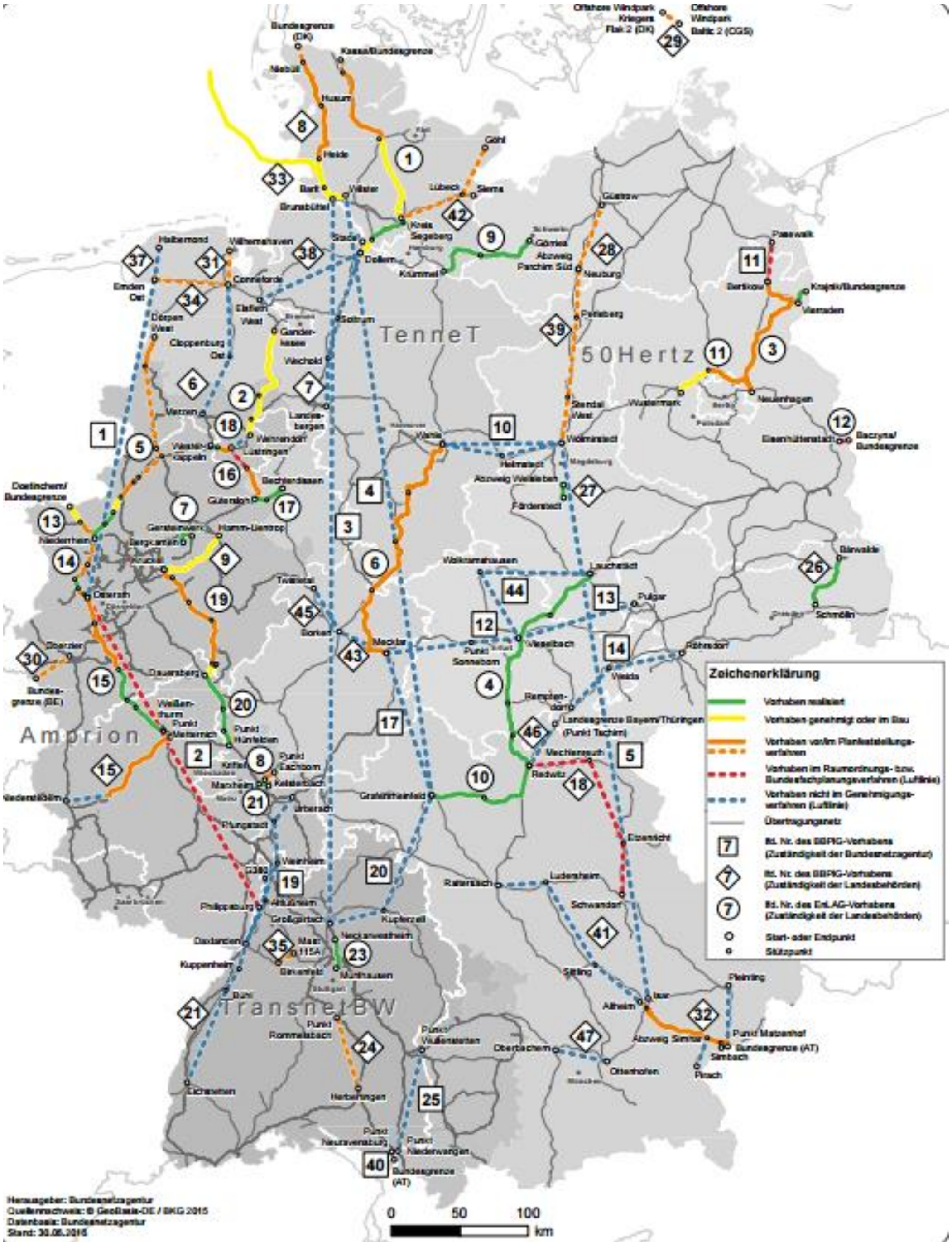
Grid expansion now seems essential for the further development of Energiewende. According to the 2017 EEG amendment, Bundesnetzagentur is set to identify so called "grid congestion zones" where building of new wind turbines will be limited to 58 percent of the average additions between 2013 and 2015 until the grid is expanded and existing bottlenecks removed. (Bundesrat 2016, 27) Similarly, the development of offshore wind capacity is set to follow the grid expansion. The already approved wind farms will be completed and operated according to the 2014 EEG, but for those that start to operate from 2021 a transitional auction model will apply: the installations will compete in two rounds of auctions for a limited amount of capacity (500 MW per year between 2021 and 2022; 700 MW between 2023 and 2025 and 840 MW annually from 2026 onwards). Also, from 2021 onwards, only wind parks in the Baltic Sea will be permitted, due to a lack of grid connections in the North Sea. Starting from 2025, the government will explore sites for future wind farms and the bidders will then compete for the right to build a wind farm at a specific location. This centralized (Danish) model is to ensure sufficient competition and to make site planning, installation approvals and grid connections more cost effective. (Clean Energy Wire 2016a)

Furthermore, the bottlenecks in the German grid make renewable energy spill over the borders and destabilize the neighboring states' grids. As a consequence, Poland and the

Czech Republic, among others, have started building phase-shifting transformers in order to protect the stability of their grids. Once online, the transformers will bounce some of the incoming power back to Germany, amplifying the congestion problems within the German grid. As a result, the redispatch and compensation costs that are already nearly as high as the sum of other costs incurred to the German TSOs could increase even further. The redispatch and compensation costs issue is further discussed in the next scenario.

The combination of physical unavailability of the grid and increased costs of maintaining grid stability could effectively halt further expansion of the renewables until the existing bottlenecks are removed by new transmission lines. As of the end of 2016 there is around 1,800 km of new lines envisaged by the EnLAG act and around 3,050 km by the BBPIG act. Out of the 1,800 EnLAG kilometers, 650 km are complete, another 850 km approved and the TSOs expect the completion of around 45% of the EnLAG line kilometers by 2017. The lines under the BBPIG, which also include the crucial parts of the North Sea-southern Germany connection (Südlink), have until now undergone only fractional development: 69 km has been completed and around 350 km approved. (Bundesnetzagentur 2016d) As a result, the Südlink connection has been postponed from 2022 to 2025, which will in turn delay the development of the North Sea wind farms and endanger the 15 GW offshore wind capacity goal that the Government envisages for 2030.

Fig. 12. Progress on expanding power lines under the EnLAG and BBPlG acts and on the PCI list by the second quarter of 2016



Note: the stages of progress are differentiated as follows: Lines not in the approval process (blue), in siting process (red), before or in the approval process (orange), approved or under construction (yellow), completed (green).

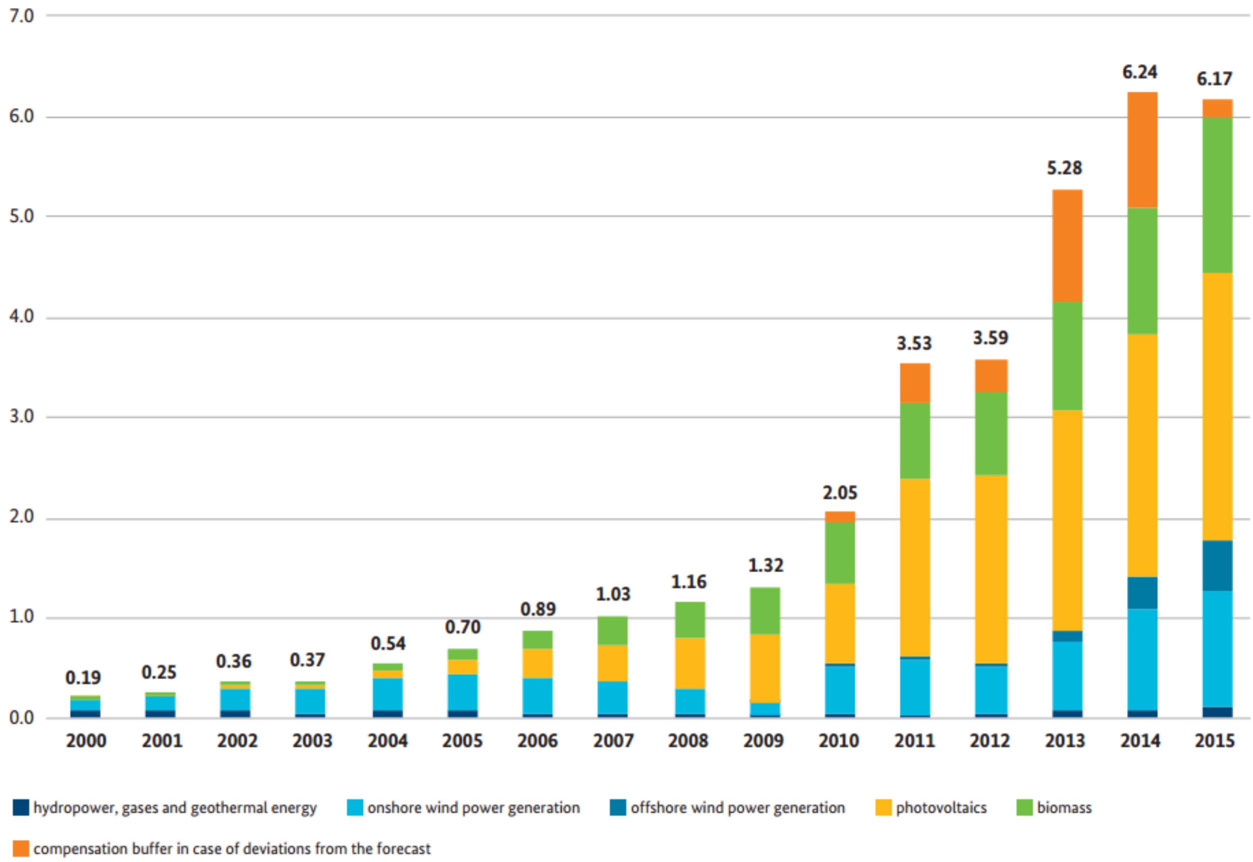
Source: (Bundesnetzagentur 2016c)

3.1.5 Incomplete energy transition

This scenario supposes declining support for the Energiewende policies due to increased costs related with RES expansion. In this case, the share of RES on electricity generation is envisaged to peak at 50%. After that, new installations will only replace the expiring ones while the conventional plants will retain their core importance for electricity supply. (50Hertz 2016, 15)

The costs of Energiewende, carried mostly by German households, have indeed increased throughout the past years. The retail prices have not followed the decreasing wholesale prices and have been constantly rising together with the share of renewables in the electricity production mix. Between 2000, when it was introduced, and 2016 the EEG surcharge has increased more than 32 times. In 2013 the surcharge made up 18% of the total retail price for electricity consumers. (Appunn 2014)

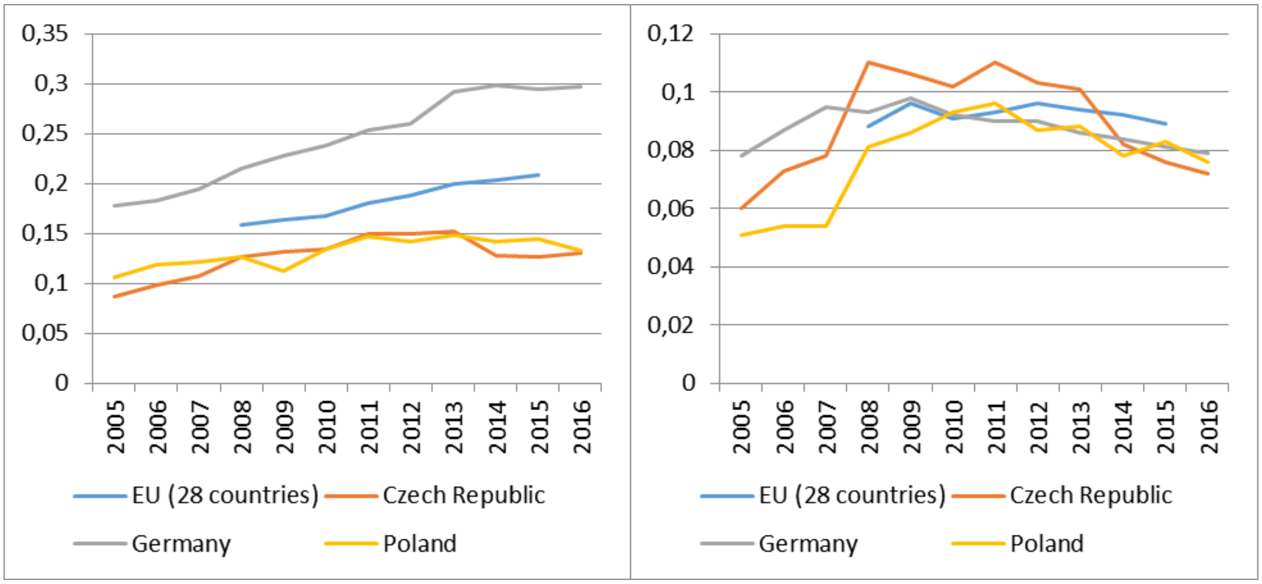
Fig. 13. EEG surcharge (c/kWh)



Source: (BMWi 2015b)

The recent developments have seen a brief decline in both the EEG surcharge and household retail prices. This happened for the first time in more than a decade. The prices for industrial customers continued to slowly decreasing – which is their trajectory since the financial crisis of 2008. Prices for industrial customers in Germany were similar to average EU retail prices. The prices for commercial customers were expectably much higher (see fig. 14).

Fig. 14. Electricity prices: medium sized households and medium sized industries (€/kWh)



Source: (Eurostat 2016)

Furthermore, from the perspective of late 2016, the 2015 decline in the EEG surcharge seems an isolated event. The surcharge continues to grow: in 2016 it increased from 6.17 c/kWh to 6,354 c/kWh and for 2017 it has been set at 6.88 ct/kWh (Netz-Trasparenz.de 2016) and it is predicted to increase further above 7 c/kWh. Furthermore, as the grid development does not keep pace with decreases in conventional generation and increases in RES generation, the need for redispatching measures also increases. Redispatch essentially means that the TSOs make the power plants in oversupplied regions ramp down their production, those in undersupplied regions ramp up production. Since the TSOs are obliged to compensate the plants for those measures[2] the costs of system services (and consequently the electricity bills) are increasing. The redispatch costs increased from €132.6 million in 2013 (Bundesnetzagentur 2015a, 14) to €186.7 million in 2014 (Bundesnetzagentur 2016b, 7) only to hit €402.5 million in 2015 (Bundesnetzagentur 2016a, 6). According to Jochen Homann, president of the Bundesnetzagentur, the redispatch costs could reach €1 billion by 2020, if the grid

[2] When grid operators tell power stations to limit production, they must compensate them for the power they would have been paid for supplying (minus expenses the power plants save on fuel). When grid operators order renewable power producers to disconnect from the network, they too must be compensated for some of their lost profit. Conventional power stations in south Germany that grid operators call on to produce extra power, do so at costs higher than the market price.

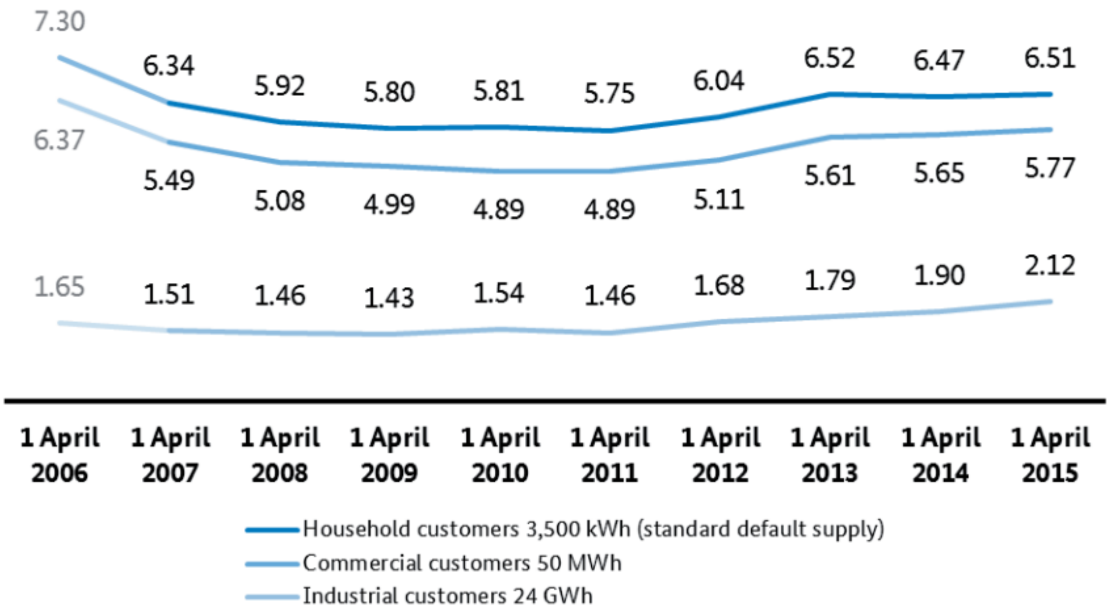
expansion is not streamlined. (Finanztreff 2016) Apart from that, the compensations paid by the TSOs to the RES operators for the curtailment of their production increased from €43.7 million in 2013 (Bundesnetzagentur 2015a, 14) to €83 million in 2014 (Bundesnetzagentur 2016b, 8) and reached €478 million in 2015 (Bundesnetzagentur 2016a, 6).

Rising costs are not the only reason that could dampen public support. The present shape of Energiewende builds on direct public participation. In 2012, as much as 46% of total installed RES capacity in Germany was owned by citizens or citizen initiatives, including energy cooperatives. The citizen initiatives benefited from investment security facilitated by the feed in tariffs, but since the introduction of the 2014 EEG reform this security has been replaced by uncertainty associated with the auction system. According to Andreas Wieg, head of the German National Office for Energy Cooperatives, the auctions are problematic for typical citizen cooperatives, because they involve very high upfront costs of 50,000 to 100,000 euros, and if the cooperative does not win the auction, that money is lost. Also, cooperatives typically only invest in a single project and cannot therefore split the risk of losing an auction - in contrast to large commercial project developers who can participate in several projects simultaneously. (Amelang 2016)

The increased costs and reduced participation opportunities could, in this scenario, cause erosion of the profound public support that Energiewende has enjoyed until now – see for example the recent summary of various polls on this issue by the Clean Energy Wire (Clean Energy Wire 2016b). However, there is also strong evidence that both the costs and the participation issues are not going to deteriorate much further. The EEG surcharge is expected to peak in the first half of the decade 2020, at a level of between 7 and 8 c/kWh (Öko-Institut 2016, 21), which represents only a slight increase from today’s 6,354 c/kWh.

The network charges, which cover the system services provided by the TSOs, have remained approximately the same between 2013 and 2015 (around 6.50 c/kWh for medium sized households), despite the combined redispatch and compensation costs increasing from €176.3 million to a staggering €880.5 million in the same period. This can be at least partially attributed to decreased costs for keeping reserves of balancing power and for energy to compensate for grid losses. (Bundesnetzagentur 2016b, 23)

Fig. 15. Network charges (c/kWh, excluding VAT)



Source: (Bundesnetzagentur 2016b, 112)

The participation opportunities then seem to be to certain extent restored by the EEG amendment of 2017. The amendment allows the citizens' energy companies[3] to build PV installations under 750 kW under the conditions determined in EEG 2014 and therefore to entirely avoid the auction system, or participate in the auction system in favorable conditions. In the case of onshore wind energy, the citizens' energy companies will not be required to obtain full-fledged approval under the Immission Control Act before making a bid. They will be awarded funding based on the price of the highest bid which won funding, rather than on the price of their bid, should they succeed in the auction. In this sense, the act seems to revert many of the issues imposed on citizens' companies by

[3] The EEG 2017 features a rather strict legal definition of a „citizens' energy company" in order to prevent distortions of auctions. The definition is featured in §3 (15) of the act and states as follows: the privileged citizens' energy companies are defined as follows: a) At least ten members of the company must be natural persons; b) each member of the company may not exercise more than 10% of the voting rights, and the natural persons must hold at least 51% of the voting rights; c) at least 51% of the voting rights must be held by members of the company who have been registered for at least one year (main residence) pursuant to Section 17 of the Federal Act on Registration in the rural district in which the site on which the wind energy installation to be erected is located. The tie-up with the rural district ensures that the company is regionally anchored. (Bundesrat 2016, 6-7)

the auction system, and since the small and mid-sized PV systems are shielded from the system entirely, the incentives for decentralized and community-based installation remain in place.

4. Energiewende's impact on the Czech Republic and Poland – the impact mechanism

Having fundamentally reshaped the biggest energy market in Europe, Energiewende undoubtedly influences also the German neighbors. We argue that there are three impact mechanisms that are facilitating that influence. Firstly, is direct market influence through price convergence. The sheer size of the German market causes the German wholesale electricity price to drive the prices of the neighboring markets if mutual interconnection capacity allows for price convergence. In other words – those markets that are well connected to the German market tend to receive the price signals from Germany. Secondly, there is the spill-over effect, through which the technological advancements and best practices in terms of policy measures will spontaneously spread from Germany to other states. Energiewende will undoubtedly make the RES technology more competitive if not directly the technology of choice for many energy planners not only in Germany but also abroad. Thirdly, Germany's decarbonization strategy echoes that of the European Union. The successes achieved by German Energiewende are likely to contribute to a more ambitious articulation of environmental goals in European energy policy and consequently also those of the national energy policies of individual Member States.

4.1 Price signals

In this chapter we introduce the mechanisms that transfer the price signals that originate from Germany and affect the energy markets of the neighboring countries. Firstly, we focus on the price convergence mechanism, which, based on the intensity of trade between the particular countries, brings the national prices closer together. Secondly, we assess the drivers of the price level and price volatility in Germany, building a framework for the price signal effects that the Energiewende process brings, and will continue to bring, to the markets beyond German borders.

4.1.1 The price convergence mechanism

This chapter aims to show how the German electricity market affects the Czech and Polish electricity markets. It starts with a brief introduction of the environment in which these markets interact - European Internal Energy Market (IEM) - and ways in which this interaction can affect the energy sectors of the involved countries. Subsequently, we examine whether the German power price (influenced by the Energiewende) affects the prices in the Czech Republic and Poland. We find that the Czech price is influenced much more than the Polish one. Therefore, analysis of factors which enable (in the case of the Czech Republic) or prevent (in the case of Poland) this price convergence follows. The last section outlines the implications of this development for the Czech and Polish energy sectors.

4.1.1.1 Integration of European electricity markets

Electricity markets of Germany, Poland and the Czech Republic coexist in the framework of the European Internal Energy Market (IEM) which has been liberalised and now is being gradually integrated. The overall aim of this integration is to encourage cross-border trade, incentivise competition and consequently achieve the lower wholesale prices of electricity. This process is hindered by two interlinked issues. Absence of the proper regulatory and trading framework being the first one, and lack of sufficient interconnectors to deliver the electricity from one country to the other being the second.

Starting with the latter, the explanation for the missing (or insufficient) links is uncomplicated. Traditionally the grids were built to satisfy the needs of national states, not to facilitate the trade between them. Construction of the interconnectors able to accommodate the growing demand for pan-European trade is an expensive and long-term project, complicated by the protracted legislative procedures, local opposition and cost- and benefit-related negotiations between involved TSOs. Despite the creation of ACER, the grouping of national regulators, partly to settle these disputes, the situation is changing very reluctantly. No universal formula is agreed to indicate a sufficient level of interconnectivity, but some guidance could be derived from the fact, that the EU itself set down, in 2002, that every member state should have interconnection capacity equal to at least 10% of its total electricity generation capacity. This target was increased to 15% in 2014. (Buchan and Keay 2015, 39) Despite the EU funds being earmarked for these investments and development of TSOs, this aim is still waiting to be achieved by the 12 MS. See the situation of Germany, Czech Republic and Poland in table 5 and note the extraordinarily weak capacity of the latter.

Tab. 5. Cross-border electricity interconnection as ratio of total generating capacity, 2014

MS above the 10% threshold		MS below the 10% threshold	
Austria	29%	Ireland	9%
Belgium	17%	Italy	7%
Bulgaria	11%	Romania	7%
Czech Republic	**17%**	Portugal	7%
Germany	**10%**	Estonia	4%
Denmark	44%	Lithuania	4%
Finland	30%	Latvia	4%
France	10%	UK	6%
Greece	11%	Spain	3%
Croatia	69%	**Poland**	**2%**
Hungary	29%	Cyprus	0%
Luxembourg	245%	Malta	0%
Netherlands	17%		
Slovenia	65%		
Sweden	26%		
Slovakia	61%		

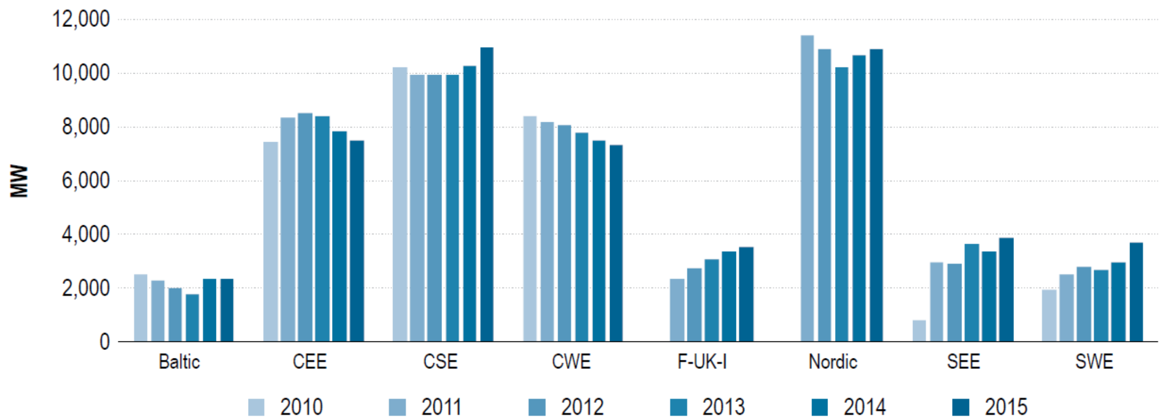
Source (Buchan and Keay, Europe´s Long Energy Journey: Towards and Energy Union? 2015, 40)

Having limited physical infrastructure, the only (provisional) remedy is its more effective utilisation, which gets us to the general regulatory framework of the IEM integration. It builds on the Target Model for electricity, the blueprint that describes the desirable architecture of the IEM. Obstacles identified on the way to this preferred set-up are addressed by the Network Codes (NC). Regarding the cross-border congestion, the Capacity Allocation and Congestion Management NC (CACM) was introduced, setting out the methods for allocating capacity in day-ahead (DA) and intraday (ID) markets in the most efficient way.

Impact of the IEM development on the cross-border trade in the EU is limited but positive. The increasing trading activity is illustrated using the following indicators.

Firstly, net transfer capacity in the majority of EU regions increases, which provides for more capacity being offered for trading.

Fig. 16. NTC averages of both directions on cross-zonal borders, aggregated per region, 2010-2015, MW

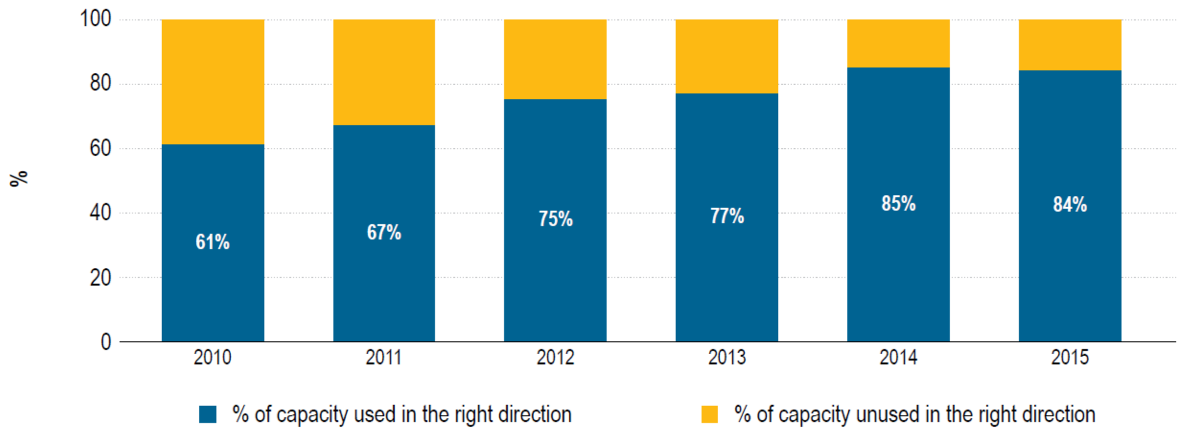


Source: (ACER/CEER 2016, 15)

Secondly, the percentage of available capacity used in the right direction (from the areas with significantly higher prices to the areas with lower prices) has been increasing. This indicates increasing efficiency of market integration, especially of the market coupling at various EU borders.[4]

[4] In 2015 the project of Price Coupling of Regions (PCR) was launched, using a common calculation algorithm and implicit auctioning on day-ahead markets. PCR covers 85 % of power consumption in the EU. It includes Germany and Poland but not the Czech Republic.

Fig. 17. Percentage of available capacity (NTC) used in the right direction in the presence of a significant price differential in all EU electricity interconnectors, 4Q 2010-2015,%



Source: (ACER/CEER 2016, 44)

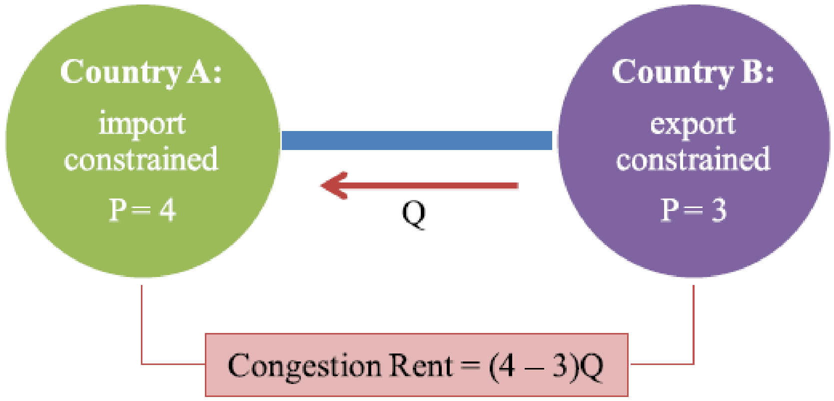
Despite its very slow development we may conclude that 1) the integration continues, allowing a greater amount of electricity to be traded across the borders of national states and 2) this process is to continue, being managed by pan-European bodies (ACER, ENTSO-E) and national bodies (TSAs, power exchanges) and welcomed by traders.

4.1.1.2 Market integration and price convergence mechanism

By the 90s, market segmentation was typical for the EU. Incumbents had neither the will (they preferred to control domestic markets over expansion) nor physical means (lack of interconnectors) or legal possibility to enter other national markets as competitors. (Buchan 2009, 33) That allowed for different wholesale prices and for capitalizing on market power in the case of some market actors. To illustrate the problem, we provide the following example:

There are two countries (A and B) connected by limited transmission capacity. Prices in the first country are higher due to the lack of generating capacity and/or higher costs of generation. Prices in country B are lower due to the surplus of electricity and/or lower generating costs. See figure 18.

Fig. 18. Interconnector congestion



Source: (Ochoa and van Ackere 2015, 523)

From the perspective of the overall efficiency of the system (in other words social welfare of the given region) the investment into the interconnection capacity would be the most justifiable. Nevertheless, on the fragmented market investor may decide to utilize its market power investing into the power generation in country A, increasing its offer price with no risk of being not dispatched. The same logic applies for the TSO. It might try to limit investments in the grid in order to collect higher congestion rents. Basically the market actors may think more strategically, not being subject to intense competition. (Ochoa and van Ackere 2015, 523)

The IEM limits this behaviour. The market integration incentivises (and is motivated in return by) the cross-border trade. Traders utilize the business opportunities offered by various prices in various countries (bidding zones), making profits from the difference.

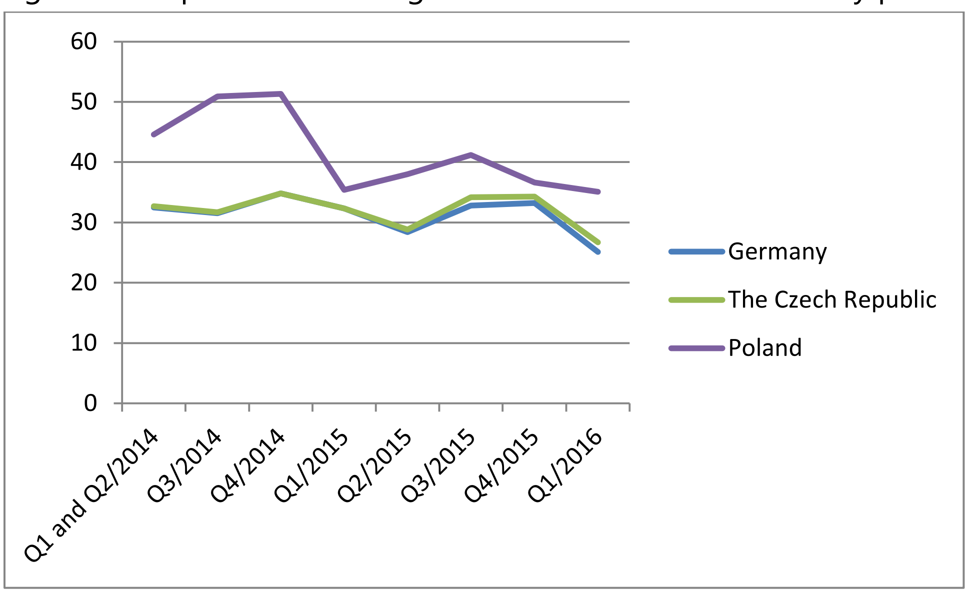
These transactions inevitably affect the economics surplus of three main categories of stakeholders in impacted markets. The general pattern is as follows: 1) producers (generators) in the area with higher prices of electricity (importers) loose part of their surplus in favor of producers in areas with cheaper production (exporters), since they are either forced to drive their prices down to stay competitive or they are pushed out of the production. 2) consumers in countries with more expensive electricity profits from the import from countries with cheaper electricity. 3) a more complicated position is that of transmission operators. If the interconnector is not congested, prices converge freely, otherwise the interconnector collects a congestion rent (cross border transport of electricity is free until the demand for transport exceeds the capacity of the interconnector) and economic incentives to trade are compromised (Ochoa and van Ackere 2015).

In this chapter we will use the same structure, focusing on the impact of cross-border electricity trade between Germany and the Czech Republic/Poland on these three groups of actors: generators, consumers and TSOs. But firstly, the actual state of cross-border trade between these countries has to be analyzed, providing information about the intensity of price convergence.

4.1.1.3 Price convergence between Germany and the Czech Republic

The figure 19 compares the development of average wholesale baseload electricity prices in Germany and the Czech Republic. We can see that the Czech and German prices converge strongly.

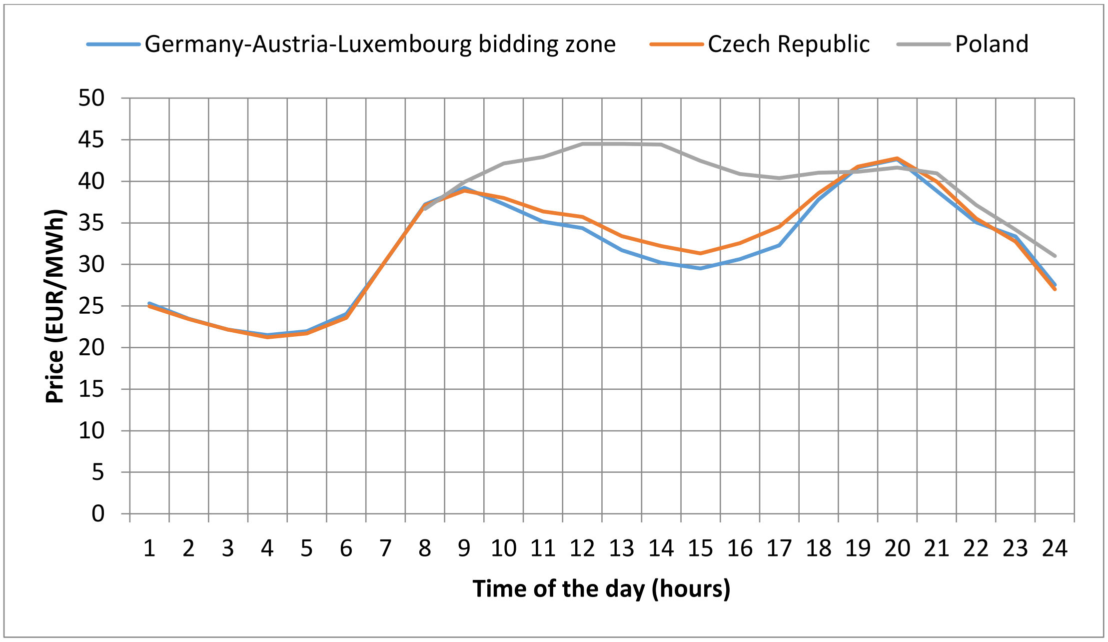
Fig. 19. Comparison of average wholesale baseload electricity prices (€/MWh)



Source: (European Commission 2016a) (European Commission 2014a) (European Commission 2014b) (European Commission 2015a) (European Commission 2015b) (European Commission 2015c) (European Commission 2015d)

Very similar results are provided when tracking the hourly development of prices. We compared the spot (day-ahead) electricity prices for each hour in 2015 in Germany and the Czech Republic. Using the function CORREL in Microsoft Excel we found that the correlation coefficient of the Czech and German prices is 0,916. As the maximum possible value of the coefficient equals 1, we consider the Czech price to be dependent on the German one. As we can see from the figure 20, the Czech price follows the German one for practically every hour of the day, on average.

Fig. 20. Average hourly spot prices in 2015



Source: author's computation

Since Germany constitutes a significantly larger market (Germany produced 592 TWh in 2014, the Czech Republic 80 TWh), convergence indicates that the Czech price is to a great extent determined by the German one. This is because the amount of electricity that can be traded between the small Czech market and the large German market is large enough to change the Czech price but too small to change the German price. We therefore may conclude that it is the Czech price that is being adjusted to the German one.

4.1.1.4 Price convergence between Germany and Poland

The polish price, on the other hand, converges much less with the German price (see figures 19 and 20). The correlation coefficient of Polish and German spot prices in 2015 equals only to 0.379.

For the reasoning we have to go back to the principles of price convergence. The core theoretical foundation in assessing common long-running dynamics in liberalized electricity markets has been The Law of One Price (Menezes, Houllier and Tamvakis 2016, 3). It states that *"goods must be sold at the same price in all parts of the market"* (Mankiw 2009, 629). If this was not true, it would show the existence of unused business opportunities. Traders could buy goods on the market with a lower price and sell it on the market with a higher price up to the point at which the prices are equal. Working on this assumption, price divergence can be understood as a deviation from a natural (convergent) state. In the Germany – Poland case, this deviation take place due to the limited interconnection capacities.

When there are limited interconnection capacities between two markets, electricity cannot be transmitted from one to the other even if there is a price differential which motivates traders to do so. Yet, even when the total transmission capacity is sufficient, capacity offered for trading may be limited. There is always some capacity reserved for unexpected situations (such as unscheduled flows). The larger volume of unscheduled flows is expected on a certain profile, the larger the reserve capacity must be and the less capacity can be offered for trading. We take into account only the capacity offered for trading because only this accounts for price convergence.[5]

The cross-border transmission capacity is offered in so called allocations. According to specific rules which may differ border to border, traders buy or reserve the capacity for a particular profile and particular time. Allocations take place in several time frames (usually a year-ahead, month-ahead, day-ahead and intraday) and for each of them different allocation mechanisms may apply (Mojžíš 2011, 112).

[5] This is because only commercial flows are priced according to the market fluctuations. Unscheduled and other flows for which capacity not offered for trading is reserved, do not change the wholesale prices.

For analysis we used 1) average offered capacity in day-ahead and intraday allocations[6] and 2) number of day-ahead and intraday allocations with no offered capacity to indicate the limitedness of the cross-border capacity.[7] We also assess these data according to the size of the markets in question. This is because the same capacity between larger markets cannot decrease a potential price differential as much as between smaller markets.

The analysis does not include year-ahead and month-ahead allocations because these are much less significant in terms of traded volumes. Yet, according to the brief analysis we made, they show similar trends regarding our indicators as day-ahead allocations.

4.1.1.4.1 Results for day-ahead allocation

The table 6 shows average offered capacity in day-ahead allocations and number of day-ahead allocations with no offered capacity. As we can see, there was no offered capacity from Germany (DE) to Poland (PL) in day-ahead allocations in 342 days of 2015.[8] By way of contrast, in all other examined directions (including the direction PL > DE) the number of days with no offered capacity was only 2. The same applies to average volume of offered capacity. The value 3.9 MW in the direction from DE > PL is extremely small.

Tab. 6. Offered capacity in day-ahead allocations on CZ-DE and PL-DE borders in 2015

Border/profile[9]	Average offered capacity in day-ahead allocations (MW)	Number of day-ahead allocations with no offered capacity
CZ-DE (sum of both profiles in both directions)	3364.3	-
DE > CZ (sum of both profiles)	1354.4	-

[6] We focus on the short-term trading as it contributes the most to price convergence.
[7] One might wonder whether the ratio of offered capacity to requested capacity would not be a better indicator. Yet, according to a representative of ČEPS, in those frequent hours with no offered capacity on this profile, traders do not tend to request any capacity as they know their demand cannot be met. Therefore, the data on requested capacity does not reflect the real demand for the capacity.
[8] The capacity was reserved for the unscheduled flows.
[9] DE has four transmission system operators (TSOs), each operating the grid in one part of the country. CZ borders two of them (50 Hertz and Tenne-T), PL borders only 50 Hertz's area. That is why there are two profiles between CZ and DE and one between PL and DE.

DE (50Hertz) > CZ	684.9	2
DE (TenneT GER) > CZ	669.5	2
CZ > DE (sum of both profiles)	2009.9	-
CZ > DE (50 Hertz)	997.3	2
CZ > DE (TenneT GER)	1012.7	2
PL-DE (sum of both directions)	822.9	**-**
DE (50Hertz) > PL	**3.9**	**342**
PL > DE (50Hertz)	819.0	2

Source: (ENTSO-E 2016a); author´s computations

It is worth noting the development of the day-ahead capacity after the first four phase shifting transformers (PST) were commissioned on the DE-PL border on June 22, 2016) (50 Hertz 2016). PSE (Polish transmission system operator) had previously stated that once the transformers start operating, an additional 500 MW of import capacity to Poland should have been available[10] (Harper 2016). The table 7 shows that after the first PSTs had been launched, capacity offered in day-ahead allocations from CZ and PL bidding zone aggregation to DE increased significantly (from 19.7 to 160 MW in average). So far the increase has not been anywhere close to the predicted 500 MW and the capacity is still small (compared to the opposite direction or CZ-DE profiles). Nevertheless, the improvement is clear and it is also visible on the lower number of allocations with no offered capacity.

Tab. 7. Changes in day-ahead allocations data after commissioning of PST on DE - PL profile on 22/6/2016

Direction	Time period	Average offered capacity (MW)	Average price of interconnection capacity in days with at least some offered capacity (EUR/MWh)	Number of allocations with no offered capacity

[10] This is because the transformers protect the Polish grid form excessive power flows and therefore less capacity has to be reserved for the unplanned flows. This capacity can be offered for trading instead. This move also should have lowered Polish wholesale prices as the new capacity available would have allowed traders to buy cheaper electricity from abroad (Harper 2016).

DE(50HzT) > BZA|PL-CZ	before (22/4/2015 - 21/4/2016)	**19.7**	**0.27**	**20***
	after (22/6/2016 - 22/8/2016)	**160**	**0.39**	**4**
BZA|PL-CZ > DE(50HzT)	before (22/4/2015 - 21/4/2016)	1190.5	0.03	0
	after (22/6/2016 - 22/8/2016)	1360.5	0.03	0

Note: For 5 days where no data are available, the actual number could be higher
Source: (ENTSO-E 2016a)*;* author's computations

Since we cannot separate PL and CZ in these data, we cannot say precisely how much Polish interconnection with Germany improved after the PSTs started operating. There is an apparent correlation between launching of the PSTs and increased offered capacity in both directions between DE (50Hertz) and the PL-CZ bidding zone aggregation. Yet, the offered capacity in the direction of Germany is much lower than what is offered for the transmission from both Czech profiles together to Germany. Thus, although our time frame of concern is 2015, we assume the transmission capacity on the PL-DE border can be considered scarcer than on the CZ-DE border even after June 22, 2016.

4.1.1.4.2 Results for intraday allocation

The table 8 shows average offered capacity in intraday allocations and number of intraday allocations with no offered capacity. The data indicate that there was much less offered capacity and many more allocations with no offered capacity on PL-DE interconnection than on the CZ-DE one. As in the case of day-ahead allocations, the direction DE > PL was the most limited. The capacity in the opposite direction was considerably larger, yet still not comparable to the capacities on the CZ-DE border.

Tab. 8. Offered capacity in intraday allocations on CZ-DE and PL-DE borders in 2015

Border/profile	Average offered capacity in intraday allocations (MW)	Number of intraday allocations with no offered capacity*
CZ–DE (sum of both profiles in both directions)	5569.86	-
DE > CZ (sum of both profiles)	2188.24	-

DE (50Hertz) > CZ	1078.22	394
DE (TenneT GER) > CZ	1110.02	386
CZ > DE (sum of both profiles)	3381.62	-
CZ > DE (50 Hertz)	1770.03	132
CZ > DE (TenneT GER)	1611.59	133
PL–DE (sum of both directions)	397.78	-
DE (50Hertz) > PL	**11**	**2041**
PL > DE (50Hertz)	386.78	616

Source: (ENSTO-E 2016b); authors' computations

Note: The ENTSO-E transparency platform primarily groups the data from intraday allocations to four-hour groups. Thus, the total number of values in 2015 is 2,190 in each direction.

Above, we illustrated a change in day-ahead allocations data after commissioning of PST on DE-PL profile on June 22, 2016. No such change took place in intraday allocations data.

To sum up, in both intraday and day-ahead allocations much less capacity was offered on the PL-DE profile than on CZ-DE profiles. Specifically, an extremely small capacity was offered in the direction DE > PL. Because the wholesale price in Germany is lower than in Poland, this is the direction which is to be utilized most if the price differential is to be eliminated. Therefore, the limited interconnection capacity can be regarded as a crucial barrier to price convergence between the two countries. At the same time, the capacity on the CZ-DE border was much larger and therefore helps explain the high level of convergence in this case.

This result is reinforced by the fact that the Polish market is almost twice the size of the Czech one. The larger the market, the larger the trading volumes that are necessary to influence the price in the market. Therefore, the relative limitedness of PL-DE cross-border capacity becomes even more evident than in the absolute numbers.

We may conclude that 1) IEM enables the price to spill over from one country to the other with the bigger market dominating price development. 2) This spill over (measured via price convergence) is possible only if the cross-border trade is unrestricted. 3) Cross-border trade between Germany and the Czech Republic is more advanced than that of Germany and Poland, resulting in a significant price convergence between the former pair, and low price convergence between latter pair of countries. 4) Based on the overall development of the IEM we may expect a gradual development of integration of the EU power markets, resulting from improvement of the regulatory framework and investments in the physical cross-border infrastructure.

4.1.2 Price level

The current low prices result from a combination of three factors: generation overcapacity, a low price of the marginal fuel and a low carbon price. According to ACER, the capacity margin for Europe as a whole now exceeds two to three times the most commonly used generation adequacy standards. This indicates an overall situation of overcapacity in Europe in spite of the recently observed decline in conventional generation capacity. (ACER 2016, 6) In Germany, the decommissioning of the nuclear plants that took place in 2011, was to a large extent compensated through the addition of new renewables alone. Between 2010 and 2016, the installed capacity in nuclear decreased from 20.4 GW to 10.8 GW. Renewables, on the other hand, grew from 26.8 to 44.2 GW (onshore wind), 0.1 to 4.0 GW (offshore wind) and 17.9 to 40.1 (solar). If adjusted for an average load factor, this translates to 7.3 GW of new renewable capacity versus 8.2 GW of the decommissioned nuclear.

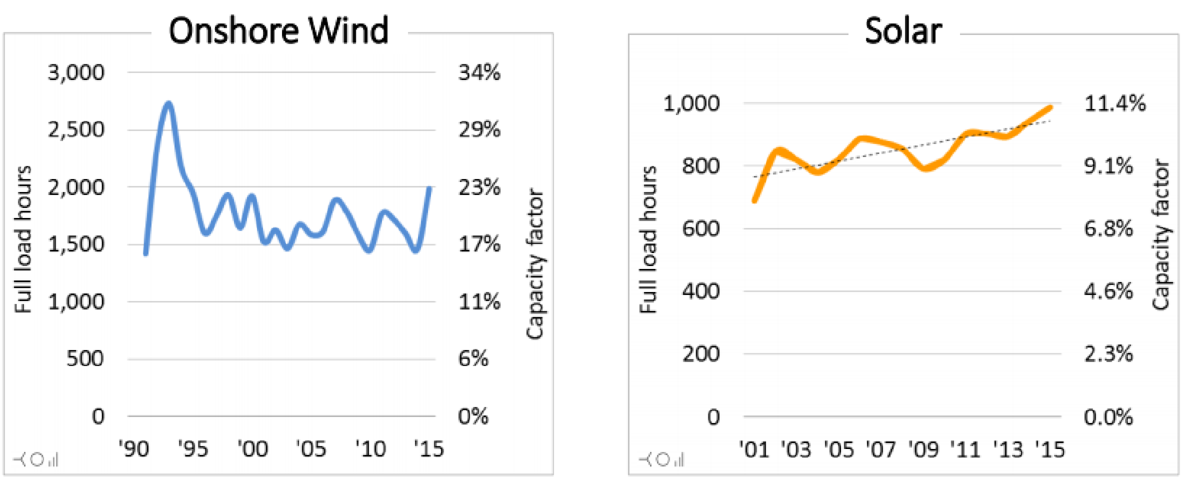
Tab. 9. Absolute and capacity factor-adjusted changes in installed capacity 2010-2016

	Capacity change (GW)	Avg. load factor	Adjusted capacity change (GW)
Nuclear	- 9.6	0.85	- 8.2
Wind onshore	+ 17.4	0.2	+ 3.5
Wind offshore	+ 3.9	0.4	+ 1.6
Solar	+ 22.2	0.1	+ 2.2
Balance	+ 33.9	-	- 0.9

Source: (Frauenhofer ISE 2016a) (Hirth 2016)

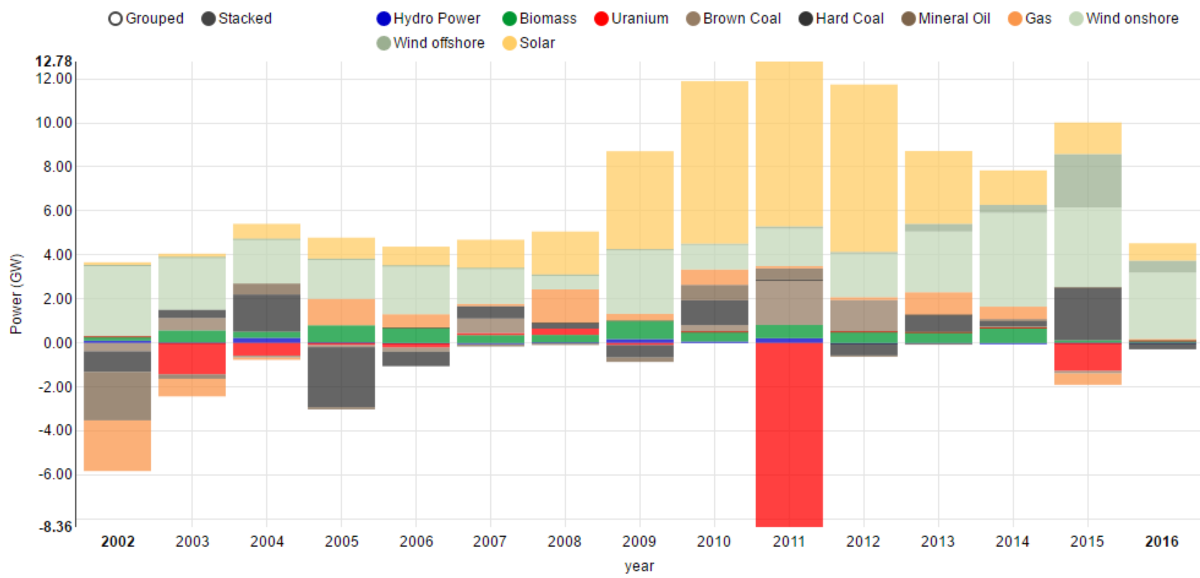
In the same period, the installed capacity in brown coal and hard coal remained essentially the same (21.3 and 28.4 GW respectively), while gas-powered generation capacity increased by 4.7 GW. The total net available capacity has therefore increased by 3.8 GW since the "Atomausstieg" decision.

Fig. 21. Capacity factor for onshore wind and solar in Germany



Source: (Hirth 2016, 6)

Fig. 22. Annual increase and decrease of net installed electricity generation capacity in Germany 2002-2016



Source: (Fraunhofer ISE 2016)

The future price level remains unclear. The decisive factors will be namely as follows: the supply/demand balance, the marginal fuel and its costs and the costs of carbon. The demand side of the supply/demand equation will depend on economic growth and penetration of electrified cars and heating systems such as heat pumps. The supply side, in turn, on the rate of closures of the currently unneeded power plants and the rate of penetration of the renewable sources. The rate itself will, according to the 2017 EEG amendment, respect the corridors set by the German government and/or follow the development of the high-voltage lines within Germany. Furthermore, increased interconnectivity and a more regional approach towards generation adequacy will enhance price convergence among the individual markets. The German price will consequently reflect also the supply/demand balance at the other important regional markets such as France or the Netherlands. The costs of carbon, related environmental legislation and regulatory support for generation flexibility will together with commodity prices decide about the marginal fuel. At this point brown coal is placed into that role, but depending on the above mentioned factors it could also be natural gas. The price of the marginal fuel will then play an important role in constituting the price of electricity.

4.1.3 Price volatility

In all described scenarios RES play either a significant or an absolutely decisive role. With the vast majority of these sources being non-dispatchable solar and wind, dependent on the changing local weather conditions, volatility of the overall electricity production is expected to increase. That defines two challenges for the system. Firstly, the remaining capacity needs to be flexible enough to cope with the volatile RES generation, ramping down supply on short notice in the period of low or zero prices. Secondly, some dispatchable generation capacity needs to be flexible enough to back-up the renewables during limited RES load.

This flexibility differs according to the different time frames. Longer time frame flexibility (one hour and more) provides adjustment to the changing residual load of renewables. And shorter time frame flexibility (up to one hour) may response to the deviation between forecast RES generation and actual outcome. (Bertsch, et al. 2014, 120)

The following flexibility options are available on the market: highly flexible generators (gas-fired power plants, some flexible coal power plants), demand side flexibility, storage and also the cross-border trade with electricity (discussed in chapter 4.1.1). See the following tables for details.

Tab. 10. Techno-economic figures for generation technologies

	Net efficiency [%]	**Availability [%]**	**FOM costs [EUR$_{2010}$/kWa]**	**Lifetime load [a]**	**Minimum [%]**	**Ramp-up times [h]**
Nuclear	33	84.5	96.6	60	45	48
Lignite	43	86.3	43.1	45	30	3–12
Lignite CHP	22	86.3	62.1	45	30	3–12
Lignite-innovative	46.5	86.3	43.1	45	30	3–12
Hard coal	46	83.8	36.1	45	30	1–6
Hard coal CHP	22	83.8	55.1	45	30	1–6
Hard coal-innovative	50	83.8	36.1	45	30	1–6
CCGT	60	84.5	28.II	30	40	0.75–3
CCGT-CHP	36	84.5	40	30	40	0.75–3
OCGT	40	84.5	17.II	25	20	0.25
Biomass gas	40	85	120	30	30	
Biomass gas CHP	30	85	130	30	30	
Biomass liquid	30	85	85	30	30	
Biomass solid	30	85	165	30	30	
Biomass solid CHP	22	85	175	30	30	
Concentrated solar power	–	–	120	25		
Geothermal (HDR)	22	85	300	30		
Geothermal	22	85	30	30		
PV ground	–	–	30	25		
PV roof	–	–	35	25		
Run-off-river hydropower	–	–	11.V	100		
Wind onshore	–	–	41	25		
Wind offshore	–	–	128	25		

Source: (Bertsch, et al. 2014, 129)

Tab. 11. Technical specifications for demand side management processes

Technologies	Balancing interval [h]	Efficiency [%]	Max. demand reduction [%]	Max. demand increase [%]
Ventilation, compressed air, circulation pumps, heat pumps, air conditioning	2	95	24–90	75–90
Medium and large water heaters (>30 l), cold storage houses, freezer, pumping	4	95	90	50–90
Dishwasher	12	100	90	90
Washing machine, dryer, night storage heating, e-mobility, aeration	24	100	25–90	25–90
Aluminum-electrolysis, cement mills, paper machine, Paper coating/calendaring, pulp refining, recycled paper treatment, electric arc furnace, chlorine-alkali-electrolysis (membrane)	8760	100	15–90	50

Source: (Bertsch, et al. 2014, 128)

Bertsch and colleagues explain the interaction between the non-dispatchable renewables and the conventional sources in their portfolio simulation of EU energy systems with 80% RES as follows: The residual load curve (load minus RES) is affected and the achievable full load hours for other technologies are reduced. Also the hourly changes of residual load possibly impose additional flexibility of the other supply technologies. And the provision of balancing power becomes more relevant due to possibly increasing absolute forecast errors. (Bertsch, et al. 2014, 123) An example of expected volatility of residual load in Germany is shown below.

Tab. 12. Deviations of hourly load changes for Germany, MW

	2011	2020	2050
Mean positive	2,242	3,083	4,150
Standard deviation positive	2,148	2,572	3,373
Max positive	11,396	14,106	22,775
Mean negative	-1,853	-2,604	-3,656
Standard deviation negative	1,420	1,922	2,727
Max negative	-8,016	-12,069	18,984

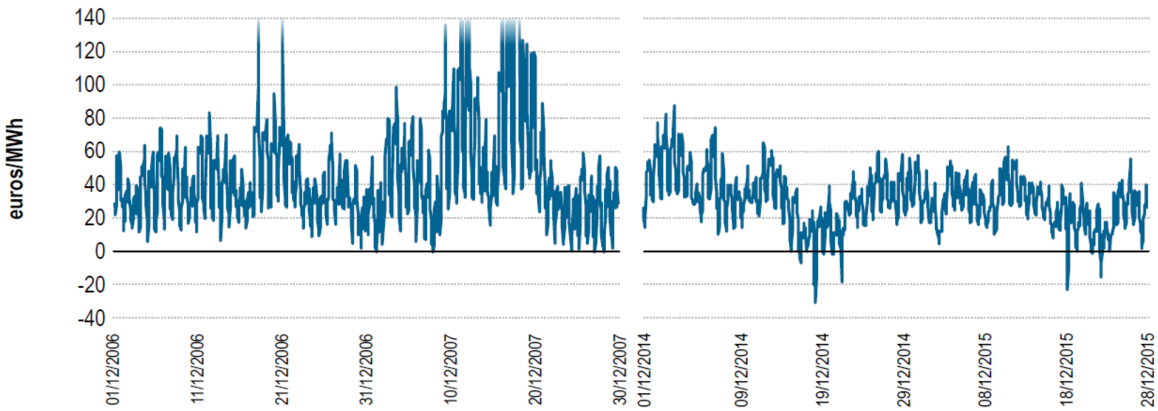
Source: (Bertsch, et al. 2014, 124)

Their results support expectations shared by economists about the profitability of different generators in the RES-based systems and consequently the feasibility of their future deployment. While base- and mid- load capacities (nuclear, lignite and partly coal) decrease significantly, the share of flexible generators (gas fired capacities, especially open-cycle turbines) increases. This, supplemented with other flexibility options, expands demand side flexibility and cross-border trade within the intraday and balancing markets.

However, these assumptions work only for the ideal market conditions where scarcity pricing (extremely high prices in periods of limited RES load) is allowed by regulators and supported by market design. Due to the penetration of intermittent generation, an increasing frequency of low-price periods would reduce the load factors of conventional generation and consequently their revenues. These revenues would be compensated by an increasing frequency of price spikes emerging at times of scarcity (ACER 2016, 7).

This, however, is not the current situation of the EU, firstly, due to the price caps that prevent free price formation in many European countries. Secondly, the market coupling of day-ahead markets plays a role, enabling for efficient use of diversity of regional sources and their production patterns. And most importantly, price peaks are muted by redundant generation capacity on the market. (ACER 2016, 6-13) With flat consumption, only slowly reduced conventional generation capacities and the booming RES sector market is flooded with electricity, driving the prices down. The situation is illustrated in the case of Germany below.

Fig. 23. Hourly day-ahead prices in Germany (€/MWh)



Source: (ACER 2016, 63)

4.2 Europeanization of Energiewende

Nothing is more distant from reality than thinking about the national energy policies of EU member states as truly "national". By nature, national states are independent, bounded by geographically-defined borders, organized by national governments and under national authority. The development of European climate and energy policy, however, gradually limits their sovereignty, subjecting their national energy sectors to EU regulation.

This process of the Europeanization of national energy policies (e.g. overcoming the heterogeneity of these policies) is characterized by development in two interlinked dimensions. The degree of centralization of decision-making structures is the first, where a crucial criterion is the involvement of supranational bodies in decision-making. On one (decentralized) side of the axis, decision-making is exclusively carried out by national governments. On the other (centralized) side, decisions are made by the supranational EU bodies. The second dimension analyzes the similarity of these policies. In this regard policies may be completely heterogeneous, using different tools to achieve an agreed aim, or completely homogenous, employing agreed and standardized solutions in all member states (Stunz, Gawel and Lehmann 2014).

Both these processes, however irregular, gradually limit the capability of national governments to independently manage the domestic energy sectors, transferring this capability to both the supranational (EU) bodies, and via the common EU policies, also to other member states. The individual decision-making of national states was supplemented and in some areas even replaced by the collective decision-making through the European energy and climate policy.

4.2.1 Costs of non-compliance

For a national government trying to push its own vision of an energy sector arrangement which is somehow different from the European consensus, this poses a very specific challenge. A sound body of both empirical and theoretical literature exists affirming the formative impact of European policies on the domestic level. EU regulation tends to change the policies (standards, instruments, problem-solving approaches and discourses), politics (processes of interest formation, aggregation and representation) and polity (institutions, public administration, economic institution and so on) at the national level. (Borzel and Risse 2009, 4)

This process of top-down Europeanization is characterized by balance between the inconvenience (termed ´misfit´ in the academic literature) between domestic and European processes, policies and institutions on one side and the adaptation pressures on the other. The more the given domestic policy differs from the European one, the higher the pressure for adaptation generated by the EU is on the given member state. In other words, if the national policies and structures differ from those of the EU significantly, EU bodies exert political, legal and sometimes financial pressure to align this diverging policy to the European one. As a result, the ´deviating´ state needs to invest resources to cope with this pressure.

In an effort to prevent the costly conflict between the national and EU levels, a country may employ two basic strategies. One is to block or water down policies potentially costly for the state. Since the EU decision-making mechanisms usually provide even the smallest members with negotiating or even blocking power this approach could be effectively used by all countries. The outcome of this strategy results from a combination of the importance of the given policy for the EU as a whole and the willingness of the non-compliant state to confront other member states and EU bodies. In addition, the impact of this approach to the rest of the EU is usually limited. The impacted country often negotiates some exceptions or compensation regarding the EU policy. Other MS might be affected but these impacts are usually limited.

A more ambitious approach is to push for those policies linked to national preferences, aligning EU policy to the domestic model. In other words, changing European policy according to national preferences. The efficiency of this strategy depends on the political leverage of a given country, sensitivity of the given issue, acceptability of this policy to other MS and many other actors. (Ohlhorst 2015). In this case, the impact on the rest of the EU might be substantial. If a country is able to alter EU policy to better fit its preferences, it means that the costs of compliance are moved to other countries.

4.2.2 The role of Germany in the EU

Based on its size, population, economics and diplomatic performance, the position of Germany in the EU is very strong. Germany has 29 out of 352 votes in the European Council (Poland 27 and the Czech Republic 12 votes), 96 seats in the European Parliament (compared to 51 and 21 for Poland and the Czech Republic respectively).

When it comes to Germany´s informal negotiation power, the country has several advantages. While small states like the Czech Republic must attract more partners in order to build a winning or at least blocking coalition, big states like Germany and Poland are in a much better position. Secondly, apart from size, structural disadvantages also matter. Policy and scientific expertise are crucial in persuading partners in the Council, or lobbing in the Commission. (Panke 2010, 16-17) Smaller administrations, which is the case of the Czech Republic, and less experience, which is the case for both these countries, have limited resources to prepare for each meeting or react quickly to new proposals. Germany on the other hand is a well-equipped and funded state, with a lot of experience in the Council negotiations. Having a large administration with experts on specific policy areas and also a higher number of staff in the EU institutions, provides Germany with a significant structural advantage over Poland and to an even bigger extent the Czech Republic. Observing the example of employees in different DGs (below), the disproportion between Germany on one side and the Czech Republic and Poland on the other is quite obvious.

Tab. 13. No. of employees in DGs responsible for EU energy and climate change legislation per country

	Czech Republic	Germany	Poland
DG ENER	8	52	28
DG ENVI	6	42	30
DG CLIMA	2	21	10

Source: (European Commission 2016b)

Administrative and expert resources provide bigger countries with another advantage. While smaller countries need to prioritize, investing precious resources in the most sensitive issues, the better-equipped countries may be able to afford to follow multiple issues simultaneously.

4.2.3 Energiewende and the European energy policy

Acknowledging the bargaining power, resources and experience of Germany we can get back to the Europeanization process, asking ourselves about the relationship between Energiewende and European energy and climate policy. Assuming that there is some difference (misfit) between these two, what strategy will Germany adopt to deflect the Europeanization pressure? Is it trying to protect its energy transition from EU regulation that could make its realization more difficult? Or is it trying to re-shape the European policy itself, shifting the costs of adaptation to other members of the EU? These questions are not coincidental; it resembles the discourse in all countries of our analysis, nevertheless with a different focus. In Germany, two different perspectives were promoted. One emphasizing that Germany´s decision to follow its own path in energy transition threatens the EU´s effort to achieve a cost-efficient transformation of the European energy market. Therefore, Germany needs to modify its plans to fit into the general EU model. The second expressed concerns that EU policy limits Germany in its efforts. And since Energiewende offers a potential role model for pan-European transformation, Europeanization of German politics is necessary. (Tews 2015, 277) In the Czech Republic and Poland this topic is considered with suspicion, with expectations that the adaptation costs will be transferred from Germany to these countries.

Due to limited space we cannot provide an analysis of overlaps of the Energiewende and European energy policy in all its facets. We will therefore focus only on the regulation of renewables, since this issue attracts a lot of political interest in all our analyzed countries.

4.2.4 Renewables in Germany and the EU

Renewable sources of energy are both a pivotal tool and the biggest success of Energiewende so far, providing more than 33% of electricity and 13.5% of energy. Two issues are of a special importance in this regard. Firstly, RES are also an irreplaceable low carbon source of energy for the system, since Germany purposefully decided not to use nuclear power plants and CCS units. Together with the energy efficiency measures, RES should deliver the 80% decrease in greenhouse gases in the country by 2050.

Secondly, the government neatly uses these sources to trade off the different interests and concerns of domestic stakeholders, keeping support from society for the

Energiewende high. By strongly supporting the participation of minor actors (municipalities, small and medium enterprises, even private persons) in RES investments, the government raises public engagement and acceptance for the new infrastructure, overcoming the issue of NIMBY. In 2013 more than one third of newly installed RES capacity was owned by local and regional initiatives, while utilities´ share was about 12%. (Tews 2015, 12)

This set-up limits the options of Germany´s government regarding the EU RES policy. Any negotiating strategy of the country on the supranational level must build on two principles. First, to promote RES as the primary source of clean and secure energy both for Germany and the EU. Second, to protect the authority of national government over settings of support and regulatory policies, for the country to be able to follow domestic aims.

Regarding the first aim, the role of Germany in shaping the overall EU approach to renewables is indisputable. During the whole process of developing the EU RES agenda, Germany supported the ambitious aims and intensive and fast integration of renewables across the EU. We may confidently conclude that the supportive EU approach to renewables mirrors to a great extent the approach of Germany.

But this concerns only the general aim of having RES in the EU energy system. Regarding the means and tools to achieve this goal the position of the EU and Germany traditionally differs. Harmonization of RES support schemes may serve as an example.

Considered from the supranational (EU) perspective, different national RES schemes are not the best solution available. Firstly, they prevent free and cost-efficient spatial allocation of generation facilities across the EU. As repeatedly demonstrated, due to different meteorological conditions across Europe, differences in generation costs vary significantly; full load hours of solar and wind based technologies between the most and the least favorable sites vary by factors of up to 100% (Fürsch 2013, 650) Secondly, they constitute barriers for the member states´ market integration. Different levels of support for various groups of generators distort the free trade, cost efficiency and compromises societal benefits of a unified European energy market.

This is the logic behind the European Commission´s long journey to introduce orchestrated (homogenous) and market-compatible RES support policy. Firstly, via a common quota system with tradable certificates. Due to the resistance of some EU member states this suggestion failed, in favor of individually set, feed-in tariff mechanisms that gradually diffused between member states. Germany was one of the most vociferous opponents of this common scheme, supported heavily by Spain. Secondly, the EU commission used tools of competitive policy to get national schemes aligned with the EU market principles. Again, Germany was a significant opponent to this effort. The German RES act had been legally challenged in 1998 (PreussenElecktra vs. Schleswag case) as a disallowed state aid, with the European Court of Justice's negative decision in 2000. Again this issue was raised by the Commission in 2012, stating that the actual version of the RES act couldn´t be justified by the previous PreussenElektra decision. The problem was mainly in support of energy intensive companies benefiting from uneven distribution of renewable surcharges in the country. The EU also released new general guidelines on state aid explicitly aimed at shaping future RES support schemes in line with the Commission´s preferences. (Strunz, Gawel and Lehmann 2016, 36) Under this combined pressure, Germany was forced to partially adjust its domestic system, introducing reformed RES act in 2014.

4.2.5 Implication for the Europeanization of Energiewende

The previous example helps us to illustrate the way Germany advances its energy transition on the EU level. Firstly, it utilizes its position as a dominant EU member state and in cooperation with likeminded countries, uploads its basic priorities into the European energy policy. Energiewende and the European energy policy are thus gradually drawing close to each other. Dissemination of renewable sources of energy, energy efficiency, reduction of greenhouse gases, all these essential building blocks of Energiewende are defended and promoted by Germany at the EU level with reasonable effect.

But this strategy refers mainly to the general principles and aims of the European energy policy, to its ´grand design´. On the more detailed level, dealing with the specific provisions and tools of this policy, Germany is far more modest. Its aim is primarily to defend Energiewende from those activities of the European Commission that could complicate the energy transition or increase its costs, holding primarily the defensive position. On this level the German government is usually criticized for the lack of effort to Europeanize the Energiewende, not the other way around (see (Schlandt, The solo draws to a close 2015). Analyzing the debate in Germany we nevertheless observe an increasing amount of voices calling for modification of this policy in favor of a more active one.

Getting back to the concerns of the Czech and Polish representatives regarding Germany using European energy policy to pass some of its costs to other member states, the conclusion is as follows. These concerns are justified, however only partially. Like any EU country, Germany uses its bargaining power to promote its visions and preferences on the supranational level. Sitting in the driving seat of the European Union Berlin´s administration is well placed to promote its vision of the decarbonized, RES powered and climate friendly EU economy and energy. Nevertheless, regarding the performance of the Energiewende itself, Germany is surprisingly modest. It focuses primarily on shielding this transition from undesirable EU interventions (provided there are some), not on its Europeanization. And even in this safeguarding position, Germany is successful only to some limited extent, as illustrated by the 2014 RES act concessions.

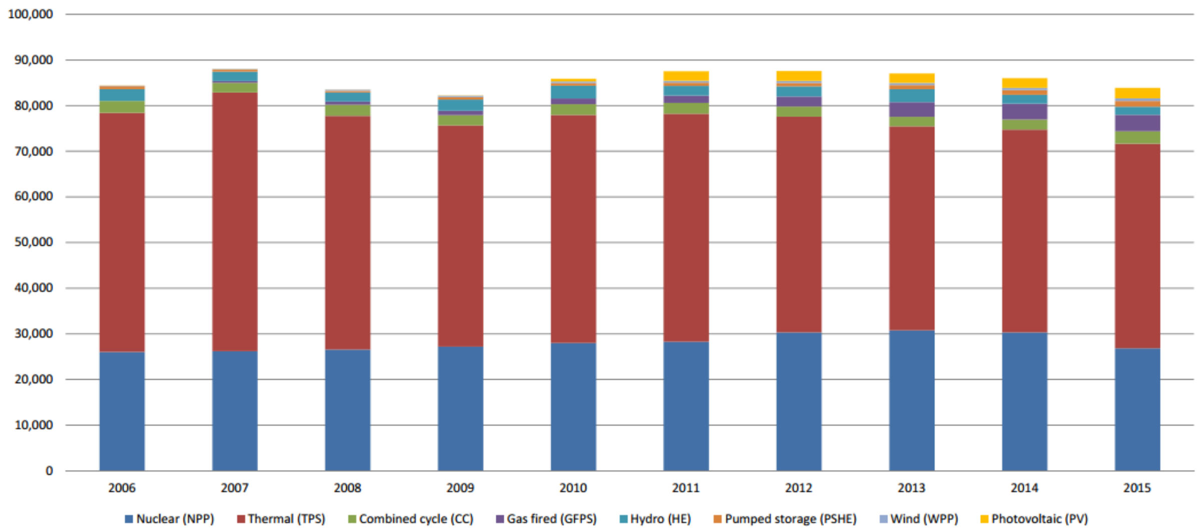
5. The impact on the Czech and Polish energy sectors

5.1 Producers

The **Czech** producers have been facing reduced revenues since the large-scale development of RES started in Germany. EBITDA of the dominant Czech producer, the ČEZ Group, has gradually decreased from a record high of €3.5 bn. in 2009 to €2.5 bn. in 2015. However, due to a low-variable cost generation portfolio (more than half of the electricity produced in 2013 came from nuclear and hydro power plants, another 38% originated from lignite plants), ČEZ has remained among the most profitable utilities in Europe – its EBITDA margin has reached 37.8% in 2013 (ČEZ 2014).

Overall, as much as 88% of the electricity generated in the Czech Republic in 2015 originated from low-merit or mid-merit sources: coal power plants (50%), nuclear plants (30%) and hydro power (2% alone or 3.5% including pumped storage).

Fig. 24. Gross electricity generation in the Czech Republic 2006-2015 (GWh)



Source: (ERÚ 2016c, 8)

Given the structure of their generation portfolio, the Czech producers will be able to survive even prolonged periods of low electricity prices. The more turbulent times can be expected to come during the 2020-2026 period, in which nearly 3 GW of coal-based capacity is expected to be phased out, and by the end of the decade, the 2 GW of capacity installed in the Dukovany NPP could be out of the market as well. As a result, the installed capacity of the currently dominating coal and nuclear sources is expected to decrease from 14 GW (out of 23 GW of total capacity in 2016) to 9 GW (out of a total of 19 GW) in 2030. (ČEPS 2016) In this period, therefore, new capacity is likely to be needed. In the short term, both ČEPS and the Ministry of Trade and Industry expect to cover this gap by reduced exports and a modest development of RES, namely solar. (ČEPS 2016), (MPO 2015c) In the long term, the more forward looking Ministry envisages development of two to four new nuclear units. For the Czech producers this means that in the short term they will be able to benefit from decreasing costs of installations triggered by Energiewende, but in the long term, their nuclear prospects are likely to prove themselves unfit for the Energiewende-adjusted regional markets. According to Oliver Koch, the leading author of the Commission's "Winter Package" set of energy-related regulations, the market will clearly prefer sources that are able to deliver electricity in the time periods when it is needed over sources that may promise to deliver a stable output of electricity on a daily basis throughout several decades, but not in a flexible manner. (Koch 2016) Given the investment risk associated with lengthy licensing and construction times and cost overruns, the private producers, including ČEZ, are likely to prefer sources other than nuclear, if there is no state aid to alleviate this risk. This would cause a significant discrepancy between the behavior of the market actors and the state energy policy.

Regarding **Polish producers**, the electricity generation is primarily concentrated among the three largest companies on the market, i.e. PGE Polska Grupa Energetyczna S.A. (37.94% of Polish electricity production), TAURON Polska Energia S.A. (10.81%) and ENEA S.A. (8.81%). The capital groups within which the three generators operate are vertically integrated, and are present in all energy subsectors – from extraction, through generation both in conventional and RES sources, to distribution and supply of electricity (Urząd Regulacji Energetyki 2016). It is typical for all three leading companies that a significant share in their ownership structure is owned by the Polish state through the State Treasury. The share of the state is as follows: PGE Polska Grupa Energetyczna S.A. (57.39%) (PGE Polska Grupa Energetyczna S.A., 2016); TAURON Polska Energia S.A. (30.06%) (TAURON Polska Energia S.A. 2016); ENEA S.A. 51.5% (Enea S.A. 2016).

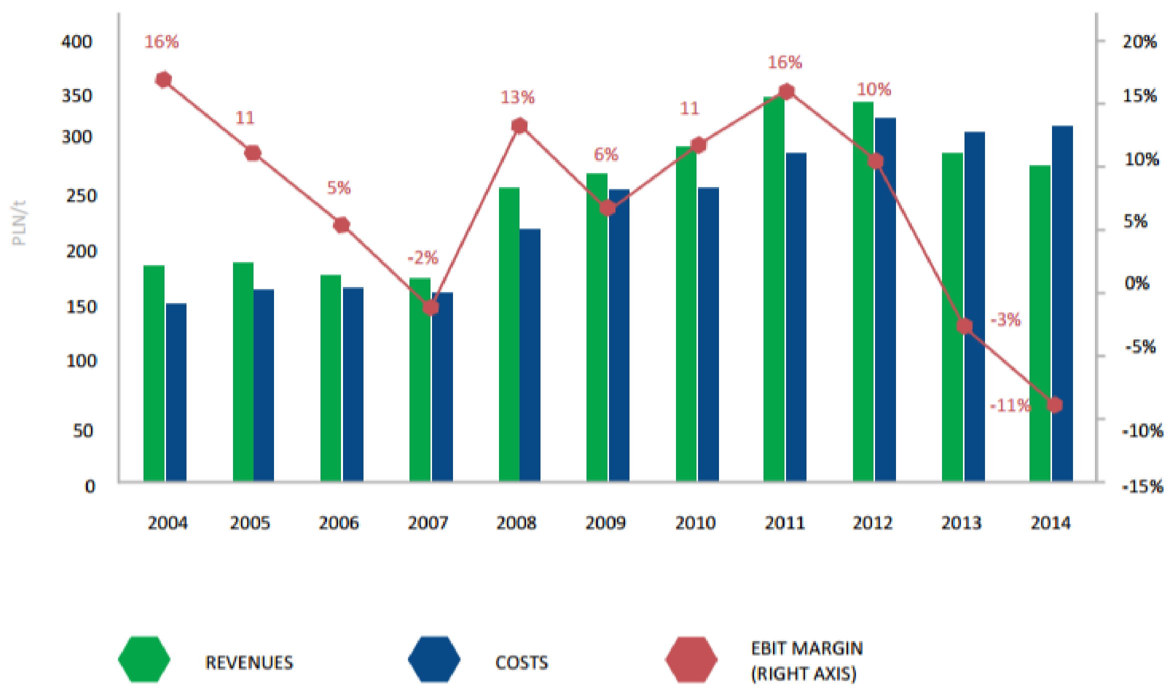
In 2015 gross domestic electricity consumption amounted to 161,438 GWh and grew by 1.7% in comparison to 2014. In 2014 Poland turned to be a net electricity importer, and the volume of imports exceeded exports by 2,167 GWh. In 2015, both imports and exports constituted more than 8% of total electricity fed into and off-taken, respectively, in the domestic balance of electricity (Urząd Regulacji Energetyki 2016). According to The Ministry of Economy, Poland faces a generation deficit that can reach 1.1 GW in 2017. (Easton 2013)

The future prospect of Polish producers depends on their ability to cope with two of the structural weaknesses of their production assets: the increasing age of generators and the usage of coal as a predominant fuel. Both these problems are serious and would need to be addressed anyway, but Energiewende put some additional pressure on for their fast and efficient solution.

Regarding the generation fleet, 47% of it is older than 30 years. The majority of older plants must operate at greater than 50% capacity, the minimum for newer plants is 40%. That results in a minimum load of approximately 10 GW of power in the system. (Forum for Energy Analysis 2015, 18) Technical limits of existing power plants prevent generators from benefiting from the relative flexibility of coal as a fuel. Since the European energy system gradually rewards flexible over base load generators, the inflexible generation fleet is a significant drawback for the competitiveness of Polish utilities on the regional market.

Since 84% of electricity in Poland is produced from coal, the prospect for generators is strongly linked to the situation in the coal mining industry. This sector faces three substantial problems: depletion of easily accessible deposits (mainly in Silesia), low productivity combined with high costs of labor; and low global prices of coal. As a result, Polish coal companies struggle to survive, see the chart below.

Fig. 25. Revenues and costs per ton of coal and EBIT margin in the Polish hard coal mining

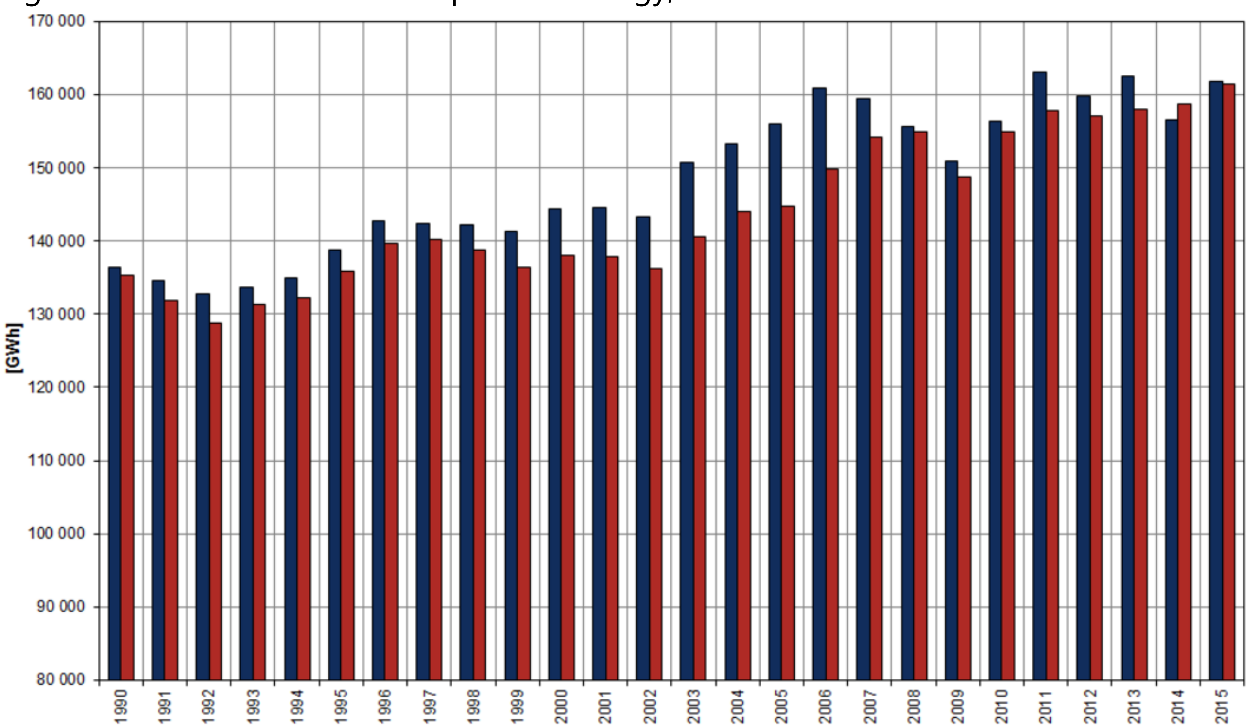


Source: (Bukowski, et al. 2015, 19)

The Polish government tries to balance some structural weaknesses of the sector using various protective measures. Direct public subsidies in this sector reached €1.2 billion in 2013 (excluding non-internalized externalities), coal miners are also supported by a favorable taxation structure, state liabilities towards retired miners etc. (Ecofys 2014, 69), (Bukowski, et al. 2015) Despite this continuous support, domestic production loses its competitiveness and faces serious financial problems. In 2014, the EBIT margins were -15% at Kompania Weglowa, 5% at KHW, -11% at JSW and 18% at Bogdanka. The net loss of the significant producer of coking and steam coal, Jastrzębska Spółka Węglowa S.A., was USD 787 million for 2015 (Martewicz 2016) and at the end of 2016 the amount of piled, unsold coal in Poland reached 5.7 million tons. (Polish coal daily 2016)

The decreasing competitiveness of domestic coal, accentuated by increasing coal imports from Russia, Australia and the Czech Republic, and reflected in the increasing costs of this essential fuel, is not the only concern. Continuing dissemination of renewables in neighboring countries decreases the average wholesale price of their electricity, since RES have marginal costs close to zero. As a result, Poland experiences growing import of comparatively cheaper electricity from Sweden, Lithuania and even Ukraine. (Mortkowitz-Bauerowa 2016)

Fig. 26. Production and consumption of energy, 1990-2015



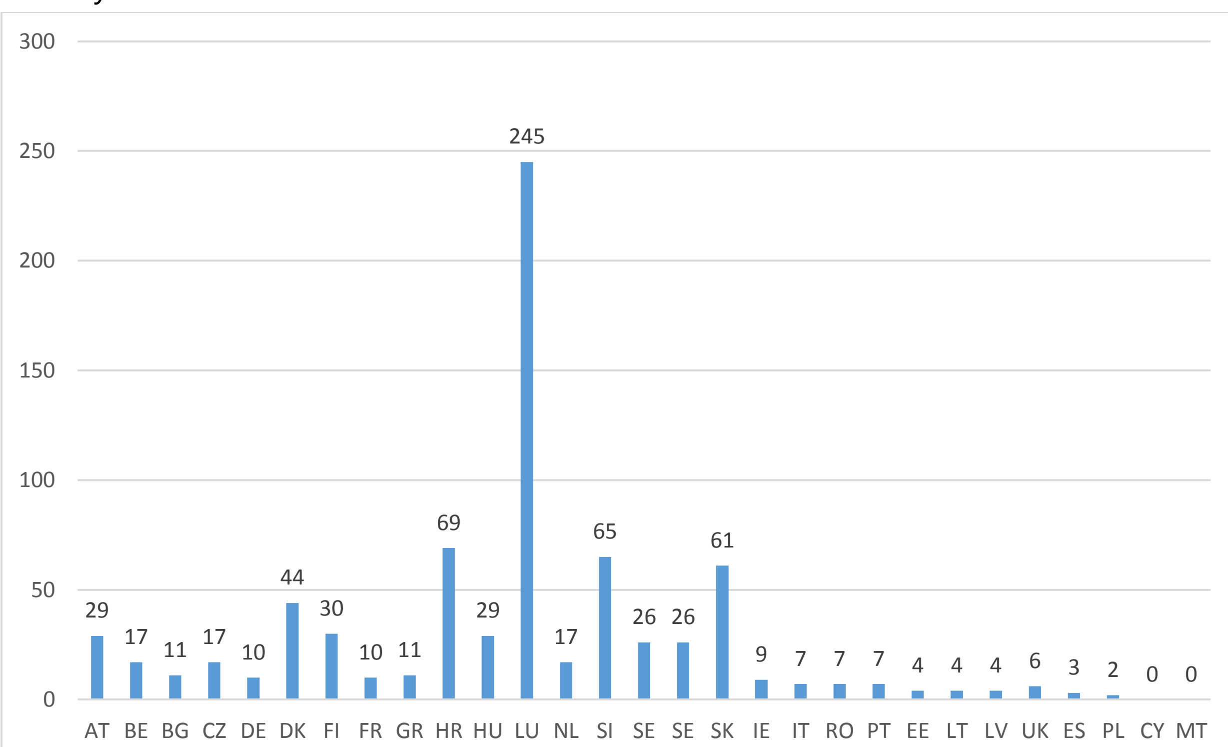
Note: Blue bars represents domestic production, red bars represents domestic consumption.

Source: (PSE 2016)

This growing inability to sell the electricity abroad is summarized in figure 26. Part of this trend could be explained by growing domestic consumption, but we also argue that inflexible Polish sources with significant marginal costs find it difficult to compete on the regional market.

Departing from the current situation to a more dynamic perspective, two expected mid-term trends will affect the future prospect of producers. Firstly, it is the increasing exposure to external price signals. So far, the Polish power sector is to a great extend shielded from the competition of third country producers. This isolation results from a combination of the lack of cross-border interconnections and curtailment of the majority of available capacity on the DE-PL border due to the unscheduled flows. As a result, generators compete primarily with their Polish peers on the domestic markets, not with producers from the third countries, including Germany.

Fig. 27. Interconnection levels for electricity in 2014, in% of installed capacity in given country



Note: The 500MW LitPol link was commissioned at the end of 2015 therefore is not included.

Source: (European Commission 2015, 5)

But according to the Energy Policy of Poland, by 2030 the country aims at having the equivalent of at least 25% of its electricity consumption in cross-border capacity. This means that the situation is to change significantly. Integration to the German price area would expose the utilities to lower (at least in the mid-term period) and volatile wholesale prices. None of these options are desirable, since utilities lack both technical and financial flexibility.

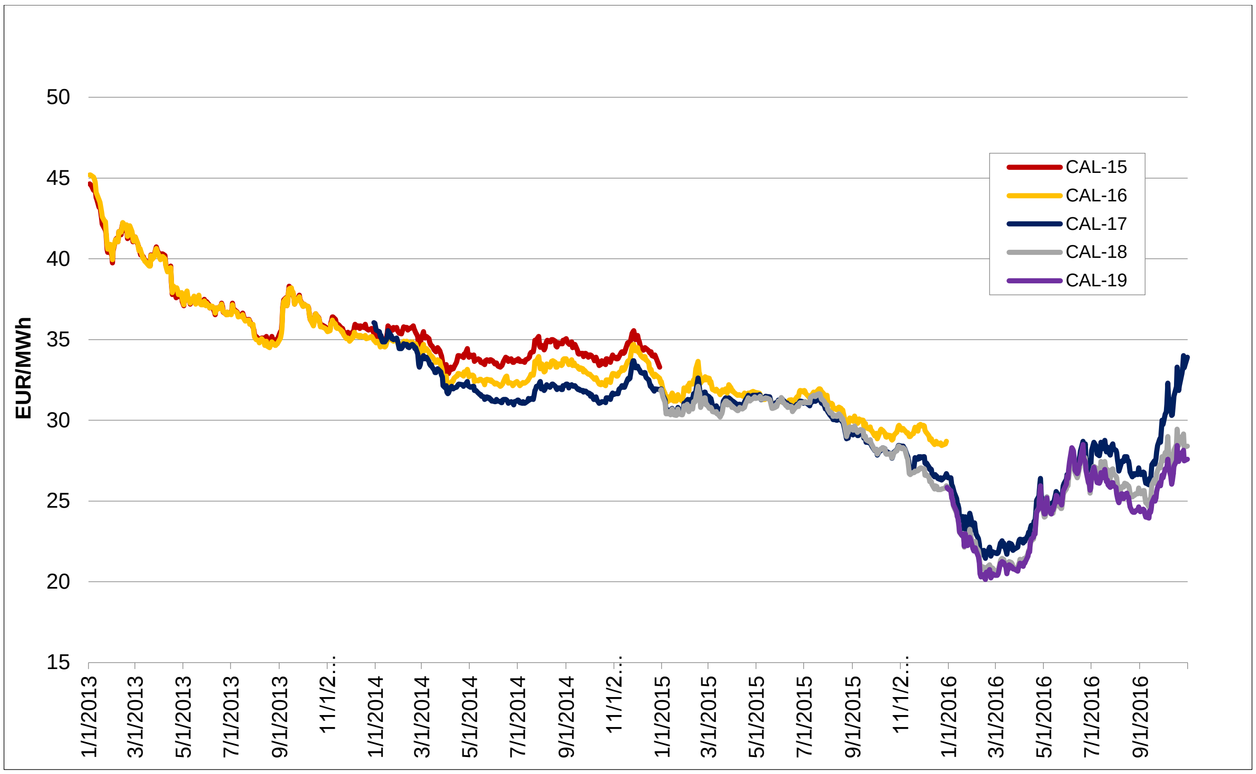
At the same time companies seem to continue in preferential investing in coal capacities. According to the data provided to ENTSO-E by Polish TSO, 3.6 GW of installed capacity should be decommissioned by 2020, with an expected replacement of 4.3 GW of coal, 1.5 GW of gas by 2020 and with overall capacity of renewables amounting to 12.5 GW by 2025. (ENTSO-E 2016c, 89) Currently, there are systemic investments carried out in Poland with a total capacity of more than 5,210 MW. The major projects include the following power plants: Stalowa Wola (TAURON Polska Energia S.A., natural gas) – 400 MW, Włocławek (PKN ORLEN S.A., natural gas) – 463 MW, Kozienice (ENEA S.A., coal) – 1,000 MW, Opole (PGE S.A., coal) – 2 x 900 MW, Turów (PGE S.A., coal) – 450 MW, Jaworzno (TAURON Polska Energia S.A., coal) – 910 MW.

While the newly installed modern coal sources may perform better on the market (faster ramp up/down times, lower minimal load, higher efficiency, lower emissions), the essential problem of low fuel diversification seems to persist.

5.2 Consumers

The **Czech consumers** have so far been among the clear winners of German Energiewende and they are expected to remain so. Since German and Czech wholesale prices are in nearly perfect correlation, the merit order effect of large-scale RES deployment in Germany is felt with the same intensity in the Czech Republic. As a result, the Czech wholesale price has decreased significantly over past years, as depicted in figure 28.

Fig. 28. Historical Prices of CZ Base CALs



Source: (PXE 2016)

Since the wholesale price (including generator/trader margin) represents more than one third of the retail price, the decrease of the wholesale price has brought along stagnation or even reduction of the retail prices (see fig. 29).

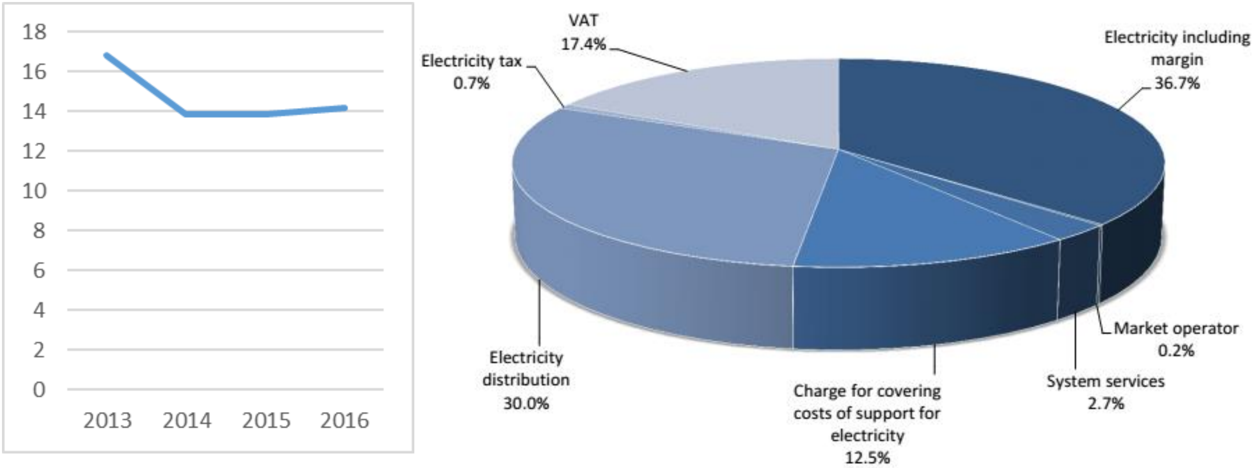
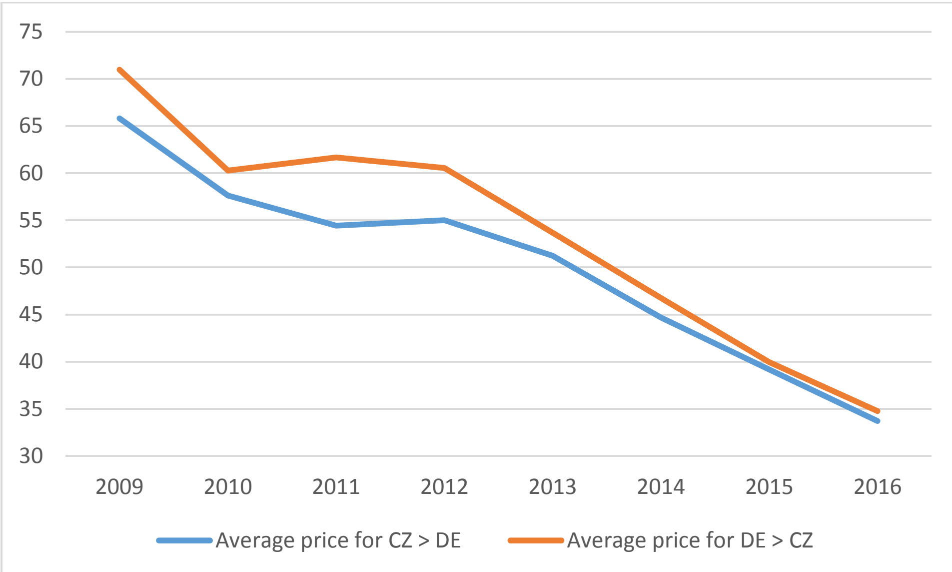


Fig. 29. Czech retail price levels 2013-2016 in c/kWh and retail price components 2015
Source: (Eurostat 2016), (ERÚ 2016a, 20)
Note: The figure shows the prices paid by a mid-sized household

Furthermore, within the bilateral trade relationship, the electricity exported from Germany to the Czech Republic has been traded at an on average higher price than electricity imported from the Czech Republic to Germany. This can be attributed to the fact that Germany sells at times of high demand and buys at times of low demand. For Czech consumers this means that electricity imports from Germany prevent price spikes during the times of high demand.

Fig. 30. Average prices for electricity traded between Germany and the Czech Republic (€/MWh)



Source: (Frauenhofer ISE 2016b)

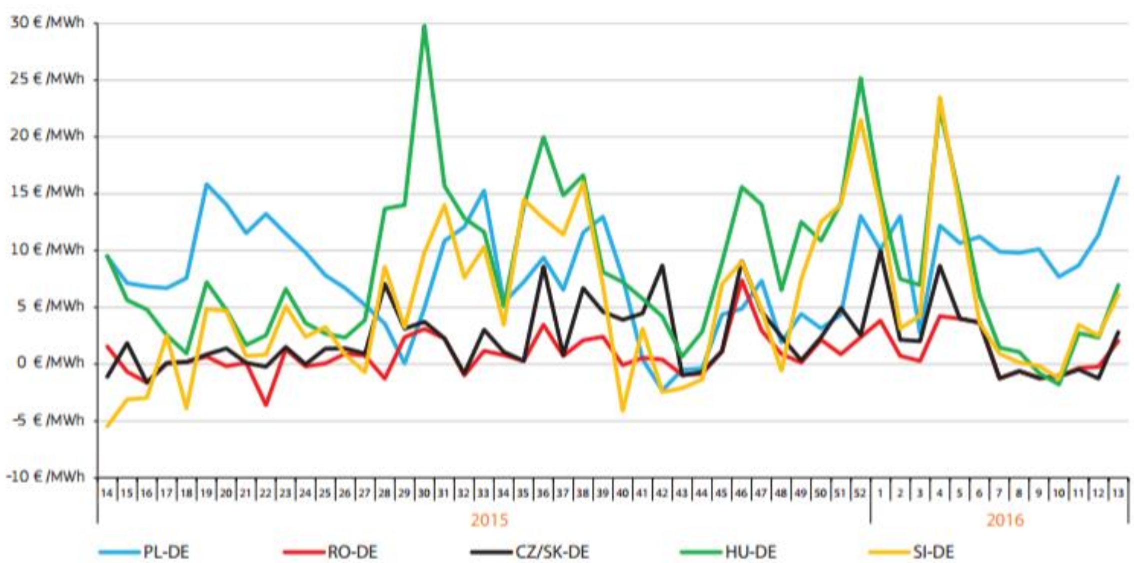
Apart from reduced electricity prices, the Czech customers can already benefit from the large-scale technological revolution that Germany has initiated and financed. The falling costs of decentralized energy systems are certainly not limited to Germany and since the falling costs of rooftop solar in Germany (9.8-14.2 c/kWh for southern Germany; Frauenhofer ISE, 2013, p.2) have already intersected with the Czech retail price, it can be expected that the number of prosumers in the Czech Republic will gradually increase. This is especially so following the 2015 amendment of the energy act, which came into force on January 1, 2016, and which simplifies the administrative requirements for connecting PV units under 10 kW which do not feed power into the grid. (Nečas 2016) Since rooftop solar systems account for only 4% of both installed solar capacity and generated solar power in 2015 (ERÚ 2016b, 17), which signals large untapped potential, the significance of distributed rooftop systems can be expected to grow.

In **Poland**, there are over 17 millions consumers of electricity, out of whom 90.3% (15.4 million) are the customers in the G tariff group, with a great majority of household consumers (over 14.5 million) purchasing electricity for household consumption. The rest of the end-users are industrial, business and institutional customers of A, B and C tariff groups. Groups A and B comprise customers supplied from the high and medium voltage grids, i.e. the so-called industrial customers, whereas group C are those connected to the low voltage grid and whose electricity consumption is for business activities (Urząd Regulacji Energetyki 2016, 44).

In 2015 over 209,000 customers from groups A, B and C actively exercised the right to purchase electricity from a chosen supplier. In the household segment their number amounted to over 375,000. This was another year that saw a dynamic increase in the number of customers who switched supplier. At the end of 2015 a 36.6% growth in the number of TPA customers was noted in comparison to 2014. (National Report, 2015)

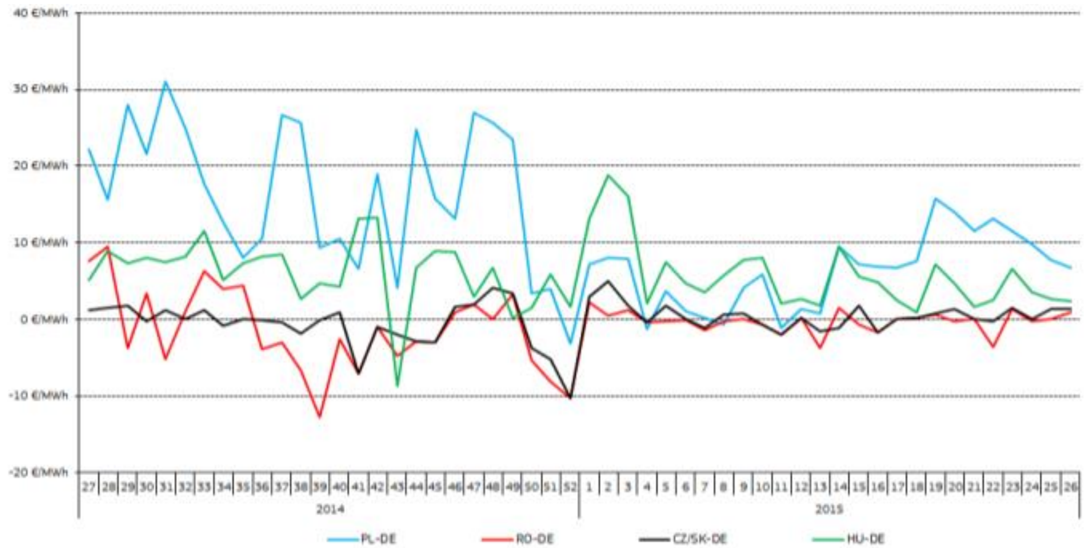
With DE-PL trade being marginal, the price convergence between those two countries is very limited. This prevents Polish customers from benefiting from lower wholesale German prices. As depicted in the figures 28 and 29, in the last 3 years Polish price premium (blue lines) to the German market range between approximately -1 €/MWh to 30 €/MWh, being for the majority of time in positive values.

Fig. 31. Regional weekly baseload price premiums or discounts to the German market, 3-4Q 2015, 1Q 2016



Source: (DG Energy 2016, 30)

Fig. 32. Regional weekly baseload price premiums or discounts to the German market, 3-4Q 2014, 1-2Q 2015



(DG Energy 2015, 22)

Limited cross-border interconnection also has some other detrimental effects, both on security of supply and consumers´ expenditures.

In August 2015 Poland experienced serious brown-out, the worst in the last 30 years. This situation was caused by a combination of the following factors: Low diversification of generation capacity, where approximately 85% electricity is produced from coal power plants in Poland. Due to the low water tables production was restricted. Also CHP plants were offline for the summer non-heating season. Some other sources were phased-out for maintenance (including the largest plant in Poland, Bełchatów) and wind power plants (app. 4% of overall production) did not feed into the system. As a result, the supply for 1,600 commercial customers were curtailed. (Forum for Energy Analysis 2015, 15) This situation could have been prevented had Poland compensated for unavailable capacity with imported electricity from abroad.

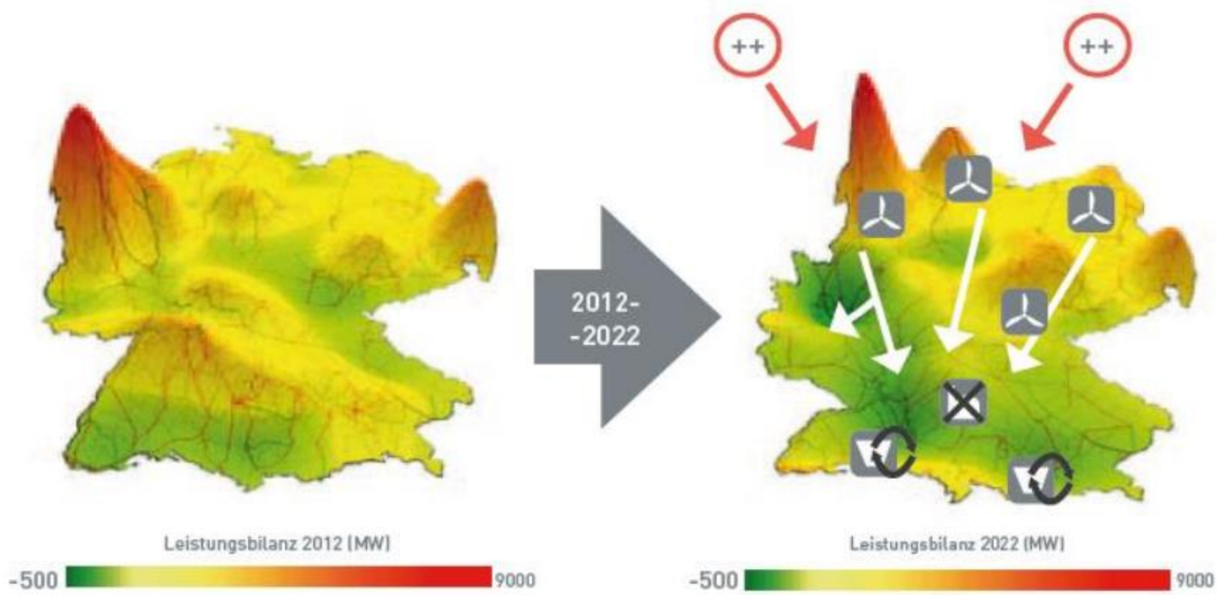
An absence of cross-border trade also increases the overall costs of resource adequacy. By not using imports to cover some peak demands, Poland needs to finance a rather high security margin which is now 18% above peak load. (Forum for Energy Analysis 2015, 24) These costs are transferred to the final customers.

Regarding the trend of technological spill-over, meaning the diffusion of decentralized renewable energy systems from Germany to other countries, this sector is rather immature in Poland. In previous years the country focused primarily on co-firing of biomass with coal and wind parks, with the latter effectively blocked in 2016 by new restrictive legislation and increases in the tax burden. Only in July 2016 was the Renewable Energy Sources Act 2015 introduced, opening a window of opportunity for other sources. It sets out two mechanisms which supplement and gradually replace the existing green certificates. Contract for difference for installations successful in internet-based auctions and feed-in tariffs for microgeneration with a capacity up to 10kW. Especially the second may stimulate the development of decentralized RES energy systems in the country (only 24.4MW of PV installation was in Poland at the end of 2014). PV generators up to 3kW should receive a FiT of PLN 0.75 (€0,184) per kWh, systems between 3-10kWh will get tariffs from PLN 0.40 – PLN 0.70. All the tariffs are to last for 20 years. (Shumkov 2015) Nevertheless, the future of this technology will depend on a combination of the following factors. The predictability of the regulatory framework is compromised by the skeptical position of the government to RES development and its significant preference for biomass energy. Furthermore, as Polish retail prices are being regulated, the profitability of sources not connected to the grid depends on the development of the political situation in the country.

5.3 Grid

Undoubtedly, one of the most burning issues connected to Energiewende is, for both Czech and Polish energy decision-makers, the problem of unscheduled electricity flows. One of the characteristic features of electricity transmission is that it follows the path of the least resistance. Electricity flows thus do not respect national borders or business arrangements. The electricity consumed in Poland, for example, is thus partially produced in, or at least passes through, the surrounding countries, depending on the regional grid topography. The more bottlenecks in the national and regional grids, the more the physical flows diverge from the contracted ones. One of the consequences of the rapid deployment of grid-fed wind power is a new bottleneck that separates northern parts of Germany from the southern parts. Since wind production tends to concentrate on the north and consumption sites on the south, the grid is not capable of direct transport of the contracted electricity between those regions. The physical flows thus pass through the grids of other countries causing several problems for their operators as well as market participants: they increase the costs of keeping the grid in balance and oblige the operators to increase the safety margin capacity at the cross-border profiles, effectively decreasing the capacity that could otherwise be allocated for trading.

Fig. 33. Generation/consumption balance in Germany 2012 and 2022



Source: (Climate Policy Initiative 2016)

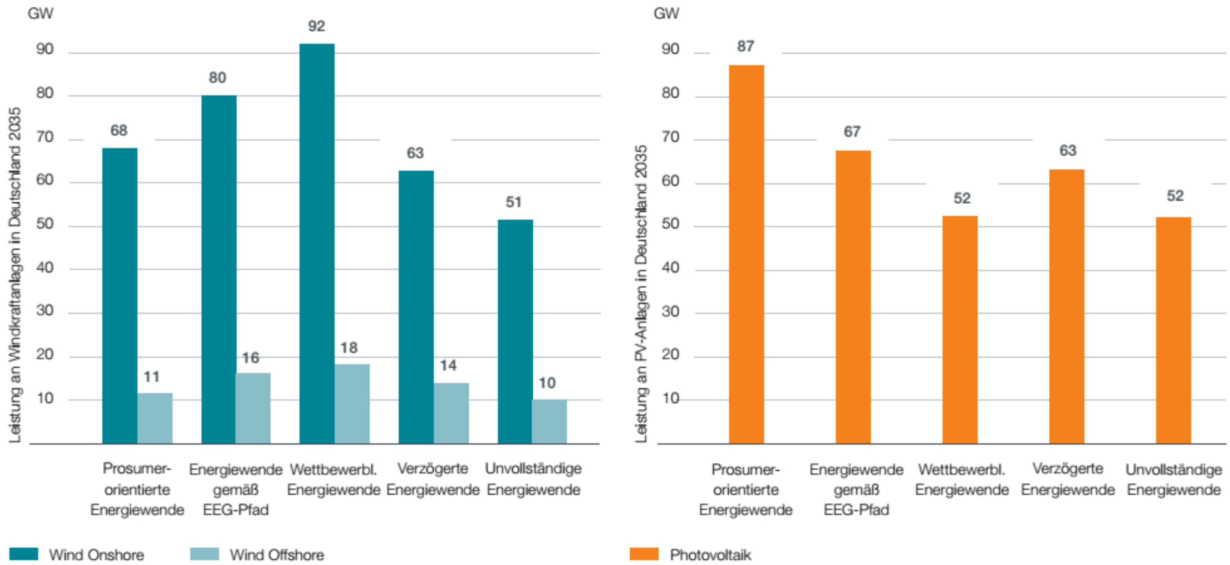
Despite the predicted supply/demand balance throughout Germany suggesting that with the decreasing generation capacity in the southern part of the country the problem will become aggravated, there are indicators suggesting that the unscheduled flows through the neighboring grids will in fact be reduced.

Firstly, there are the technical barriers installed by the grid operators in both the Czech Republic and Poland. The so called phase-shifting transformers (PST), which are able to reflect the excess power at the respective line back to the grid of origin, are currently being installed on the Czech-German borders. The first stage of PST deployment at the Polish-German border was already completed in April 2016. The second stage will follow the development of the German Uckermark line, which is now put on hold due to permitting issues. (ENTSO-E 2016d) The PST alone should be able to increase the stability of the grids and allow the operators to allocate more capacity for trade. The increased trade capacity, however, does not necessarily follow, as at each cross-border point both TSOs allocate trading capacity according to their grid load expectations. The final allocated capacity of the cross-border profile is then the lower value of both allocations. In this sense, 50Hertz, the German TSO, will likely be incentivized to undershoot the trading capacity, leave a bigger safety margin for the unexpected flows and thus prevent the PSTs from entering operation and reduce the costs of re-dispatch within the German grid that would occur should the PSTs be activated.

Secondly, the German-Austrian common bidding zone is about to split into two markets. The common bidding intensifies the trade between the two countries beyond the capacity of the German grid and cross-border interconnection. Consequently, a significant part of the German-Austrian physical trade volumes pass through the neighboring countries, namely Poland, the Czech Republic and Slovakia. As the grids of all the involved countries are not able to sustain the growing physical exchange between Germany and Austria, Bundesnetzagentur, the German regulator, instructed German TSOs to prepare a capacity allocation mechanism at the German-Austrian border as of July 3, 2018. (Platts 2016) Despite the main reason for this step lying most probably in the regulator's efforts to alleviate the German re-dispatch problem (Austrian consumption adds to the south German one, increasing the disparity between the supply/demand balances in the north and the south), its consequences will also be manifested through the reduced volume in the unscheduled flows in the region.

Thirdly, according to the 2017 EEG amendment, the further deployment of renewable sources will take the grid development much more into account. This means that the 50Hertz's third scenario, Competitive Energiewende, which assumes the priority of development of the most competitive technologies in the most favorable locations (i.e. wind energy on Germany's north), is not likely to materialize. Instead, onshore wind energy is to become much more evenly distributed across the country and the offshore farm grid connections will depend on the grid's capacity.

Fig. 34. Installed wind and solar capacity in the 50Hertz scenarios



Source: (50Hertz 2016, 24)

5.4 State energy policy

The **Czech energy policy** has been articulated in the 2015 update of the State Energy Policy (SEP) strategic document, which outlines the government's vision for the national energy sector between 2015 and 2040. (MPO 2015c) The SEP update puts a strong emphasis on self-sufficiency in electricity production and future development of nuclear energy, which is envisaged to become a backbone of the Czech electricity generation portfolio after a wave of coal plant shutdowns planned for the 2020-2026 period. (ČEPS 2016)

Tab. 1: The structure of the Czech electricity generation portfolio in 2040 according to SEP

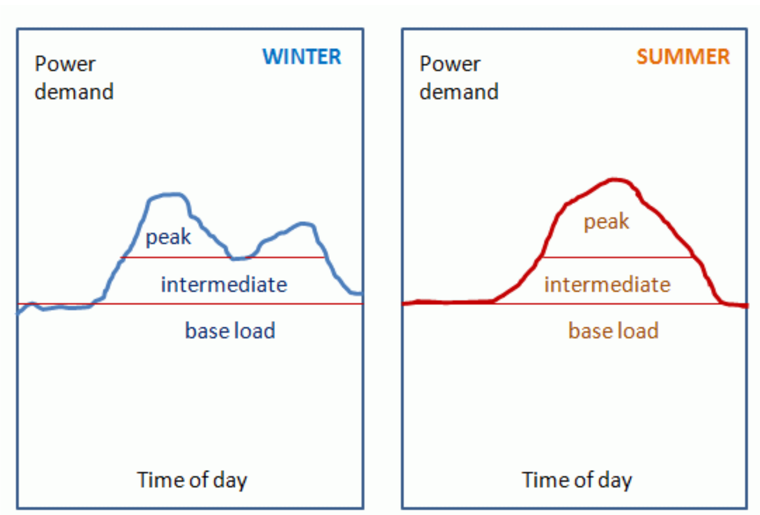
Source	Share
Nuclear	46 – 58%
RES	18 – 25%
Natural gas	5 – 15%
Black coal and lignite	11 – 21%

Source: (MPO 2015c, 46)

Considering the current and expected developments on the regional market, the bet on nuclear seem questionable. The main reasons for this are as follows: the new units of chronically inflexible nuclear are to be connected into a system where flexibility is expected to be the most important property of a generation unit; the new units will most likely be needed long before the grid-connection of the new nuclear reactors; the costs of nuclear are gradually increasing while the costs of competing technologies (namely RES) are decreasing – investing in nuclear could therefore mean supporting a non-competitive technology.

The limited flexibility of nuclear raises doubts about its ability to fit into the electricity system of the upcoming decades. Paradoxical as it may seem, nuclear suffers similar problems as non-dispatchable RES when it comes to flexibility. On one hand, non-dispatchable RES do not provide electricity at the exact times needed. On the other hand, nuclear feeds electricity in continuously, including times when it is not needed. In this sense it is important to acknowledge that with a growing share of RES, the established load structure, i.e. the division between base load, intermediate load and peak load, will erode.

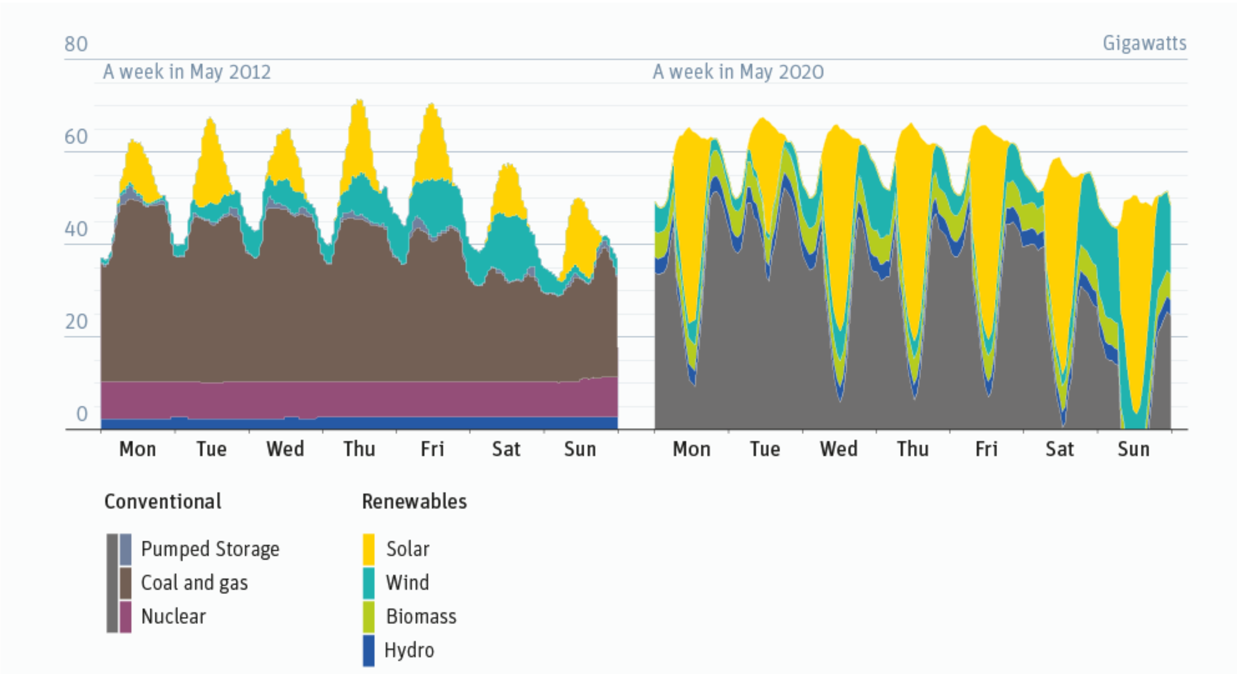
Fig. 35. Standard load structure in winter and summer



Source: (Fedkin 2016)

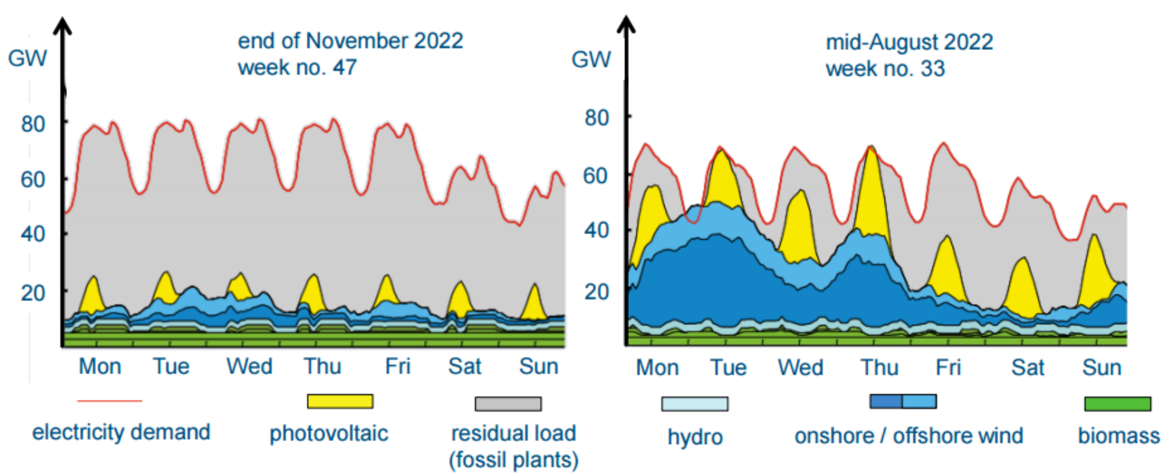
There will be time periods where the RES will cover as much as 100% of the actual load as well as periods where they will account for just over 20% (see figure 33). Importantly, these periods will change fast (see figure 34), leaving very little margin for sources that are designed to run at 80-90% capacity factor as is nuclear.

Fig. 36. Electricity generation structure in May 2012 and May 2020



Source: (Morris and Pehnt 2012, 31)

Fig. 37. Electricity generation structure in November 2022 and August 2022



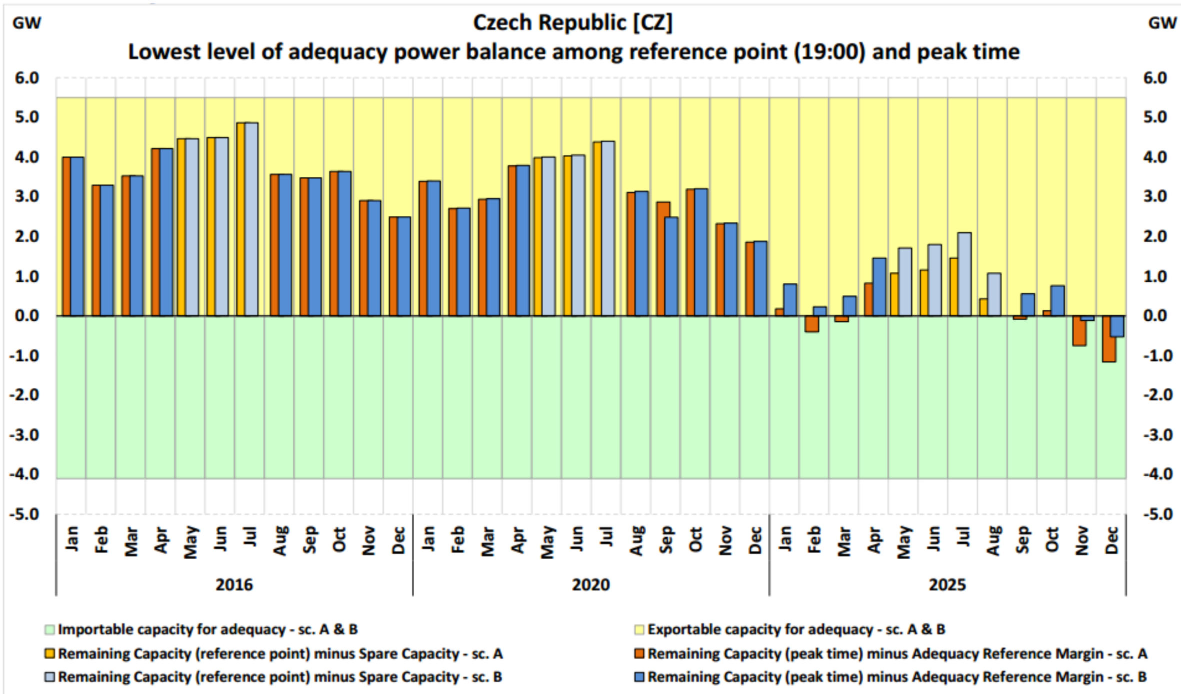
Source: (Agora Energiewende 2012)

In this sense it will be difficult to operate new nuclear plants profitably on a market with high RES penetration. Such markets will most likely prefer sources that are capable of providing electricity at exactly those times when needed, albeit at higher prices, over sources capable of delivering low-variable cost electricity over long periods without interruption. Maintaining the 84.5% capacity factor as envisaged by the Supplementary Analytical Material of the SEP 2015 update (MPO 2015a, 55) seems to therefore be an increasingly difficult task.

Another grave problem connected with the nuclear option is the lengthy approval and construction times which, combined with high investment costs and their chronic over-runs, places nuclear among risky investment ventures. The National Action Plan for the Development of the Nuclear Energy (NAP) expects the overall approval and construction process of the new units to take between 17.5 and 22.3 years (MPO 2015b, 68), which means that the new units will be connected sometimes between 2035 and 2040 if the whole process starts in 2017.

However, according to ENTSO-E, which uses data from ČEPS, the generation adequacy on the Czech market will be questioned as soon as 2025 unless new capacity beyond that already known to ČEPS is build.

Fig. 38. Generation adequacy in the ENTSO-E scenarios for CR



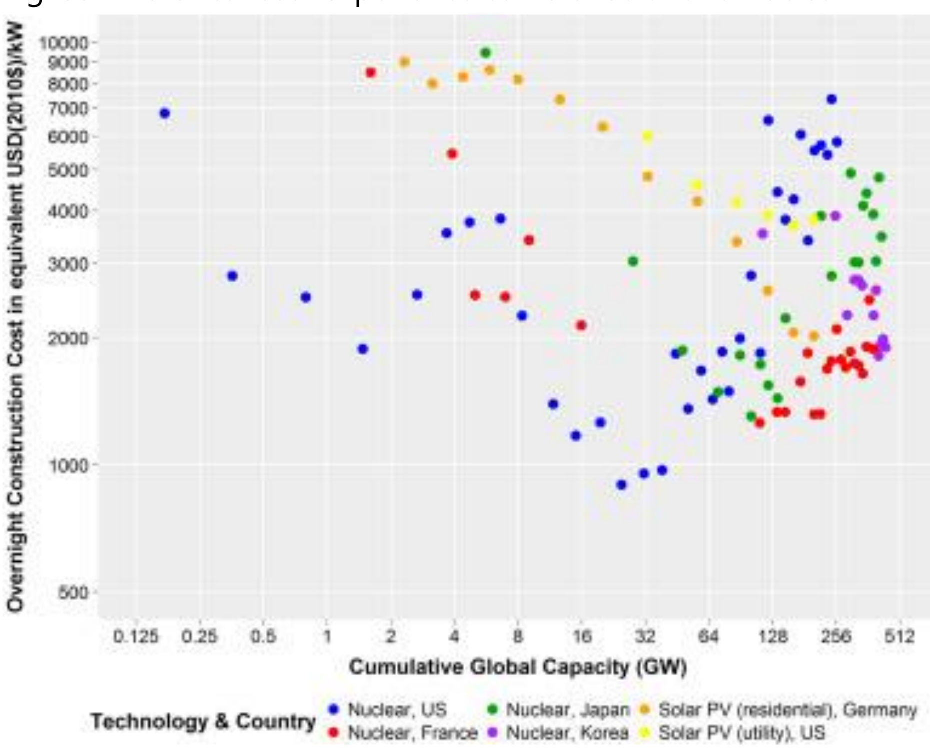
Source: (ENTSO-E 2015b, 43)

That capacity could by no means be nuclear. Other sources with shorter approval and construction times will be needed to come online in the mid-2020s: gas fired plants that need four to five years or RES that need just around one or two years. Importantly, the life-span of both technologies goes well beyond those 10-15 years between the coal shutdowns in the first half of the 2020s and the grid connection of the envisaged nuclear units that shall take place between 2035 and 2040, provided their preparatory phase indeed starts in 2017.

There are two possible outcomes for this setting. First, after smooth approval and construction process the new nuclear units will come online in mid-2030s, only to find that the market is already saturated by the sources connected during the 2020s. The new units would thus add to an excess production that will need to be exported. As this is not necessarily a negative thing per se, it is important to acknowledge that the decision to build the new units will not be passed any time soon unless some form of state aid is guaranteed. As this is likely to result in some form of contract for difference guaranteed by the Czech electricity consumers it can be concluded that if the new units are built and connected according to the existing plans, the electricity they are to produce will most likely end up being exported to the surrounding markets at prices subsidized by the Czech consumers.

Second, a late final investment decision and/or delays in the approval and construction process will postpone the connection of the new blocks to 2040 or even later. Given the rapid development of the RES technologies in the past ten years, there is a serious risk that the new units will be connected to a grid of an entirely different market than we have now. For 2040, the Germans plan to cover 65% of their electricity consumption via RES technologies and in 2050 it will be as much as 80%. (Germany.info 2012) Furthermore, the 2016 Energy Outlook by IEA expects that globally, nearly 60% of all new power generation capacity to 2040 will come from renewables and, by 2040, the majority of renewables-based generation will be competitive without any subsidies. (IEA 2016, 4)

Fig. 39. Historical cost experience curve of solar and nuclear



Source: (Lovering, Yip a Nordhaus 2016)

In this case, the new units may come online right in time to replace the slowly retiring capacity installed to bridge the 2025-204x period, and provide the much sought-after generation adequacy, but they will do so at immense costs: the NAP envisages contract for difference for the units with a strike price at 86 €/MWh considering WACC of 8%. (MPO 2015b, 71) This is rather a high price considering that by 2040 solar PV is expected to see its average cost cut by 40-70% in comparison with today's situation (IEA 2016, 4), where, notably, a German PV auction can already yield in the price of 72.3 €/MWh as shown in August 2016. Despite this, the Ministry of Trade and Industry does not expect the RES technologies to become viable and competitive alternatives to the conventional sources before the 2070s, as it envisages the contract for difference to run for 35 years. (MPO 2015b, 73)

To conclude, the Czech energy policy, as defined in the 2015 SEP update, is growing further away from the direction of both the global and regional energy sectors. Maintaining this policy will therefore be increasingly costly and difficult as nuclear does not seem to fit into the most probable shape of the future regional market and as any form of state aid for the envisaged units could trigger the infringement procedure by the European Commission.

The position of the **Polish government** in the energy sector of the country is traditionally very strong, justified primarily by the security of supply concerns. This approach reflects a general opinion that the state is able, as the only entity, to ensure energy security. As noted above, the state treasury owns 57.4% shares of PGE, 30% of Tauron, 51.5% of ENEA and the government is used to vigorously exerting its opinion over the development of the energy sector. That provides utilities with some benefits, with government preferring stability and predictability of the system over the internal or cross-border competition. Nevertheless, it also means that any strategic planning of utilities needs to fit into the parameters set by the government, focusing not only on energy but on political aims as well.

As a primary tool of the energy security of the country, consecutive governments emphasize coal. Despite growing imports, coal is still considered a major tool of energy security for the country – an indigenous source that limits the dependency on foreign fuels. Social considerations also play a role, with 0.7% of employment directly in the mining sector (Bukowski, et al. 2015, 10) and vehement labor unions.

While acknowledging some positive impact of coal in the electricity mix for security of supply and reliability of electricity supply, we argue that an effort by the Polish government to preserve its existing role compromises the long-term stability of the energy system.

The first problem is the economics of the existing coal-based generation fleet in the changing regional environment. As described in the previous chapter, there is an anticipated exposure to the German electricity trade call for introducing more flexibility at the expense of base load sources. Moreover, this issue cannot be isolated to Germany´s Energiewende only. As indicated by the trade dispute between PSE and the Estonian electricity producer Eesti Energia, the rather rigid production of the existing Polish fleet struggles to cope with the volatile cross-border regional trade and inflow of cheaper electricity. (Krajewski 2016), (Barteczko and Mardiste 2016)

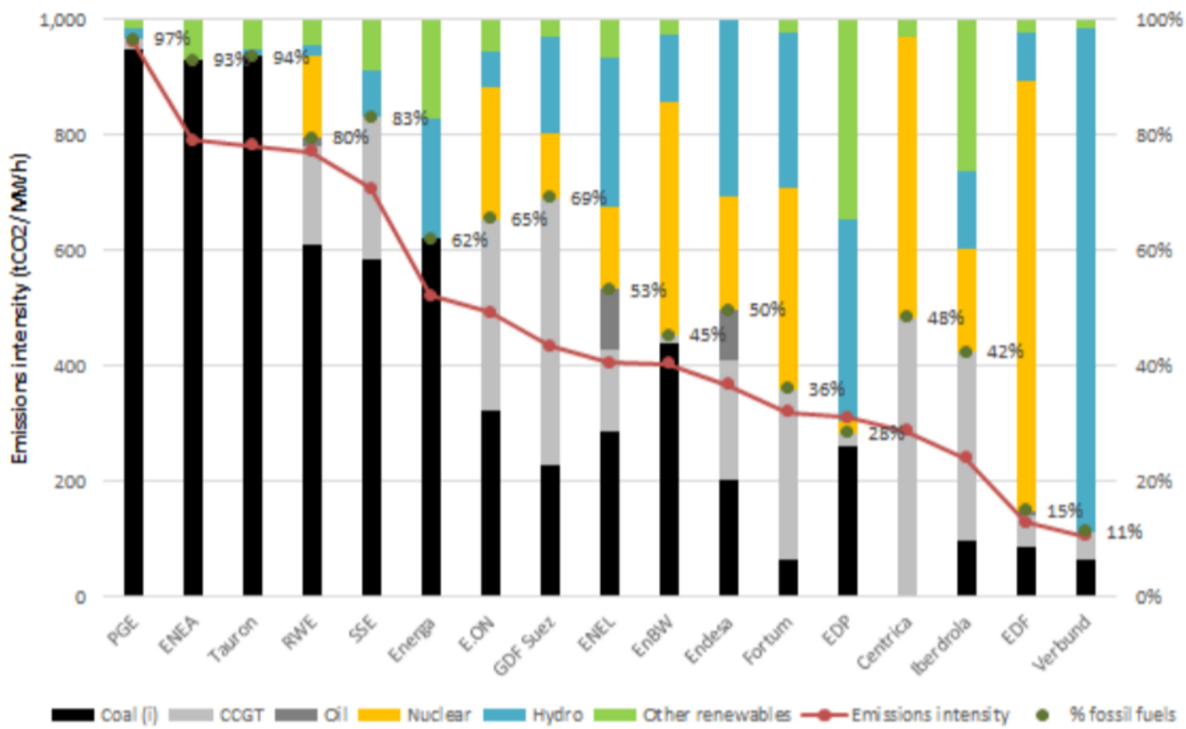
Secondly, preserving dependence on coal requires the Polish government to invest more and more energy and resources to shield the domestic power sector from the de-carbonization trends of European energy policy. Since Germany plays a significant role in shaping this policy and the shift to low-carbon energy is one of its primary aims, we have decided to also include this agenda into the study.

Regarding the climate agenda, the EU Emission Trading System (EU ETS) is the major tool for greenhouse gases regulation in the EU. Since its launch in 2005, EU ETS has suffered from an internal flaw – a chronic surplus of carbon allowances. Once this problem was revealed in 2006, the prices of allowances collapsed and never really recovered. Later on the system was reformed as a part of the 2009 energy and climate package, with the measures coming into force only in 2013. Results of this reform were negligible, with a surplus of 20 bn. allowances identified in 2015 (due to the economic crisis of 2008, growth of renewables, energy efficiency investments and other factors). (Buchan and Keay 2015)

In October 2014, energy and climate targets for 2030 were agreed: a binding target of 40% reduction in emissions and a binding target of 27% of renewables in total energy consumption. To achieve these goals the restoration of the EU ETS was acknowledged and some reforms were introduced. Firstly, phasing out (backloading) of 900 million allowances from the auctioning in the 2014-2016 period and their phasing back into the system in 2019-2020. And secondly, the introduction of a Market Stability Reserve, whereby a certain amount of excess allowances could be taken in and out to stabilize the price of carbon in the system. (Buchan and Keay, Europe´s Long Energy Journey: Towards and Energy Union? 2015, 29-31) The position of EU ETS, however damaged, was again re-instated by the European Council. It affirmed that "a well-functioning, reformed Emissions Trading System (ETS) [...] will be the main European instrument to achieve this (40% reduction of emissions) target". (European Council 2014, 2)

If this EU effort to increase the cost of carbon succeeds, the profitability of coal fired power plants would be seriously undermined. The graph below describes the emission intensity of major EU utilities, stressing the exposure of Polish companies to any carbon pricing.

Fig. 40. Emissions intensity and production by resource type in 2013



(CDP, 2016, p. 3)

As we can see, in the preparation of a long-term energy strategy, the government faces multiple issues. Coal, as a preferred source of secure electricity supply, doesn´t fit well into the changing regional environment. While European regulation tends to increase its costs, volatile RES-based production of neighboring countries increases the value of more flexible sources. Analyzing the available data, we find that achieving multiple governmental goals (dominant role for coal in the system, its economic sustainability, participation in the European internal electricity market and compliance to EU energy and climate policy) is simply not possible. At least some of these goals have to be sacrificed in the near future.

6. Recommendations

6.1 The Czech Republic

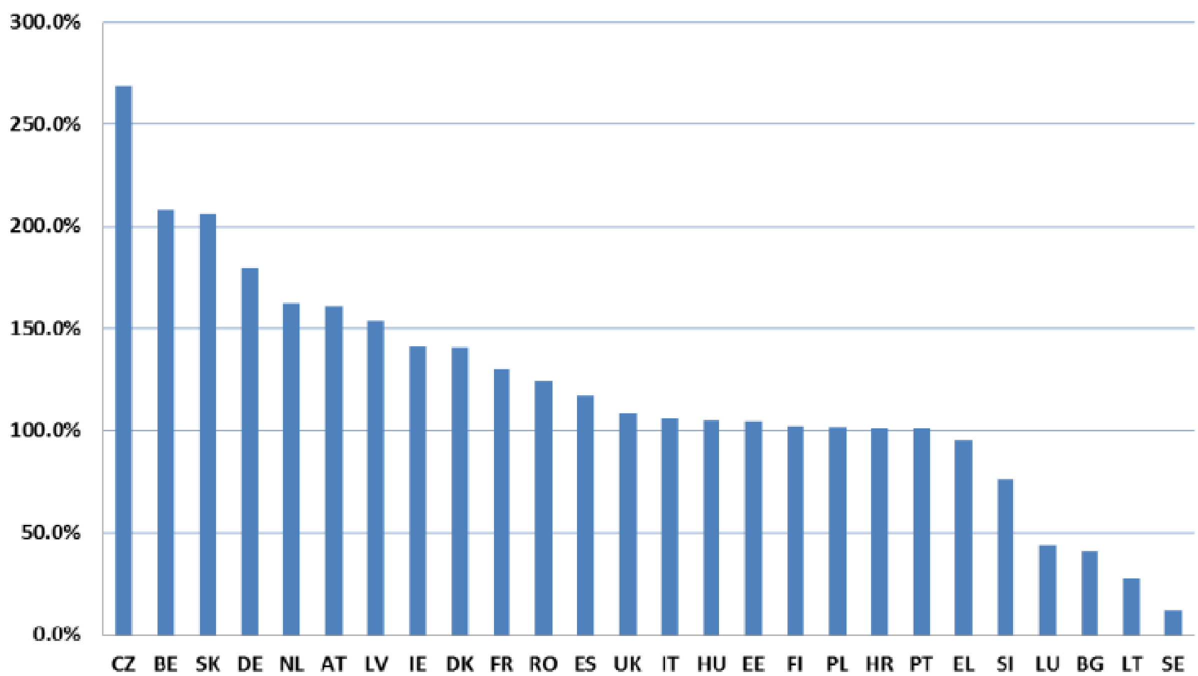
The Czech decision-makers now face two interconnected challenges: first, to navigate the path-dependent energy industry through the turbulent times that are ahead, and, second, to find the way to either catalyze the development of the new nuclear or justify and prepare a non-nuclear alternative.

To tackle both challenges, we recommend the decision-makers to initiate reformulation of the State Energy Policy (SEP). The 2015 SEP update is based on outdated or unrealistic assumptions, such as the assumed 17% capacity factor for offshore wind power plants (in reality it is around 40% on average), or the future oil price, which is set unrealistically high in the calculation models (for 2015, the 2015 published SEP expected price that was 70 dollars higher than the actual price). What is more, the update envisages policies that have turned unachievable just one year after its publication, such as grid-connection of the new nuclear units before 2035. The SEP therefore cannot fulfill the main goal for which it was introduced – to provide the industries a credible outline of the future shape of the nation's energy sector, and as such needs to be reformulated.

When doing so, the decision-makers need to take into account the current and expected trends in energy technology development and employ advanced planning techniques to mitigate the risks. First of all, the costs of the renewables are falling fast and this trend is expected to continue. IEA predicts that by 2040, 60% of all new generation capacity will come from renewables, the majority of which will be competitive without any subsidies. (IEA 2016, 4) The renewables therefore cannot be further dismissed as too expensive, unfit for the Czech weather conditions, or insufficient in terms of power output.

Similarly, natural gas needs to be finally acknowledged as a viable fuel for electricity generation in the Czech Republic. In this sense, the prevailing framing of the country's gas import dependency as a security threat has to be confronted with empirical reality. The Czech Republic displays by far the best values of the N-1 security of supply indicator among the European countries, it has a direct access to the LNG terminals and liquid gas hubs in Belgium, Germany and the Netherlands, and the gas market outlook promises more competition on the supply side, as newcomers join the existing producers and as gas consumption in Europe is decreasing due to increased thermal efficiency of buildings.

Fig. 41. The N-1 security of gas supply scores in 2013



Source: (European Commission 2014, 8)

We therefore recommend the Czech decision-makers to prepare credible future scenarios, in which the Czech energy system would be based on renewables, natural gas or their combination. At the same time, the decision-makers need to reconsider the sustainability of the pro-nuclear energy policy. There is a substantial evidence suggesting that the nuclear will not be fitting into the RES & flexibility based energy systems that are widely accepted as the most likely arrangement of the future energy

sectors around the World. Betting on the nuclear essentially means believing that the market of 2040-2075 will look pretty much the same as the market of early 2000s, when the nuclear was a viable option.
Given the undisputable trends that are now shaping the energy industry both regionally and globally, we see this belief as ill-founded. We emphasize that if the policies that are derived from this belief materialize, the Czech consumers will find themselves locked-in in a decades-lasting support scheme for the new nuclear units, the only effect of which would be reduced purchasing power of households and compromised competitiveness of industries.

Lastly, finding ourselves in a turbulent time period, past axioms such as ever-growing energy consumption or ever-increasing prices of energy commodities can no longer be considered as a sufficient policy rationale. Therefore, regardless of the outcome of the decision whether to go ahead with the pro-nuclear energy policy or not, there need to be much more robust cost-benefit and risk-assessment analyses behind this decision to justify it.

6.2 Poland

As discussed in previous chapters, the Polish energy sector is strongly security-of-supply oriented. The government embraces responsibility for this security, being very active in the managing and shaping of the sector. This state dirigisme ideologically and practically builds on two pillars: (1) The maximal self-sufficiency in energy carriers and their transformation to electricity, heat and transportation. This is reflected in an unprecedented role for coal, which is favored despite its questionable environmental and financial performance. (2) Rather reserved approach to the role of the market and trade. Polish governments traditionally prefer stability and predictability of the regulated market with limited cross-border trade over the low predictability of a strongly competitive and interconnected market. Retail prices in Poland are still partially regulated, with the state maintaining ownership of utilities, and cross-border trade often openly depicted by governmental representatives as a source of instability.

This approach is gradually challenged by some contradictory trends that have dominated the EU discourse and every day practice in the last years. Energy security is no longer the unchallenged criterion of performance of any energy sector. It is now accompanied by the aims of economic efficiency and environmental acceptance. The fundamental role of the government is suppressed in favor of market forces that are expected to deliver both low prices and energy security, also due to the intensive cross-border trade.

To combine these two approaches to the energy sector is almost an impossible task, since many of their provisions are contradictory. That places Poland in a very difficult position. Being part of the EU, recognizing the principles of the European energy and climate policy and participating in the internal energy market, the country needs to find a compromise between the European perspective and its own vision. At the same time, this compromise may undermine the very basics of the Polish energy strategy. The Polish government now seems to have two options:

1) To continue in the established course. This option would provide social stability for the coal industry and ensure a sufficient level of security and predictability of the system. However, the costs of this option will increase significantly. The country will need to invest more and more of its resources to shield its electricity sector from both the market and environmental principles of European energy and climate policy and from the dissatisfaction of the other member states, prevented from accessing the Polish power market and forced to bear the environmental costs of Polish coal oriented policy.

2) To find a compromise between the Polish energy preferences and the changing European environment. This entails balancing out the emphasis on energy security, overall costs of the system and environmental acceptability, sacrificing part of the coal industry in favor of generation diversification and undermining the position of Polish utilities exposing them to internal and external competition. In the short term it would (most probably) lead to turmoil with serious financial and political costs. The second problem is the still developing (energy) situation in the EU, which complicates predicting the future shape of the European energy industry and planning the most suitable energy strategy at the member state level. From the long term view, however, we see this as the only viable option. Although the EU's vision and its regulatory set-up may change in the future, the technical revolution of RES, fueled by Germany and many other states around the World, is now impossible to stop. Future energy systems will be (at least partially)

based on renewables and their introduction will enforce significant changes. Acknowledging this fact, we argue that countries willing and able to utilize this trend would obtain a significant comparative advantage over those that cement their energy industry in a system based on a single conventional technology.

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8. Annexes

8.1 Stakeholder analysis methodology

Stakeholder analysis is regarded as an appropriate methodological solution to map positions of relevant stakeholders around a policy issue as important as Energiewende. This method is therefore applied in this study to uncover various facets of the German energy transition and to assess its impacts upon the neighboring states. The ministries of energy and TSOs of the Czech Republic and Poland appear as relevant stakeholders for this study. Ultimately, 8 in-depth interviews were conducted with 10 respondents within the stakeholder analysis. Under the umbrella term MoE are meant the Ministry of Industry and Trade of the Czech Republic and the Ministry of Energy of Poland. Likewise, TSOs refer to the Czech Transmission System Operator ČEPS a.s. (hereinafter ČEPS) and Polish Transmission System Operator PSE S.A. (hereinafter PSE).

Table 3. Stakeholder interviews

Country / institution	MoE*	MFA**	TSO	ČEZ***
Czech Republic	2	-	1	1
Poland	1	1	2	-

Notes:

* One of the interviews is not included in the analysis as the respondent did not want his statements to be regarded as the official position of the Czech MoE.

** An interview at the Ministry of Foreign Affairs of Poland was conducted with a respondent who is closely dealing with the energy sector and well familiar with the research topic.

*** though ČEZ is out of the defined research design, an interview with a representative of ČEZ was conducted for the sake of getting more firsthand and in-depth information about influences which Czech and Polish electricity markets face in the course of Energiewende.

All interviews were recorded except for two interviews from the sample as the next table indicates.

Table 4. Recorded stakeholder interviews

Country / institution	MoE	MFA	TSO	ČEZ
Czech Republic	2 (recorded)	-	1 (recorded)	1 (reconstructed)
Poland	1 (recorded)	1 (reconstructed)	2 (recorded)	-

No fixed number of respondents was established ahead of time. Sufficiency and saturation of information are two major criteria which determined this research setting. (Seidman 2013, 58-59) In terms of sufficiency, the sampling rules while developing the research design determined no strict adherence to numbers. All respondents were expected to present official positions of the stakeholder institutions and the information provided was expected to coincide in its core if delivered by other respondents from the same stakeholder institution. In terms of saturation of information, interviews were conducted until the interviewers learned anything decidedly new about the topic. This signaled that the saturation point was reached.

All interviews were conducted following the approach of semi-structured qualitative interviewing (Arksey and Knight 1999), (Kvale 1996) In-depth interviews expect answers along with a description or explanation and therefore they are treated in this study as an essential tool in exploring the similarities and differences of respondents' experiences. Basic interview questions (table 14) served as a general guideline and implied additional questions depending upon information obtained during the interviews. Question wording and sequence was handled rather flexibly by the interviewers. The respondents were asked to respond to the following questions:

Tab. 14. Interview questions

1. What is your position at the institution which you represent? How do you deal with an electricity market within responsibilities assigned to you? 2. How would you evaluate the progress of Energiewende in Germany towards the set objectives? What are the major challenges which Germany faces in regard to this? 3. What is the most optimal electricity market design for Germany in your opinion and why? How would you describe the role of the Czech Republic and Poland in the German debate about the most optimal electricity market design in Germany? 4. What kind of implications does Energiewende exert upon the Czech Republic and Poland? How do they differ for both countries? 5. How would you evaluate bilateral and multilateral cooperation with the Czech Republic / Poland / Germany in discussing steps to smooth negative effects upon domestic electricity markets of the Czech Republic and Poland?

Interviews were recorded, if permitted, and duly transcribed. Text-based files were processed using PROSUITE – QDA Miner software.

8.2 Code scheme development

Handling of data obtained in the in-depth qualitative interviews followed a concrete sequence of steps to provide for validity and reliability of final results in a stakeholder analysis. All interviews were fully transcribed. No data reductions were done in order not to lose potentially important data. (Richards 2009, 60-61) This is to avoid the risk of discarding data, which at first view appeared off-topic, but subsequently was found to re-occur in the completed/final transcripts. Prior to analyzing the acquired data, we elaborated a coding scheme to proceed with the transcribed materials step by step. (Weber 1990) They are as follows:

8.2.1 Defining the coding units

Coding units are basic units of a text to be classified. Generally, a unit in content analysis is an identifiable message or message component. (Neuendorf 2002, 71) Units may range from a word to a paragraph and the whole text being referred to as units of data collection, units of sampling or units of analysis. For the purpose of this analysis, the coding unit is a sentence – a minimum coding unit carrying a particular message. Setting coding units at the level of words and phrases that occur closely together is likely to provide meaningless results in our case. A minimum coding unit implies that a coding unit may contain a larger part of a text than several adjacent sentences but cannot be reduced to less than a sentence.

8.2.2 Defining the codes and development of a codebook

The coding scheme operates with codes which are clustered into categories. Each category is broken down into as many codes as necessary to reflect all aspects of the same topic which are touched upon by the respondents. In its turn, each code comprises a variety of thematic statements, brought together by a core idea expressed in a code. The coding scheme proceeds from understanding that codes are not mutually exclusive and a coding unit can be classified simultaneously within two or more codes. In other words, coding units may be assigned to multiple codes. This approach makes it possible to generate co-occurring codes and thus reveal relationships between codes which otherwise would be hidden in the linear code lists.

At this stage a codebook is developed. Codes apply a nominal level of measurement therefore their reordering within categories makes no difference in the meaning of a scale. (Neuendorf 2002, 120)

8.2.3 Testing coding on sample of text

After coding units were defined and codes were developed, a codebook was tested while coding one of the interviews in order to check the codebook for consistency and see whether this sampled coding suggested a need to revise the codebook. Once the codebook was refined, sample coding was repeated until no dubious results were produced.

8.2.4 Coding the whole corpus of transcribed interviews

After the codebook had been thoroughly tested for accuracy and reliability and revised, all interviews were coded using PROSUITE – QDA Miner software.

8.3 Codebook of the stakeholder analysis

The codebook contains two major parts focusing upon (1) implications of Energiewende for Germany as perceived by the respondents and (2) implications for the Czech Republic and Poland. Each category of the codebook encompasses a set of codes. Each of them contains a number of the thematic statements which are the code contents.

Tab. 15. Category and code explanation. German context

Category	Code
Achievements of Energiewende	• increase_share_renewables • technological_advantage • industrial_competitiveness_success
Challenges of Energiewende	• renewables_lack_economic_feasibility • delay_grid_expansion_time • delay_grid_expansion_opposition • delay_grid_expansion_security • delay_grid_expansion_price • delay_grid_expansion_neighbors • single_price_zone_opposition • reduction_CO2_emissions • nuclear_phase-out • industrial_competitiveness_loss
Public acceptance of Energiewende	• public_ acceptance_majority
Influence of Energiewende upon the EU energy policy	• energy_mix_EU_member_states

Tab. 16. Category and code explanation. Czech / Polish

Category	*Code*
Achievements of CR and PL in dealing with Energiewende	• public_support_renewables
Challenges for CR and PL in the result of Energiewende	• security_grid_unscheduled_flows • trade limitations_lack_transmission_capacities • risk_end_consumer_price_increase • public_support_renewables_subsidies
Solutions	• grid_security_PSTs
Disagreements	• DE-AT_bidding_zone_splitting_for • DE-AT_bidding_zone_splitting_against • remedial measures • capacity_allocation_mechanisms _opposition • EU_ETS_position_CR_PL
Uncertainties and delays	• CEE_CWE_market coupling_obstacles • ENTSO-E_capacity_calculation_regions
Cooperation	• cooperation_CR_PL_MoE • cooperation_CR_PL_TSOs • cooperation_multilateral_CR_PL_MoE • cooperation_ multilateral_CR_PL_TSOs
Suggestions	• EW_implementation_grid_development_de_future • remedial measures_future • DE-AT_bidding_zone_splitting_future • bidding_zones_configuration_future

8.3.1 Category: Achievements of Energiewende in Germany

This category lists all developments taking place in Germany perceived by the respondents as positive results of the German energy transition.

- CODE: increase_share_renewables
  - substantial increase of the share of renewables in the German energy mix
  - deep penetration of renewables as the only EW target achieved without delay

- CODE: technological_advantage
  - EW as an incentive for technological know-how and advantage
  - EW as a driving force for a new market niche in German export profile
  - leading role of Germany in a wind power sector

- CODE: industrial_competitiveness_success
  - German exemplary industrial policy and ability to retain its competitive lead
  - exemptions from the renewable energy surcharge for German industry positively seen as ability of the latter to avoid factors weakening its market position

8.3.2 Category: Challenges of Energiewende for Germany

This category represents the difficulties Germany faces in relation with Energiewende.

- CODE: renewables_lack_economic_feasibility
  - renewables are economically not feasible unless they are subsidized
  - individual households as main bearers of the EW burden
  - renewables as a hurdle for generation capacity renewal
  - intermittency of renewables and introduction of strategic reserve

- CODE: delayed_grid_expansion_time
  - plans to expand the grid are behind the schedule

- CODE: delayed_grid_expansion_opposition
  - grid expansion plans envisage a huge delay due to public resistance

- CODE: delayed_grid_expansion_security

- delay in grid expansion leads to congestion in the German grid

- CODE: delayed_grid_expansion_price
  - delay in grid expansion is a potential driving force for increase of electricity prices
  - grid congestion forces TSOs to resort to costly remedial measures
  - delay in grid expansion fuels risk for splitting of a single price zone in Germany

CODE: delayed_grid_expansion_neighbors
  - delay in grid expansion destabilizes grids of the neighboring states

- CODE: single_price_zone_opposition
  - negative stance of German energy companies towards splitting of a single price zone
  - decreasing public support for EW in case of splitting of the single price zone due to differentiated residential electricity prices across Germany

- CODE: reduction_CO2_emissions
  - no big success in reducing CO2 emission targets
  - low probability of coal phase-out in the foreseable future

- CODE: nuclear_phase-out
  - nuclear phase-out as a quickly taken decision with no proper consideration of consequences

- CODE: industrial_competitiveness_loss
  - undermined market position of Germany in the PV sector by the Chinese manufacturers

8.3.3 Category: Public acceptance of Energiewende in Germany

This category lists the explanations for the high public support of Energiewende in Germany and demonstrates how it is conditioned.

- CODE: public_ acceptance_majority
  - EW enjoys broad support in Germany
  - broad support of EW in Germany is consistely high over years
  - support for EW as an indicator for acceptance of current EW costs

8.3.4 Category: The influence of Energiewende upon the EU energy policy

The category focuses on the German role within the European energy policy formation.

- CODE: energy_mix_EU_member_states
  - Germany's successful lobbying activity in Brussels
  - German influence upon the energy mix of the EU member states towards being more renewable-focused
  - EU member states as potential importers of German know-how in the renewable sector

8.3.5 Category: Achievements of Czech Republic and Poland

This category depicts changing public support because it is seen as generally positive aspiration towards more decarbonized economy and growing environmental consciousness among Czech and Polish population promoted by Energiewende.

- CODE: public_support_renewables
  - growing public support for renewables in Czech Republic influenced by EW
  - growing public support for renewables in Poland influenced by EW

8.3.6 Category: Challenges for Czech Republic and Poland

This category lists all challenges witnessed by Czech Republic and Poland in the areas in which they are affected by Energiewende. Particularly, the category refers to public support pointing out a discrepancy between support towards the renewable energy sources and unwillingness to bear costs for their maintenance.

- CODE: security_grid_ unscheduled_flows
  - unscheduled flows to Czech Republic and Poland due to delay in grid expansion plans in Germany
  - increased amount of unscheduled flows to Czech Republic and Poland in the last years

- CODE: trade limitations_lack_transmission_capacities
  - exclusion of DE-AT bidding zone from the capacity allocation mechanisms in CEE region
  - no or very limited transmission capacities being available for traders in Czech Republic and Poland
  - huge commercial electricity exchange between Austria and Germany exceeding transmission capacity on the AT-DE border

- CODE: risk_end_consumer_price_increase
  - risk of rising residential electricity prices because of mounting remedial measures

- CODE: public_support_renewables_subsidies
  - people in Czech Republic demonstrate no willingness to subsidize electricity from renewables
  - people in Poland demonstrate no willingness to subsidize electricity from renewables

8.3.7 Category: Solutions

This category is focused upon installation of PSTs on the Czech and Polish borders with Germany which are broadly seen as a tool to deal with unscheduled flows from Germany.

- CODE: grid_security_PSTs
  - PSTs as a compromise between TSOs to deal with unscheduled flows from Germany
  - PSTs as a means to provide operational grid security in Czech Republic and Poland
  - PSTs as an example of PCI in the EU

Category: Disagreements

The category focuses on issues over which the positions of the Czech Republic and Poland diverge.

- CODE: DE-AT_bidding_zone_splitting_for
  - active role of Poland in advocating for splitting of DE-AT bidding zone
  - position of Czech Republic in favor of splitting of DE-AT bidding zone

- CODE: AT-DE_bidding_zone_splitting_against
  - Austria as a strong opponent of splitting of DE-AT bidding zone
  - rise of residential electricity prices in Austria inthe result of splitting of DE-AT bidding zone
  - Germany as an opponent of splitting of DE-AT bidding zone
  - undermined market position of energy-trading companies benefiting from existence of DE-AT bidding zone

- CODE: remedial measures
  - cost sharing for remedial actions as a source of disagreement amongTSOs
  - growing need for remedial actions in the last years
  - witnessed lack of re-dispatch capacities

- CODE: capacity_allocation_mechanisms_opposition
  - economic interests of market players
  - unwillingness to redesign bidding zones in the EU

- CODE: EU_ETS_ position_CR_PL
  - CR favors more stringent ETS unlike Poland

8.3.8 Category: Uncertainty and delays

This category represents the issues related to Energiewende which are uncertain andface delay in decision taking or implementation.

- CODE: CEE_CWE_market coupling_obstacles
  - postponed market coupling until a decision about future of DE-AT bidding zone

- CODE: ENTSO-E_capacity_calculation_regions
  - necessity to come to an agreement about the optimal configuration of capacity calculation regions

8.3.9 Category: Cooperation

This category features cooperation among Czech and Polish MoE and TSOs in both bilateral and multilateral formats and depicts issues deems by the respondents as relevant to be raised in the interviews.

- CODE: cooperation_CR_PL_MoE
  - this code focuses on bilateral cooperation among two ministries and covers all related topics which sheds light on perceptions about cooperation between these institutions

- CODE: cooperation_CR_PL_TSOs
  - this code contains the statements which cover cooperation among Czech and Polish TSOs

- CODE: cooperation_multilateral_MoE
  - this code captures utterances of the respondents related to cooperation of Czech and Polish MoEs with their German counterparts and/or other MoE in various multilateral settings

- CODE: cooperation_multilateral_TSOs
  - this code dwells on cooperation between Czech and Polish TSOs with Germany TSO and/or TSOs of some other countries in multilateral format

8.3.10 Category: Suggestions

This category lists suggestions for smoother implementation of Energiewende. It also includes suggestions which seek to prevent aggravation of negative effects of Energiewende upon Czech Republic and Poland.

- CODE: EW_implementation_grid development_de_future
  - to take all possible additional steps to accelerate the grid upgrade and grid expansion in Germany

- CODE: remedial measures_future
  - to resort to bilateral and multilateral re-dispatch measures every time deemed necessarily to ensure stability and security of the grid

- CODE: DE-AT _bidding_zone_splitting_future
  - to further advocate for splitting of the DE-AT bidding zone
  - to negotiate possible splitting of the DE-AT bidding zone with Germany which is perceived not to be as strong opponent of splitting as Austria

- CODE: bidding_zones_configuration_future
  - support ENTSO-E in evaluating optimal configuration of bidding zones in the CEE region
  - support market coupling between CWE and CEE regions after configuration of bidding zones are defined not being detrimental to economic interests of CEE countries