FORUM FOR
ENERGY ANALYSIS

ELEMENTS OF MARKET DESIGN FOR POLAND

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Forum for Energy Analysis:
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The aim of the Forum for Energy Anlysis is to conduct a dialogue focused on the power sector that is open to the diverse opinions of all stakeholders in Poland, based on analysis-orientated strategic thinking about the upcoming key challenges in the sector.

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1. KEY MESSAGES

- Both the European power sector at large and the Polish power sector in particular find themselves at a pivotal moment. Power systems are in transition, driven by commitments to continuing emissions reductions, growing penetration of renewables, and the need to provide affordable and reliable power.
- The European Commission's Energy Union Package has closely linked European goals for climate and energy policy. Renewed commitments to emissions reductions are accompanied by the recognition that decarbonizing the power sector will require greater commitment to timely realization of the internal energy market (IEM).
- The Polish power system faces a number of challenges, stemming from the profile of its power system, rising demand for power during summer peaks, and increasing penetration of renewable resources on the system. Its largely homogenous fleet of inflexible, aging thermal plants struggles to secure system adequacy despite a high reserve margin (18 percent), particularly during summer peaks, night valleys, and as the share of renewables grows.
- Addressing these challenges is essential to securing system reliability and will require a close look at how the Polish market incentivizes, or deters, investment in the portfolio of resources needed to secure reliable system operations.
- Poland needs a more diverse, flexible portfolio of resources to secure system reliability. Barriers to resource diversification include delays in market coupling, barriers to demand response, distortions in the energy market, and a continued focus on investment in more of the same, rather than in resources with the operational profiles needed to serve the system.
- The Polish market is largely isolated from its neighbors. Expanding beyond a national footprint in power sector operations and reliability planning can increase the system's reliability and flexibility at lower cost than relying on resources within national borders alone.
- Experience in other jurisdictions demonstrates that demand response is a reliable, low-cost, flexible resource that can help balance the system and can meet up to ten percent or more of peak demand. Poland must remove barriers that currently limit the participation of demand response in markets and system operations.
- Efficient markets are essential for delivering system reliability in real time and stimulating investment in the longer term. One key challenge, not only for Poland but also many other European Union (EU) Member States, is to remove distortions from energy markets. In Poland, two essential steps toward accomplishing this are: (*1*) allowing excess capacity to retire when it is no longer economically viable, thereby restoring a healthy balance between supply and demand; and (*2*) revisiting the purpose and design of the operating reserve, which currently distorts market prices without providing additional security to the system.

2. INTRODUCTION

In July 2015, the European Commission released a communication launching a consultation process on "new energy market design." This communication followed on the Commission's Energy Union Package, which has closely linked the goals for European climate and energy policy and deepened commitment to the IEM as a fundamental dimension of European energy policy.

According to the European Commission market design is the set of arrangements which govern how market actors generate, trade, supply and consume electricity and use the electricity infrastructure[1]. These arrangements can help to transform the energy system. The wholesale and retail markets should provide the basis for investment decisions, and boost the development of new services by companies. The European Commission's new electricity market design initiative aims to improve the functioning of the internal electricity market in order to allow electricity to move freely to where and when it is most needed, reap maximum benefits for society from cross-border competition and provide the right signals and incentives to drive the right investments, while fully integrating increasing shares of renewable energies.

These developments are important for Poland, where the power market faces many challenges. Many of the country's conventional power plants are more than 30 — and some even more than 50 — years old, and will need to be retired in the coming years. At the same time, Poland faces increasing system stress in summer, as demonstrated in August 2015, when Polskie Sieci Elektroenergetyczne (PSE), the transmission system operator (TSO), was forced to curtail load to balance the power system. The power sector faces other challenges, too, including a decreasing capacity margin to meet winter peak demand owing to the aging power fleet and additional planned plant retirements, as well as the challenge of integrating a rising share of renewable resources in a system dominated by large thermal plants with limited flexibility. Moreover, although Poland has significant underutilized interconnection capacity with its neighbors, it continues to assess power system adequacy in isolation. In the new national legislative period, 2015–2019, many of these challenges will need to be addressed.

The solutions to the multiple challenges facing the Polish power system are not straightforward. They will require a close look at the role of markets in driving investment, but also at what might be needed in the interim to secure system reliability before markets are fully liberalized and integrated across borders. The changing landscape calls for a shift in focus from ensuring that there is enough baseload capacity to meet passive demand, to assessing the optimal mix of operational capabilities to balance a system with an increasingly active demand side and a rising share of renewable resources. The most cost-effective solutions will incorporate all available resources on both the supply and demand sides, and will rely not just on domestic resources but on available resources throughout the region. This transition must happen in parallel to the market transition underway in Europe.

This paper focuses on market design as the central driver that governs how market actors generate, trade, supply, and consume and use the electricity infrastructure[2]. The paper also refers to

[1] European Commission. (2015, July). Energy: *New Market Design to Pave the Way for a New Deal for Consumers* [Fact sheet]. Retrieved from: http://europa.eu/rapid/press-release_MEMO-15-5351_en.htm

[2] Note that even in a fully liberalized electricity market, the transmission and distribution functions remain regulated. See: European Commission. (2015, July). *Energy: New Market Design to Pave the Way for a New Deal for Consumers* [Fact sheet]. Retrieved from: http://europa.eu/rapid/press-release_MEMO-15-5351_en.htm

some extent to out-of-market interventions, such as capacity remuneration mechanisms (CRMs), as additional tools used by policymakers to correct for market inefficiencies. It does not address all aspects of market design that exist or that are emphasized in the Commission's recent communication and consultation on new market design. Nor does it provide the solution for how Poland's power markets should evolve to fully participate in the IEM. Instead, this paper focuses on the logical first steps for Poland to take toward full integration into the IEM, based on the need to address immediate challenges while maintaining a longer-term perspective. To accomplish this, we consider two fundamental criteria underlying power sector development: reliability and flexibility.

Reliability refers to the central objective of the power system: ensuring the availability of sufficient resources to meet demand for service at virtually all times and at a reasonable cost. Reliability operates in two dimensions:

- An operational dimension in which a combination of available resources is deployed to match expected demand in real time; and
- An investment dimension in which investment is required in both the quantity and quality of resources needed to meet future demand — all at the lowest reasonable cost.

Flexibility refers to the operational ability of various resources on the supply and demand side to respond to system needs by ramping up, ramping down, and turning on and off quickly and often. As the power system transitions to one with more intermittent generation, investment in flexibility on the supply and demand side will become increasingly important to secure system reliability lowest overall cost.

This paper begins with an overview of the European Commission's latest thinking concerning the IEM and new market design. Next, it describes Poland's power system and current market design. It then turns to challenges facing the Polish power system and the role of market design in helping to overcome challenges on the system. Finally, it provides recommendations for reforms that will help ensure system reliability while also moving Poland in the direction that the European Commission has outlined for the IEM.

Expert Panel

The Forum for Energy Analysis distinguishes itself by the fact that it not only prepares studies, but it also discusses the results of the studies with an interdisciplinary Expert Panel before the publication of subsequent policy papers. The purpose of such an approach is to increase the transparency of the process of preparing analyses and formulating recommendations and to improve their quality. The Expert Panel is composed of representatives of energy companies, academic institutions, independent experts, industry, government officials, and non-governmental organizations. It is important to underline, however, that although this text draws on opinions from the Expert Panel, it has not been jointly agreed upon with them.

3. EUROPEAN CONTEXT

Over the past year, the European Commission and Council have refined their vision for the evolution of Europe's climate and energy policy. In October 2014, the European Council agreed on a 2030 emissions reduction target of at least 40 percent from 1990 levels, alongside 2030 renewable and energy efficiency targets of at least 27 percent. For renewables, this is estimated to translate to a share of 45 to 53 percent renewables in the power sector across Europe compared to the estimated share of approximately 34 percent derived from the 2020 target.[3] In February 2015, the European Commission unveiled its vision of a European "Energy Union," which builds on Europe's climate and energy policy to further the five dimensions of energy security, European energy market integration, energy efficiency, decarbonization, and research and innovation.

The case for moving further and faster in reforming Europe's electricity markets is set out in the series of documents the Commission published as part of their consultation on the Energy Union vision[4]:

- Communications on new market design and a new deal for energy consumers[5];
- Launch of a public consultation process on new market design[6];
- Consultation paper on supply security[7]; and
- Launch of State Aid sector inquiry into capacity markets (including Poland's)[8]

These documents lay out a path to a future European electricity market design that prioritizes full implementation of the Third Energy Package, and introduces further steps toward European market integration. Europe's "new energy market design" paves the way for an affordable transition to a secure, low-carbon electricity system, with high penetration of variable renewable resources and flexible demand and supply.

In these various documents, the Commission has specified details for a vision of a future European electricity market that **prioritizes demand-side resources** (including energy efficiency and demand response) and an active role for consumers, **promotes a regional approach** to energy policy and resource adequacy, and emphasizes the need for **markets that work** by reflecting the value customers place on supply and that are designed to encourage investment in resources in the amount and with the capabilities needed to ensure system security at lowest cost. This vision is underpinned by governance arrangements that include strengthening the role of the European Network of Transmission System Operators for Electricity (ENTSO-E) and the Agency for the Cooperation of Energy Regulators (ACER), as well as increased cooperation between Member States in system operation.[9]

[3] The RES-E range mentioned refers to the scenarios with a greenhouse gas reduction of 40 percent. See: European Commission. (2014). *Impact Assessment Accompanying the Communication "A Policy Framework for Climate and Energy in the Period From 2020 up to 2030*." SWD (2014) 15 final. Retrieved from: http://ec.europa.eu/smart-regulation/impact/ia_carried_out/docs/ia_2014/swd_2014_0015_en.pdf

[4] For the full Energy Union consultation package, see: http://ec.europa.eu/energy/sites/ener/files/publication/FOR%20WEB%20energyunion_with%20_annex_en.pdf

[5] European Commission. (2015, July). *Delivering a New Deal for Energy Consumers*. COM (2015) 339 final. Retrieved from: https://ec.europa.eu/energy/sites/ener/files/documents/1_EN_ACT_part1_v8.pdf

[6] European Commission. (2015, July). *Launching the Public Consultation Process on a New Energy Market Design*. COM (2015) 340 final. Retrieved from: http://ec.europa.eu/energy/sites/ener/files/documents/1_EN_ACT_part1_v11.pdf

[7] European Commission. (2015, July). *Consultation Paper on Risk Preparedness in the Area of Security of Electricity Supply*. Retrieved from: https://ec.europa.eu/energy/sites/ener/files/documents/DG%20ENER_ConsultationPaperSoSelectricity14July.pdf

[8] European Commission. (2015, April). *State Aid: Commission Launches Sector Inquiry Into Mechanisms to Ensure Electricity Supplies* [Press release]. Retrieved from: http://europa.eu/rapid/press-release_IP-15-4891_en.htm

[9] The first steps in regional cooperation on system operation issues have been taken with the establishment of Regional Security Coordination Initiatives (for details, see: https://www.entsoe.eu/news-events/announcements/announcements-archive/Pages/News/Creation-of-SCC,-first-RSCI-in-South-East-Europe.aspx). However, there is a need to go further and establish regional operational centers that are responsible for cross-border planning and operation in real time to ensure that interconnection between Member States can be utilized efficiently and safely.

The following sections examine these topics in more detail and lead into the discussion on how Poland can increase flexibility and improve the reliability of its power system.

3.1. DEMAND-SIDE RESOURCES

Demand-side resources, including energy efficiency and demand response, play a central role in the new energy market design vision.

The Commission has recognized the potential for energy efficiency to reduce investment needs across the full range of energy sector planning and investment. For this reason, the concept of "energy efficiency first" is being applied in all decision-making relating to development of the Energy Union.[10]

The Commission also recognizes the value and importance of demand-side participation in energy markets. Demand response in particular is important for the cost-effective integration of intermittent renewable generation. For this reason, the Commission emphasizes the importance of liquid markets with prices allowed to reflect the value consumers place on supply, and encourages greater market opening to demand-side participation, including through aggregators.

Overcoming barriers to demand response is essential. These barriers include a lack of information on consumption, limited retail market competition, price caps, and other interventions that prevent the necessary price signals reaching customers. Third-party entities that could help customers manage their demand are often excluded from the market by rules that favor incumbent suppliers.

If the benefits of a fully responsive demand side are to be realized, these barriers need to be addressed. Wholesale and retail markets will need to be linked more closely to ensure that customers are exposed to appropriate price signals, whereas interventions that distort those signals will need to be discouraged. Third-party entities engaged in the aggregation of demand to provide system services need access to the market on equal terms to those enjoyed by incumbents. The relationships between these aggregators and traditional suppliers need to be standardized and ensure that neither party is disadvantaged. In addition, system services need to be designed to reflect the characteristics of both generation and demand, so that generation and demand can compete in the provision of these services on an equal footing.

3.2. A REGIONAL APPROACH TO ENERGY POLICY AND RESOURCE ADEQUACY

Expanding the footprint of energy markets, system operations, and energy policy has proven to be the lowest-cost route to a secure, low-carbon power sector.[11] The Commission emphasizes

[10] European Commission. COM (2015) 340 final, p 3. The Commission has not specifically defined "energy efficiency first," a concept that originated in the United States. For explanations of the concept, see: Cowart, R. (2014, December). *Unlocking the Promise of the Energy Union: "Efficiency First" is Key.* Brussels, Belgium: The Regulatory Assistance Project. Retrieved from: http://www.raponline.org/document/download/id/7401; Bayer, E. (2015, February). *Efficiency First: Key Points for the Energy Union Communication.* Brussels, Belgium: The Regulatory Assistance Project. Retrieved from: http://www.raponline.org/document/download/id/7507; and Coalition for Energy Savings. (2015, May). *"Energy Efficiency First": How to Make it Happen.* Retrieved from: http://energycoalition.eu/sites/default/files/20150504%20Energy%20Efficiency%20First%20-%20making%20it%20happen%20FINAL_0.pdf

[11] Hogan, M., & Weston, F. (2014, December). *Power Market Operations and System Reliability: A Contribution to the Market Design Debate in the Pentalateral Energy Forum.* Berlin: The Regulatory Assistance Project on behalf of Agora Energiewende. Retrieved from: http://www.agora-energiewende.de/fileadmin/Projekte/2014/Power-Market-Operations/Agora_Power_Market_Operations_and_System_Reliability_web.pdf

the importance of a regional approach to energy sector development in several contexts, including in the design of renewables support schemes, prioritization of investment in infrastructure, security of supply, and system operations.

3.3. SUPPORTING DEVELOPMENT OF RENEWABLE GENERATION

The Commission emphasizes the need for continued development of renewable generation across Europe. As part of this development, a more regional approach to renewable support needs to be adopted in preference to uncoordinated and unilateral action by Member States. A more coordinated approach would allow capacity to be developed in the areas of the highest resource efficiency, reducing the overall cost of achieving Europe's renewables targets. To achieve this outcome, a framework to formalize the participation of non-domestic capacity in national support schemes will need to be developed.

3.4. INFRASTRUCTURE FOR A FUNCTIONING MARKET

An efficient, integrated, low-carbon electricity market that delivers energy reliably and at lowest cost will require a robust European transmission system with adequate levels of interconnection. However, interconnection between some Member States is currently inadequate, and the Commission has therefore established a 10 percent interconnection target to be met by 2020 and plans to increase the target to 15 percent or more by 2030.[12]

3.5. A EUROPEAN APPROACH TO SECURITY OF SUPPLY

A number of Member States anticipate inadequate levels of generation capacity in years to come and have or plan to introduce CRMs to encourage investment. A redesigned electricity market, in which short-term prices fully reflect the value of scarcity and in which market participants are fully incentivized to hedge short-term price risk, should ensure sufficient investment. However, the Commission accepts that the introduction of CRMs may be justified in circumstances in which a genuine capacity shortage exists and market failures remain.

Although CRMs may be justified under these circumstances, the uncoordinated adoption of capacity support schemes is likely to undermine market coupling. Different CRM designs will impact on energy prices differently, distorting market prices and cross-border flows. In addition, the characteristics of some CRMs are likely to provide a lifeline to time-expired carbon-producing generation capacity and delay decommissioning. Experience with CRMs in other jurisdictions has further demonstrated that they often result in over-investment, which increases costs to consumers.[13] This would act in opposition to other European policy initiatives, such as the improved ETS, and make the achievement of decarbonization goals more difficult. In view of its concerns over the fragmented approach to assessing resource adequacy and the need for capacity support, the Commission has launched a sector inquiry into Member State CRMs and will report on its findings later in the year.[14]

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[12] European Commission. (2015, February). *Achieving the 10% Electricity Interconnection Target: Making Europe's Electricity Grid Fit for 2020.* COM (2015) 82 final. Retrieved from: http://ec.europa.eu/priorities/energy-union/docs/interconnectors_en.pdf. Interconnection priorities are supported through Projects of Common Interest and funding through the Connecting Europe Facility.

[13] Hogan & Weston. (2014).

[14] European Commission. (2015, April). See supra note 7.

Furthermore, as Europe as a whole is forecast to have a capacity surplus for the foreseeable future, there is an obvious need to develop a regional and ultimately European approach to resource adequacy assessment to ensure security of supply and minimize costs. Developing a regional approach will require the adoption of a standard methodology for assessing resource adequacy and for assessing and including the contribution to be made by interconnection. With these in place, a common understanding of the regional need for capacity would be established. Assuming an appropriate interconnection contribution when assessing capacity needs would further ensure that supply reliability was delivered on a collective basis in real time.

3.6. MARKETS THAT WORK

The Commission provides a vision of an optimized electricity market in which the value of scarcity reflected in short-term prices drives sufficient investment. Ensuring that short-term prices reflect the value that customers place on energy is key to the development of demand-side participation, investment in flexible resources, and cross-border trade, all of which are necessary to ensure cost-effective supply reliability and the efficient integration of intermittent generation.

Significant progress has been made in developing regional day-ahead markets through market coupling. This process is expected to continue, and the Commission emphasizes the need for all Member States to couple their day-ahead markets in order to fully implement the Third Energy Package and work toward pan-European market integration. In addition, more rapid progress needs to be made in regionalizing the intra-day and balancing markets to take advantage of short-term temporal and technology diversity and fully deliver the benefits that increased demand-side participation, flexibility, and cross-border trade can bring.

If regional markets are to work efficiently, a common approach to managing congestion and delivering transmission capacity to the market needs to be adopted. Regional markets should reflect congestion boundaries and not national borders. In addition, there is a need to remove or at least harmonize constraints on wholesale market prices in order to fully incentivize demand- and supply-side flexibility and allow the value of interconnection to be maximized.

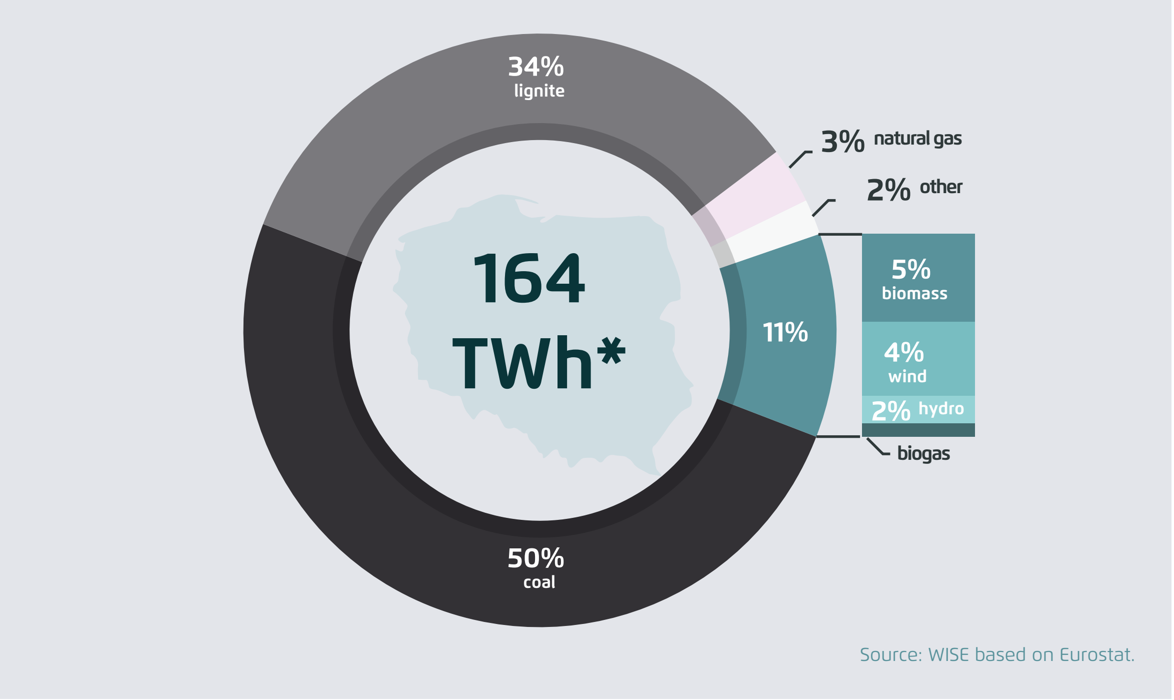
The deployment of low- or zero-carbon generation such as wind and solar in the transition to sustainable electricity systems will increase price volatility and reduce demand for conventional generation. To prevent these uncertainties reducing the appetite for investment, the Commission recognizes that properly functioning long-term markets are important, in addition to the short-term markets discussed earlier. Market participants need to have a strong incentive to hedge short-term price risk by entering into long-term contracts. These contracts will ensure the necessary investment in flexible resources, including generation, storage, and demand. In other words, there needs to be a strong linkage between short-term and longer-term markets in order to provide the flexible resource necessary to ensure supply reliability going forward.

4. OVERVIEW OF POLISH POWER SYSTEM AND MARKET DESIGN

4.1. CURRENT SITUATION

The Polish power system is dominated by hard coal and lignite, with relatively small shares of renewable energy and natural gas. Over the past several years, the share of renewable (non-hydro) resources has grown, particularly co-firing of biomass and more recently onshore wind. More wind — up to 8.9 gigawatts (GW) — is expected to come onto the system over the next five years.[15]

Figure 1. Energy Mix of Electricity Production in Poland in 2013



Source: WISE based on Eurostat

Load has been growing at an average rate of 0.25 percent from 2010 to 2015, whereas GDP has been increasing by 2.5 to 3.5 percent annually.[16]

Total production was almost 160 terawatt-hours (TWh) in 2014. The system's annual peak is in winter — in 2015, the annual peak of 25,535 MW occurred on January 29 at 5:15 pm.[17] The summer peak is much lower — 22,265 megawatts (MW) reached on September 1, 2015 between 1

[15] ENTSO-E. (2015). *2015 Scenario Outlook & Adequacy Forecast.* Retrieved from: https://www.entsoe.eu/Documents/SDC%20documents/SOAF/150630_SOAF_2015_publication_wcover.pdf

[16] For a visual representation of the trend over time of gross domestic product growth and energy demand, see: Polskie Sieci Elektroenergetyczne. (2015a). *Plan rozwoju w zakresie zaspokojenia obecnego i przyszłego zapotrzebowania na energię elektryczną na lata 2016-2025*, p 21. Retrieved from: http://www.pse.pl/uploads/kontener/4695projekt-PRSP2016-2025-13072015.pdf

[17] Polskie Sieci Elektroenergetyczne. (2015a). p 24.

and 2 pm. Still, Poland faces its greatest reliability problems in summer and early autumn. There are a number of reasons for this, and as discussed in the next section, these times represent the greatest short-term challenge to securing reliable operation of Poland's power system.[18]

Poland operates an energy-only market with operating and strategic reserves. The market structure is presented in Table 1.

Table 1. Energy-Only Market With Operating and Strategic Reserve in Poland

<table>
<tr><td colspan="4">Commercial Market</td><td colspan="5">Services of TSO</td></tr>
<tr><td>Bilateral Contracts</td><td colspan="3">Power Exchange (TGE S.A.)</td><td colspan="5">PSE S.A.</td></tr>
<tr><td>Forward Market</td><td>Day-Ahead Market</td><td colspan="2">Intraday Market</td><td>Balancing Market</td><td>Primary/ Secondary Reserves*</td><td>Operating Reserve**</td><td>Strategic Reserve</td><td>DSR</td></tr>
<tr><td>Protection from price volatility</td><td colspan="3">Correcting contractual positions</td><td colspan="3" rowspan="2">Hourly products</td><td colspan="2" rowspan="2">Deployed upon request</td></tr>
<tr><td colspan="3">Products – BASE, PEAK, OFF-PEAK, various time scales, contracts up to three years ahead</td><td>Hourly products</td></tr>
<tr><td colspan="3">High liquidity</td><td>Low liquidity</td><td colspan="2">Addressing plant and network constraints</td><td>Enhancing reliability of the system</td><td colspan="2">Higher security in case of a serious breakdown of vital units</td></tr>
<tr><td>Data on volume not available</td><td>186.7 TWh in 2014</td><td>23.7 TWh in 2014</td><td>0.083 TWh in 2014</td><td colspan="2">1.37 TWh in 2014 (balancing market)</td><td>18% of monthly peak (at least 4.15 GW)</td><td>830 MW</td><td>200 MW</td></tr>
</table>

*** Primary/secondary reserves refer to "second" and "minute" reserves and are procured on an annual basis by way of bilateral agreements. Tertiary or hourly reserves are predominantly purchased by way of the day-ahead balancing market.**

**** This is the "operating reserve" established by PSE in January, 2014.**

Source: Own design based on data from TGE and PSE

4.2.. ELECTRICITY MARKET

The market is served mainly by the Polish Power Exchange, which offers a broad array of products in the forward, day-ahead, and intraday markets. A minor part of forward trade volumes occurs in bilateral contracts between trade companies and large consumers. The forward and day-ahead markets are very liquid, whereas the intraday market is almost inactive. The latter can be explained by the characteristics of the energy mix, which is still dominated by hard coal and lignite (84 percent; see Figure 1) and is characterized by a relatively flat merit order and low variability of supply.

A price cap of 1500 zloty (357 euros) has been set for the day-ahead and balancing markets. However, neither market has reached the cap. The highest price recorded in the day-ahead market was 1359.16 zloty/MWh, between 4 and 5 pm on November 25, 2014. The highest price recorded in the balancing market was 1471 zloty/MWh between noon and 1 pm on August 31, 2010. The minimum price on the day-ahead market and balancing market for capacity offers is

[18] It is also worth noting that PSE predicts that the most serious scarcity situation in the system over the next ten years will occur in September 2016.

set at zero, and for reducing capacity on the balancing market is set at 70 zloty/MWh.[19] The highest prices coincide with seasonal trends observed on the Polish power system — that is, spot prices tend to be higher in summer and lower in winter.

The Power Exchange also plays an important role in coordinating cross-border trade through market coupling, discussed in more detail later in this paper. PSE is in charge of managing the balancing market and various system services.

The balancing market applies marginal prices for either adding incremental production or reducing marginal production in a given dispatchable unit. Large consumers can participate in the balancing market by submitting offers for demand response services; however, this has not happened so far. Imbalances are paid for through a marginal dual-price mechanism: participants who are long with respect to their declared contractual position are paid at the system sell price, and participants who are short are required to buy balancing energy at the system buy price.

4.3. SUPPORTING SECURITY OF SUPPLY – RESERVES

In 2014, PSE introduced two new instruments to help secure system adequacy: an operating reserve and a strategic reserve (or "cold reserve"). Both instruments provide payments to resources for availability and performance. The strategic reserve has been contracted, but will only commence operation in 2016. The operating reserve has been active since January 2014. These instruments have been introduced as a transitional measure to secure system stability, as a response to the planned decommissioning of 3.4 GW of coal-fired capacity in 2016–2020.[20] However, as discussed later in this paper, understanding the dimensions of resource adequacy in Poland requires a deeper look at the dynamics of the power system and markets. The assumption has been that these instruments will be replaced with a longer-term solution to secure resource adequacy. The cost of the reserves is passed through to customers through their distribution tariffs.

The level of the operating reserves is set at 18 percent of the average maximum load the previous year, calculated as the average of the maximum loads for each month. Adjustments to this value are made based on projected load growth, minus the contracted-for strategic reserve.[21]

In 2015, the level of required reserves was 4.15 GW per hour. A reference price of 37.28 zloty/MWh was set for the reserves. The price aims to cover the average fixed costs of spinning units at peak hours; it declines when the required reserves on the system exceed 4.15 GW/h to maintain an 18-percent reserve margin. Reserves must be maintained during peak hours, defined as 7 am to 10 pm on all workdays. The regulator approved a total budget of 450 million zloty for 2014 and 405 million zloty for 2015.[22]

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[19] See: Polish Power Exchange (TGE). (2011). *Szczegółowe zasady obrotu i rozliczeń dla energii elektrycznej na Rynku Dnia Następnego.* Retrieved from: http://www.tge.pl/files/10-2011/18-10-2011/26.10.2011_szczegolowezasadyobrotuirozliczenrdn__tekstjednolity.pdf; and PSE. (2004). *Regulations of the Electrical Energy Balancing Market.* Retrieved from: http://www.pse.pl/uploads/kontener/Regulations_of_the_electrical_energy_balancing_market.pdf

[20] Polskie Sieci Elektroenergetyczne. (2015). p 29.

[21] Polskie Sieci Elektroenergetyczne. (2013, October). *Karta Aktualizacji nr CB/9/2013 Instrukcji Ruchu i Eksploatacji Sieci Przesylowej - Bilansowanie systemu i zarzadzanie ograniczeniami systemowymi*. Retrieved from: http://www.pse.pl/uploads/kontener/KA_CB9_2013_IRiESP-Bilansowanie.pdf

[22] Polskie Sieci Elektroenergetyczne. *Parametry modelu rozliczeń operacyjnej rezerwy mocy dla 2015 roku*.

The strategic reserve serves to support the system in case of failure of one or more baseload units. It can only be activated with advance notice, as units require time to warm up, typically eight to ten hours. Contracts have been concluded for 830 MW of capacity, with operations envisaged for 2016–2020. The maximum annual cost of maintaining the strategic reserve is 174 million zloty. The units in the strategic reserve are old plants that were scheduled for retirement, but whose retirement PSE has postponed to address an anticipated capacity shortfall.

Other resources available to the system include demand response and energy imports from neighboring countries. However, to date, both of these resources have been limited. PSE has contracted for approximately 200 MW of demand-side response — far below what experience in other jurisdictions indicates is possible.[23] Contracts remunerate demand-response providers for performance, but unlike contracts for reserves, do not compensate providers for availability.

4.4. INTERCONNECTIONS

Poland has 8 GW of interconnection capacity with neighboring countries (6.5 GW with EU Member States), but commercial exchanges are limited owing to delays in market coupling and flows in the region that congest interconnector capacity.[24] In 2014, imports accounted for only two percent of total annual energy consumption.

5. CHALLENGES OF THE POLISH POWER SYSTEM

Poland faces a number of challenges to securing resource adequacy, including surplus capacity on the system and a deficit of resource capabilities, difficulty in integrating renewables, and limited interconnection capacity. This section addresses the challenges to resource adequacy in more detail, followed by a discussion of how pursuing solutions related to the IEM can help Poland improve reliability and increase flexibility on its system.

5.1. CAPACITY SURPLUS AND CAPABILITIES DEFICIT

The Polish power sector is currently over-supplied in terms of capacity, even while it lacks the resource capabilities to meet system needs. That is, there is a greater margin of resources above peak load on the system than necessary under reasonable reliability criteria. This has the effect of depressing prices in the energy market, and blocking investment in new resources.

Understanding the nature of Poland's over-supply requires a close look at the characteristics of the power system. Resource adequacy relies on meeting system demand with a security margin at all times of the year, including when annual peak demand occurs and at the times of greatest

[23] According to an analysis conducted by SIA Partners, Poland has more than 2 GW of demand response potential — enough to cover about 7.5 percent of peak load. See: SIA Partners. (2015). *Demand Response: A Study of the Potential in Europe.* Retrieved from: http://energy.sia-partners.com/wpfiles/2015/02/20141218_Article_DR-potential-in-Europe-1.pdf

[24] Although Member States were not under a binding obligation to couple their day-ahead markets by the end of 2014, the European Council adopted this target and there was a clear push to meet it. By the end of 2014, more than 75 percent of Member States had coupled their day-ahead markets, with the CEE region standing out as the laggard. See: Agency for the Cooperation of Energy Regulators. (2014). *Annual Activity Report*, p 4. Retrieved from: http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20annual%20activity%20report%20for%20the%20year%202014.pdf

system stress. The power system is built around these periods of time to ensure secure operations in all hours of the year.

In Poland the time of greatest system stress occurs in summer, whereas peak demand occurs in winter. To date, Poland has not had any significant system events in winter; instead, reliability has been threatened in summer. The year 2015 was an exceptional year: a new seasonal peak was reached on September 1, 2015, and the system experienced the biggest reliability event in 30 years in August 2015. A close look at the state of the power system on August 20 reveals that the reliability threat lies not in a lack of capacity on the system, but in the operational profile of available resources and other system constraints that emerge under hot, dry weather conditions.

Capacity Shortage in August 2015

On August 10, 2015, net generating capacity on the system was 38.7 GW. However, for a number of reasons, only about 65 percent of this capacity was reliably available. The collective output of plants was even lower.[25] Reasons for unavailable capacity included:

- Approximately 40 percent of combined heat and power (CHP) plants offline for the season;
- Capacity factor of wind at approximately five percent;
- Planned modernization and renovations;
- Operational restrictions owing to high air and water temperatures and low water tables (see below); and
- Emergency shutdown of the largest unit at Poland's largest power plant, Bełchatów.[26]

Demand exceeded available capacity on the system by 883 MW in the morning and 571 MW in the evening.[27] Additional operational reserves of 18 percent of load were expected to be available to the system; however, as the reserves are composed of the spinning reserves of thermal plants on the system, they were largely unavailable owing to the same weather-related restrictions that affected the wider fleet. Network congestion further restricted the flow of power. And Poland had limited available interconnection capacity and demand-response resources on which to rely. In combination, these restrictions led to forced curtailments to 1600 commercial customers – the first such event in 30 years.[28]

[25] Polskie Sieci Elektroenergetyczne Operator *Bilans mocy w szczycie rannym i wieczornym*. (2015, August 10). Retrieved from: http://www.pse.pl/index.php?modul=21&id_rap=11&data=2015-08-10

[26] Bełchatów is a 3000-MW facility. A day before demand curtailment, an 858-MW unit unexpectedly went offline. Combined with scheduled maintenance of three smaller units, a total of 1400 MW was unavailable to the system.

[27] See supra note 24.

[28] Polskie Sieci Elektroenergetyczne. (2015b). *Operator systemu przesyłowego (OSP) wprowadza ograniczenia w dostarczaniu i poborze energii elektrycznej. Ogłoszono 19 i 20 stopień zasilania.* August 10, 2015. Retrieved from: http://www.pse.pl/index.php?dzid=14&did=2471

Based on the causes of system stress in summer, the power system must address several key issues. First, it is important to address foreseeable system constraints in advance: some CHP plants might be activated on a temporary basis to avoid curtailments; timing of planned renovations can be shifted somewhat; and power lines may be adjusted to reduce "sag" at high ambient temperatures, which would reduce some of the congestion.

In addition to these measures, it is important to recognize the problem posed by an aging power fleet and by the homogeneity of the power system; 47 percent of the power fleet is more than 30 years old, and another 17 percent is more than 25 years old. These plants run at lower capacity factors than modern thermal plants, and require more frequent maintenance. As a result, the reliably available capacity to the system at any given time is well below the net generating capacity. PSE predicts increasing resource scarcity between now and 2025, owing to retirement of the oldest, highest-emitting plants.[29] However, the timing of plant retirements is unclear, as many plants expected to retire are being maintained in the strategic reserve and plants require regulatory approval to exit the system, which can delay their decommissioning.

As discussed previously, Poland must address both the capacity surplus in a transparent manner, and enable investment in the mix of resources that is needed to ensure system reliability. This includes investment in flexible and low-emissions resources.

5.2. THE OPERATING RESERVE

As described earlier, in 2013, PSE identified the need to introduce two new mechanisms to ensure resource adequacy: the operating and strategic reserves. These mechanisms were a reaction to an oversupply of capacity that led to low prices and the concern that some plants would not be profitable and would leave the system if they did not receive additional remuneration.[30] This section focuses on problems that have emerged with the operating reserve. The strategic reserve will only commence operations in 2016.

There are several problems with how the operating reserve has been structured that limit its effectiveness and result in market distortions. Understanding these problems helps clarify why the operating reserve as structured does not fulfill its goals.

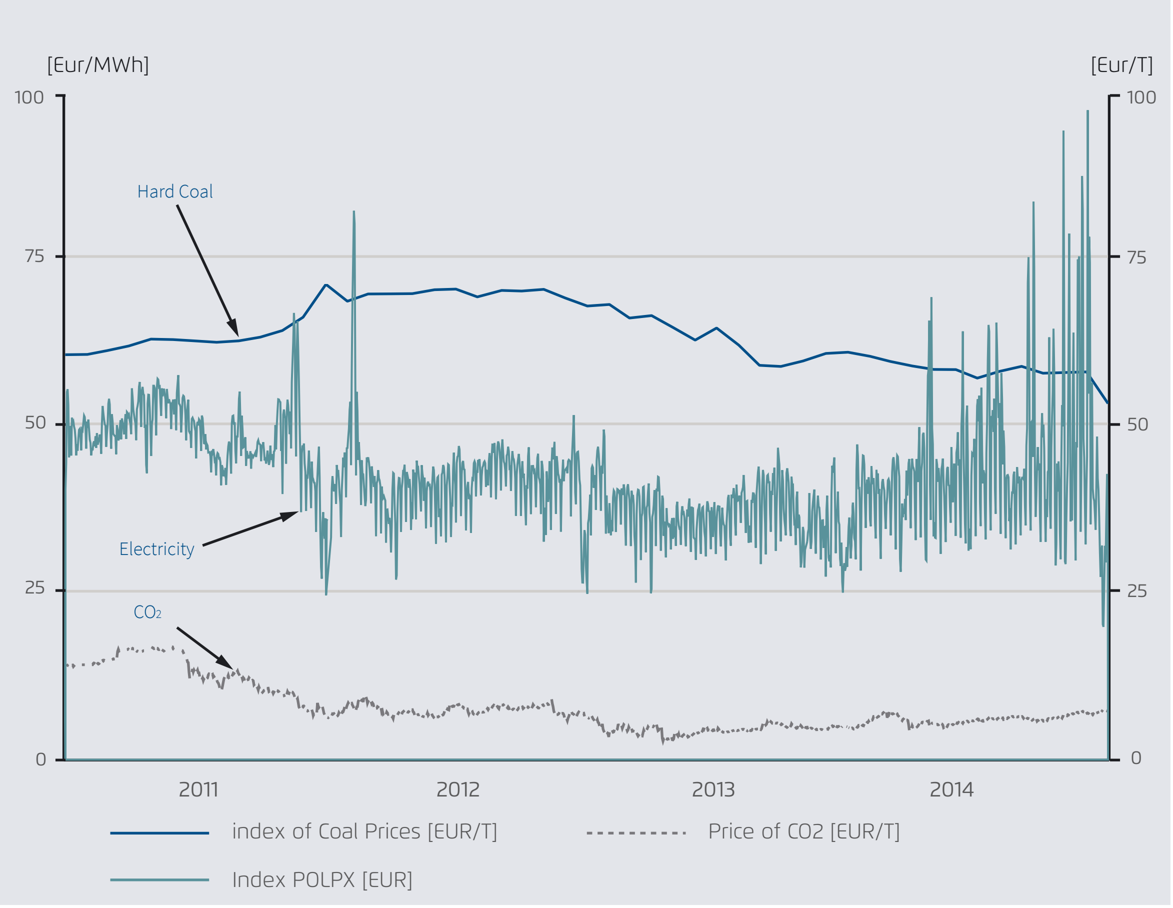
First, the operating reserve allows arbitrage between the energy market, balancing markets, and operating reserve. The way the reserve is structured, the residual capacity of resources on the system automatically enters into the reserve and receives remuneration for readiness between the hours of 7 am and 10 pm on all working days. Resources might therefore choose to bid more or less capacity into the energy and balancing markets, depending on whether they see a higher return in the market or in the operating reserve. This type of activity explains the increase in wholesale prices on the energy market that occurred after introduction of the reserve.

Figure 2 illustrates how wholesale prices in Poland increased after introducing the operating reserve, even though coal prices decreased and carbon dioxide allowance prices were stable.

29 This dynamic is reflected in ENTSO-E's SOAF 2015 report.

30 Polskie Sieci Elektroenergetyczne. (2013, September). *Karta Aktualizacji nr CB/9/2013 IRiESP – projekt.* Retrieved from: http://www.pse.pl/index.php?modul=10&gid=475

Figure 2. Day-Ahead Prices Contrasted With Hard Coal and Carbon Dioxide Prices



Source: Own design based on TGE and www.sendeco2.com/index-uk.asp

The effect of the operating reserve on the energy market has translated into greater costs to consumers. Although the Regulator approved a budget of 450 million zloty for 2014 for the operating reserve, in fact, the cost to consumers was much higher, owing to indirect effects in wholesale markets, which in turn raised retail prices.

The operating reserve has not guaranteed full system security as illustrated by the reliability problems experienced in August, 2015. There are two reasons for this. First, the reserve remunerates residual capacity, which in theory should be able to help balance the system, but in practice is often constrained during times of system stress. In particular, thermal plants make up the capacity in the reserve, and these plants might face severe constraints when water resources are limited (dry hot weather or dry winter) and they are needed most. Second, there are no penalties for non-performance, which means that there is no incentive for resources to deliver or insure against non-performance.

5.3. INTEGRATION OF RENEWABLES

One of the greatest challenges to integration of renewables in Poland today is that of integrating variable resources, and in particular wind. Wind tends to blow strongly at night, when load on the system is low. In Poland, this causes a challenge owing to operating restrictions of inflexible capacity on the system. As more wind comes onto the system, net demand (gross demand less the contribution from zero-marginal-cost renewables) may drop to very low levels. This means that the level of coal-fired capacity required to cover net demand will be variable, and may be quite low.

In many energy systems, for example in the United Kingdom, coal-fired units can be shut down when needed. But in Poland, a combination of network constraints and technical constraints of coal-fired plants restricts the ability to ramp down or shut off coal plants when they are not needed. A substantial portion of coal capacity in Poland cannot be shut off at night, as it would not be able to ramp up to meet the next day's demands. Moreover, many plants must operate at greater than 50 percent capacity (40 percent for supercritical units under construction), which translates to approximately 10 GW of power.

Several of the recommendations for resource diversification in this paper will help integrate wind in Poland at night. Moreover, it will be important to address the operational limitations of coal plants on the Polish system because of the current dominance of the Polish power fleet by large coal and lignite plants. It is possible for coal plants to run at lower minimum thresholds than 40 or 50 percent, as is the case in Poland. For example, typical coal-fired plants in Germany can maintain production at a 30-percent load factor.[31] Negative prices may also need to be allowed to remunerate capacity for exiting the system when needed.

5.4. LIMITED INTERCONNECTOR CAPACITY

Despite the 6.5 GW of interconnector capacity between Poland and its neighbors, Poland remains one of the most isolated energy systems in Europe. In 2014, Poland covered two percent of energy demand with imports; only Cyprus and Malta had lower import contributions.[32] Most of this capacity is unavailable because of a combination of delays in market coupling and unplanned physical flows that congest transmission lines.

Although most European countries and regions have coupled their day-ahead power markets, Poland continues to experience delays in coupling its day-ahead market with other countries in the Central Eastern Europe (CEE) region. So far, Poland has only coupled its day-ahead market with one other market — Nord Pool — along the 600-MW asynchronous interconnector with Sweden. The situation is expected to improve with the activation of the new interconnector between Poland and Lithuania, which will increase interconnector capacity with the Nord Pool market by an additional 500 MW. However, Poland still needs to resolve differences in hours of market operation to complete market coupling with the Czech Republic and Slovakia, and couple its day-ahead market with the remaining CEE markets.[33]

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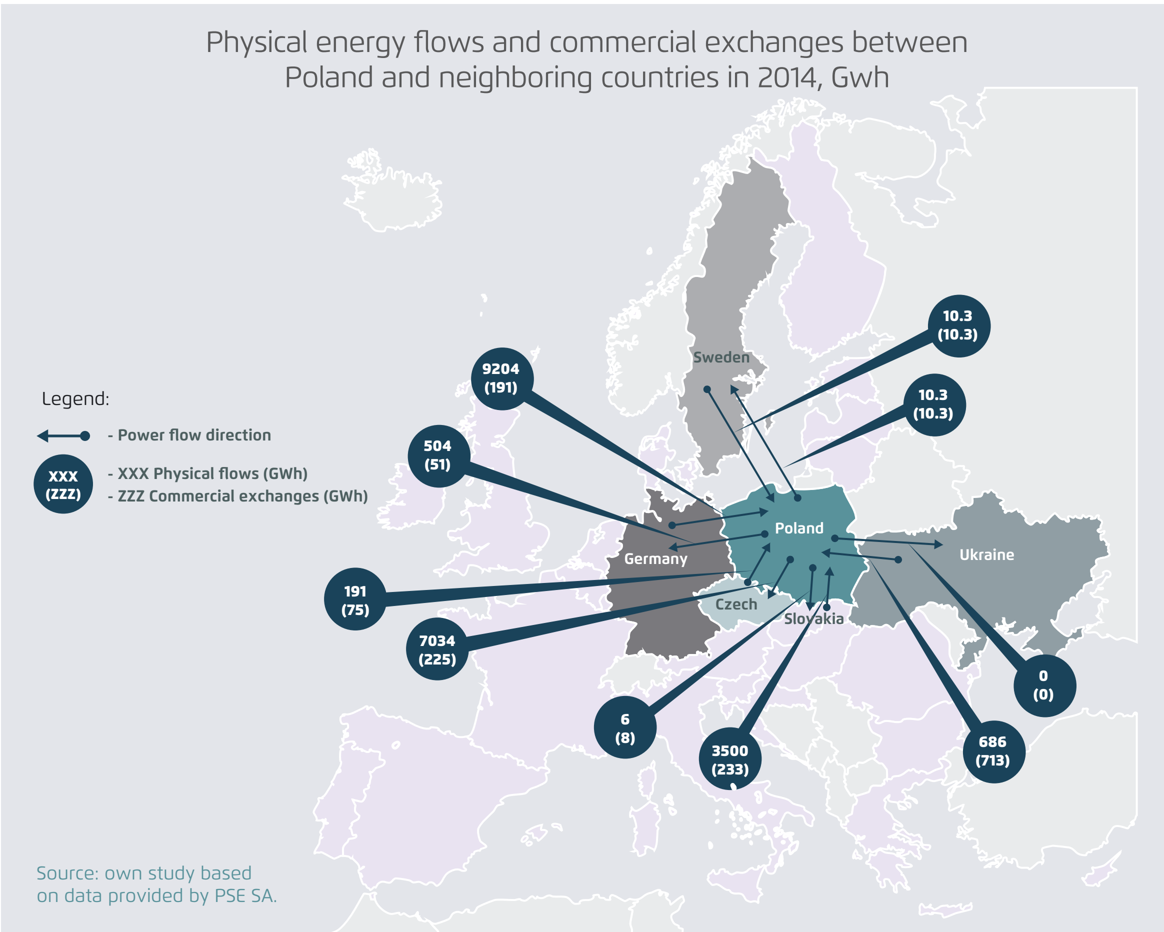
31 Dirschauer, W. (2012). *Efficiency and Flexibility of Coal-Fired Power Plants.* Presentation for Vattenfal at European Coal Round Table, Brussels, Belgium: March 21, 2012. Retrieved from: http://euracoal2.org/download/Public-Archive/Events/EP-Round-Table-on-Coal/20120321-16th/Dirschauer.pdf

32 ENTSO-E. (2014). *Scenario Outlook and Adequacy Forecast 2014-2030.* Retrieved from: https://www.entsoe.eu/Documents/SDC%20documents/SOAF/141031_SOAF%202014-2030_.pdf

33 See supra note 23 for the status of day-ahead market coupling in Europe.

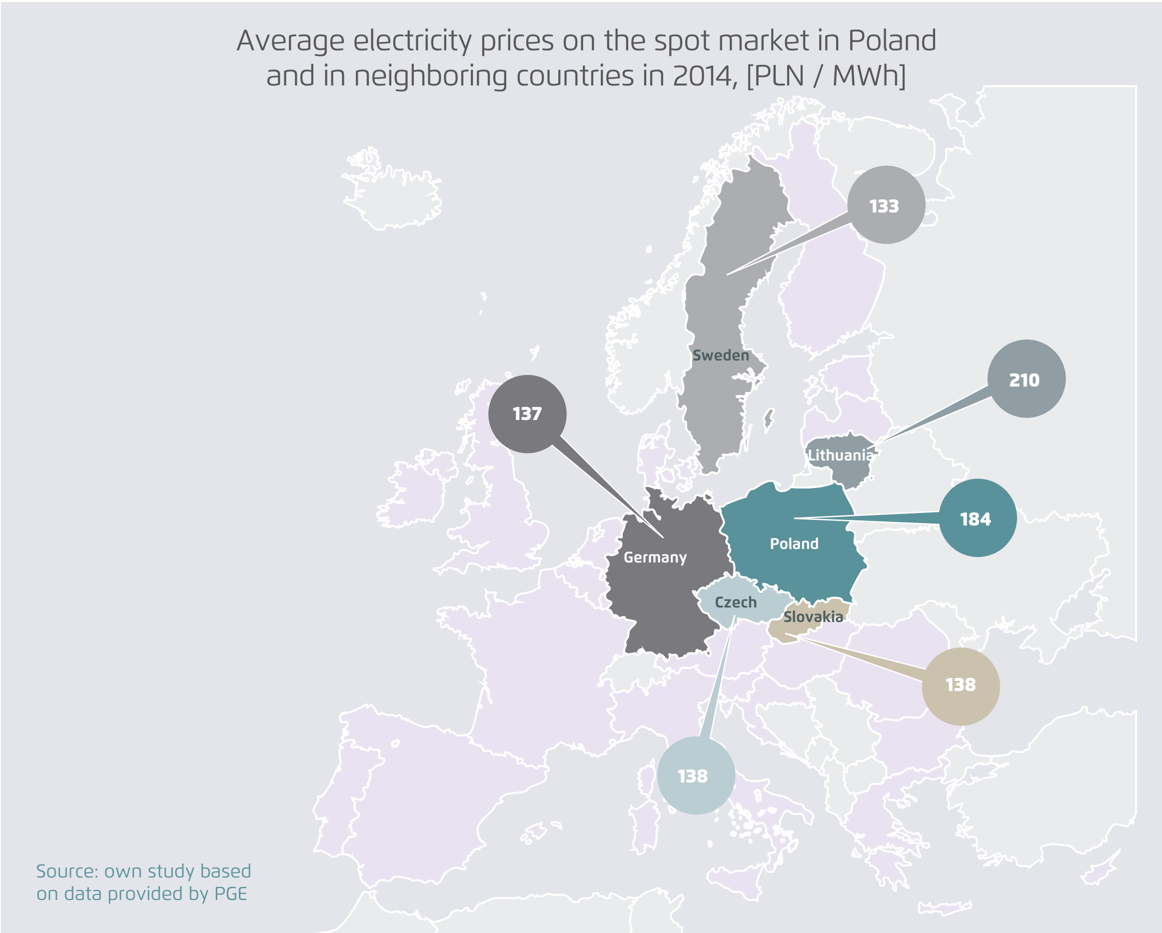
Unplanned physical flows further limit Poland's ability to import energy. These flows primarily occur when generating capacity in northern Germany exceeds the capacity of the German transmission system to transport energy from north to south. Because transmission systems are physically interconnected in the region (i.e., they are not constrained by national borders), the excess energy flows through the transmission lines of neighboring systems. This results in unplanned flows through Poland and its neighbors to reach Southern Germany. Figure 3 demonstrates the problem of unplanned flows by comparing the difference between commercial and physical flows between Poland and its neighbors.

Figure 3. Unplanned Flow Comparison



The limitations on cross-border capacity can be seen in the difference between wholesale energy prices in Poland and its neighbors. Figure 4 below illustrates that wholesale market prices in Poland were significantly higher than those in surrounding Member States throughout 2014.

Figure 4. Comparison of Day-Ahead Prices in Poland and Neighboring Countries in 2014 (in zloty/MWh)



Source: Own design based on data from PGE

PSE has been working with its German counterpart, 50hertz, to reduce the impact of unplanned physical flows on transmission lines. Following a pilot period implementing a "virtual phase shifting agreement" in which the two TSOs cooperated to implement operational measures to address unplanned flows by redispatching, they determined that physical phase shifting transformers are needed to help address the problem. In January 2016, a phase shifter on the southern Mikułowa-Hagenwerder line is expected to be operational, followed by a phase shifter on the Northern Vierraden-Krajnik line in 2017. Another solution to this problem might be the introduction of bidding zones, which better reflect generation and demand, better allocation of capacities, and market coupling.

6. STEPS TOWARD GREATER RELIABILITY AND FLEXIBILITY

This section addresses some of the solutions that can be implemented in the near-term to address the chief challenges and barriers to short- and mid-term reliability of the Polish power system. The solutions align with priorities for the IEM, and include: enabling greater participation of demand-side resources in markets and system operations; expanding available interconnector capacity; focusing on resource capabilities and a broader geographic footprint in assessing resource adequacy; and improving price formation in the market.

6.1. DEMAND-SIDE RESOURCES

Demand-side resources can deliver flexible services to the power system reliably and at low cost compared to supply-side resources. The Commission has found that "Energy efficiency and demand response are often better options for balancing supply and demand than building or keeping in operation more power plants or network lines."[34] There is a range of literature supporting both the role of demand-side resources and energy efficiency in avoiding or deferring more costly investment in generation and transmission and distribution lines.[35]

Poland has significant untapped demand response potential. PSE has contracted approximately 200 MW of demand response resources and issued a tender for an additional 200 MW. This will represent less than two percent of summer and winter peaks. Meanwhile, experience elsewhere has demonstrated that demand response has the ability to cover ten percent or more of peak needs, and often outperforms supply-side resources in terms of reliable delivery.[36] As referenced earlier, recent analysis has demonstrated that Poland can cover approximately 7.5 percent of peak needs with demand response, further emphasizing that this is a significantly under-utilized resource in Poland.[37]

This untapped potential can help address several of the reliability challenges mentioned earlier. Demand response can help meet summer peak, as demand resources are not constrained by the environmental conditions that limit operations of thermal generators. It can also support the system in winter when the demand is much higher. Large industrial customers have emphasized the importance of planned load shifting as demand response to prevent the unplanned curtailments imposed on them in August 2015.[38] Demand-side resources can further help integrate renewables by ramping down, but also ramping up activity in response to fluctuations in output from variable renewable resources. The latter feature is particularly useful in Poland, where increasing load on the system at night can help address challenges to integration of wind.

The Commission emphasizes the importance of engaging the demand side in both wholesale and retail markets. This includes eliminating barriers to demand-side participation in wholesale markets, including those faced by third-party aggregators, enabling demand-side participation

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[34] European Commission. COM (2015) 339, p 5.

[35] See: Neme, C., & Grevatt, J. (2015). *Energy Efficiency as a T&D Resource*. Energy Futures Group: Produced for Northeast Energy Efficiency Partnerships. Retrieved from: http://www.neep.org/sites/default/files/products/EMV-Forum-Geo-Targeting_Final_2015-01-20.pdf; and Neme, C., & Sedano, R. (2012). *US Experience With Efficiency as a Transmission and Distribution System Resource.* Montpelier, VT: The Regulatory Assistance Project. Retrieved from: http:// www.raponline.org/document/download/id/4765

[36] Demand response covers more than ten percent of peak demand in the PJM market in the United States, and nearly eight percent of peak demand in three other major US markets: ISO-NE, NYISO, and MISO. See: Hurley, D., et al. (2013). *Demand Response as a Power System Resource.* Synapse Energy Economics, Inc: Produced for The Regulatory Assistance Project. Retrieved from: www.raponline.org/document/download/id/6597

[37] SIA Partners. (2015); see supra note 22.

[38] Forum Odbiorców Energii Elektrycznej i Gazu. (2015, August). *List otwarty do Premiera Kopacz* Retrieved from: http://www.cire.pl/pokaz-pdf-%252Fpliki%252F1%252Flist_otwarty_premier_kopacz_ograniczenia.pdf

on a level playing field with supply in wholesale markets, and adjusting retail tariffs to reflect variations in wholesale prices.

In Poland, it is important to ensure that demand response contracted by the TSO is treated the same as supply-side resources — that is, that it receives payments for both readiness and performance. Markets should provide a level playing field for demand response, and barriers to demand-response participation in wholesale, balancing, and reserve markets must be identified and addressed. Lastly, retail prices should more closely reflect wholesale market prices. The first step in Poland is to remove the low daytime rate for many households during the summer peak season.

6.2. INTERCONNECTORS

Securing system reliability over a greater geographic footprint has been proven to lower the costs of reliably meeting system needs.[39] And integration of day-ahead and, progressively, intra-day markets lies at the heart of the IEM, which aims to ensure secure and cost-efficient development and management of the electricity system.[40]

Cross-border trade can benefit Poland as a whole, although it might be perceived as a challenge for domestic power companies. Currently wholesale prices in Poland are significantly higher than in neighboring EU Member States. Market coupling with Germany will allow Poland to benefit from lower-priced imported energy, which presents a benefit to consumers and a challenge to power generators. It will further help increase the security of the Polish power system.

A number of measures can help open up interconnector capacity between Poland and its neighbors. Completing coupling of the Polish day-ahead market with the CEE and Baltic Energy Market Interconnection Plan (BEMIP) regions is essential to enable trade along the 6.5 GW of interconnectors with Poland and to bring prices in those regions into balance.[41] It is also a process under the Third Energy Package that was envisioned to be completed throughout Europe by the end of 2014.

Unplanned flows from Germany will continue to some extent until a longer-term solution is reached within Germany (either building more North-South transmission grids or better allocation of price zones). However, installation of phase shifting transformers should allow more capacity to be available for cross-border trade. It is important to deploy the phase shifters in a way that maximizes available capacity for commercial flows. And in the longer term, it is important to move toward a system of flow-based capacity allocation as called for by the Capacity Allocation and Congestion Management Network Code, which entered into force in August 2015. This will lead to better allocation of capacity across the region.

Despite the challenges in the national power system, the Ministry of the Economy and PSE continue to rely solely on domestic resources in assessing system adequacy.[42] Yet as the price differentials between Poland and neighboring countries indicate, Poland could depend on cross-

39 Hogan & Weston. (2014).
40 European Commission. COM (2015) 340 final. See also: Hogan & Weston. (2014).
41 The CEE region includes Austria, Czech Republic, Germany, Hungary, Poland, Slovakia, and Slovenia. The BEMIP aims to integrate the power systems of Estonia, Latvia, and Lithuania with the Nordic countries, Poland, and Germany.
42 PSE. (2015). p 37.

border flows to meet some of its peak needs. This would be in line with the European Commission's emphasis on regional or European-wide approaches to ensure secure and cost-efficient development and management of the electricity system.[43]

6.3. RESOURCE ADEQUACY METHODOLOGY

The Polish market does not have a capacity deficit; it has a capabilities deficit characterized by the lack of resources with the capabilities needed to secure reliable systems operation in stress cases[44]. The clearest illustration of this is during the summer peak, when the capacity of thermal generators is severely restricted, although the power system could face some of the same restrictions in winter if water tables were low. Despite a healthy security margin of 18 percent above peak load, Poland runs into resource adequacy challenges. Similarly, as more variable renewable resources come onto the system, it will be important to consider the ability of resources on the supply and demand side to respond flexibly to the variable levels of supply.

In assessing resource adequacy, therefore, it is important for Poland to move beyond the traditional focus of ensuring that there is enough baseload capacity to meet the annual peak with an added security margin. The evolving power system will be increasingly characterized by the output of variable renewable resources, both in Poland and in neighboring countries. This means that resource adequacy will require analysis of both the anticipated times of greatest system stress, and the ability of the power system to respond with an adequate mix of resource capabilities.

In its Target Methodology for Adequacy Assessment, ENTSO-E recognizes the need to consider flexibility in the system on the supply and demand side as key factors in determining resource adequacy. This means that for thermal power plants, assessments will include the type of plant, ramp rates (up/down), minimum and maximum stable generation, and minimum on and off times. Importantly for Poland, analysis will also consider any must-run constraints resulting from technology, grid constraints, heat supply obligations, or other factors.[45] Moreover, adequacy assessments will consider storage and more detailed information on demand-side management/demand-side response.

The footprint of resource adequacy assessments will also need to expand to account for the significant contribution that interconnectors can make to help balance power systems. Sharing resources across interconnected areas can help increase reliability and lower the costs of balancing the system.[46] In this area, significant progress has been made by the Pentalateral Energy Forum, a framework for regional cooperation toward improved electricity market integration and security of supply in Central-Western Europe.[47] In March 2015, the Pentalateral Forum issued a joint resource adequacy assessment prepared by member TSOs. The assessment was based on an advanced new common methodology that goes beyond the current ENTSO-E model in assessing

[43] European Commission. COM(2015) 340 final. See also: Hogan & Weston. (2014).

[44] FAE, (2014). *Risk of the Capacity Shortage in Polish Power System Until 2020*. Retrieved from: http://www.fae.org.pl/en/analysis/risk-of-a-capacity-shortage-in-the-polish-electricity-system-up-to-2020.html

[45] ENTSO-E. (2014). *Target Methodology for Adequacy Assessment*. Retrieved from: https://www.entsoe.eu/Documents/SDC%20documents/SOAF/141014_Target_Methodology_for_Adequacy_Assessment_after_Consultation.pdf

[46] ENTSO-E. (2014).

[47] The Pentalateral Forum includes Belgium, the Netherlands, and Luxembourg (Benelux), Germany, France, Austria, and Switzerland.

regional resource adequacy. The Pentalateral assessment is based on a probabilistic modeling for all hours of the year, which enables a more consistent assessment of variable renewable energy generation, projected interconnector flows, demand-side management, and flexibility in the market.[48] This methodology has allowed the region to optimize resource availability across the region to determine where the resource adequacy challenges lie once regional cooperation and the full range of supply- and demand-side resource capabilities have been taken into account.

ENTSO-E is planning to go a step further. As outlined in its Target Methodology for Adequacy Assessment, it is advancing rapidly with plans to introduce a fully stochastic approach to resource adequacy assessment in the near future.[49]

PSE's most recent resource adequacy assessment takes a traditional approach of assessing adequacy in terms of capacity (not capabilities), primarily on the supply side, and disregarding the potential of interconnectors to provide support from neighboring systems. Given the immediate challenges of summer and autumn peaks and the growing challenge of integrating variable renewable resources into the system, along with the need to retire significant baseload capacity over the next decade, Poland stands to benefit from a broadened scope of resource adequacy that includes a look at operational capabilities of the supply and demand sides and considers the role of interconnectors in supplying system services.

6.4. PRICE FORMATION

Proper market design is fundamental to the IEM and to well-functioning liberalized power markets. Markets must maintain a healthy balance between supply and demand and allow for full scarcity pricing to send the right price signals to investors to build the right amount and type of resources needed on the system. The European Commission has emphasized that the most cost-efficient power system will rely on a fully functioning European-wide electricity market, with cross-border short-term markets that fully reflect the value of scarcity, and long-term markets that enable investment.[50]

The Polish energy market currently suffers from price distortions, which limit system security by restricting the price signals needed to stimulate new investment. Two significant factors affecting prices are the surplus capacity on the system, which depresses prices on the energy market, and the operating reserve, which raises them without increasing system security. A third feature, regulatory barriers to exit, further affects the investment climate as it slows the exit of uneconomic resources from the system. This combination of surplus capacity, operating reserve, and barriers to exit reinforce each other, and entrench price distortions in the market.

Several measures can help improve the efficiency of price formation in the market, which in turn is essential to minimizing system costs and stimulating investment in the mix of resources needed by the system. First, removing regulatory barriers to exit will increase the transparency of when resources will exit the system, improving the investment climate for new resources. Moreover, balancing supply with demand will bring market prices in line with the value of re-

[48] Pentalateral Energy Forum. (2015). *Support Group 2 Generation Adequacy Assessment* [Final version]. Retrieved from: https://www.bmwi.de/BMWi/Redaktion/PDF/G/gemeinsamer-versorgungssicherheitsbericht,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf

[49] ENTSO-E. (2014).

[50] European Commission. (2015, July). See supra note 5.

sources on the system. Next, the distortive effect of the operating reserve must be addressed by re-evaluating the structure and function of the operating reserve. This will require identification of whether Poland requires an additional reliability mechanism (such as a CRM) to stimulate needed investment, and whether it requires additional operating reserves to address operational challenges in real-time.

To the extent that another instrument is required to secure reliability, it is important to consider its structure and purpose. The current operating reserve operates much like a selective CRM, rather than a traditional reserve mechanism. Like a CRM, the reserve provides availability payments to resources that then also participate in the market, although only a fraction of system resources receive remuneration. Unlike a CRM (or traditional reserve mechanism), however, there are no penalties for non-performance, and the level of reserves is determined on an hourly rather than a forward basis. Although a capacity margin of 18 percent is not unreasonable, typical operating reserve levels amount to four to six percent of peak load. In fact, Poland already has in place traditional reserve mechanisms — primary, secondary, and tertiary reserves that provide system services in second, minute, and hourly increments. In short, it is important to identify whether Poland requires more operating or reliability resources on the system, and if so, design an instrument fit for purpose.

Finally, it is important to align internal market considerations with other elements of market design, including the move to regional resource adequacy assessments, market coupling, and enabling greater demand-side resource participation in the markets. It may be that implementation of these recommendations will defer the need for an additional resource adequacy mechanism by expanding the portfolio and geographic footprint of resources available to the system.

7. RECOMMENDATIONS

The following recommendations address the first-order steps Poland can take to improve system reliability, increase flexibility and resource diversity, and align the Polish power market with the European Commission's direction for the IEM.

Improving Market Efficiency

1. Currently, the Polish market is over-supplied in terms of capacity, while it lacks resources with the capabilities to respond to system stress. Poland should lift regulatory barriers to allowing uneconomic resources to exit the market, unless they are needed to temporarily ensure system security. This will help restore a healthy balance between supply and demand, which is the first step in allowing markets to reflect the marginal cost of power at different times of day and night.
2. The operating reserve as designed does not work properly, and therefore needs to be redesigned or replaced.
3. Although Poland has not reached its price caps to date, it should consider lifting price caps on the balancing market to allow full scarcity pricing moving forward.

Improving Flexibility

1. Demand-side resources represent a low-cost, flexible resource; however, currently demand response faces a number of barriers to deployment. Poland should remove these market barriers, allowing demand response to participate in the energy, balancing, and reserve markets — as well as in a CRM if Poland pursues one — on equal terms with supply-side resources.
2. Low distribution fees between the hours of 1 pm and 5 pm for households with time-of-use tariffs exacerbate the summer peak by incentivizing greater consumption during peak hours. Poland should eliminate the lower prices in summer to immediately remove the additional strain on the system caused by them. This would be a first step toward a retail pricing system that reflects wholesale prices, as encouraged by the Commission.
3. Market coupling is at the heart of the IEM. Linking with neighboring markets can lower market prices in Poland and increase the reliability of the power system by providing greater import capabilities during times of system stress. Poland should couple its market with the CEE and BEMIP markets.
4. Poland should prepare to couple its intra-day and balancing markets and expedite the move to flow-based cross-border capacity allocation calculation — both steps to help Poland balance its system more reliably and at lower cost.
5. Overcoming the low volume of commercial flows along Poland's western and southern borders related with unplanned power flows requires action from both Poland and Germany. PSE must not restrict cross-border flows unless necessary to maintain stability on the transmission system. And Poland should encourage Germany to clarify how to jointly address unplanned flows.
6. In December 2015, work on a new phase shifter between Germany and Poland on the Mikułowa-Hagenwerder link will be completed, and from October 2017 the phase shifter on the Vierraden-Krajnik link is scheduled to be operational. These phase shifters should be used to enable greater trade between Germany and Poland by backing off unplanned flows and creating room for scheduled flows until a longer-term solution is in place. The phase shifter should be used to free as much of the available capacity as possible.

8. ACRONYMS

ACER – Agency for the Cooperation of Energy Regulators

BEMIP – Baltic Energy Market Interconnection Plan

CEE – Central Eastern Europe

CHP – Combined Heat and Power

CRM – Capacity Remuneration Mechanism

ENTSO-E – European Network of Transmission System Operators for Electricity

EU – European Union

GW – Gigawatts

IEM – Internal Energy Market

MW – Megawatts

PSE – Polskie Sieci Elektroenergetyczne

TSO – Transmission System Operator

TWh – Terawatt-hours

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