REKK SFPA Slovak Foreign Policy Association AMO.CZ INSTYTUT JAGIELLOŃSKI

‘Beyond gas’ – energy security issues in the V4 after 2020

Final Synthesis Report

October 2018

The title of the research project: 'Beyond gas' – energy security issues in the V4 after 2020

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The REKK Foundation for Regional Policy Co-operation in Energy and Infrastructure is a Budapest based think tank. The goal of the REKK Foundation is to contribute to the formation of sustainable energy systems in Central Europe, both from a business and environmental perspective. Its mission statement is to provide a platform for open-ended, European-wide dialogue between government and business actors, infrastructure operators, energy producers and traders, regulators and consumers, professional journalists and other interested private entities. The Foundation develops policy briefs and issue papers with forward-looking proposals concerning challenges posed by energy and infrastructure systems and organize regional forums allowing stakeholders to become familiar with the latest technological and regulatory developments within the industry.

In accordance with its statute (Article III), the Research Center of the Slovak Foreign Policy Association (RC SFPA) provides the following publicly beneficial services: prepares independent expert analyses of the key questions in the field of international relations and the Slovak foreign policy; publishes periodical and non-periodical publications, the role of which is to intensify knowledge in the area of international relations and the Slovak foreign policy and they are at the same time a source of credible academic information in the field of international affairs and the Slovak foreign policy suitable for specialists as well as for a lay public; organizes professional events and participates in the international expert debate concerning international relations and security research; provides a creative environment for the rise of a new generation of Slovak professionals in the field of international affairs; encourages broader interest of Slovak citizens in global affairs and in a more profound understanding of the importance of foreign policy and its interconnection with domestic politics.

The main aim of Association for International Affairs (AMO) is to promote research and education in the field of international relations. The organization formulates and publishes briefings, research, and policy papers, organizes international conferences, expert seminars, round tables, and public debates, organizes educational projects, presents critical assessments and comments on current issues for local and international press, creates favorable conditions for the growth of a new generation of experts supports interest in international relations among the general public cooperates with a number of like-minded local and international institutions. AMO has focused on the issues connected with V4 cooperation for a long time. Regarding its recent activities in the field of energy policy, AMO has provided a continuous monitoring of the energy policy development in the Czech Republic, as part of a consulting service provided by the German Council on Foreign Relations (DGAP).

The Jagiellonian Institute was founded in 2006 by Professor Wojciech Roszkowski. The academic background and political experience of the founder translated into the creation of an independent analytical center. The Institute's general mission is to work on upgrading Poland and Central and Eastern Europe in the world. The Jagiellonian Institute concentrates on promoting Poland's security, on supporting entrepreneurship and technological and scientific development, as well as on improving the competitiveness of the Polish economy. The scope of the activities of the Jagiellonian Institute is very wide, but the subject of particular interest are politics of memory, energy market, infrastructure, finance, international relations and broadly understood security and strategy planning.

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Executive Summary

The aim of the paper is to elaborate the energy security challenges for the V4 region (with a possibility of extending it to neighboring countries) in the post 2020 period. This period is selected on purpose, as by that time the number of regional priority gas infrastructure projects are to be implemented which might shift the focus of supply security related regional energy discussions from gas to electricity and renewables. The paper is based on the stakeholder interviews, a workshop discussion and on the research done by the project partners. The outcome is the short list of key challenges shaping the energy future of the region which could help shaping post-2020 EU financing for regional energy projects.

To arrive to this goal the *Beyond Gas Beyond 2020* research project has been conducted between June 2018 and October 2018. The project was led by REKK (Hungary), with participating partners Slovak Foreign Policy Association (Slovakia), AMO (the Czech Republic) and Institute Jagiellonski (Poland). The project followed a four-step approach:

- *Semi–structured interviews conducted with the main stakeholders of the energy sector of each V4 country.* The four participating research institutes carried out in–depth interviews with the following institutions in their respective countries to make a stock of the most important long–term energy security issues: responsible ministries (ministries responsible for energy and for foreign affairs), energy regulator, transmission system operators (TSOs) and energy sector companies and main investors. This method ensured that in all countries the same problem areas have been covered at the altogether 40 interviews.

- *Country Reports.* The country reports have been prepared by the own research of the project partners and based on the results of the interviews. The reports are concise collection of issues, raised and identified by the researchers and the interviewed stakeholders regarding the security of electricity supply (short term operational security, medium term system adequacy (generation and network), long term risks in regulation and market) and security of natural gas supply (short term import disruption, medium term system adequacy (generation and network), long term risks in regulation and market design and import source diversity).

- *Workshop organized for government representatives and energy research institutes.* The participants of the workshop represented the V4 countries' MFAs and EnMins and the partner research institutes. They discussed the mid–term results and evaluated the energy security challenges identified in during the interviews and in the country reports on 14th September 2018 in Budapest.

- *Final Synthesis Report.* The findings of the research are summarized in the Synthesis Report.

The main finding is that despite substantial development in the resilience of the natural gas infrastructure in the last decade both in the EU and in the V4 countries as well, we still cannot say, that we are „beyond gas". Gas remains an important part of the energy mix of the V4 countries in the next decade, hence security of supply and market integration in natural gas is still high on the V4 agenda.

The project identified the following main challenges:

1. One of the most prominent challenge in the region is brought by the EU decarbonisation policy, which requires a profound transition process in the electricity sector. The official target of 40 per cent decarbonisation by 2030 might be lifted upwards toward 45 per cent, which means a significant transformation of the sector. One of the main instruments to achieve this goal is to significantly **increase renewable based generation** in all EU member states, amongst them in the V4 countries. Although the new target setting process does not prescribe national targets, policy makers soon – by the end of 2019 – will have to come up with national commitments toward RES and energy efficiency targets according to the new EU governance regulations and reflect it in their National Energy and Climate Plans (NECP). This increase would entail significant efforts to

    a. *Define RES target correctly:* V4 countries face the problems of setting up RES targets in their NECPs, which should be ambitious enough for the contribution to the overall EU target, but with targets that also reflect the overall burden of the electricity sector and on the consumers.

    b. *Integrate RES into the electricity systems successfully:* To increase renewable based generation, the regulatory framework and costs of integrating several thousand MWs of intermittent renewable power generating capacities to the grid should be dealt with.

2. The next potential shock is also a decarbonization process relates one, namely the **coal phase–out.** The electricity sectors of the EU member states will have to enter a more stringent decarbonization phase after 2020 pushed by the ETS reforms (preliminary Council decision is just adopted including increasing pace of tightening allowances from 1.74 per cent to 2.2 per cent after 2020 and further measures) and by the new Industrial Emissions Directive having very stringent emission ceilings on coal and lignite-based power generators. The V4 countries can mostly be characterized by heavy reliance on coal generation (in 2015 the share of coal and lignite in electricity generation stands at CZ: 49 per cent, HU: 19 per cent, PL: 79 per cent, SK: 10 per cent), so these changes can have serious impacts, that can trigger energy security concerns.

3. **The increasing share of nuclear** in the region is the consequence of current V4 Energy Strategies. The Czech Republic, Hungary and Slovakia has decided to extend their nuclear generation capacities, and Poland is considering this option, too. These investments go hand in hand with huge investment cost, nuclear safety measures and usually delays. In the meanwhile, the huge nuclear projects might discourage the investments to building other type of power units.

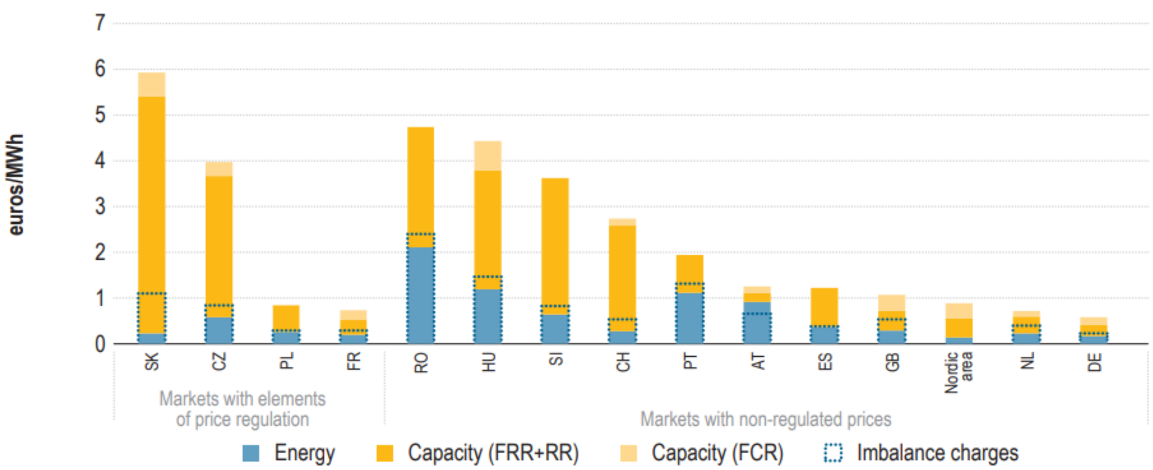
4. The Challenges 1–3 together lead to combined, more important energy security problem. As the RES shares will increase and most of the V4 countries are planning to introduce new power plants in their power system

beyond 2030, this will raise further questions on the future operation of electricity markets. Although nuclear power is a carbon–neutral technology, it represents an inflexible unit in a power portfolio, operated mainly in base–load manner. The **coexistence of these nuclear plants in a power system, where RES shares could be as high as 30–50 per cent, raises system operation concerns**. Higher RES levels would require the existence of *sufficient level of flexible capacities*, but new nuclear plants might erode the investment environment for building new flexible – like gas fired – units. This leads to a further medium-term issue in the V4 countries, namely *maintaining system adequacy* in the region.

5. **The generation adequacy** has been also identified as upcoming energy security challenge. However, the target level of generation capacity of a given country compared to the consumption relies on the priorities of the national energy strategy.

6. **High balancing costs**: In the V4 countries the electricity sector participants already face significant additional costs in their balancing markets. According to the latest Market Monitoring Report of ACER (2016)[1], electricity markets of Slovakia, the Czech Republic and Hungary (together with Romania) face the highest balancing costs in Europe, in a range of 4–6 €/MWh, compared to the below 1 €/MWh balancing cost of the Western European markets. Poland is the only V4 country presenting EU average balancing cost level.

Figure 1: Overall costs of balancing (capacity and energy) and imbalance prices over national electricity demand in a selection of European markets, 2016, Source: ACER[2]



7. The research put great emphasis on evaluating the import gas dependency after 2020 and its role in energy security. **The V4 region is not beyond gas** because of several reasons. While the household gas consumption might decline due to energy efficiency investments and growing share of electric heating, *research results*

[1] Annual report on the results of monitoring the internal electricity and gas markets in 2016, Electricity Wholesale Markets Volume, ACER, 2017 October; pp 51, Figure 27, Available online: https://acer.europa.eu/Official_documents/Publications/ACER%20Market%20Monitoring%20Report%202016%20%20Document%20histo/ACER%20Market%20Monitoring%20Report%202016%20-%20ELECTRICITY.pdf (accessed on October 18, 2018).

[2] Annual report on the results of monitoring the internal electricity and gas markets in 2016, ACER, op. cit.

show that natural gas is expected to remain significant fuel source in electricity generation, and in industry sector. As a consequence of the second challenge, the phase out and closing of many coal units in the region, there will be need for alternatives, like natural gas as transition fuel. Besides, as described at challenges 1,3 and 4, parallel to the increasing nuclear and renewable generation capacities, the flexibility will play a greater role in the system, and gas fired units are in a good position to ensure that. Thus, as no increase is expected in the domestic production in the V4 countries, energy security issues will be related to natural gas import in a great extent after 2020, too.

8. The gas markets of the V4 countries are mature markets, hence - despite recent recovery of the gas consumption after the financial crisis - future expectations regarding gas consumption increase in all V4 counties are moderate, a rather stagnating gas market is envisaged. Decreasing domestic production in all EU countries and potential future role of gas as a transition fuel supporting decarbonization goals indicate a growing gas import dependence. Russian share of import is about to grow from 34% in 2017 to close to 40% by 2030 on an EU level.[3] This is even more **relevant in the V4 countries where Russian supplies are about 80% of the import**. Despite the universally high Russian import share there are some differences identifiable, however between the V4 countries. For Czech Republic and Slovakia, significant amount of alternative gas sources are available. For Hungary the number of alternatives are more scarce while currently Poland is not able to satisfy its demand without Russian gas currently.

9. Diversification of supply plans target connecting the countries to the global LNG market by regasification terminals in Poland and in Croatia, to the Norwegian fields through the Baltic Pipe and to the Romanian offshore gas production fields through the Romanian Hungarian Interconnector**. Despite general support for each other's projects there is no single project proposed by the V4 countries as an absolute priority.** On the other hand, at the individual country level, some of these projects would enhance energy security in the affected countries. Common negative sense surrounds the Russian backed large pipeline projects that aim to bypass Ukraine as a transit route. The agreement is much broader against Nord Stream 2 than the support for any of the V4 countries projects. It is a shared opinion that the project would worsen the utilization of existing infrastructure and would undermine security of supply of the region related not only to gas disruptions but in a broader sense as well.

10. Looking into the other proposed PCI projects the diverging interests and different priorities assigned to the projects by the individual countries result in delays of implementation and tensions between the neighbouring countries (see the example of Stork II or the Croatian LNG). Some projects seem to be less of a priority for any party (eg. Eastring). Better understanding of the priorities and the obstacles to timely implementation could foster cooperation and reaching agreements necessary to overcome the obstacles.

[3] REKK modelling

Chapter I: Energy security challenges after 2020

Section I: State of the energy security indexes in the region

In this section our aim is to give a brief overview based on existing energy related statistics, forecasts and main energy security indexes. In this sense our analysis is generally descriptive as we try to give a comprehensive description about the state of energy security in Czech Republic, Hungary, Slovakia and Poland. The main factors behind the current situation and potential future policy measures which can improve energy security will be discussed in the following sections.

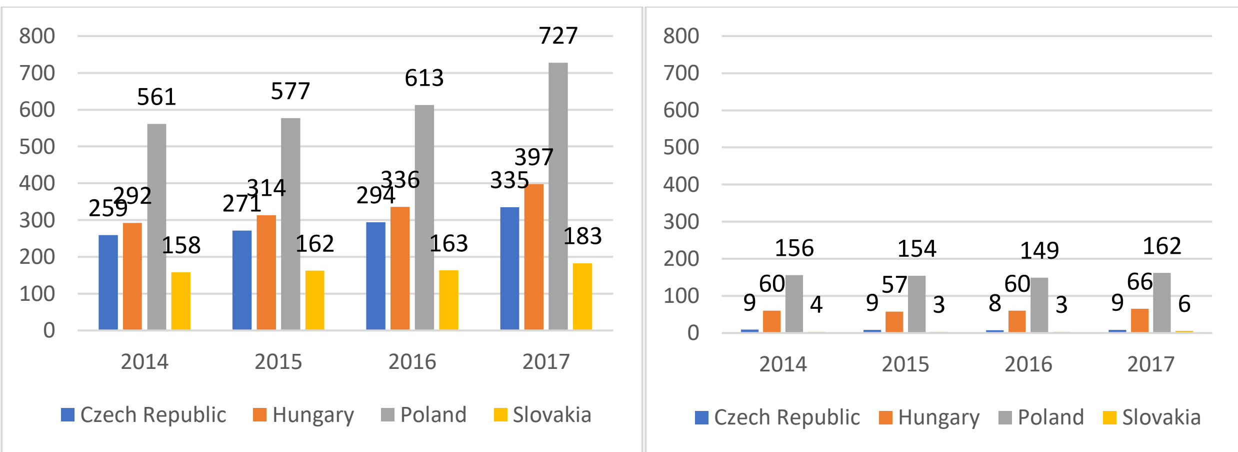
We focus mainly on the electricity and natural gas sector. Related to the natural gas sector, we will present consumption and production statistics to determine the import need of the examined country. In the V4 countries the most important natural gas security concern is the import dependence from Russian gas. For this reason, we examine at what extent alternative sources are available to cover their needs based on the so-called Exposure-index (E-index) developed by REKK. For the electricity sector we present the current generation mix of the V4 countries and forecast for the future fuel mix- based on ENTSO TYNDP 2018. Additionally, we calculate generation adequacy and system adequacy indexes, and present the results of the ENTSO-E Mid-term adequacy forecast (MAF) in order to draw conclusions related to energy security.

A. Natural gas market

Current situation

Figure 2 shows the natural gas production and consumption values for the V4 countries between 2014 and 2017 based on Eurostat values.

Figure 2: Natural gas consumption (on the left) and production (on the right) in the V4 countries, TJ, 2014-2017; Source: Eurostat



Poland is the largest natural gas consumer in the region with 600 PJ yearly consumption, followed by Hungary and Czech Republic with 300 PJ. In Slovakia a relatively smaller amount, approximately 150 PJ is consumed. On the other hand, significant production of gas is only present in Poland and Hungary with the values 160 PJ and 60 PJ respectively. This means that similarly to most of the European states V4 countries are heavily dependent on foreign gas sources. Of course, the level of dependence differs significantly, as Czech Republic and Slovakia produce only 2-3% of their inland consumption compared to Hungary (~20%) and Poland (~25%).

Based on the forecast of ENTSO TYNDP 2018 no significant changes are expected until 2030 in the natural gas consumption. The forecasts show, that the consumption in Poland and Czech Republic will increase, while in Hungary and Slovakia it will remain relatively constant. As no significant increase is expected in the production for all V4 countries energy security issues are and will be related to natural gas import in a great extent.

Russia as a main supplier

As the imported magnitude of natural gas is very high relative to the consumption, it is an important security of supply question that from what import source a country can supply its own consumption. Economic theory suggests, that if a country can supply itself from several alternative sources it's a better solution than a full dependency on a sole supplier, because as a result of competition prices become lower and there are alternatives available in case of supply disruptions.

It is well known that for the V4 countries Russia is the dominant natural gas supplier. Based on Eurostat data in 2016 the import share of Russian originated gas was more than 90% in Czech Republic, Slovakia and Hungary relative to gross inland consumption and 69% in Poland. It is important that Eurostat accounts for the origin of the gas not the actual trading partner. To give an example Czech Republic has a long-term contract (LTC) with Norway. In practice however, it is a swap deal as Norwegian gas is supplied to Germany and Russian originated gas from Germany is supplied to Czech Republic in exchange.

If we investigate actual trade relations, approximately 65% of Czech consumption is imported from Russia, the other 35% contains the LTC from Norway and spot purchases from Germany. (Langvad, 2017)[4]. It is more difficult to determine the exact share of Russian gas in Hungary's import. Approximately 65-70% of the country's import arrives directly from Russia through LTC contract. The other 30-35% percent is supplied from Austria which amount is a combination spot trades and short-term contracts for gas of Russian origin (Langvad, 2017). The more than 90% share for Slovakia and the 70% share for Poland is realistic. By looking at the import shares however even with the explanation of Eurostat data it is evident that Russia plays a major role as a natural gas supplier for the V4 countries.

The dominant role of Russia is supplemented by the fact that all V4 countries have long-term contracts with Russia which legal constraint significantly determines the V4's natural gas import behavior. Czech Republic has an LTC with Russia until 2035 which accounts around 50 TWh of yearly natural gas import (Langvad, 2017). The LTC of Hungary expired in 2016 but Russia and Hungary negotiated a deal which allows to use the unconsumed take or pay amounts

[4] Langvad, E. (2017). Hungary and the Czech Republic's Approach to Gas Security.

from the contract until 2021[5]. The LTC of Poland runs until 2022[6], while the Slovakian until 2029[7]. In this sense Hungary and Poland have to decide in the near future whether they would like to extend their contract with Russia, while Czech Republic and Slovakia are tied to Russian gas by contract until 2030s.

Dependency on Russian gas

According to our view the amount of imported gas from country X is a simple and straightforward indicator but not necessarily the best measure of dependency from country X and energy security. It is possible that a country imports a significant portion of their consumption from country X if that source is the most competitive from a broad list of alternatives. In this case, if supply disruptions occur or gas from country X becomes more expensive it is possible to import gas from other sources. We argue that energy security problems are present if the country does not have enough supply alternatives which situation generates a significant market power for the dominant supplier.

To capture the above-mentioned effect, we introduce the Exposure-index (E-index), which aims to capture the share of available alternatives related to consumption. E-index is defined in Equation 1:

(1) $E = \frac{C-P-I_{max}}{C}$

C stands for the annual consumption level, P is the annual production, while I_{max} is the maximum import capacity per year from non-Russian source. The domestic production P affects the exposure index negatively: the higher the domestic sources of gas, lower the exposure index. Similarly, the alternative import capacity from non-Russian sources has a negative effect on the exposure index: the more alternative sources are available for a country to import, the less exposed it is to a single supplier. The effect of consumption is positive, but considerably weaker than the other two variables.

Values of the E-index can range between $-\infty$ and 1. If the E-index takes the value 1 this means that in the given period, the country is not able to produce natural gas or import it form a source different than Russia. So, if E-index is 1, the country’s consumption is totally dependent on Russia. It is important to note, that by the value of 0 the country is theoretically able to sustain itself without Russian gas. This means that negative E-index value represent the extent of alternatives that are available for the country.

In Table 1 we present the E-index values for all V4 countries between 2010-2017:

Table 1: E-index of the V4 countries, 2010-2017; Source: Rekk's own calculation based on ENTSO-G and Eurostat

	CZ	HU	PL	SK
2010	-0.50	0.53	0.64	-0.83
2011	-0.70	0.50	0.62	-0.64
2012	-3.10	0.47	0.62	-1.34

[5] http://www.gazpromexport.ru/en/partners/hungary/
[6] http://www.gazpromexport.ru/en/partners/poland/
[7] http://www.gazpromexport.ru/en/partners/slovakia/

2013	-4.84	0.45	0.61	-2.82
2014	-5.80	0.40	0.56	-7.29
2015	-5.88	-0.02	0.58	-5.84
2016	-5.67	-0.01	0.61	-6.87
2017	-4.13	0.02	0.35	-5.73

It is visible that in all V4 countries the dependency form Russian gas decreased between 2010 and 2017 as the values of E-index became significantly lower. The data shows however that the situation is entirely different if we compare these processes. In 2010 Czech Republic and Slovakia were theoretically able to supply themselves without Russian gas as their E-indexes were less than zero; -0.50 and -0.83 respectively. In the 2010s these two countries were able to diversify their potential supply portfolio which resulted in a less than -4 E-index for both of them in 2017. This result means that for Slovakia and Czech Republic a significant amount of alternative gas is present to satisfy their demand through the huge transmission capacities that connect them to the liquid German and Austrian market. To allow for that they invested into reverse flow capabilities on the existing pipeline system.

The situation is more complex with respect to Hungary and Poland as those countries could supply 53% and 65% of their consumption only form Russian source in 2010. In both countries however, important and costly new investments into infrastructure had been commissioned until 2017 as Hungary has built the Hungarian- Slovakian natural gas interconnector (commissioned in 2015) which enables the country to import 127 GWh/d natural gas from Slovakia[8]. Poland built the Swinoujscie LNG terminal with the technical capacity of 158 GWh/d. Both investments had significant effects on E-index as Hungary's E-index decreased to 0.02 by 2017, while Poland's to 0.35.

So, in 2017 Slovakia and Czech Republic consider Russian gas as one competitive source as they can satisfy their demand from alternative directions. The situation of Hungary is difficult to decide with an E-index close to zero as this means that on a yearly average basis the country is theoretically able to sustain itself without Russian gas. On the other hand, in winter months for example when consumption is significantly higher, it is not possible. For Poland still the third of the countries' gas consumption is solely dependent on Russian gas. In Hungary however with the planned expansion of the Romanian-Hungarian interconnector and with the completion of Krk LNG, while in Poland with the completion of the capacity extension of Swinoujscie LNG the value of E-index will potential decrease in the near future which will enhance energy security further.

B. Electricity market

Current state and forecast

In the sub-section we describe the current state of the V4 electricity markets and present some forecasts about electricity generation and demand. The forecasts are based on the ENTSO TYNDP 2018. The report predicts future

[8] Other investments are not considered in the E index are investments into commercial and strategic storage sites, interconnection to Romania and to Croatia, as these later pipelines still lack the investments necessary from the neighboring TSO to allow for bidirectional flows. When writing this study, both directions show promising developments.

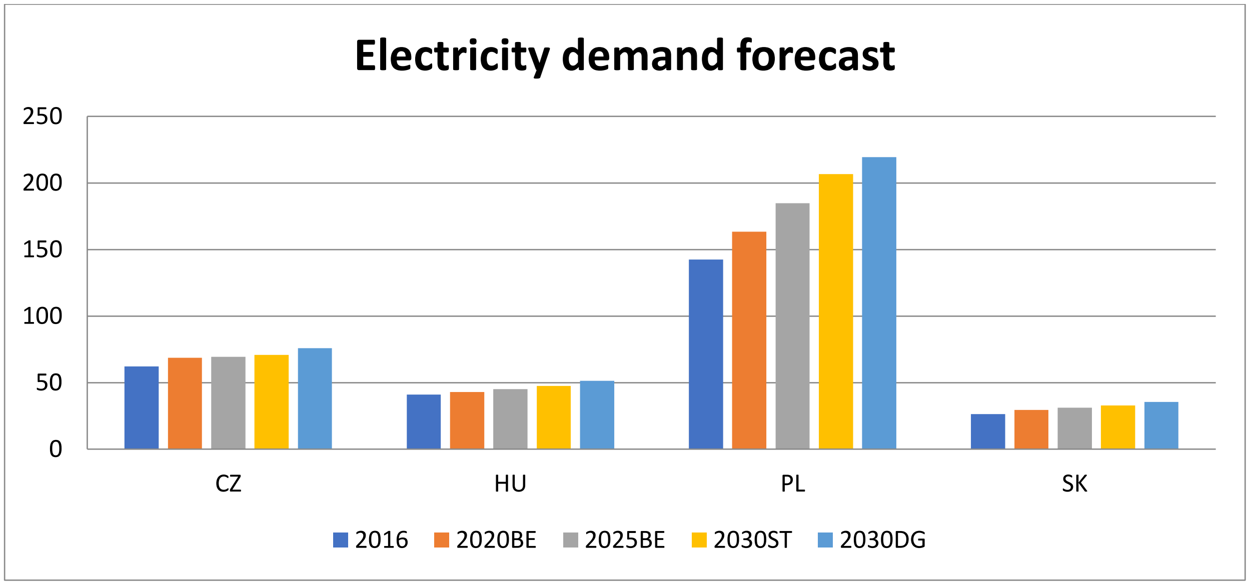
energy consumption and electricity generation mix for 2020, 2025, 2030 and 2040 based on predefined set of possible scenarios. We will present some relevant figures from the report for 2020 and 2030.

For 2020 there are no specific scenarios defined, there is only "best estimate" scenario is forecasted. For 2040 however, ENTSO introduces three different development paths, which are the following:

1. *Sustainable Transition (ST):* The aim of this scenario to reduce CO_2 emission by substituting coal and lignite with gas in the power sector.
2. *Distributed Generation (DG):* Which assumes a decentralized power generation and prosumers on the energy markets. This scenario assumes intense penetration of electric vehicles and PV. Therefore, gas consumption is envisaged to plummet.
3. *Global Climate Action (GCA)*: In this scenario global action is taken for full decarbonization, mainly based on high renewable penetration and with the usage of nuclear power. This scenario is only relevant however after 2030 so we won't consider it in our analysis.

Figure 3 shows the expected evolution of electricity consumption in the V4 countries for in 2016 based on Eurostat values and estimates for 2020, 2025 and 2030 based on ENTSO TYNDP 2018.

Figure 3: Electricity demand in the V4 countries and future forecast, 2016-2030, TWh/y, Source: Eurostat, ENTSO TYNDP 2018



Currently the largest electricity market is Poland with a consumption of approximately 142 TWh/y which is more than two times as much as the second largest market of Czech Republic. Hungary and Slovakia are smaller markets with a total consumption of 41 and 26 TWh/y in 2016. In all countries the forecast shows a projected increase in demand until 2020. This increase is relatively small in Hungary (1.8 TWh), moderate in Czech Republic (6.6 TWh) and Slovakia (3.3 TWh) and drastic in Poland (21 TWh) even after considering the size of the polish electricity market. Between 2020 and 2030 however some other differences are identifiable.

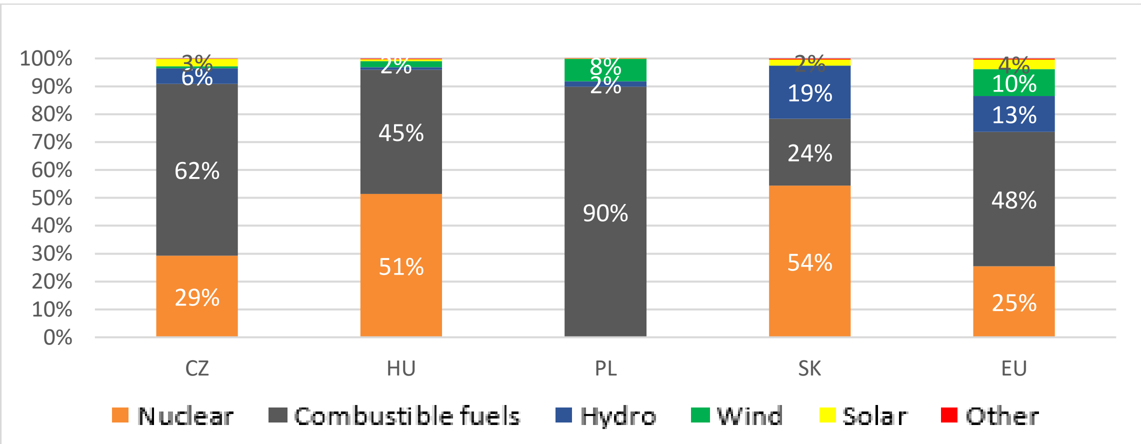
The evolution pattern of Czech Republic and Slovakia is very similar, with a slow increase in electricity consumption for all future periods. The consumption values are relatively constant in these countries in the former between 2020 and 2030 the demand will increase from 68 to 70 TWh/y in the ST scenario, while in the latter it changes from 29 to 32 TWh/y in the same period. Based on the forecast Hungary will experience a higher demand growth, as the consumption is expected to change between 2020 and 2030 with approximately 5 TWh/year.

The situation very different in Poland, as based on the estimation, electricity consumption will rapidly grow in the upcoming years. The 2020 value is already expected to be 163 TWh/y, based on whether we consider the ST or the DG scenario it will increase to 206 or 219 TWh/y respectively. For all countries in 2030 the DG scenario results in higher electricity demand than the ST scenario.

By looking at the electricity generation it is visible that both the magnitude of the produced electricity and the generation fuel mix is very different in the V4 countries. Based on Eurostat data, the greatest electricity producer is Poland with approximately 152 TWh/y energy which is more than the other three V4 countries combined. A significant generation is present in the Czech Republic as well where 77.5 TWh/y electric energy was generated in the same year. The magnitude of produced electricity is similar in Hungary and Slovakia with 29.5 and 25.2 TWh/y respectively.

Figure 4 shows the electricity generation mix of the V4 countries and the European Union average in 2016.

Figure 4: Electricity generation mix of the V4 countries, 2016; Source: Eurostat



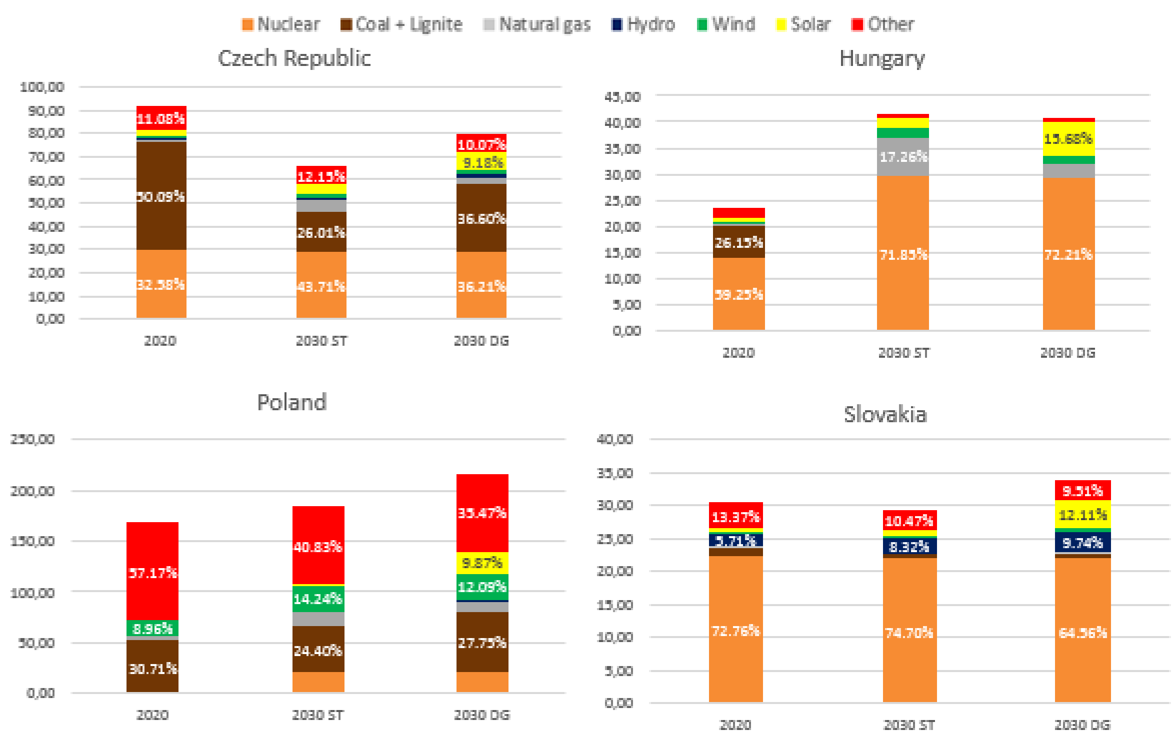
It is evident that the generation structure is very different in the four countries. Nuclear energy plays an important role in the region as expect from Poland all countries have significant nuclear capacities. Hungarian and Slovakian energy sector is heavily dependent on nuclear energy as in both countries more than 50% of produced energy is generated with this technology. In the future, the role of nuclear energy will probably increase in these countries with the planned new capacities at Mochovce and Paks, which we will discuss in more detail in the later chapters.

The role of combustible fuels is relevant in all V4 countries, but many differences can be identified. Poland and Czech Republic rely mostly in combustible fuels in electricity generation, Poland with a 90% share while Czech Republic with a 60% share of the total generation. In both countries, almost all of these generation is based on coal or lignite, which impose an important strategical challenge for the countries' governments with respect to climate policy goals. The role of combustibles is also relevant in Hungary and Slovakia but with smaller share in total electricity production (45% and 25%). Additionally, role of coal was not as important in these two countries as both had significant natural gas-based production as well in 2016. In all countries biomass and waste-based production accounts for 5-7% percent of total production which also incorporated in the combustible fuel category in Figure 4.

The renewable penetration in the electricity sector was highest in Slovakia in 2016 it was 25% based on IEA data. In all other countries it just surpassed 10%. The high share of renewables in Slovakia is the result of the great amount of hydro capacities. Almost 20% of the country's electricity generation was based on hydropower in 2016. Hydro also plays an important role in Czech Republic's energy mix with 6% share of the total generation. Wind power has a relevant share in Poland with 8% while the relative importance of PV is highest in Czech Republic and Slovakia with 3% and 2% respectively. In Hungary nor hydro, nor wind nor PV based electricity generation played an important role in 2016.

Finally, we present the outlook for 2025 and 2030 regarding the expected generation mix for the V4 countries. Figure 5 shows the forecasted electricity generation mix in 2020 and in 2030 based on ENTSO TYNDP 2018. As the fuel mixes will be discussed in more details in the following chapters of our study, we only briefly summarize the expected evaluation of electricity generation patterns.

Figure 5: Electricity generation mix forecasts for the V4 countries, TWh/y, 2020 & 2030, source: ENTSO TYNDP 2018



In the Czech Republic in both scenarios for 2030 generation capacity will face a sharp decrease overall relative to 2020. This decrease is the result of the disappearing coal and lignite-based production as in ST scenario it decreases to 17 000 while in DG to 30 000 GWh/year from 46 000 GWh/year. This decrease is at some level compensated by an increase in natural gas-based production in ST scenario and an increase in PV production in DG scenario. In both cases however nuclear and coal-based production remains the most important sources of electricity in 2030.

Hungary will produce twice as much electricity in 2030 than in 2020 in both scenarios. Mainly it is the consequence of the large increase in nuclear electricity generation, which remains Hungary's largest source of electricity in 2030. Additionally, in both scenarios coal and lignite completely disappears from the country's power generation portfolio. In the ST scenario additional significant increase in generation is observable in natural gas while in DG scenario in solar based generation.

In Poland electricity production increases significantly in both scenarios between 2020 and 2030. The increase is driven by the possible completion of new nuclear capacities until 2030. The completion of this project however is highly questionable, Poland has not yet developed a complete solution to how they will substitute their decreasing coal-based generation. Additionally, in both scenarios wind-based generation increases while biomass-based production decreases significantly. A large PV capacity expansion and production increase is expected in the DG scenario. Coal remains the most important fuel in the power generation sector in both scenarios.

According to ENTSO Report no major changes in the Slovakian power generation sector are expected between 2020 and 2030 as according to the plans the new nuclear capacities will become operational until 2020. In the ST scenario electricity production remains relatively constant between 2020 and 2030, while in DG scenario an approximate 5000 GWh/year increase is expected, mostly as a result of greater PV penetration.

Generation and system adequacy

The energy security position of an electricity system can be evaluated by comparing available generation capacities to consumption, taking into account only the domestic generation capacities, or both domestic and import sources. These are measured by generation adequacy (GA) and system adequacy (SA) indexes. These two indexes are defined in Equation 2 and Equation 3:

$$(2)\quad GA = \frac{G-C}{C}$$

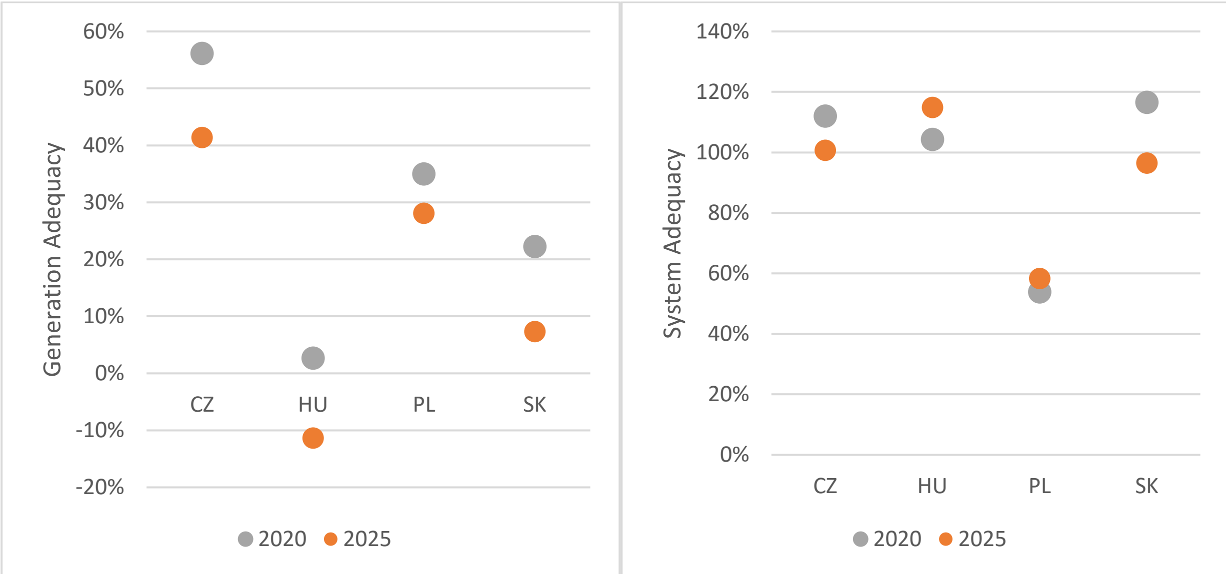
$$(3)\quad SA = \frac{G+I-C}{C}$$

Where G stands for the maximum amount of electricity that can be produced within the given country, I represent the amount of electricity that can be imported into the country while C stands for consumption. In this sense generation adequacy shows that to what extent domestic production can account for domestic demand, while system adequacy shows the same with imports allowed. If the generation adequacy value is negative that means that domestic electricity generation itself cannot fulfil all the domestic demand. A negative system adequacy value means that even with import, the country's demand exceeds available supplies, which is a sign of serious adequacy problems.

Even a positive value which is close to zero can be a sign of adequacy issues as if a disruption occurs in production or import, the system still will not be able to fulfil demand.

Based on REKK's modelling work and data gathering we calculated the generation and system adequacy indicators for the V4 countries for 2020 and 2025. The results of the calculation are summarized in Figure 6.

Figure 6: Generation and system adequacy of the V4 countries, 2020 & 2025, Source: Rekk's own calculations



Looking at the generation adequacy calaculations we can identify that the situation are very diverse between the different V4 countries. The generation adequacy values in 2020 are positive for all countries but as in the case of Hungary its value is only 3%, for Czech Republic it is 56%. Slovakia and Poland are inbetween with the values 22% and 35% respectively. This means that Czech Republic fulfill its consumption with their own power plant as the country generates 1.5 times more electricity than it needs. No serious generation adequacy issues occur in Poland and Slovakia as well. The 3% value for Hungary however means, that theoreticaly the country's electricity production can barely fulfill the demand.

For 2025 the generation adequacy index for all countries decreases relative to the 2020 values. Adequacy levele remains high in Czech Republic and Poland with 41% and 28% respectively. The self-sufficency of Slovakia becomes an important question in 2025 as generation adequacy decreases to 9%. Additionaly, based on the calculation Hungary won't be able to cover its demand solely based on own electricity generatioan as generation adequacy index for the country in 2025 decreses to -11%. This means that Hungary remains heavily import dependent until 2025.

However as countries can trade with each other, system adequacy gives a more detailed description about energy security. In 2020 all V4 countries but Poland will have a system adequacy indicator higher than 100% based on our results. For Poland the system adequacy measure is 54%. We concluded that the generation adequacy worsend for all V4 countries between 2020 and 2025, but this is not the case for system adequacy. We can observe a small improvement in the situation of Hungary and Poland, while a decrease in Czech Republic and Slovakia. The general situation however does not change based on our results as in 2025 the sytem adequacy measures of Hungary, Czech Republic and Slovakia remains around 100% while in Poland around 60%.

The adequacy indicator analyis showed that neither of the V4 countries are facing serious security of supply risks. On the other hand it also shows that Slovakia and at an even larger extent Hungary system adequacy measures shows good results mostly as a consequence of wide variety of import options. In contradiction with the above mentioned two countries, the adequacy level of Poland is mostly affected by the country’s own generation capacity. On top of that the expected system adequacy measure is significantly lower in Poland, than in the other V4 countries.

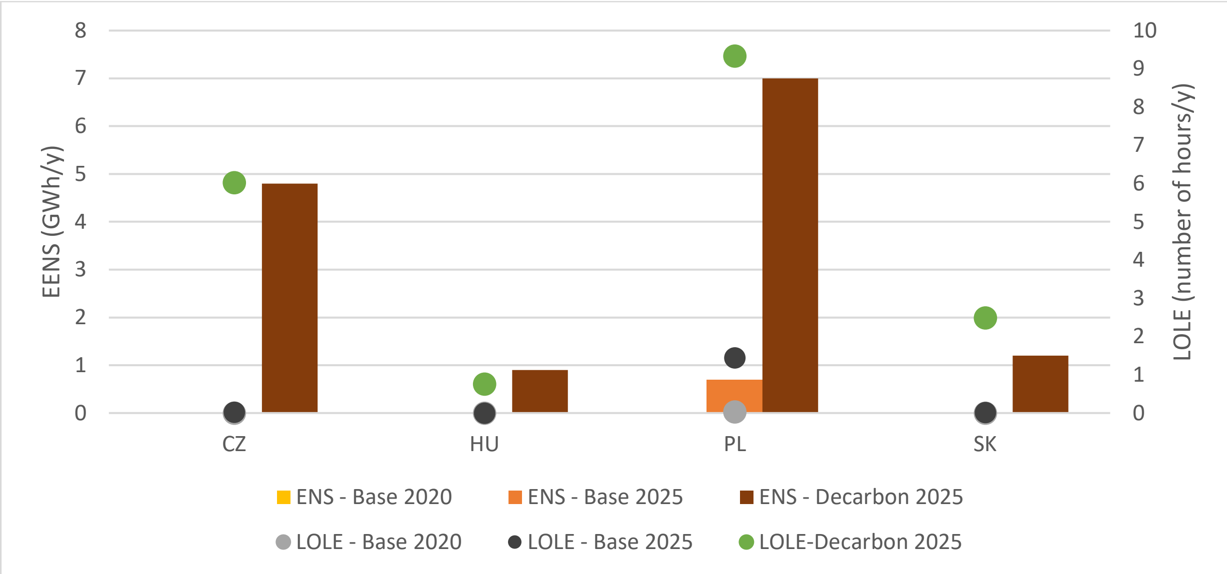
Adequacy modelling

Adequacy however can be measured in a more complex way through modelling. In a modelling framework not just simple capacity values can be calculated, but detailed interactions and trade with neighboring countries can be represented. In every year ENTSO-E publishes the Mid-term adequacy report (MAF) in order to evaluate the security of supply risk related to the European countries. In this sub-section we present the main findings of the 2018 MAF report, with respect to the V4 countries.

In the MAF report ENTSO-E models with several models for all hours of 2020 and 2025. The models generally focus on two important outcome variables, which are Expected Energy Not Served (EENS) and Loss of Load Expectations (LOLE). EENS shows that in a given year how much GWh energy was not supplied (measured in GWh/y) as demand exceeded available supplies, which are the sum of domestic production and import. LOLE shows the number of hours in which energy was not supplied. The variables are estimated with five different models, final results are the simple average values of the five models’ outcome.

Figure 7 summarizes the average EENS and LOLE values for the V4 countries in 2020 and 2025. We present the results of two scenarios, the base case which can be considered as a best estimate, and a decarbonization scenario. According to ENTSO-E the decarbonization scenario can be considered as a stress test as in this setting all countries decommission high carbonized generation capacities until 2025, without replacing them with new capacities. This scenario would result a capacity decrease of 23.36 GW in total in Europe, of which more than 8 GW capacity would be closed in Germany. From the V4 countries Czech Republic and Poland would be affected significantly with a capacity decommissioning around 1.5 GW for each country. Hungary and Slovakia are not significantly affected.

Figure 7: EENS and LOLE values for the V4 countries, 2020 & 2025, Source: ENTSO-E MAF Report 2018



By looking at the result we can see that in the base case scenario we cannot identify serious problems based on the modeling results. In 2020 both LOLE and EENS average values are very close to zero. For 2025 the situation changes only a little as for Czech Republic, Hungary and Slovakia the measured values do not change, however in case of Poland LOLE increases to 1.44 while EENS to 0.7 GWh/y.

With respect to Czech Republic the MAF report highlights that the country faces no adequacy risk until 2025. The conclusion is similar in Slovakia, however the report states that the presented good adequacy measures are only achievable if the two new nuclear units at Mochovce will be commissioned until 2020. The situation of Hungary is very interesting because based on the modelling the country will remain very heavily import dependent until 2025 (the new nuclear power plant at Paks will be commissioned after 2025), but modeling results does not indicate any adequacy problems as the country is very well interconnected with their neighbors.

The 2017 MAF report forecasted serious adequacy problems for Poland. Since the completion of the 2017 report however the country introduced a capacity mechanism. According to ENTSO-E modelling this policy intervention significantly reduced the adequacy risk at Poland. In 2025 some supply issues remain as the estimated LOLE is 1.44 hour/y while the EENS is 0.7 GWh/y, but these values are not critically high.

The adequacy measures changes, drastically however in case of a fast-paced decarbonization. The decommissioning of capacities would affect Czech Republic and Poland drastically with a LOLE values 4.8 and 7 hour/y, and EENS values 6 and 9.3 GWh/y respectively. These are the two countries where capacity reduction in the sensitivity scenario was drastic. It is important to note however that the other two V4 countries would be affected as well. In Slovakia LOLE reaches 2.5 hour/year while EENS increases to 1.2 GWh/y. The most robust country in this sensitivity scenario is Hungary as the LOLE only increases 0.76 hour/y with an EENS of 0.9 GWh/y.

To conclude this section the ENTSO-E MAF analysis shows that in neither of the V4 countries are serious adequacy issues present until 2025, but the system of Czech Republic and Poland are sensitive to fast-paced decarbonization. To evade adequacy problems Slovakia should commission its new nuclear capacities until 2020 while Hungary remains heavily import dependent this will not result in adequacy problems.

Section II: Decarbonization challenges

A. Future of coal

Based on the findings of Section II, coal is still an important energy source in the Visegrad Group countries, resulting in the serious challenge of deciding about the path and pace of transition of coal towards decarbonization.

Pressure on changes

Visegrad Group coal generation is a historical heritage with many old coal plants in the region where very rapid depreciation of assets is not expected. Based on the interview outcomes and on the roundtable on electricity sector at the Budapest Workshop, it has been concluded that one of the challenges shared among all Visegrad Group countries is decarbonization policy. The European Union's climate and energy policy sets an ambitious goal to reduce CO2 emissions and increase share of renewable energy sources in energy mixes, squeezing out coal-based electricity production continuously.

In the meantime, the V4 countries are facing the increasing goals of energy efficiency. Eurostat data show that Energy intensity in Visegrad countries is high above European Union average. That means one needs more energy to produce one unit of GDP than in countries with higher energy efficiency. In Hungary it is 177 percent more, in Poland 207 percent, in Slovakia 234 percent and Czech Republic 249 percent[9] above the EU average.

According to the high share of coal presented in Section I and the above energy efficiency values, the companies and power plants under the ETS scheme are to be pressured with projected increase of EU Emission Trading Scheme prices increase in whole Europe, with especially great challenges for the V4 region. Paris Agreement on global fight against climate change calls to increase efforts to keep the global prices increase under 1.5 Celsius degrees. According to the Carbon Tracker report, if European Commission aligns European climate policy to Paris Agreement goal, that would mean an increase in EU ETS prices for CO2 emission permit from present level around 20 euro per ton to even 55 euro in 2030[10].

That would create an increased pressure on energy sector to replace the high-emission energy sources like coal-based generation. With such EU ETS prices increase a transition would demand quick and expensive investment in alternative generation from nuclear and/or gas and renewables. However, the forecasts on EU ETS prices prognoses

[9] Eurostat, E3G, 2013
[10] https://www.carbontracker.org/eu-carbon-prices-could-double-by-2021-and-quadruple-by-2030/

differ. According to Polish authorities and business it might even decrease because of European Commission intervention or relaxed climate policy of new political forces in European Parliament in coming years[11].

The stakeholders of all V4 countries perceived the decarbonization as a challenge. For the Czech Republic, the alternatives to consider are changing generation into more nuclear or renewables combined. The same challenge stands in front of Poland which needs to decide how to fulfill an ambitious EU target of renewables generation and in front of Slovakia, looking for adequate renewables support scheme. Hungary might face a risk of price volatility connected to increased renewables generation. All Visegrad Group countries will need to elaborate a path towards decarbonization in the Integrated National Energy and Climate Plans for each of them to be presented to the EC until the end of 2018[12].

Path and pace of Energy transition

As a long-term solution, large investments are required to meet environmental standards in the electricity production of the region. In the short term, the risk of gap in energy generation could be lowered by subsidies for existing generation like the capacity market reform to be introduced in Poland. This solution might be limited by new regulation from European Commission: Clean Energy for All Europeans EU regulation package will introduce a limit on support from capacity market to units with emissions under 550 g CO_2/KWh, thus coal generation which is generating emission higher than this limit must be excluded from this mechanism. This could create a gap to be filled only with new generation.

Besides enhancing the circumstances of the generation side, the region might consider using the advantages of trans-border electricity trade better. The V4 stakeholders and representatives are pursuing an idea of flexible capacities for regional balancing. Polish representatives underlined the prospects of developing electricity imports from Germany, through Czech Republic and Slovakia, to Poland. Poland also brought up the risk of loop-flows to be addressed by Transmission System Operators.

As a longer term a solution, the energy transition will lead to the decrease of conventional high-emission generation parallel to the declining coal production in every Visegrad Group country. In 2017 it decreased to 15,4 mln ton of oil equivalent in Czech Republic (-3,8 percent), to 1,3 mln in Hungary (-13,5 percent) and to 49,6 mln in Poland (-4,4 percent). The future forecasts show that – especially in Poland – it is expected that domestic coal production will decline faster than coal-based electricity generation. It will lead to increase in coal imports and that is a political factor to be waged in Visegrad Group if they want to increase such reliance. This risk was underlined by Polish

[11] http://biznesalert.com/tchorzewski-ec-emissions-prices/, https://www.carbontracker.org/eu-carbon-prices-could-double-by-2021-and-quadruple-by-2030/
[12] https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/governance-energy-union

representatives. The alternative to increased coal imports is also an increase in nuclear and/or in renewable generation or increasing electricity imports.

Further challenge identified during the research was the potentially high big mothballing rate[13]. According to gathered data Czech Republic is safe, because it will have an overcapacity. But other three states are going to note high mothballing rate: Hungary -43 percent, Poland -27 percent and Slovakia -6 percent. To Poland the main issue is to replace old coal base with new generation from nuclear, natural gas and renewables, while both Slovakia and Hungary predict issues with nuclear project developments. The challenge of rising energy import share was also emphasized by many interviewees. To prevent increasing dependence on imports new power generation should provide the smallest CO2 emission possible and have the shortest pace of construction available. This is why Visegrad Group countries might favor gas, renewables and nuclear in their energy mix beyond 2030. However, even with significant nuclear investment in place, renewables and gas project might become a priority because of quick pace of their development.

Mátra case

MATRA Power Plant (first block started operation in 1969) is Hungary's largest coal-fired power plant with 950 MW installed capacity. The company uses lignite to produce electricity, which is extracted from local mines with opencast technology.

The current situation of the MATRA Power Plant is sensitive due to various reasons. As it provides close to 18% of the Hungarian production, its not too distant closure poses Security of Supply challenges in the Hungarian energy policy. Second, the plant ownership has recently changed, and the new owner is close to the ruling governing party, which brings some uncertainty on the planned closure of the plant in 2025-27. The plant also burns biomass in co-firing in significant amount (below 10%, yearly 0.5 TWh) and its reduction will have significant impact on the countries RES deployment.

The company's mid-term plans, published in August, 2018 react strongly to the current uncertain situation. Newly adopted strategy of the company targets to stabilize its status as one of the most important employers of the region and to maintain the its market position, recognizing the fact that the "coal era" is expected to end in a decade. According to the strategy until 2030 the main directions of development are renewable based electricity generation, balancing and energy storage.

- installation of two photovoltaic power plants, total of 40 MW capacity,
- installation of a new facility to burn annually 400 thousand tons of refuse derived fuel by 2021,
- acquisition of the company's biomass supplier, Geosol,
- installation of a 5 MW dry storage in cooperation with Tesla,
- installation of a new conventional pump-storage power plant with 600 MW capacity.

Last year the company realized 9 billion HUF (approximately 28 million EUR) loss so the management decided to sell the company's 16 MW photovoltaic power plant in Visonta and some other properties to finance new investments.

[13] ENTSO-E TYNDP 2018

Besides future plans the company is determined to maintain its core activity by building a new coal fired block with the latest technological solution. The implementation and financial plans to build a high-tech block with Oxy-fuel technology are in progress, studies about the suitability of the site has been conducted and concluded with a positive judgement. In the short term the role of biomass, solar energy and refuse derived fuel is expected to be more important, as the opening of new coal mine is planned for 2020.

Summary

To sum up, the future of coal in the Visegrad Group region is bringing up huge uncertainty, pressured by the climate policy of European Union. The conclusion of the debates shows a need of diversification in national energy mixes. In this term, Poland is looking for a way to keep coal in its mix for as long as it is possible, while thanks to nuclear generation other Visegrad Group countries are not under the same pressure and consider changes towards more nuclear or renewable and natural gas generation. However, because of national characteristics the pace of Energy transition and its path might differ among Czech Republic, Hungary, Poland and Slovakia.

B. Future of nuclear in the region

In general, the **countries of the Visegrad Group share a positive attitude towards nuclear energy,** compared especially to both their German-speaking neighbours Germany and Austria. Nevertheless, **each state finds itself in a different position towards nuclear energy.** Three of them have already included nuclear energy into their national energy mix (CZ, HU, SK); in two of the countries, additional units are currently under construction (HU, SK), and two of them consider to build some as well (CZ, PL).

Hence, in the foreseeable future the Visegrad countries are most likely not going to join the trend of de-nuclearization that currently dominates some western-European countries; on the contrary, **nuclear-based electricity production is going to be maintained or even rise** as kind of a balance to current expansion of intermittent renewable sources.

Nonetheless, construction of a new nuclear unit or a whole power plant is always a project for years, sometimes even decades, **bears enormous financial and political costs** and due to a quickly transforming energy environment could even face issues regarding its immediate economic profitability. This is **what nuclear projects in all four states have in common – necessity of strong political decisions**.

Czech Republic

Table 2: Operating Czech power reactors, Source: World Nuclear Association, 2018.

Operating Czech power reactors

Reactor	Model	Net MWe	First power	Licence to
Dukovany 1	VVER-440 V-213	468	1985	indefinite
Dukovany 2	VVER-440 V-213	471	1986	indefinite
Dukovany 3	VVER-440 V-213	468	1986	indefinite
Dukovany 4	VVER-440 V-213	471	1987	indefinite
Temelin 1	VVER-1000 V-320	1028	2000	2020
Temelin 2	VVER-1000 V-320	1026	2003	2022
Total (6)		**3932**		

Brief history

The nuclear power plant Dukovany is the older of nuclear sources in the Czech Republic. Four units had been gradually put in operation from 1985 till 1987 in cooperation of Czech companies with entities from the former Soviet Union (EnergoProjekt and Skoda Praha). Currently the plant represents one of the most frequented energy-related topics of the national politics, as the estimated phase-out is approaching – which is also one of the reasons, why NPP Dukovany is under even higher attention and were given higher priority.

At the end of 1970s, the younger plant Temelin was supposed to be built as a four-unit power plant. However, due to the turbulent period of 1989 and later, the plan has been reduced to two units only (see more about the expected expansion see below). First electricity supplies from Temelin were introduced to the grid in December 2000, and today it is the largest energy source in the country.[14]

Current state

Both Czech nuclear power plants are planned to be kept in operation until 2040s and 2060s respectively, helping to reach climate goals by replacing mostly coal based generation. At least this is the strategy outlined in the State Energy Policy. The document counts on nuclear power to replace coal as the main pillar of electricity generation by 2040 when it should reach 46 or 58% of total gross power generation (currently around 33%).

The most discussed topic in the Czech electricity sector is the proposed construction of new units in the nuclear power plant Dukovany. One new nuclear unit (1,000 MW) should be put in operation in the location by 2035, followed by another one later. The final decision on the construction has been delayed; the most important obstacle is the general uncertainty over electricity prices in the future and economic profitability of the new units. A final verdict is expected

[14] Historie a současnost elektrárny Temelín. *ČEZ*, 2018. Available: https://www.cez.cz/cs/vyroba-elektriny/jaderna-energetika/jaderne-elektrarny-cez/ete/historie-a-soucasnost.html

at the end of 2018. Several international companies or consortia from Japan, France, China, South Korea, Russia and the US have already expressed their interest in the project as suppliers of technology.

Similar problems with macroeconomic forecasts already led to the cancellation of Temelin nuclear power plant expansion in 2014. One or two new nuclear blocs were supposed to be built there in addition to the existing nuclear units (2× 1055 MW), as was announced in 2008. CEZ, the partly state-owned operator and owner of both plants, had been already processing the tender for few years, when the government decided to give no financial guarantees of economic profitability of the project. In reaction to this decision, CEZ cancelled the tender and has frozen the whole project.

Hungary

Table 3: Operating Hungarian power reactors, Source: World Nuclear Association, 2018.

Operating Hungarian power reactors

Reactor	Model	Net MWe	First power	Scheduled close
Paks 1	VVER-440/V-213	470	1982	2032
Paks 2	VVER-440/V-213	473	1984	2034
Paks 3	VVER-440/V-213	473	1986	2036
Paks 4	VVER-440/V-213	473	1987	2037
Total (4)	1889 MWe (2000 MWe gross)			

Brief history

Construction of the first pair of units in Hungarian location Paks was launched (in cooperation with Atomenergoexport) in 1974, with another pair in 1979; all were gradually put in operation until 1987. The plant is owned and operated by a subsidiary company of the state-owned MVM Hungarian Electricity Ltd.

The lifetimes of all units was predicted for 30 years, but as no technical objections were found, all of them could stay in service for further two decades and have been furthermore technically improved repeatedly.

Current state

Nuclear energy sector today plays a significant role in the electricity production of Hungary. The units in Paks location produce roughly half of all electricity production of the country, while they represent 23% of overall installed capacity (the total electricity generation capacity in Hungary reached 8266 MW in 2016).

As the current 2000 MW of installed capacity is going to be phased out around mid-2030s, the government of Hungary decided to build two additional units in Paks. They were actually planned to be constructed in the 1980s, however, the plans were cancelled due to developments of 1989.[15]

After a lengthy domestic debate, in 2009 the parliament of Hungary approved the decision to build the two units, and later to launch a public tender. However, in January 2014, instead of continuing with the tender the government signed an agreement with Russian Rosatom on construction of the units as well as 80% of financial coverage in a form of a state loan by the state of Russia, which shall be repaid in the future. These steps were widely criticized (e.g. by Austria) and had to be negotiated also with the European Commission. At the end of the day, Hungary gained success with an argument of technical exclusivity. [16]

Despite political debates, construction of new units with planned capacity 2400 MW has already started and they are planned to be commissioned at the end of 2020s – and thus for several years not only replace, but temporarily supplement the generation provided by the older units.[17]

Poland

Poland is the only country of the Visegrad area without any commercial generation of electricity from nuclear sources. The Polish government has already expressed its interest in development on this field; e.g. in 2010 released an official Polish Nuclear Power program[18] as an eventual alternative for the future development of national energy sector. The document outlines a plan to establish nuclear-based production in three phases: 1000 MW by 2024, 3000 MW by 2030 and 6000 MW by 2035.

Nevertheless, there has not been neither any specific decision about the practical matters of the project (such as financial background, technology, fuel) nor any significant decision about the realisation of the program as such. Also the proposed date of 2024 as well as 2030 for the start of operation is highly unrealistic. Hence, even despite proven foreign interest in launching projects in Poland,[19] the future of nuclear energy in the country remains uncertain; and deserves a strong political decision. A new energy policy for the state for 2030-2050 is among the most-awaited documents.

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[15] Nuclear Power in Hungary. *World Nuclear Association*, 2018. Available: http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/hungary.aspx

[16] Commission told Hungary how to win approval for Russia-backed nuclear plant. *Euractiv.com*, 2018. Available: https://www.euractiv.com/section/energy/news/commission-told-hungary-how-to-win-approval-for-russia-backed-nuclear-plant/

[17] The new blocks will be ready on schedule. *Website of the Government of Hungary, Minister Without Portfolio*, 2018. Available: http://www.kormany.hu/en/minister-without-portfolio/news/the-new-blocks-will-be-ready-on-schedule

[18] NIK o realizacji Programu polskiej energetyki jądrowej (PPEJ). *Supreme Audit Office of the Republic of Poland* (*NIK)*, 23.3. 2018. Available: https://www.nik.gov.pl/aktualnosci/nik-o-realizacji-programu-polskiej-energetyki-jadrowej-ppej.html

[19] Korean companies to help Polish nuclear power. *Poland in English*, 20.9.2018. Available: https://polandinenglish.info/39097320/korean-companies-to-help-polish-nuclear-power

Slovak Republic

Table 4: Operating Slovak power reactors, Source: World Nuclear Association, 2018

Operating Slovak power reactors

Reactor	Model	Net MWe	First power	Expected closure
Bohunice V2-1	V-213	472	1984	2024
Bohunice V2-2	V-213	472	1985	2025
Mochovce 1	V-213	436	1998	
Mochovce 2	V-213	436	1999	
Total (4)		**1816 MWe**		

Brief history

The nuclear electricity production sector has been established in the former Czechoslovakia. The construction of the very first nuclear power plant started in 1958 in the location Jaslovske Bohunice. However, despite being put in commercial operation in 1972, the unit had to be shut down in 1977 because of serious technical issues.

In 1972, the government started another project of construction of two units in cooperation with Atomenergoexport. The first unit had been connected to the grid in in 1978; the second two years later, and were kept in operation until 2006, respectively 2008. Their shutdown was among conditions for Slovakia to join the European Union.

In the same location, in 1984 and in 1985 respectively, two following Atomenergoproekt-designed units were also put in commercial operation. During the recent years, both went through series of general modernisation; bringing the capacity of each unit from 440 gross to 505 MWe gross (472 MWe net) and prolonging their expected lifespan even until mid-2050s.[20]

Current state

The current Slovak nuclear energy policy is outlined in the new version of Energy Policy of Slovak Republic since October 2014 and possess a high importance[21] - in 2016, nuclear power plants already generated the main portion of electricity in Slovakia (53.8% or 14 774 GWh; they represent 24.7% of installed capacity).

In 1982, a plan was adopted to build further two units in the location Mochovce. Construction of four units was already planned there in the 1980s, but the plans have not been implemented due to the turmoil of the revolution and 1990s; thus the first two units were finished in 1998 and 2000 respectively. The last two are currently under construction and are expected to be put in operation in the upcoming foreseeable future, most likely during the

[20] Nuclear Power in Slovakia. *World Nuclear Association*, 2018. Available: http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/slovakia.aspx
[21] Energy policy of Slovak republic. MHSR, 2014. Available: https://www.mhsr.sk/uploads/files/47NgRIPQ.pdf

following two years, bringing 2x471 MW of additional installed capacity into the Slovakian power system – which means that each unit is about to cover 13% of domestic consumption of Slovakia.[22]

Thus, Slovakia is going to have six nuclear units with installed capacity of 500 MW after the completion and modernisation of NPP Mochovce 3, 4 and will have total installed generation capacity at all nuclear power plants of approximately 3,000 MW in 2020 with annual generation of 23,400 GWh.[23]

C. RES & Co-existence of nuclear and renewables: How to ensure flexibility

The aim of this chapter is to summarize future challenges and regional actions to be taken regarding the coal generation in V4. It is based on V4 Energy Think Tank Budapest Workshop: roundtable on electricity talks. Think tanks from Visegrad Group countries were to take a stock of security of supply issues that are important from the viewpoint of their Energy policies. Those can be seperated into capacity adequacy related issues, interconnection issues, system flexibility issues, decarbonisation policy related challenges and distribution network issues.

As presented in the previous chapter in three out of the four V4 countries nuclear energy represents an important part of power generation and will do so in the future as well. On the other hand, RES deployment is on the rise, that poses serious challenges regarding system balancing. Nuclear power plants are (mostly) not suitable for balancing, thus these countries will face a power system, where huge non-flexible baseload capacities and higher and higher share of renewable – basically intermittent – capacities will coexist. In order to understand the possible consequences, estimate expected costs and identify potential solutions we first give a brief overview on past and future renewable developments in the region.[24]

State and future of renewables: penetration and support schemes

Renewable energy related policies, and especially support schemes are challenging to set, as technical developments and breakthroughs shape the economic environment continuously. Several countries faced extremely fast renewable penetration as a result of "too high" support levels, adjusted too late. Slovakia and the Czech Republic both found themselves in such a situation when starting their renewable support programs.

Slovakia has set out its renewable support system in 2009, when setting a high feed-in-tariff accompanied with preferential grid access and arrived to around 200 MW installed capacity of PV in one year. To avoid too high financial burdens due to renewable support budget, subsidies for large PV installation has ended in 2011. Since then, only small and/or rooftop installations are supported. Still, by 2018 577 MW PV capacity has been installed. Slovakia has already reached its 2020 RES target of 24%[25] for electricity, mostly thanks to its hydro based generation capacities (11% of total installed capacities). However, the country is still lagging behind in the heating and cooling sector, thus

[22] Mochovce 3 a 4 ve výstavbě. *Slovenské elektrárne*, 2018. Available: https://www.seas.sk/mochovce-3-4

[23] Slovenské elektrárne, 2018. Available: https://www.seas.sk/mochovce-3-4

[24] Data and findings are based on the country reports if not otherwise indicated

[25] National Renewable Energy Action Plan, Slovak Republic, https://ec.europa.eu/energy/en/topics/renewable-energy/national-action-plans

the overall RES target is not reached yet. This can lead to a need for further RES-E capacities, but only if this solution remains the more feasible compared to renewable heat.

The situation regarding solar supports was similar, but even more extreme in case of the Czech Republic. Generous feed-in-tariffs were introduced also for 2009-2010 – the years of steep decline in PV panel prices -, that resulted in a "PV-boom": by now, from the 2380 MW renewable capacities around 2100 MW is solar. This high uptake resulted in increased final consumer prices and a significant burden for the state budget – even a solar tax was introduced in 2010 (for larger than 30 kW PV capacity), as an ex post correction. As a result, the country has already reached its renewable targets for 2020, but due to policy documents another 1000-2000 MW solar capacity is to be installed until 2030. The development of wind power (the other important intermittent source) has been effectively hindered by complicated permit procedure and protests of local civil organizations.

Quick penetration of PV capacities seems to arrive to Hungary a decade later: after slow progress, as a result of change in support schemes, at the end of 2016 (just in time to be registered in the former system) around 2000 MW PV capacity licenses were applied for. In the new support system (called METÁR) feed-in premium was introduced, instead of feed-in tariffs (with the exception of household PPs). This means, that producers (other than households) need to bring their energy to the market and will receive the support in a form of a supplement, to reach a pre-defined price level. Also, the support period was shortened, and (above 1 MW capacity) support is offered through an auction. The government tries to help the realization of these projects and incentivizing planning of others through regulation and facilitation of easier licensing. This led to even more planned PV capacity (latest estimation based on market participants' opinion is 2500-3000 MW). Wind capacities are prohibited to be installed too close to populated areas, meaning practically can not be placed to any location inside Hungary.

In Poland total installed RES capacities account for 8.5 GW, from which almost 6 GW is on-shore wind, and only 107 MW is PV. With these capacities 10% of inland electricity production can be managed from renewable sources. All other sources are fossil based, that – in comparison to the other three countries – puts Poland to a better situation regarding system integration and balancing, as fossil fueled power plants are much more suitable for providing flexibility than nuclear power plants.

System integration and balancing

Czech electricity generation system has to deal with uncertainties related to the fuels it is based on. The need for nuclear plants to replace coal in base load generation is getting clearer but the market conditions are not favorable for such huge investments. If nuclear is not a feasible option for the country the market could shift towards to natural gas which is a favorable fuel in terms of the ongoing EU market liberalization, new infrastructure projects, the new opportunities of the potential expansion of LNG market, but also raises energy security issues and exposure to high natural gas prices.

The expansion of natural gas fired power plants has a limited magnitude as these are mostly seen as peak load sources able to balance other sources like renewables. Natural gas fired plants could generate as base load sources, but current capacity is not enough to ensure that sufficiently. Integration of decentralized power generation is one major challenge for TSO and the DSOs, next to energy storage, electromobility or the increasing role of aggregators. However, according to government representatives, the integration of intermittent sources into the grid should not pose problems in the near future. The establishment of technical solutions and legislative conditions for future providers of flexibility and aggregation is also an inevitable step for the regulator.

Sudden increase in renewable penetration in Hungary can cause significant changes on the wholesale market and will pose a great challenge for DSOs. Decentralized household PVs can feed in electricity to the grid, but if needed, power is used in-house. DSOs are obliged to offer a local connection point for free for power plants willing to connect to medium voltage level, within 3 kilometers from their grid. All these puts additional financial burden to DSOs, while the integration of significant amount of intermittent capacity in the system is a great challenge alone.

Higher share of RES and the new nuclear facility raises question regarding the role, necessity and financial viability of fossil fueled power plants. Higher share of renewables usually leads to lower wholesale prices, that possibly puts fossil fueled power plants into a difficult financial situation. In the same time this situation requires more capacities that are flexible and reliable enough to keep the system in balance. Maintaining the capacities that are suitable for balancing is difficult as the closure of Matra Power Plant is approaching and several natural gas fired plant went to a permanent shut down and significant capacities are facing a decision soon. The reoccurrence of price spikes might help to keep them in the system, but if not, some form of support should ensure their operation.

Expected decrease of revenues for DSOs as a result of growing RES generations is an important issue in Poland too. However, as the country provides its baseload generation by coal-based power plants, the volume of non-flexible generation is smaller than in the other countries. Polish energy policy foresees the possibility of two nuclear power plants, but as the standard timeframe of such investment is ten years the current status will last at least until the end of the next decade.

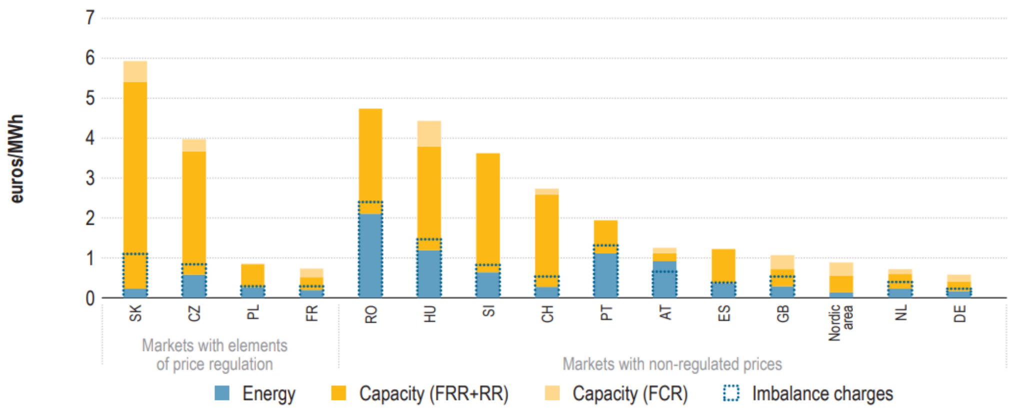
Slovakia continuously develops its nuclear and RES generation while the capacities of other sources, like coal and natural gas based power plants are decreasing. Currently two coal-based facilities and hydro power plants ensure flexibility on the Slovakian electricity market. Production of these facilities is reducing, and their technical condition deteriorates as there aren’t much investments due to the need to limit emissions.

The problem of grid stability vis-a-vis decrease of flexible sources like gas- or coal-fired power plants and commencement of new and non-flexible nuclear sources is very important and has been stressed by the Slovakian regulator. The main challenge in electricity area will be to balance the grid.

Two new reactors which will be connected to the grid expectedly in a year will turn Slovakia into net exporter. These nuclear facilities are able to provide only base load and RES are specific for their intermittent nature (which in combination with preferential access to the grid increase the need for a back-up capacity), so coal-fired and gas-fired power plants play an important role in balancing the grid system. Thus, the two new reactors will further contribute to the existing problems with grid balancing. Unstable and hardly predictable RES sources will need to be balanced in a system with a very high share of electricity from rigid (and base load) nuclear sources.

According to the ACER Market Monitoring Report balancing costs differ a lot in the V4 countries but are in line with the previous status descriptions. Cost of balancing is very high in all of the V4 countries excepting Poland, where the problem of non-flexible nuclear generation is not present.

Figure 8: Overall costs of balancing (capacity and energy) and imbalance prices over national electricity demand in a selection of European markets, Source: ACER MMR 2016, Data provided by NRAs through the EW template (2017) and ACER calculations



The role of flexible capacities is important as the cost of generation of balancing energy accounts for a significant part of overall costs in some countries, especially in Hungary and to some extent in Poland. However, in Slovakia and the Czech Republic the overwhelming part of balancing costs is the costs of procuring balancing capacity.

Unit costs of activating balancing energy is the lowest in countries where prices are regulated, for example in Slovakia where the energy activated from reserves has regulated price just like energy activated from automatically activated Frequency Restoration Reserves in the Czech Republic. These lower unit costs do not necessarily cover all expenses, presumably additional costs occur when reserves are tied up.

Capacity mechanisms

In the V4 region only the Polish electricity market has a capacity mechanism. The electricity capacity market with a market wide capacity mechanism in the Polish market was approved by the European Commission in February 2018. This mechanism is created to support security of supply as it rewards the providers of generation capacity in return for maintaining existing capacities or investing in new capacities. So this change in the market helps to reverse negative processes like the deterioration of conventional fossil fuel based generation capacities as Poland is highly exposed to mothballing risks. It is expected that significant baseload capacities will be decommissioned in a decade, but the more important concern is to meet peak hour demand, so it is crucial for Poland to install more peak load generation capacities like PVs.

Capacity mechanisms operate in most of the Western European countries but there is a lively debate in the topic in Eastern countries too. Czech regulator strictly claimed the view that energy-only market is not enough for the country but they were probably influenced by the development of capacity remuneration mechanisms and strategic reserves in several European countries. So it is expected that the regulator aims to react to these trends and develops tools to support generation capacities which are essential to provide grid stability. According to the opinions of market players it is foreseen that strategic reserve could be applied in the country in the near future.

To sum up integration and balancing of intermittent RES capacities will mainly be an important issue for Slovakia, the Czech Republic and Hungary, and be of less interest for Poland. All three above mentioned countries will make securing continuous, predictable income challenging for fossil fueled based power plants, as nuclear based capacities on their own will probably turn even net importer countries to net exporters. The need for flexible capacities next to intermittent RES will be there however, thus solutions need to be considered to keep these plants in the system.

Section III: V4 Region is not Beyond Gas

Security of supply of natural gas has been the most prominent energy issue within energy policies of the V4 countries since the 2009 gas crisis. This energy source gained importance especially in connection to energy security as its uninterrupted supplies became one of the top priorities not only within the V4 group, but also at the EU level. Although natural gas is a fossil fuel and its burning produces CO_2 as well as other emissions, the amount of emissions is much smaller compared to other fossil fuels like coal (especially lignite with a very low carbon content) or oil. Natural gas is therefore considered to be a bridging energy source – a bridge between heavily polluting sources and renewable sources of energy. It can replace existing fuels much easier than renewables (for example, coal-fired power plants can be retrofitted to use natural gas, ships can be upgraded to use natural gas as fuel, etc.) while it is fully compatible with the existing infrastructure (does not require back-up like renewables, can be used in centralised systems, it is stable, predictable, and flexible, etc.). On the other hand, the V4 countries (and the EU as such) is heavily dependent on its supplies from third countries (Poland and Hungary produce considerable share of total gas consumption domestically, however, the latter experiences significant drop of production). Moreover, renewables have to dominate energy mix of the EU countries if the ambitious goals of 2050 Energy Strategy which objective is to create decarbonised economy have to be met[26].

One of the main results of this research entitled "Beyond Gas" is – paradoxically – that natural gas is here, in the V4 region, to stay. Natural gas is considered by the V4 countries to be a key energy source within their energy mix and, what is crucial for their energy sector, an answer to several challenges that the region faces. Problems of the V4 countries discussed in the Section 2 connected to decarbonisation (decrease utilisation of coal and increase use of renewables for energy generation in systems with high share or nuclear) can be solved with increased use of gas in electricity generation. Natural gas is therefore considered to have a crucial role in the energy mix of the V4 countries in the future. Moreover, the newly built infrastructure as well as pipelines under construction further increase energy security of the region in natural gas sector and create a lock-in of natural gas for longer period making this energy source a firm part of the future development of V4 energy sector.

The role of natural gas in energy mixes of the V4 countries

[26] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0885&from=EN

The role of natural gas in energy mixes of the V4 countries is not the same, however, there is an expectation that its share will increase (the Czech Republic and Poland due to switching from coal-based generation to gas-fired units) or that it will at least stay stable in short- and mid-term perspective (Slovakia and Hungary, where no switching in the power sector is expected). Most of the natural gas V4 countries consume is supplied by Gazprom on the basis of long-term contracts. The only exceptionis the Czech Republic that currently does not have such contract and buys its gas on spot markets. All V4 countries have access also to natural gas spot markets, ie the Central European Gas Hub in Baumgarten or NCG in Germany. Poland can access the global LNG markets via the LNG terminal, on which they can buy natural gas on a short-term basis. For Hungary the planned LNG Krk in Croatia will be a significant diversification project allowing access to alternative supplies to Russian gas (however, additional compressor expansion is needed in Croatia). Italian and Polish LNG terminals are possible sources of LNG for Hungary too, however, the cost of sourcing gas via these routes is more costly.

All four countries have diversified their natural gas sources during the last period (in most cases especially after the 2009 gas crisis, although in the case of the Czech Republic there has been a diversification also much sooner) and they also upgraded storage that is sufficient to cover their needs or even provides surplus capacities (Hungary). Poland is currently in the process of significantly increasing its storage capacity (from 3 to 7 bcm until 2025).

Hungary is able to cover its consumption by non-Russian supplies, there is sufficient infrastructure to allow such step. However, the infrastructure faces also some physical limits. For example, the utilisation rate of a pipeline between Hungary and Austria (HAG) is very high and it has repeatedly reached its physical limits. A high priority for Hungary is to upgrade pipeline capacity between Hungary and Romania that has nowadays very low capacity in the direction to Hungary (0.1 bmc/year). After the upgrade, the pipeline will enable Hungary to gain access to alternative supplies and also to Romanian domestic production.

Development of gas infrastructure

There is a cooperation between V4 countries in the development of PCIprojects, most of which are part of “North-South gas corridor”. Implementation of many of these PCIs is supported by Connecting Europe Facility financial instrument of the European Commission.

Table

The most challenging infrastructural project for the V4 countries is Nord Stream 2 pipeline. On the one hand there is Poland with a very strong position against the pipeline backed by Slovakia with negative attitude. On the other hand there is the Czech Republic and Hungary that are assuming neutral approach. Polish position is that Nord Stream 2 will limit market competition and undermine competitiveness of diversification projects supported by the European Union. Slovaks opposes Nord Stream 2 as they see it as a way how Russia wants to circumvent Ukraine – and therefore also Slovakia – as transit country. Czechs have a neutral position together with Hungary . Slovak and Czech positions towards transit are very similar, they both view it as a guarantor of energy security. However, the consequences of Nord Stream 2 commencement will be opposite in this area – while the Czech Republic expect increase, Slovakia expect sharp decrease of transit (similar to the decrease of transit volumes after Nord Stream 1 was finished).

Moreover, for Slovakia this issue is connected also to a risk of stranded assets. With the current contract between Russia and Ukraine on transit (via Brotherhood pipeline system) terminates at the end of 2019, the future of this transit – that is directly connected to Slovak system – is unclear. Although Slovak TSO has a transit contract with Gazprom until 2028, the development in connection to Ukrainian-Russian relations and possible building of Nord Stream 2 are in Slovakia viewed with scepticism. In order to replace the expected loss of transit capacity after 2019, Slovak TSO is developing Eastring pipeline that is supposed to connect Slovak transmission system with proposed Turk Stream.

Poland strongly supports Ukrainian transit that it sees as an important for energy security of the whole EU. Polish government prioritize Baltic Pipe, connecting Denmark with Poland as the main diversification project in natural gas area (the final investment decision shall be made until the end of 2018). The government is trying to finish the interconnector before renegotiating supply contract with Gazprom to get better position (the current contract expires in 2022). However, it is not clear whether there will be a new contract with Gazprom. The goal of the current Polish projects in natural gas area is to support full replacement of supplies from Gazprom as the mutual relations between the two countries are very weak. Polish gas company PGNiG and Gazprom are currently having an arbitration concerning gas price for pipeline gas flowing to the country via Yamal pipeline.

The second issue where there is no agreement between V4 countries is a new proposed gas interconnector (BACI pipeline) between Austria and the Czech Republic. Currently are these two countries connected via Slovakia and the main reason for development of this new pipeline is Czech TSO's (Net4Gas) disagreement with Slovak TSO's (Eustream) transit policy and pricing. However, the Czech regulator's negative position towards this pipeline, supported by the Slovak TSO postponed development of this project.

The role of natural gas in energy generation

All V4 countries except for Poland expect in the short and mid-term problems with grid stability besides loop/transit flows (see the previous section). The main challenge is the future composition of energy mix that will consist mostly of unflexible nuclear base load and intermittent renewables sources of energy – a combination that will make electricity grid difficult to balance. The solution to this problem is considered to be connected to gas-fired power plants. These are flexible and thus can provide grid balancing (different types of regulation) as well as back-up for difficult-to-predict renewables. Gasfired power generation is currently not competitive with other fuels of generation, consequently and a lot of gas-fired capacity in the region was mothballed. The current decrease of natural gas price and slight increase in wholesale electricity price and CO2 prices and expected changes in grid balancing support revitalisation of this type of power generation.

The most important gas-fired power plant in Slovakia is Malženice that has 436 MW of installed capacity and was recently bought by Západoslovenská energetika, a.s. a partly state-owned electricity company with the aim of using it for balancing purposes. Czech Republic also faces problems with intermittent RES connected to stability of the electricity grid. Coal-fired power plants are helping to keep high level of grid stability. However, they will be facing decommissioning in the period after 2035 what will influence grid stability (characterised by a high share of RES and nuclear). Natural gas is viewed by the Czech TSO as a source to cover peaks, to balance the system, not as a provider of base load. There is an expectation, that this type of power plants will replace coal-fired power plants place in regulation. However, other Czech stakeholders see natural gas as more complex solution to energy issues of the country. Current installed capacity of gas-fired power plants is about 1850 MW.

A significant challenge for Hungarian electricity system would present a situation when the decommissioning of Paks 1 would come before commissioning of Paks 2 and the country would stay without a base load generation (coal-fired Mátra power plant will be decommissioned soon). Natural gas can be a solution to this problem too. However, 1200 MW of gas-fired power plants were mothballed during last 5-10 years with a questionable restarting option. These power plants have proven to be expensive and only reoccurrence of price hikes might help them to keep them in the Hungarian system.

Contrary to other V4 countries, Polish electricity grid has already experienced problems with insufficient peak load generation. Especially during the summer months when demand was higher due to the use of air conditioning the Polish grid has experienced situations of grid overload. Increased share of RES (as envisioned in the latest proposals by the EU) can further negatively influence stability of the Polish grid. However, according to Polish authorities, these problems could be remedied with the help of capacity market reform (see previous Section). Natural gas is in Poland viewed much less as a solution to grid balancing issue and more like a solution to air quality problem - Polish Ministry of Energy recommends development of small scale LNG that can support gasification of the country. This, in turn, can help mitigate climate issues and problem with low air quality.

Section IV: Actions at national and regional level

Gas dependency related answers

Poland can already access the global LNG markets via the LNG terminal. Further significant diversification projects allowing access to alternative supplies to Russian gas are the planned LNG terminal in Croatia and extension of the already existing Polish LNG regasification capacities. The extension of LNG facilities will ensure better connection to the global LNG market.

While it is challenging to find gas pipelines projects which envoys high priority support from all the four countries, it is possible to implement **gas infrastructure related investment risk mitigation strategies** which might help to share the investment costs and expected gains among the countries. All countries except for Poland are able to supply (theoretically) the import need from alternative sources, but further gas infra investments will be on the table after 2020, too.

The third way of adaptation to gas dependence is by following the mainstream European trends and **increase the domestic RES–E deployment** in a more dynamic way. Up until now, the V4 countries followed a rather ambiguous path in this respect, characterized either by a static, slow deployment of PV, wind and biomass capacities, or even having retroactive changes in their renewable support schemes (e.g. the case of the Czech Republic in 2011–2012 after the steep uptake of PV penetration capacities) or a very sluggish legislative procedure introducing a new support schemes after the old styled FIT schemes are halted (e.g. Hungary and Poland). The region is not very active in introducing new RES auction schemes neither, only Poland had two PV related tenders in 2016–2017, but e.g. the planned wind tender of this year was cancelled. If this trend would change, and the V4 would take a more dynamic approach in this area, that would mean a possible adaptation path, where energy security would be positively affected. RES–E is counted as domestic resource, once built, and would help the countries to reduce use of imported natural gas, further improving security of supply.

System adequacy related answers

An answer to the regional system adequacy concerns could be **expanding nuclear capacities**, as three V4 countries have serious plans to extend their nuclear fleet, and even Poland considers this option. Again, this option has to be viewed through the energy security perspective. The utilisation of large base load generation capacities, such as nuclear will have their questionmarks in the future in a transformed EU electricity system with high RES deployment, requiring rather flexible than base–load units.

Flexibility related answers

In addition to hard measures (e.g. building up new flexible capacities or paying capacity payments for idle fossil generators) the answer to growing flexibility needs could be the **further integration of electricity systems.** In a more integrated regional and EU–wide electricity system, handling the variation caused by high production volatility would be less costly, and system adequacy issues not even arise in contrast to single national systems, where adequacy of the system must be maintained within the national borders. In this area the V4 countries show a mixed picture, Poland operates close to 'island' mode, meaning very narrow interconnection margin with neighbours (even if physically some connections are in place e.g. the new PL–LT line), Hungary being connected to its southern neighbours, but having network constraints with Slovakia and Austria. The result is, that while Slovakian and Czech electricity markets are coupled with the integrated European market, Hungary and Poland stay out of the 'continental' price zone (even if Hungary is part of the market-coupling with Slovakia and the Czech Republic), and consumers in these countries have to pay significant mark–ups compared to the continental zone (as high as 6–10 €/MWh). So, the question is whether V4 (mainly Hungary and Poland) could join the coupled market of the EU. A deeper integration of course would have serious impact on the domestic generation fleet as well, as old, inefficient coal plants could be easily priced out by low cost renewables in quite many hours of the year, and if helped by a higher carbon price, this impact could be immense. Further actions which have been identified to raise flexibility:

- Regional integration of balancing market
- Opening up RES support schemes regionally
- Capacity mechanism

Horizontal answers

Although cybersecurity is mainly dealt under national governance, sharing information and best practices would help to achieve deeper understanding of potential attack. Similarly, in case of DSO investment need, actions are not more efficient at regional level, but knowledge sharing remains useful. Overall energy security of the region could also be enhanced by energy savings and incentivising demand–side–management, so there is lower level of energy consumption to meet.

Answers to challenges arriving out of the region

The external challenges, faced by the V4 countries, might be answered by common position, too. The burning problems of loop–flows, with a significant impact on the electricity markets of this region, increases overall volatility in V4 electricity markets, e.g. through varying available net transfer capacity (NTC) levels, and reduce trade opportunities amongst the V4 countries causing significant economic losses due to network bottlenecks in certain time periods. Although individual country solutions were applied (e.g. phase–shifters at the borders of Germany with Poland and Czech Republic), a real and sustainable solution could be the reduction of the network bottlenecks within the borders of Germany. Elaborating regional position on external challenges is vital.

Chapter II: Workshop conclusions

Conclusions of the Workshop held 14 September 2018

A. Electricity sector

The electricity sectors of the V4 countries share similar security of supply issues in the timeframe of 2020-2030. One of the most prominent challenge in the region is brought by the EU **decarbonisation policy**, which requires a profound transition process in the electricity sector. The official target of 40 % decarbonisation by 2030 might be lifted upwards toward 45%, which means a significant transformation of the sector. One of the main instruments to achieve this goal is to significantly increase renewable based generation in all EU member states, amongst them in the V4 countries. Although the new target setting process does not prescribe national targets, policy makers soon - by the end of 2019 - will have to come up with national commitments toward RES and energy efficiency targets according to the new EU governance regulations and reflect it in their National Energy and Climate Plans (NECP).

Although no national targets exist, preliminary assessment suggest a range of RES to be achieved are in the following range:

- Czech Republic: 15-19%,
- Hungary: 14-20%,
- Poland: 18-22%,
- Slovakia: 15-20%.[27]

If the increased RES target of 32% will become binding on the EU these targets could be as high as 23-24% in the V4 countries, according to the draft methodology proposed.

This increase would entail significant RES integration costs for the V4 countries, where electricity sector participants already face significant additional costs in their balancing markets. According to the latest Market Monitoring Report of ACER (2016), electricity markets of Slovakia, the Czech Republic and Hungary (together with Romania) face the highest **balancing costs** in Europe, in a range of 4-6 €/MWh, compared to the below 1 €/MWh balancing cost of the Western European markets. This high balancing cost level could further increase, if no significant changes in the RES dispatching rules are introduced. Poland is the only V4 country presenting EU average balancing cost level.

in addition to the integration cost, high level of **financing cost** could also prevail in V4 countries, due to the higher level of WACC costs in the region. According to the latest estimates (DIACORE 2016 and Eclareon-Ecofys 2017) V4

[27] source: EU SWD(2016) 418 final. This reflects the overall RES target of 2016. In the electricity sector it might mean over 20% shares in the V4 countries

countries might pay 2-4% higher WACC for their PV and wind investments than Western EU member countries, meaning a significant financial burden on end users.

V4 countries face the problems of **setting up RES targets** in their NECPs, which should be ambitious enough for the contribution to the overall EU target, but with targets that also reflect the overall burden of the electricity sector and on the consumers.

The future RES deployment is a pressing issue for the policy makers in the V4 countries, and whether **opening up RES support schemes** regionally would help to answer at least some of the raised issues – e.g. reducing financial burden and integration costs of renewables. Similar question could be raised for the **regionalisation of balancing markets**: can we expect more efficient operation, if cross-border balancing would be available for the V4 region?

A further issue was also raised during the Beyond gas workshop concerning the **nuclear developments** in all V4 countries. All of them - including Poland that has presently no nuclear reactor - is planning to introduce new power plants in their power system beyond 2030, raising further questions on the future operation of electricity markets. Although being carbon-neutral technology, nuclear power represents an inflexible unit in a power portfolio, operated in base-load manner. Their coexistence in a power system, where RES shares could be as high as 30-50% raises system operation concerns. Higher RES levels would require the existence of sufficient level of flexible capacities, but new nuclear plants might erode the investment environment for building new flexible units.

This leads to a further medium term issue in the V4 countries, namely **maintaining system adequacy** in the region. While maintaining generation adequacy is a national issue, where every country could decide on what level of generation self-sufficiency satisfies the preferred national supply security level, system adequacy is a regional issue. **Realising the planned new infrastructure developments** in the region can help to achieve system adequacy looking beyond the national borders, and it can be a cost efficient option to realise a targeted level of system adequacy. Building up new interconnectors require the cooperation of the two involved countries, but as the welfare distribution effects and trading opportunities are affected in a wider region, a V4 regional cooperation and information sharing would be desired in this field as well. The planned new Hungary-Slovakia interconnectors, which are in the TYNDP since many years, can be one of the most important achievement in this field planned to be finalised within two years.

Two further issues were also raised during the final Beyond Gas workshop and were also mentioned by some of the interviewees. The first is the importance of realising the available **energy saving** options in the V4 countries, where most countries lag behind their energy efficiency targets. The second is the upcoming issue of **cybersecurity**, which might have profound impact in the future operation of the electricity networks, although presently none of the V4 countries experienced cybersecurity problems. Although these are mainly issues dealt under national governance, sharing information and best practices would help to achieve deeper integration of the electricity markets in the V4 countries. The new EU governance process that require the coordination of national plans (NECP) amongst the neighbours, can help to expand this type of cooperation as well amongst the V4 countries.

B. Gas sector

The gas markets of the V4 countries are mature markets, hence - despite recent recovery of the gas consumption after the financial crisis - future expectations regarding gas consumption increase in all V4 counties are moderate, a stagnating gas market is envisaged. Decreasing domestic production in all EU countries and potential future role of gas as a transition fuel supporting decarbonization indicate a growing gas import dependence. Russian share of import is about to grow from 34% in 2017 to close to 40% by 2030 on an EU level.[28]

The security of supply in natural gas dominated the policy agenda of the V4 states and even the EU for the last decade. Much has been achieved since the 2009 gas crisis, which originated in the Russian Ukrainian gas dispute. At the time of the 2009 gas crisis gas shipments from Russia through Ukraine were halted for two weeks, causing severe disruptions at the beginning of January leading to high costs for the economies, and in some countries (especially in the Balkans) the supply of household consumers was also problematic. The short-term resilience of the gas system was addressed by different means in the countries depending on their geographical location, policy choices and capabilities.

The Czech Republic and Slovakia invested into reverse flow on their existing pipeline system, and by that connected their natural gas markets physically to the more liquid North- West European market. Poland invested into LNG regasification terminal to have access to the global gas market and also strengthened connections to the German liquid market. Hungary has invested into strategic storage and new interconnectors to the neighbours (Croatia, Slovakia, Romania). Due to these measures, the short-term resilience has improved a lot, all countries except for Poland are able to supply (theoretically) the import need from alternative sources. As a consequence of better interconnectivity gas prices in the region converged to those of Western-Europe, the wholesale gas price is converging to TTF plus transportation costs.

Still, there are several project plans in all V4 countries on the PCI list, supported by market integration and security of supply arguments. These projects were discussed in the workshop in detail. Despite of general political support for each others' project, the support sometimes is closer to "not interested" or to "questionable". For example, in case of the STORK II project (Interconnector between Poland and Czech Republic) tensions between the hosting parties arise as the project is high priority for one party and less of a priority for the other. Some projects are even more controversial, like the BACI project (interconnector between the Czech Republic and Austria) that is supported by the Czech Republic but is opposed by Slovakia.

To measure the strength of support for the individual projects, workshop participants were asked to rate the projects on a scale from minus 1 to plus 3[29]. Based on this simplified priority ranking, there were some important conclusions reached:

[28] REKK modelling

[29] Participants by country had to agree to assign a score in teams. Minus 1 means considering a project being against the countries' interest, 0 means being neutral, 1 means less of a priority, 2 means high priority, 3 means that project will be implemented by 2022.

- There is no single PCI project that would be high priority for all V4 countries. (none received 2 points from each country)
- We could classify the Polish LNG as a regional interest project, where all countries were supportive (no zero or negative score was given).
- Regionally supported projects are the Baltic Pipe project and the Croatian LNG, which would also bring new source to the region, the Slovakia-Poland Interconnector and STORK II that would increase interconnectivity between V4 countries. (only positive or zero scores)
- Divisive project category covers the projects that have only one supporter or has at least one opponent, we only have BACI project in this category.
- Projects that have at least two opponents are against V4 interest, the Nord Stream 2 and the South Stream projects fall into this category.

Participants of the workshop concluded, that broadest agreement was reached about the negative sentiments: V4 common interest is against the implementation of the Russian-backed pipeline projects that aim to bypass Ukraine with the transit flows. These projects are worsening the utilization of existing infrastructure not only in Ukraine but within the V4 counties as well. Redirection of flows would reduce the available capacities on interconnectors from the West for competitively priced gas. The South Stream project was less negatively scored than the Nord Stream 2.

Table 5: Evaluation of gas pipeline projects in the V4 region

Classification	Project	Score results
Absolute priority	no such project	only 2 or 3
Regional interest	Polish LNG	only positive scores
Regional support	Baltic Pipe, Polish-Slovak interconnector, Croatian LNG, Stork II,	max 1 zero all other positive
National rather than regional projects	BRUA 1st Phase and Eastring	more than one zero but no negative
Divisive project	BACI	has one opponent or only one supporter
Against V4 interest	Nord Stream. South Stream	has two opponents

Chapter III: Country cases

Section I: The Czech Republic

A. Executive summary

The aim of this country report is to describe the situation facing the electricity and natural gas markets in the Czech Republic and identify longer term energy security challenges that may arise up to 2030. The report is based on desk research and 11 semi-structured interviews with representatives of the relevant government bodies, energy companies and other stakeholders in the Czech Republic, conducted between July and September 2018.

Electric power system in the Czech Republic

The electricity sector in the Czech Republic is characterized by significant overcapacity which, together with a dense transmission grid and sufficient interconnection capacity, ensures stable functioning of the system at least until the year 2030. One significant concern for grid stability has been the loop flows emanating from Germany, for which gradual extension of the German grid seems to be the only viable long-term solution.

However in the long term from 2030 to 2050 the system will face considerable challenges. Within this period, the existing conventional components of the Czech energy mix will have to be effectively replaced by new sources. The State Energy Policy counts on nuclear power to replace coal as the main pillar of electricity generation by 2040, but fulfilment of this goal is complicated by the unfavourable market situation for the construction of new nuclear blocs.

Policymakers could abandon plans for these nuclear blocs in favour of natural gas power plants. Related energy security concerns for natural gas have been mitigated in recent years by ongoing liberalization of the EU natural gas market, new infrastructure projects and the development of the global LNG market support, all supporting the possibility of a more intensive utilization of natural gas in the Czech power system.

According to other opinions, a substantial increase of renewable energy generation could become the cornerstone of Czechia's energy system post-2030 after the decline of the existing conventional sources. This would require a stable and predictable regulatory environment to for ensure adequate investment into not only renewable sources but the development of the electricity distribution system.

New technologies and market players are entering the market, such as electromobility, energy storage, prosumers, energy communities and aggregators, which will pose new challenges for the adaptation of Czech legislative and regulatory environment in the upcoming years.

Natural gas in the Czech Republic

With marginal domestic gas production, the Czech Republic is completely dependent on gas imports. However, because it is a transit country, well-connected to the Western European liberalised markets, and possesses significant gas storages, significant price shocks or shortage of supplies are not expected to affect the country in the foreseeable future. Three politically controversial pieces of infrastructure are in various stages of development would affect the current status quo for Czechia: BACI, STORK II and Nord Stream II.

Innovative technologies such as Power2Gas are on the radar of relevant stakeholders, however, due to relatively high costs (compared to “traditional” natural gas) they are not being pursued by businesses for now. This could change if technological developments drive down costs, coinciding with the expansion of intermittent renewable resources.

The Czech Republic possesses sufficient levels of gas in storages to cover months of above-average demand (during winters). However, this comfortable situation could be jeopardized by less favourable European gas market conditions that are challenging the conventional storage business model. Competition from other sources of flexibility and declining seasonal gas spreads are squeezing profit of storage operators, which poses an acute risk to Northern Moravia where the existence of storages is necessary to ensure gas supplies.

Cyber security of the energy system

Regarding cyber security and information management, the level of protection meets basic security criteria. However, certain reserves remain in all sectors of contemporary industry and digital economy.

B. Domestic electricity sector

1. Short-term electricity market risks (1-2 years)

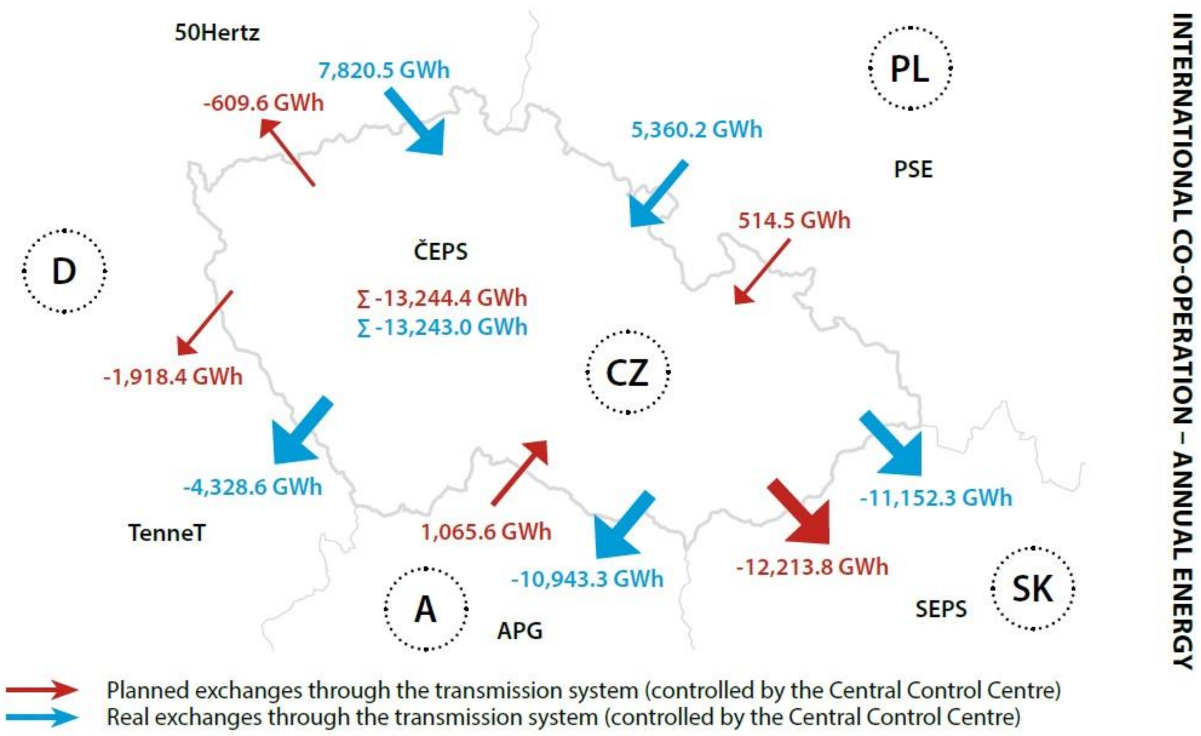
Electricity price related risks

The electricity market in the Czech Republic has witnessed a significant rise in wholesale prices throughout 2018. It follows the increasing prices at the EEX energy exchange in Leipzig, Germany, with the price at the PXE exchange in Prague reaching its highest level in the last six years at the beginning of September, moving beyond 55 EUR/MWh. Price trends are difficult to predict at the moment, leaving some of the smaller traders in a difficult situation as they try to navigate lower prices and find themselves in financial uncertainty. For the larger companies, this is a more manageable situation. The Czech energy system as a whole remains less vulnerable to the negative impacts of European price spikes as long as the country maintains its long-term position as an exporter of electricity or as a country which relies on domestic electricity generation.

Risk of Power Outages

The level of electricity export has traditionally been high in the Czech Republic. In 2017, it reached 13 TWh (see Figure 9), a significant portion of the total 81 TWh net electricity generation.[30] Temporary declines in exports are mostly caused by planned technical outages in the two Czech nuclear power plants, Dukovany and Temelín. This generation overcapacity may be an object of criticism as a massive exploitation of domestic sources (especially brown coal reserves). On the other hand, this robust generation base provides the country with a high level of supply security. Thanks to the adequate generation base, a dense transmission system and sufficient interconnection capacity, the Czech Republic is not expected to face any significant risk of power outages in the upcoming years. One significant security concern in terms of grid stability has been the loop flows of electricity from Germany. Four Phase Shifting Transformers (PSTs) have been installed at the border which helped to stabilize the situation. However, gradual extension of the German grid seems to be the only adequate long-term solution of this problem (see more below).

Figure 9: International co-operation – annual energy 2017. Source: ČEPS, 2018



[30] Yearly report on electricity. *Energy Regulatory Office (ERÚ)*. 2017. Page 5. <https://www.eru.cz/documents/10540/4580209/Yearly_report_electricity_2017.pdf/a4042a98-8750-4524-bb3c-f172ecba2f3b> Accessed 11 September 2018.

2. New generation capacity related risks (up to 2030)

Renewable penetration

In 2017, the installed capacity of intermittent renewable generation constituted approximately 2,380 MW out of the total 22,266 MW. The installed capacity of solar power plants (2,070 MW) by far surpassed the wind power plants (308 MW),[31] as the development of wind power has been effectively hindered by complicated permit procedures and protests of local civic organizations in recent years. The high number of solar power plants, on the other hand, came into existence as part of the so called "solar boom" which occurred between 2009 and 2010 when a steep decline in the price of photovoltaic panels collided with generous feed-in tariffs to create explosive but short-lived growth. This allowed for the easy fulfilment of the EU renewable energy target set for 2020 (13% share in gross final energy consumption) but also led to higher priced electricity for final consumers and a burden for the state budget (financial support for the renewable energy surpassed 1.5 billion EUR annually in the years 2015-2017). A 26% solar tax was introduced in 2010 for photovoltaic power systems over 30 kW which were put into operation between 2009 and 2010. It should have originally expired in 2013, but was prolonged until the end of the power plants' lifetime and lowered to 10%.[32] In spite of these retroactive measures which curtailed the benefits for solar plant owners, and the significant drop in the price of technologies for renewable energy generation, the public image of green energy has been seriously harmed by the past developments and every decision concerning the sector is politically sensitive. In contrast to this, several energy companies have already adopted renewable energy sources into their strategic documentation and business vision. According to some experts, renewable energy generation has a chance to become the anchor of Czechia's energy system after 2030 when the lifetime of today's conventional sources expires (described below). One of the requirements for a successful realization of this vision would be the establishment of a stable and predictable regulatory environment in the upcoming years.

According to the State Energy Policy which is the main strategic document for the energy sector in the Czech Republic, the installed capacity of wind power should reach 760 MW and solar electricity 3,291 MW by 2030.[33] This would meet the estimated requirements arising from the EU Renewable Energy Directive's recast, if the EU target was set at the 27% of gross final energy consumption originally proposed by the European Commission. Under this scenario, the share of renewable energy would reach approximately 18% in the Czech Republic.[34] However, the Council of the EU and the European Parliament reached an agreement in June 2018 on an EU-wide renewable energy target of 32%. According to the estimates of the Czech Chamber of Renewable Energy, the new EU target might translate into

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[31] ERÚ, 25.

[32] Pre-election Prague says solar power too expensive. *EURACTIV.com*, 1 September 2017. <https://www.euractiv.com/section/energy-environment/news/pre-election-prague-says-solar-power-too-expensive/> Accessed 11 September 2018.

[33] Expected electricity and gas balance report. *Operátor trhu s elektřinou (OTE)*. 2017. Page 13. <http://www.ote-cr.cz/statistika/dlouhodoba-rovnovaha-elektrina/uvod/files_ddr_e_uvod/prezentacni-material.pdf> Accessed 26 June 2018.

[34] National benchmarks for a more ambitious EU 2030 RES target. *Ecofys*, 2018. <https://www.ecofys.com/en/publications/national-benchmarks-for-a-more-ambitious-eu-2030-res-target/> Accessed 11 September 2018.

approximately 22% share of renewable energy in the Czech gross final energy consumption. In 2016, the share of renewables amounted on approximately 15%.[35]

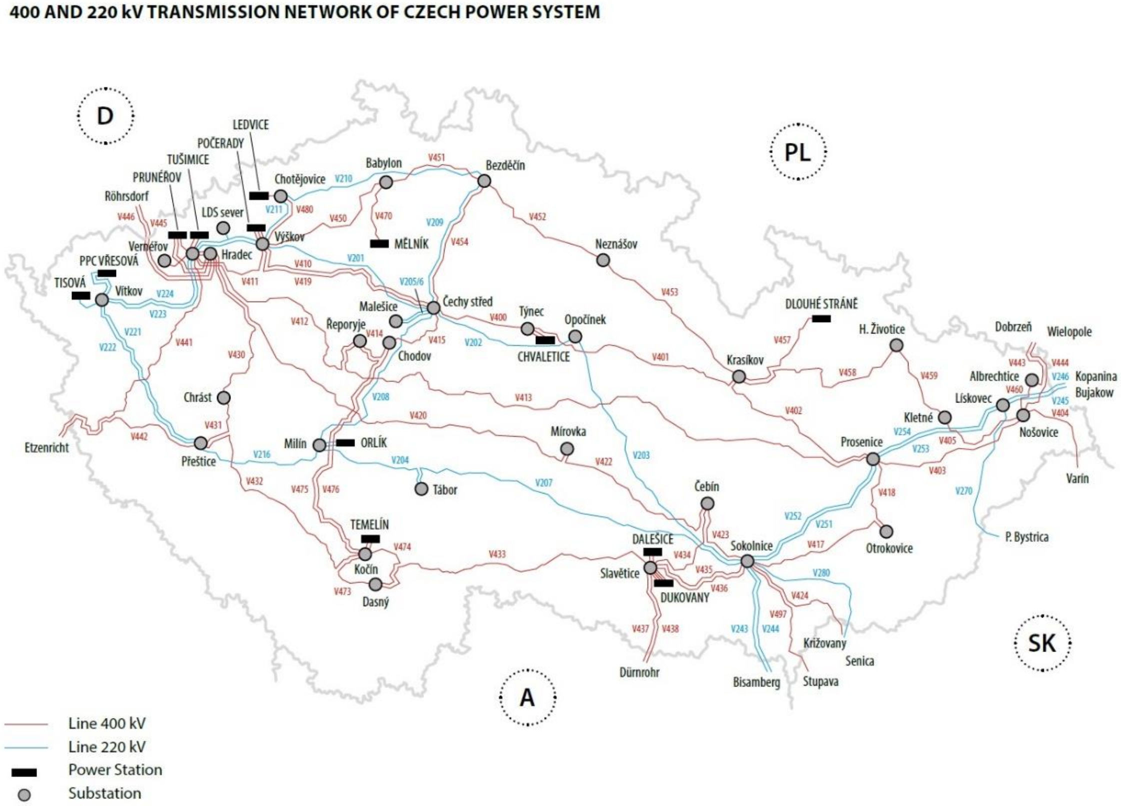
Besides the scenario outlined by the State Energy Policy, the Czech operator of electricity and gas market (OTE) examined two other scenarios for achieving the EU Energy Roadmap 2050 targets; one emphasizes energy savings measures and the other low-emission energy sources. The estimation of intermittent installed capacity does not differ from the conceptual scenario in the energy savings scenario. However, if the emphasis is on the development of low-emission energy sources, the installed capacity of solar power plants would have to reach 4,150 MW in 2030 (see Tables 6, 7, 8).[36] The State Energy Policy expects that photovoltaics will be used solely on the roofs and other fixed structures of buildings. Some energy companies and promoters of green energy suggest that the potential of brownfield areas should also be exploited significantly.

While renewable energy helps to reduce energy import dependency, intermittency leads to energy security challenges connected to the stability of the system. However, all three scenarios examined by OTE show that the reliability of power balance meets the standard with sufficient reserve capacity in the outlook to 2030, although by this time winter and summer generation discrepancies might appear from different consumption renewable share trends. One of the reasons for the currently strong reliability of the energy system is the ongoing utilization of brown-coal power plants, which will only decline significantly after 2035 in all three scenarios.[37]

From the technical perspective, the Czech TSO ČEPS emphasizes its preparedness to incorporate renewable and decentralized sources of electricity into the national grid without significant threats to the stability of the system. The Czech electricity transmission grid (displayed in Figure 10) is considered robust enough to withstand integration of renewable resources, since this is planned in national strategic documents, and ČEPS should be able to manage the development of renewable sources at least up to 2040. However, the TSO claims that legal assurance of transparent and competitive markets is key, otherwise market distortions can jeopardize full and effective integration of renewables. More challenges may arise at the level of distribution system with the entrance of new elements, such as the electrification of mobility or self-consumption (see below).

[35] 4th progress report from MS - towards the EU's 2020 renewable energy goals. *European Commission*, 2018. <https://ec.europa.eu/energy/en/topics/renewable-energy/progress-reports> Accessed 11 September 2018.
[36] OTE, 17.
[37] OTE, 28-29.

Figure 10: Transmission network of Czech power system. Source: ČEPS, 2018.



3. Maintenance, availability or closure of existing conventional electricity generation capacities

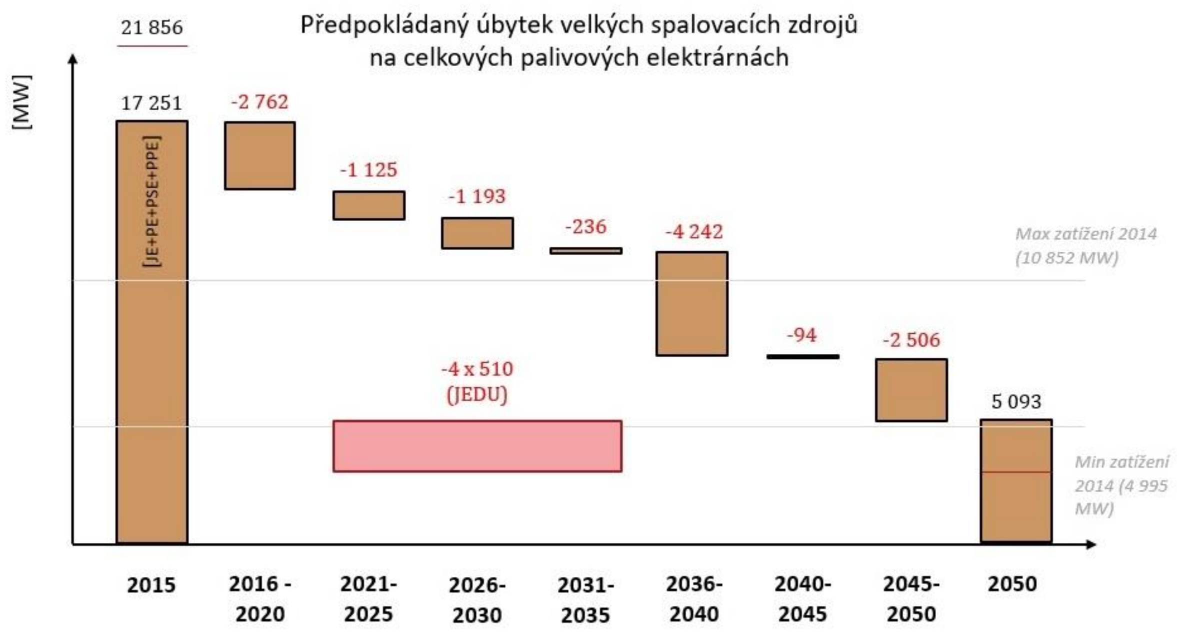
Coal power plants

The brown coal sector[38] will see a gradual decline in the upcoming three decades, due to natural exhaustion of coal reserves, coal mining limits set in several localities and environmental regulations, in particular the European Commission's conclusions on “Best Available Techniques” for large combustion plants. The required investment to meet further environmental requirements outlined in national transition plans as late as July 2020 would make these plants uneconomical, and it is therefore expected that the capacity of approximately 2,700 MW (representing roughly one third of the today’s 8,900 MW installed capacity of brown coal sources will be decommissioned by 2021). In compliance with the State Energy Policy, approximately 1,400 MW installed capacity remains in the system by 2050, while in the scenarios following the EU Roadmap 2050 targets the decline is almost complete (see Tables 6, 7, 8).[39] In any case, taking into account the ageing of existing nuclear power plants analysed below, the present conventional part of Czechia’s energy mix will need to be effectively replaced by 2050. While in 2015, the existing conventional

[38] The role of hard coal is practically negligible in the context of Czech electricity sector.
[39] OTE, 24–25.

power plants were able to cover the annual peak load (10,852 MW) with a sufficient reserve (17,251 MW installed capacity), the remaining elements would only cover half in 2050 (see Figure 11).

Figure 11: The expected decline of large combustion sources – total installed capacity of nuclear + thermal + gas fired + combined cycle power plants. Source: Ministry of Industry and Trade of the Czech Republic, 2018.



The decommissioning of base load coal fired power plants is seen as a critical challenge by TSO ČEPS, which also takes into account the actual risk of nuclear capacities being partly out of operation. According to the company's representatives, there is only a limited possibility to replace these generation sources with natural gas fired power plants which are mostly seen as peak load sources for balancing intermittent renewable sources throughout the year. Their utilization as base load sources does not guarantee the self-sufficiency of the Czech energy system and rather increases import dependency, the TSO says. On the other hand, some other stakeholders and experts see natural gas as the source which could potentially replace coal and nuclear as pillars of power generation, provided that the EU gas market achieves a sufficient level of liberalisation, interconnection and diversification of sources.

The above-mentioned study by OTE examined the development of natural-gas-based electricity production under different scenarios. Current capacity of natural gas units is approximately 1,850 MW. By 2050, the highest natural gas capacity is expected in the conceptual case study at approximately 5,100 MW while in both EU case studies it should be roughly 4,000 MW. These sources are to cover baseload and semi-peak load, as well as to serve as quick starting regulation reserves. Small-scale combined heat and power sources of small capacities and usage in the traditional heating industry are included in this number as well.[40]

[40] OTE, 24–25.

The role of coal power plants as regulation capacities will have to be partly replaced by natural gas regulating units, nuclear power plant capacities, and energy storage. The deployment of natural gas regulating sources varies under different scenarios. The scenario based on the State Energy Policy assumptions foresees only 160 MW installed capacity of these power plants, while the scenarios following the EU Roadmap 2050 count 1,960 MW. The scope of the facilities for daily accumulation should amount to approximately 800 MW in the conceptual case study, roughly 1,600 MW in the EU-Roadmap scenario focusing on energy savings and up to 3,400 MW in the scenario which emphasises the development on low-emission energy sources.[41]

Nuclear power plants

The State Energy Policy counts on nuclear power to replace coal as the main pillar of electricity generation by 2040 when it should reach 46 or 58% of total gross power generation, helping the country fulfil both stable electricity supplies and climate goals. Construction of new nuclear blocs is therefore one of the key elements of Czechia's energy policy, as the existing units do not have sufficient installed capacity to meet this target. While in 2017, nuclear power plants represented 4,290 MW out of the total 22,266 MW installed capacity in the Czech Republic,[42] they should reach 5,490 MW in 2040 and 7,050 MW in 2050, according to the scenario outlined in the national strategic document and examined by OTE. According to the EU Roadmap 2050 low-emission energy source scenario, by 2050 an installed capacity of 8,250 MW in nuclear power plants would be needed (see Tables 6, 7, 8).[43]

The planned lifespan of existing blocks in the nuclear power plant Dukovany (4× 510 MW, VVER 440) has been extended until 2035–2037. One new nuclear unit (1,000 MW) is expected to be put in operation in this location by that time, followed by another one later. One or two new nuclear blocs should be also built in the Temelín location where the existing nuclear units (2× 1055 MW, VVER 1000) are expected to generate electricity until 2060–2062. However, the decision-making process on how the new nuclear blocks will be financed is continuously falling behind schedule. Results of the governments' deliberation should have been announced in spring 2018, but it is now expected that it will only happen at the end of the year. According to the government's representatives, the process is already 2–3 years delayed, and while legislative amendments could streamline and accelerate the permitting processes and licencing procedures, preparation of such amendments in of itself would take significant time.

A final decision is complicated by the uncertainties over the wholesale price of electricity in the upcoming decades. The price of electricity futures is currently rising, but the importance of base load power plants is expected to decrease in the future when more flexible sources able to respond to demand peaks and valleys cause by intermittent sources will be valued. Such flexibility cannot be provided by nuclear power plants, although the technical possibilities are improving, as is the predictability of intermittent power generation. In such an environment, nuclear power plant investors demand guarantees by the state to avoid financial loss at a time when current nuclear projects in Europe

[41] OTE, 26.
[42] ERÚ, 25.
[43] OTE, 13.

face significant delays and budget overruns. There is a dispute in the Czech Republic whether the investment costs and risks should be borne by the state itself or the half state-owned company ČEZ, which operates the existing power plants – the latter scenario being opposed by minority shareholders. In this context, scenarios for the split of ČEZ into two or more entities is also being considered.

Similar financial challenges already led to the cancellation of the Temelín nuclear power plant expansion in 2014. This raises uncertainty over the ability of the Czech Republic to execute its energy strategy, if indeed nuclear power is considered a cornerstone of its future energy mix. Extending the license for the operation of Dukovany power plant until 2045–2047 might be a temporary solution to this problem since the main components remain in good condition. However, the security requirements for nuclear power plants set by international rules have been tightening since the Fukushima accident in 2011, and it is unclear whether the maintenance of the existing blocs will remain economically viable for ČEZ in the future.

In case the construction plans for new nuclear blocs are not put into practice, the strategy could shift towards a system underpinned by natural gas power plants. As was already mentioned, this source carries greater energy security risks, as it would mean higher dependency on imports. On the other hand, the ongoing liberalization of the EU natural gas market, new infrastructure projects and the development of the global LNG market support the arguments for a more intensive utilization of this source in the Czech Republic. However, due to its geographical position, the country would still rely on natural gas supplied through pipelines, which would expose its energy system to risks connected with potential technical problems and accidents occurring on the transit route. Additionally, the shift from nuclear to natural gas could not happen overnight, as it would also require construction of new gas connection pipes, and the construction of new gas power plants might also not avoid encounter with the so called NIMBY effect.

The security of nuclear fuel supply has been at the center of public discussion in the Czech Republic. So far, no significant interruptions have emerged with regular supplies, but dependence on a single Russian supplier is naturally seen as a risk to national security. Through the activity of the Nuclear Research Institute ÚJV Řež, the Czech Republic was part of the EU-funded project known as the "European Supply of Safe Nuclear Fuel" intended to diversify the nuclear fuel supply to VVER-440 reactors in Europe.[44] Euratom Supply Agency (ESA) itself continues to work for the security of supply by evaluating supply contracts submitted to it for conclusion and acknowledging duly notified transactions covering provision of services in the entire nuclear fuel cycle. This also takes into account the European Commission's Communication from 28 May 2014 on the European Energy Security Strategy, which put emphasis on the security of energy supplies, including nuclear.[45] Nevertheless, the selection of technology supplier for the new nuclear power plants in the Czech Republic remains a critical issue, as the process of construction brings a years-long

[44] Annual Report 2017. *Euratom Supply Agency (ESA)*, 2018. Page 25. <http://ec.europa.eu/euratom/ar/last.pdf> Accessed 11 September 2018.
[45] ESA, 47.

intensive encounter with the selected partner in a strategically important area. The counterintelligence Security Information Service (BIS) has repeatedly warned against additional possible threats related to construction of new nuclear blocks, if foreign companies from non-allied countries are involved in the project: technological and informational espionage, presence of highly-risky FDI etc.[46]

Table 6: Development of the installed capacity of the power generation base in the Czech Republic according to the scenario based on the State Energy Policy, examined by OTE. Source: OTE, 2017

Případová studie Koncepční – instalovaný výkon (MW)
Conceptual case study – installed capacity (MW)

skupina zdrojů | *power sources*	2017	2020	2025	2030	2035	2040	2045	2050
stávající tepelné elektrárny fossil power plants	10 378	10 240	7 537	7 455	6 911	4 783	3 313	3 438
stávající zdroje – PPC a SCGT current units – CCGT and SCGT	1 918	1 945	1 990	2 034	2 079	3 079	2 518	2 563
bioplynové stanice biogas plants	423	444	479	514	549	584	619	654
stávající jaderné elektrárny current nuclear power plants	4 290	4 290	4 290	4 290	4 290	4 290	2 250	2 250
nové hnědouhelné bloky new brown coal units	660	660	660	660	660	660	660	660
mikrokogenerace micro-CHP	10	24	71	119	167	214	261	306
nové zdroje – PPC a SCGT new units – CCGT and SCGT	0	0	0	0	120	590	1 860	1 860
nové jaderné elektrárny new nuclear power plants	0	0	0	0	0	1 200	4 800	4 800
vodní elektrárny hydro (excluding PSHPP)	1 110	1 113	1 118	1 123	1 128	1 133	1 138	1 143
větrné elektrárny wind	308	470	662	760	935	1 110	1 120	1 130
fotovoltaické elektrárny solar	2 130	2 131	3 024	3 291	4 451	5 610	5 660	5 710
geotermální elektrárny geothermal sources	0	0	5	10	15	20	25	30
akumulace (včetně PVE) storage (including PSHPP)	1 170	1 170	1 170	1 170	1 530	1 890	1 940	1 990
ES ČR celkem Czech power system in total	**22 397**	**22 486**	**21 005**	**21 426**	**22 835**	**25 163**	**26 164**	**26 534**

Table 7: Development of the installed capacity of the power generation base in the Czech Republic according to the scenario focused on energy savings, examined by OTE. Source: OTE, 2017.

Případová studie Unijní – úspory – instalovaný výkon (MW)
EU – Energy Savings case study – installed capacity (MW)

skupina zdrojů | *power sources*	2017	2020	2025	2030	2035	2040	2045	2050
stávající tepelné elektrárny fossil power plants	10 378	10 240	7 537	7 455	6 860	4 203	2 984	2 198
stávající zdroje – PPC a SCGT current units – CCGT and SCGT	1 909	1 909	1 909	1 909	1 909	1 929	1 084	1 047
bioplynové stanice biogas plants	423	444	479	514	549	584	619	654
stávající jaderné elektrárny current nuclear power plants	4 290	4 290	4 290	4 290	4 290	4 290	2 250	2 250
nové hnědouhelné bloky new brown coal units	660	660	660	660	660	660	660	0
mikrokogenerace micro-CHP	7	7	7	7	7	7	7	7
nové zdroje – PPC a SCGT new units – CCGT and SCGT	0	0	0	0	120	750	1 860	2 820
nové jaderné elektrárny new nuclear power plants	0	0	0	0	0	1 200	4 800	4 800
vodní elektrárny hydro (excluding PSHPP)	1 110	1 113	1 118	1 123	1 128	1 133	1 138	1 143
větrné elektrárny wind	308	470	662	760	935	1 110	1 120	1 130
fotovoltaické elektrárny solar	2 130	2 131	3 024	3 291	4 451	5 610	6 769	7 929
geotermální elektrárny geothermal sources	0	0	5	10	15	20	25	30
akumulace (včetně PVE) storage (including PSHPP)	1 170	1 170	1 170	1 170	1 530	1 890	2 350	2 810
ES ČR celkem Czech power system in total	**22 385**	**22 434**	**20 860**	**21 189**	**22 454**	**23 386**	**25 667**	**26 819**

[46] Annual reports. *Security Information Service of the Czech Republic (BIS)*. <https://www.bis.cz/annual-reports/> Accessed 11 September 2018.

Table 8: Development of the installed capacity of the power generation base in the Czech Republic according to the scenario focused on low-emission sources, examined by OTE. Source: OTE, 2017.

Případová studie Unijní – nízkoemisní zdroje – instalovaný výkon (MW)
EU – Low-Emission Sources case study – installed capacity (MW)

skupina zdrojů | *power sources*	2017	2020	2025	2030	2035	2040	2045	2050
stávající tepelné elektrárny fossil power plants	10 378	10 240	7 537	7 455	6 860	4 203	2 984	2 198
stávající zdroje – PPC a SCGT current units – CCGT and SCGT	1 909	1 909	1 909	1 909	1 909	1 929	1 084	1 047
bioplynové stanice biogas plants	431	476	551	626	701	776	851	926
stávající jaderné elektrárny current nuclear power plants	4 290	4 290	4 290	4 290	4 290	4 290	2 250	2 250
nové hnědouhelné bloky new brown coal units	660	660	660	660	660	660	660	0
mikrokogenerace micro-CHP	7	7	7	7	7	7	7	7
nové zdroje – PPC a SCGT new units – CCGT and SCGT	0	0	0	0	280	1 540	2 820	2 820
nové jaderné elektrárny new nuclear power plants	0	0	0	0	0	1 200	4 800	6 000
vodní elektrárny hydro (excluding PSHPP)	1 110	1 113	1 118	1 123	1 128	1 133	1 138	1 143
větrné elektrárny wind	308	470	662	760	2 055	3 350	4 250	5 150
fotovoltaické elektrárny solar	2 130	2 131	3 925	4 150	8 250	12 350	14 625	16 900
geotermální elektrárny geothermal sources	0	0	5	10	135	260	385	510
akumulace (včetně PVE) storage (including PSHPP)	1 170	1 170	1 170	1 170	2 120	3 070	3 820	4 570
ES ČR celkem Czech power system in total	**22 393**	**22 466**	**21 834**	**22 160**	**28 395**	**34 768**	**39 675**	**43 522**

4. Security concerns related to energy infrastructure

Interconnectors & Transmission system

One of the main security concerns in terms of grid stability has been the loop flows of electricity from Germany during instances of high wind generation output in northern Germany and high demand for electricity in southern Germany and Austria that outstrips the domestic German grid capacity. This issue has also been one of the stumbling blocks for the EU-wide day-ahead market coupling, as the European target model uses the flow-based method for capacity calculation and allocation. According to Czech representatives, such approach could even intensify the problem of loop flows.

The TSO ČEPS installed four (two at each of the two 400 KV lines connecting the Czech system with the eastern part of Germany) Phase Shifting Transformers (PSTs) at the substation Hradec u Kadaně in northwest Bohemia in the course of 2017, starting their full operation in September. This measure is believed to help the Czech TSO to transfer maximum amount of electricity without compromising the reliability of the power supply in the Czech Republic. The split of German-Austrian bidding zone should also ensure more stability, as the volume of electricity flowing from the north to the south should decrease.

However, the only adequate long-term solution for this problem would be the expansion of the domestic German grid. According to the Czech TSO, if the development does not correspond with the massive expansion of renewable resources in the northern part of the country, the system of PSTs might be insufficient to protect neighbouring states against serious imbalances. Furthermore, it is necessary to mention that similar PSTs are installed on the border between Germany and Poland and these units influence each other significantly. Thus, coordination and planning across the wider region has utmost importance.

Distribution system

Challenges arising from new technologies and business models that are entering the electricity market have to be faced mainly by the operators of distribution system (DSOs) on the low voltage level. The higher voltage levels are usually more stable and already equipped with smart elements. The Czech TSO and DSOs have been preparing for the development of decentralized power generation, renewable sources of energy, energy storage, electromobility or the increasing role of aggregators. This process is based on several strategic documents augmenting the State Energy Policy, such as the National Action Plan for Smart Grids,[47] the National Action Plan for Renewables Sources of Energy,[48] and the National Action Plan for Clean Mobility.[49]

According to the representatives of ČEPS, there is no threat arising from this development for the Czech energy system, which should be successfully managed towards the 2040 outlook. The TSO perceives several inevitable developments: integration of the decentralized generation, RES, energy storage, electromobility and the aggregators into the energy system management, non-discriminatory market approach towards all participants and the establishment of technical solutions and legislative conditions for future providers of flexibility and aggregation. The government representatives also believe that the integration of intermittent sources into the Czech grid should not pose problems in a medium-term horizon.

Distribution system operators see the increasing deployment of electric vehicles (EVs) in the future as one of the main challenges for managing expected peak loads. They emphasize it will be crucial for them to have instruments at their disposal which will enable control over the EVs' charging. On the other hand, the deployment of EVs may be seen also as an opportunity in terms of power storage.

While batteries for domestic electricity storage are becoming commercially viable for some companies, the approach towards large utility scale batteries remains cautious. The first two (1.2 MWh and 1.75 MWH) were put in operation in 2017. From commercial point of view, investing in the grid may still be seen as a better option by the distribution system operators. However, energy storage is an area receiving significant resources from the state towards research and development .

[47] Available at <https://www.mpo.cz/dokument158711.html>.
[48] Available at <https://www.mpo.cz/cz/energetika/elektroenergetika/obnovitelne-zdroje/narodni-akcni-plan-pro-obnovitelne-zdroje-energie--169894/>.
[49] Available at <https://www.mpo.cz/en/industry/manufacturing-industry/automotive-industry/national-action-plan-for-clean-mobility--179151/>.

5. *System adequacy based on ENTSO-E MAF report*

According to the Mid-term Adequacy Forecast of the association of operators ENTSO-E, no significant adequacy problems are expected in the 2020 to 2025 horizon in the Czech Republic as far as security of supply, change in the availability of interconnection capacity or any issues related to the risk of power plants mothballing during this period.[50]

6. *Security of supply issues related to domestic regulation*

The development of energy storage capacities is one of the challenges that the national regulation has to face. The operators of the first large battery storages expect an amendment of the Energy Act which would update rules for energy storage allowing investors to operate various storage systems in the Czech Republic. At the moment, the companies are not able to sell electricity to the market because they do not possess licenses. This amendment is currently being prepared, but it will not embrace the issue of energy storage in a holistic way. That will be the task of a completely new Energy Act in the future which will be based on the requirements set by the EU Winter Package.

An amendment to the Act on Promoted Energy Sources is also being prepared. It should bring new rules for renewable energy auctions that are supposed to apply after 2020. The Ministry of Industry and Trade looked for applicable models to other EU countries, including Germany, France and Denmark. If adopted, the scheme would restore support for the operation of new solar and wind power plants, for the first time since 2013.

Another important task for the Energy Regulatory Office and the Ministry of Industry and Trade is the review of electricity tariff structure. There was already one attempt to adopt a new tariff structure with the aim of increasing the share of electricity network costs to prosumers, but the process was postponed in 2016.

The debate in the Czech Republic has also been influenced by the development of capacity remuneration mechanisms and strategic reserves in several European countries. The Czech government has long been the singular proponent of the energy-only market in the V4, but if other EU MSs continue supporting conventional electricity generation the Czech energy system will also have to react to such decisions. According to some opinions, a strategic reserve could benefit the Czech energy system. This would presumably support a backup role for coal fired generation and later natural gas power plants or power storage systems. However, such debate has only started recently in the Czech Republic.

Finally, Czech legislation and regulation will be affected by the EU Winter Energy Package. The State Energy Policy will have to reflect the integrated National Energy and Climate Plan currently under preparation as part of the EU Regulation on the Governance of the Energy Union.

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[50] Mid-term adequacy forecast, 2017 edition. *ENTSO-E,* 2018. Page 75. <https://docstore.entsoe.eu/Documents/SDC%20documents/MAF/MAF_2017_report_for_consultation.pdf> Accessed 26 June 2018.

Section II: Hungary

A. Introduction

Since 2009, the Hungarian energy policy focused on improving gas supply diversification has been largely successful. Thus, Hungary is well positioned approaching 2020 and thereafter, to pursue new priorities for the post-2020 period.

Beyond securing gas supply, the main energy security challenge will be balancing the increasing share of intermittent renewable energy sources with expanding nuclear baseload. The future of the lignite industry, contributing 20% of the Hungarian electricity production currently, is uncertain. Distributed energy resources will challenge electricity distribution networks in the future.

These challenges, on the other hand, make the quest for energy supply easier: renewable energy-sources are domestic, mitigating exposure to imports. To test this hypothesis, we investigated the challenges that the Hungarian energy sector will face between 2020 and 2030, conducting 11 interviews during 2018 July-August related to the energy security problems we have identified. An earlier version of this country report was delivered to the interviewees prior to the meeting in order to go deeper into the topics.

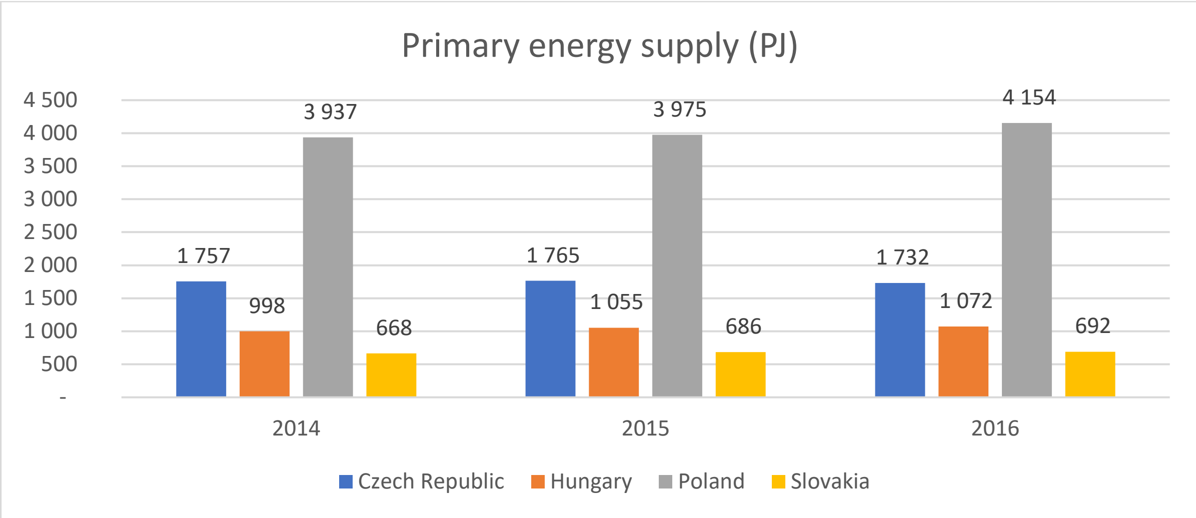
B. State of the Hungarian energy sector in the Visegrad context

Primary energy supply in Hungary is nearly 1 million TJ, 45% of which is produced domestically. Compared to V4 neighbors and the EU average, energy consumption per capita is low, with final consumption about 75 GJ annually. Of 8266 MW aggregate electricity capacity in 2016, 23% is nuclear, 68% fossil fuel, and less than 10% RES. Meanwhile, nuclear power accounts for approximately half of total electricity production, and aside from 5% RES, the rest is provided by fossil fuels. Gross natural gas consumption is growing in Hungary (exceeding 300 000 TJ), and nearly 20% is from domestic sources.

Figure 12 shows the primary energy supply[51] in the V4 countries, showing moderate growth over a three year period.

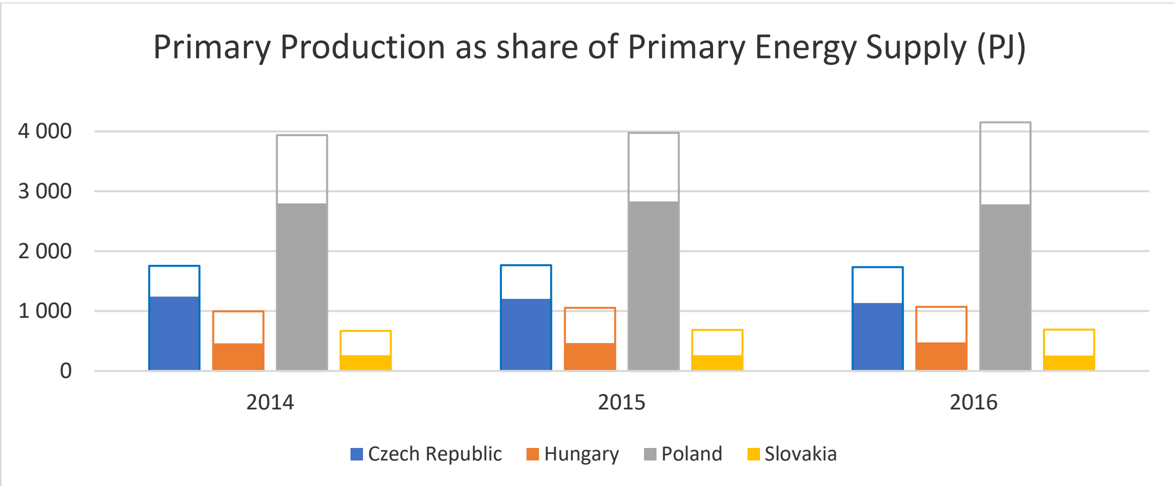
[51]Primary energy supply includes energy production, trade balance minus international bunkers and stock changes.

Figure 12: Primary energy supply in Hungary, compare to other V4 countries, 2014-16, Source: Eurostat



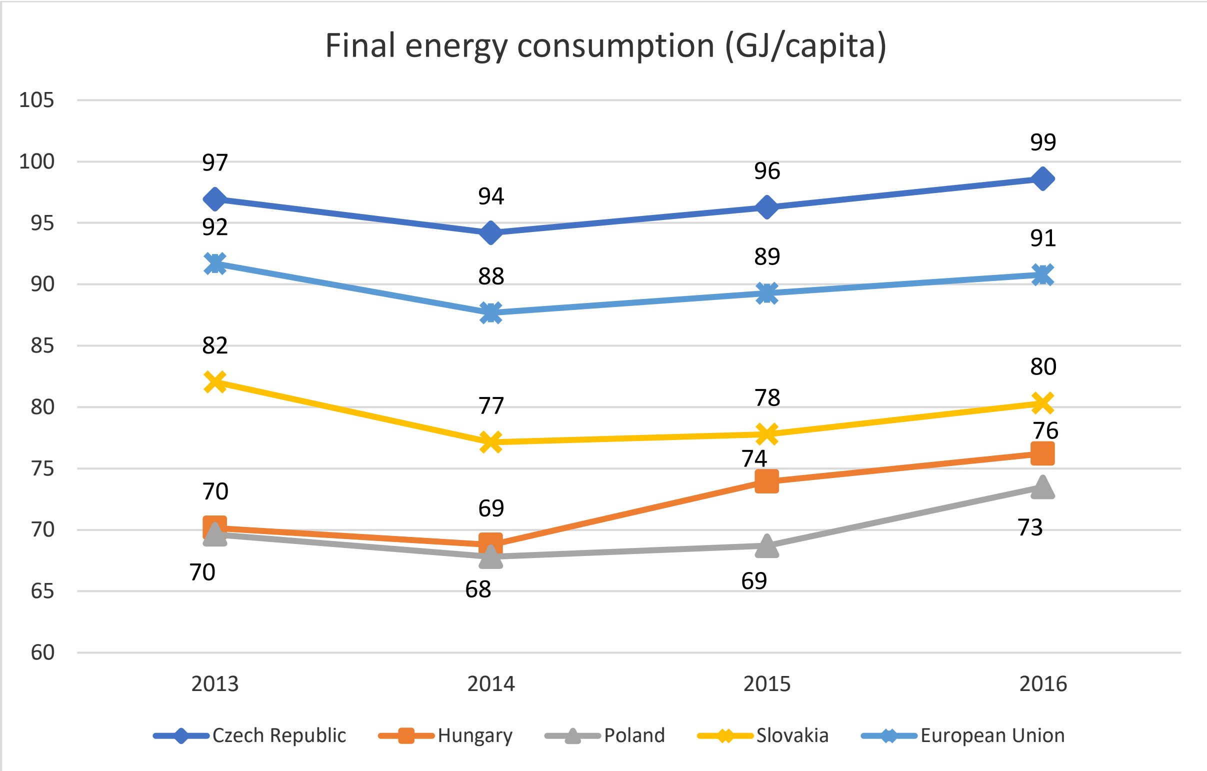
Nearly half (44.5%) of Hungarian energy supply is met almost from domestic production, and from import energy sources. Poland and the Czech Republic are more robust in terms of domestic energy supply while Slovakia is more in line with Hungary.

Figure 13: Primary production compared to primary energy supply in Hungary, and in other V4 countries, 2014-16, Source: Eurostat



Hungary's per capita energy consumption is typical for the region and below the European Union average. As shown in Figure 14, Czech Republic has the highest in the V4, also significantly higher volume than the European average. The trends are similar in the recent years with moderate growth and a small drop in 2014.

Figure 14: Primary energy supply in Hungary, compare to other V4 countries, 2014-16



The sum of *electricity generation capacities* in the V4 are shown in Table 9. The capacities are approximately proportionate to the size of the respective energy markets with the exception of Slovakia, which has capacity nearly equaling Hungary despite its considerably smaller market size.

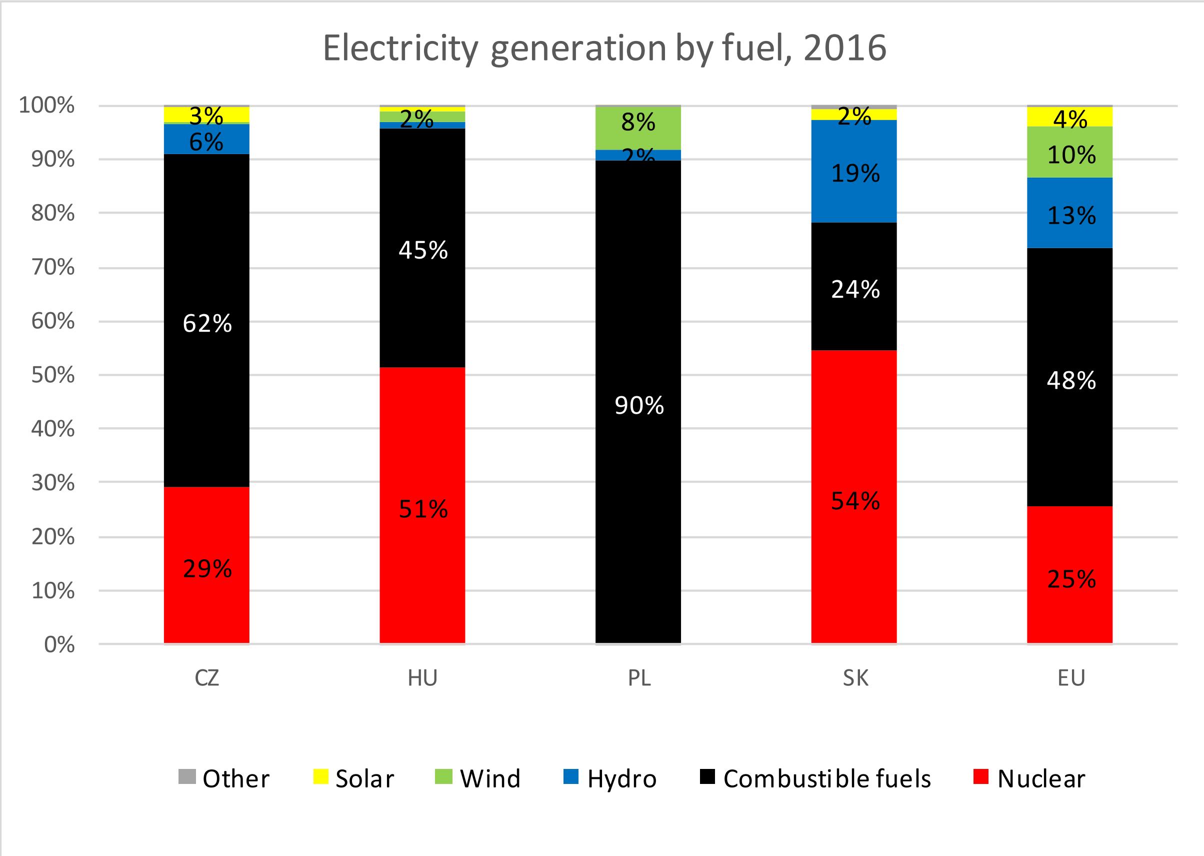
Table 9: Capacity in GW, 2016 , Source: Entso-E database

	CZ	HU	PL	SK
Total Installed Capacity of Power Stations	20.291	8.266	38.278	8.102

Despite growth in recent years, the share of renewables-based electricity generation in Hungary remains low.

Figure 15 shows that V4 countries share significant capacities of fossil fuel burning plants, and with the exception of Poland, nuclear plants have a stable 20-25% share. The four countries have a very different profile in terms of renewable capacities.

Figure 15: Primary energy supply in Hungary, compare to other V4 countries, 2014-16, Source: REKK, Eurostat



In terms of RES-E, Hungary lags behind the V4 and the EU average with 96% of electricity production nuclear and combustible fuel sources. The share of nuclear generation is even higher in Slovakia, which together with hydro, uses a very low share of combustible fuels.

Poland is the exception, without nuclear, and 90 % of production based on combustible fuels.

After declining from 2010 to 2014, natural gas consumption in the V4 rebounded except in Slovakia.

V4 countries are highly dependent on foreign gas sources, though Czech Republic and Slovakia produce only 2-3% of their inland consumption compared to Hungary (~20%) and Poland (~25%).

C. Security of Supply challenges related to the domestic electricity sector in Hungary

1. Short-term electricity market risks

The two most important short-term risks on the region’s electricity markets are

- the occurrence of price spikes and
- power outages.

Extreme weather conditions in 2017 affected all of the V4 countries, highlighting the energy security challenges they face. Hungary experienced the highest price spikes in January 2017, and later in July and August prices jumped again as a result of a summer heat wave. Despite 4M market-coupling, Hungarian HUPX prices tracked the Balkan markets in extreme situations, rising far above Slovak and Czech prices in several hours. The recurring price spikes are representative of systemic risks identified by all interviewees;. At the same time, this also sends positive signals to investors maintain or expand new (fossil fueled) capacities.

It is also important to note that, according to our analysis (see: [52] and [53]), the Hungarian system is far from introducing any kind of consumer restrictions, even in these tight situations. This service quality indicators are also indicative: average SAIFI (average number of non-planned interruptions/consumer/year) and SAIDI (average length of non-planned interruptions/consumer/year) values between 2014 and 2016 were 1.074 and 84 minutes respectively (based on data from HEPURA[54]), including interruptions due to extreme weather conditions. With these values, Hungary underperforms compared most Western-European countries but has the best results among the V4 according to the CEER's 2016 Quality Benchmarking report[55]. The interviewees do not perceive this to be a problem after 2020.

Thus, for Hungary sudden price spikes are a more serious risk than power outages, especially on the short-run.

2. *New generation capacity related risks on a longer run*

Renewable penetration

RES capacities in Hungary were fledgling until the last few years, and might revert in the near future.

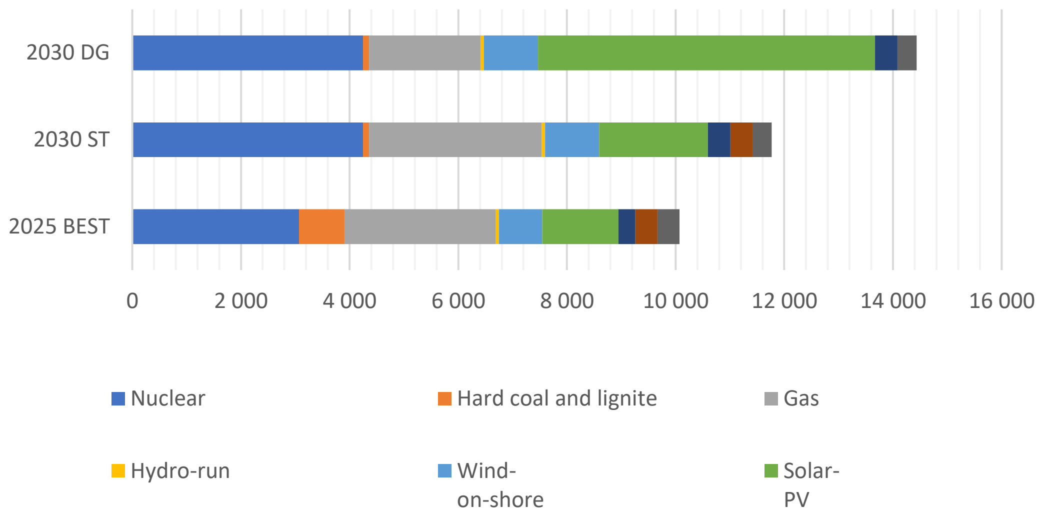
At the end of 2016, feed-in tariffs were replaced by a new regulatory scheme, the so-called METÁR. This supported new RES investments with the exception of household units. METÁR offers a feed-in premium rather than a feed-in tariff, meaning producers (other than households) receive the support for electricity they sell to reach a pre-defined price level. The support period was also shortened, and for more than 0.5 MW capacity the auction is set as procurement method, further increasing risks of investors.

The imminent change to a less friendly system led to a massive spike in applications under the last days of the former system in 2016, totaling around 2000 MW PV capacity, roughly equivalent to the existing nuclear capacity in Hungary. Since then, further government support through targeted regulation and streamlined licensing registration led to

[52] Kácsor and Mezősi: Analysing the 2017 January price hike in HUPX, https://rekk.org/research-paper/67/analysing-the-2017-january-price-hike-in-hupx
[53] Kácsor, Mezősi, Diallo and Törőcsik: Twin peaks?, https://rekk.org/research-paper/79/twin-peaks
[54] Presentation by Hungarian Energy and Public Utility Regulatory Authority, http://www.mee.hu/files/files/ASTRON_2017_v1_GP.pdf
[55] 6TH CEER BENCHMARKING REPORT ON THE QUALITY OF ELECTRICITY AND GAS SUPPLY 2016, https://www.ceer.eu/documents/104400/-/-/d064733a-9614-e320-a068-2086ed27be7f

even more planned PV capacity, estimated to be 2500-3000 MW by some market participants. Such a sudden increase of intermittent capacity in a system with an average load of around 4800 MW would have a significant consequences for wholesale prices, as emphasized by interviewees.

Figure 16: ENTSO-E forecast for Installed capacities in Hungary, MW, Source: ENTSO-E-G, TYNDP 2018



To estimate this price effect on the Hungarian wholesale market, REKK carried out a simplified calculation (for details see [2]) that showed a drastic change not only in price levels but the structure of daily price curves. Instead of the highest prices matching hours with the highest demand, enough PV capacity would lead to double-peaks (morning and evening peaks), and much lower prices in the middle of the day when PV generation is usually the highest. With more exposure to intermittency, accurate forecasting of PV generation will play a key role both for system operators and traders.

Besides the wholesale market, high RES penetration has an even more significant 'double' impact on retail prices. On one hand, only non-household RES producers pay the subsidy according to the 2013 utility bill cut, Thus, a sudden increase in RES capacities can put an unfair burden on industrial customers. The second issue is the need for more reserve capacities and balancing, which could be very costly with downward pressure on prices, also shouldered by the non-household consumers.

It is worth noting that wind energy is not supported in Hungary due to a regulation that sets nearly impossible technical conditions for wind power plant installations, such distance from towns and villages (for details see [56]).

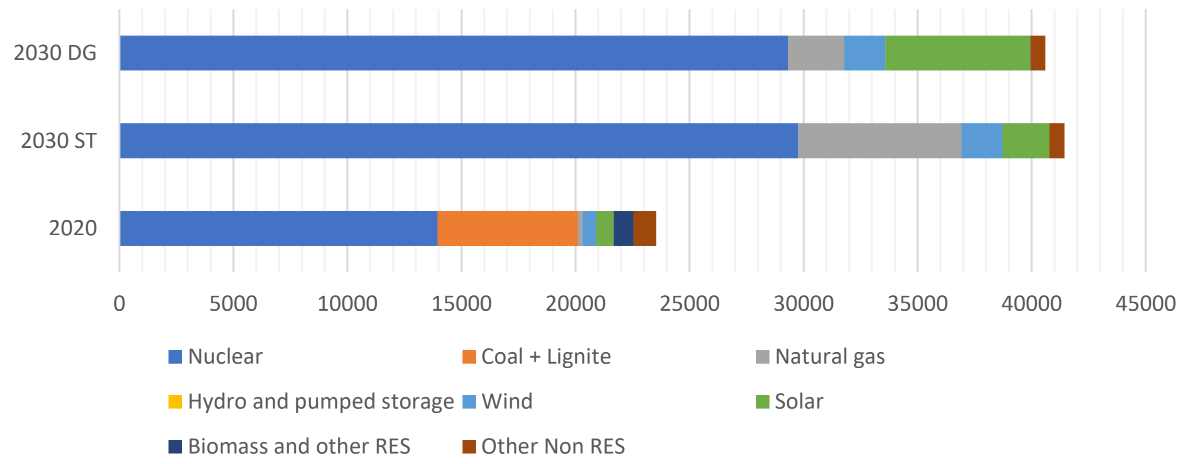
New nuclear power plants

In Hungary, the construction of new blocks of the nuclear power plant Paks 2 planned for 2026-27 is a key element of the national energy strategy.

[56] Mezősi: From where does it blow?, https://rekk.org/research-paper/54/from-where-does-it-blow

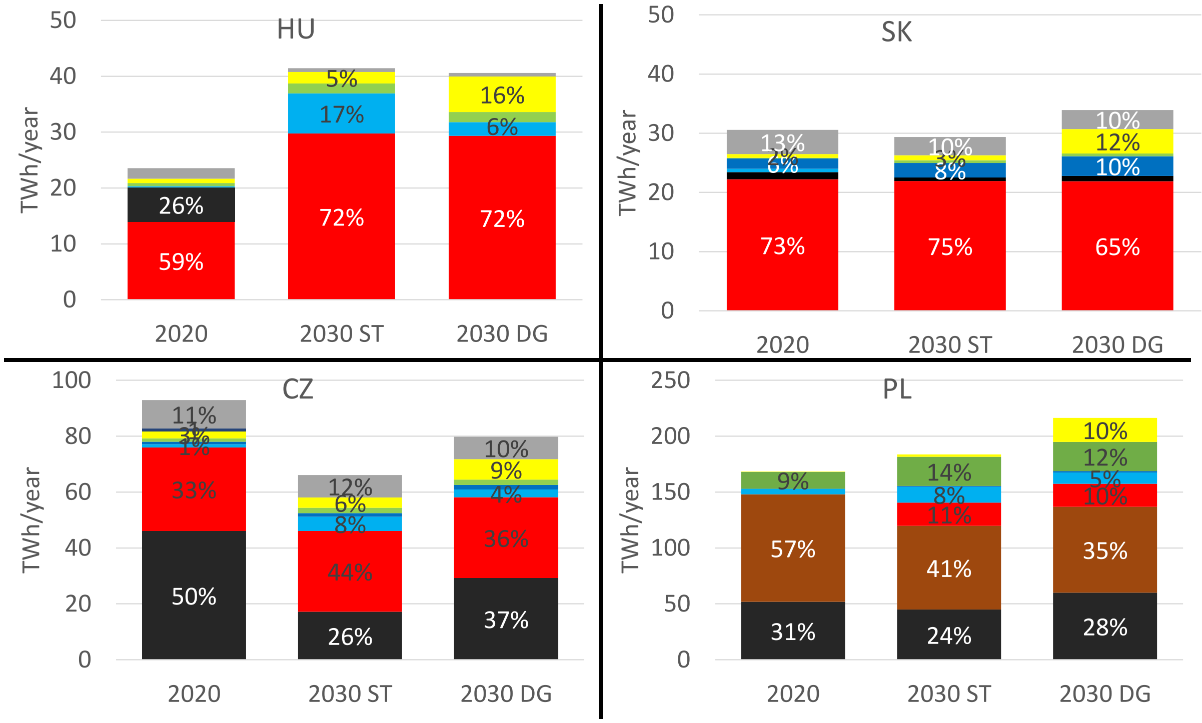
With such a massive infrastructure projects, time horizons remain uncertain. Itis possible that Paks 1 and 2 run in parallel for some time with the planned decommissioning of Paks 1 scheduled for 2032-2037. While this might have a very positive impact on Hungary's import/export position, it could also put downward prices on electricity prices which might hurt fossil fuelled power plant operators.

Figure 17: Electricity generation forecast, Hungary, Source: ENTSO-E-G, TYNDP 2018



From a system adequacy point of view, the Matra lignite plant will come to the end of its lifetime soon, which could leave Hungary vulnerable in the absence of enough reliable base load capacity if Paks 2 is significantly delayed which cannot be completely ruled out.

Figure 18: Future expectations for electricity generation mix, V4 countries, Source: REKK, ENTSO-E-G



Maintenance, availability or closure of existing conventional electricity generation capacities

Across Europe there is a lively debate regarding the role and necessity of fossil fueled power plants to complement intermittent renewable capacities. A higher share of RES requires more flexible and reliable capacities that can keep the system in balance. The downward pressure that RES exerts can also threaten the economic viability of fossil plants.

The above-mentioned imminent closure of Mátra lignite power plant (950 MW) makes this topic particularly salient. In the last 5 to 10 years several natural gas power plants (more than 1200 MW capacity) were taken offline permanently and most cannot be reactivated. A significant amount of natural gas-based capacity is facing similar decisions between a costly refurbishment and shutting down. The reoccurrence of price spikes might help to keep them in the system, but if not, some form of support would be needed to ensure their operation.

3. *Security concerns related to energy infrastructure*

Interconnectors & Transmission system

In the past few years TSOs in the region have faced difficulties as a result of unplanned flows at interconnection points, mentioned by most of the interviewees. These flows mostly originate in Germany, where domestic infrastructure has not been capable of moving the higher RES sources in the north of the country to large consumption centers in the south. The flows had a negative on available Net Transfer Capacities on several borders, reducing availability and causing serious economic damage for end consumers via higher prices.

One possible solution to this problem is the planned “decoupling” of the German-Austrian market zone. The introduction of the DE-AT interconnection point, with a defined (non-finite) capacity, should alter the flow-structure of the region, allowing for more available capacity on the existing and planned SK-HU interconnectors.

On the other hand, splitting the German-Austrian bidding zone could create more separation between the Hungary and the cheap German market, along with exposure to weather conditions through the high share of hydro generation in Austria. Hungary already faces the consequences of drought periods in the Balkans, and the separation of the Austrian market might exasperate this situation.

Distribution system

A sudden increase in renewable penetration not only can cause significant changes on the wholesale market but poses a challenge for DSOs. Most of the solar capacities in Hungary are connected to the distribution system and household PVs can feed electricity into the grid, but if needed, power is used in-house. As a form of support, this type of “prosumer” only pays a network usage fee for their net consumption. In the latest regulation adopted in 2018, DSOs are obliged to offer a local connection point for power plants willing to connect to medium voltage level within 3 kilometers from the grid. This creates an additional financial burden for DSOs, on top of dealing with new intermittent capacity.

System adequacy

Based on the ENTSO-E MAF (Mid-term Adequacy Forecast) report,[57] Hungary will continue to rely on electricity imports in the medium term (2020-2025). Nonetheless, adequacy indicators are satisfactory, with loss of Load Expectation values close to 0 in four out of five analyzed scenarios. As mentioned above, the overall adequacy situation will depends on the timeline of commissioning of Paks 2 and decommissioning of Paks 1, while import fluctuating according to available domestic fossil capacities.

Risks related to domestic regulation

Probably the most important security of supply related regulatory issues for the Hungarian electricity market are the so-called “utility lines and pipes tax” and the “Robin-hood” tax (income tax of energy suppliers), both adopted in 2012. Already maintenance-related investments have been postponed or tightened, and there is serious risk of underinvestment in the future.

According to the regulated retail tariffs, maintaining low household energy prices for households could be challenging in the long run with tightening CO_2 emission quotas, growth of RES support, and several other factors.

[57] https://docstore.entsoe.eu/Documents/SDC%20documents/MAF/MAF_2017_report_for_consultation.pdf

D. Security of supply challenges related to the domestic natural gas sector

1. *Short-term natural gas market risks*

Natural gas price related risks & Risk of natural gas supply disruption

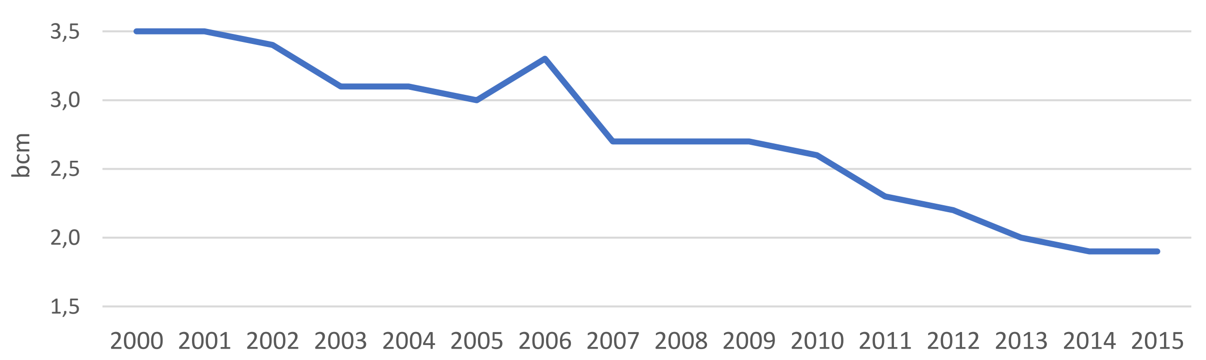
Compared to electricity prices, natural gas prices are relatively much less volatile. In March 2018, however, Europe experienced a shortage over a few days which sent prices on TTF up to 80 EUR/MWh from the typical 20-24 €/MWh range. As a result, there were no inflows to Hungary from the Western direction., but storage provided the necessary flexibility to substitute imports. The CEEGEX prices did not respond to the price shock even in neighboring Austria, which is indicative of low liquidity and absence of firm reverse flow from Hungary to Austria and Hungary to Slovakia. Altogether we conclude that there is no serious security of supply risk in Hungary in reaction to short term price signals, which was corroborated by the interviews.

According to European regulation, Hungary has a Prevention and an Emergency Action plan. The European Commission requires country action plans to be detailed enough and provide solutions to major emergency situations. On the other hand, the Commission identified some concerns related to the definition of vulnerable consumers, requiring a more detailed description pertaining to transit and export restrictions during an emergency.

Risks related to production

Natural gas production in Hungary has been in a state of decline since the start of 1990s; from 4.9 bcm in 1990 to 3.5 billion in 2000 and 1.9 bcm in 2015. The 1.9 bcm accounts for about 20% of the total natural gas consumption in Hungary.

Figure 19: Hungarian natural gas production 2000-2015, Source: Hungarian Statistical Office



Based on the IEA estimation the proven reserves of the country were approximately 74 bcm of conventional gas in 2015, which would keep current production levels for approximately 40 years. However existing Hungarian gas fields are maturing and reductions are expected. According to FGSZ, the Hungarian TSO, the expected production after 2020 can be less than 1 bcm. This decline would pose a significant risk for the Hungarian Energy sector already heavily dependent on Russian gas. For a large part of the Hungarian production fields that started operation before 1998, the regulated price is close to the cost of the operator (MOL), and by law their production is dedicated to reducing household costs. There are, however, a growing share of independents working under a concession scheme that allows volumes to be sold at the market price.

The forecast for the domestic natural gas production was confirmed by the main stakeholders during the interviews.

2. Natural gas supply source diversification

Long-term contracts

Hungary had a long-term contract with Russia which was set to expire in 2015. Then, in 2016, they renegotiated the deal, allowing Hungary to import quantities not consumed from the original contract until 2021. It is important to note however, that a large portion of gas which is imported from Austria originates in Russia, leaving the share of natural gas imports from Russian origin as high as 95%.

With sufficient alternative routes, the high share of Russian gas is not a problem. Hungary is theoretically able to sustain itself without Russian gas according to its 2017 Exposure-index (E-index) score of 0.01. The E-index is calculated by subtracting yearly domestic production and capacity of infrastructure delivering non-Russian gas from yearly consumption, divided by yearly consumption.

With an E-index score close to 0, it is an important question for Hungary whether to extend the long-term contract with Russia or not, as theoretically the country can sustain itself without the extension of the contract. The issue is closely related to security of supply since re-contracting the LTC for a larger quantity generally grants a more stable supply pattern. On the other hand, if import supply disruptions occur, Hungary would be vulnerable because of the high dependency rate.

Supply route diversification

Based on the above description, supply route diversification is one of the most important issues related to supply security of the natural gas sectors.

Figure 20: Hungarian Transmission System, Source: ENTSO-G

One of the most important alternative routes for Hungary is through the HAG pipeline from Austria, but it is heavily utilized and often physically congested despite a capacity extension in 2016.

Hungary is also linked with Serbia, Slovakia, Romania, Ukraine and Croatia. The UA line is mainly used for receiving Russian gas through Ukraine, and the Serbian interconnector is generally used for further export. There are also plans for a Hungarian-Slovenian pipeline, and with the current gas flows it would potentially serve as an export pipeline for Hungary as well. The Slovakian interconnector increases the supply security of Hungary through its utilization close to zero. Romania could further serve Hungary as an important alternative source with its significant exploitable offshore resources and the extension of the Romanian–Hungarian direction from what is currently 0.1 bcm to 4.4. bcm. Hungarian companies have already booked the whole capacity of the route until 2037.

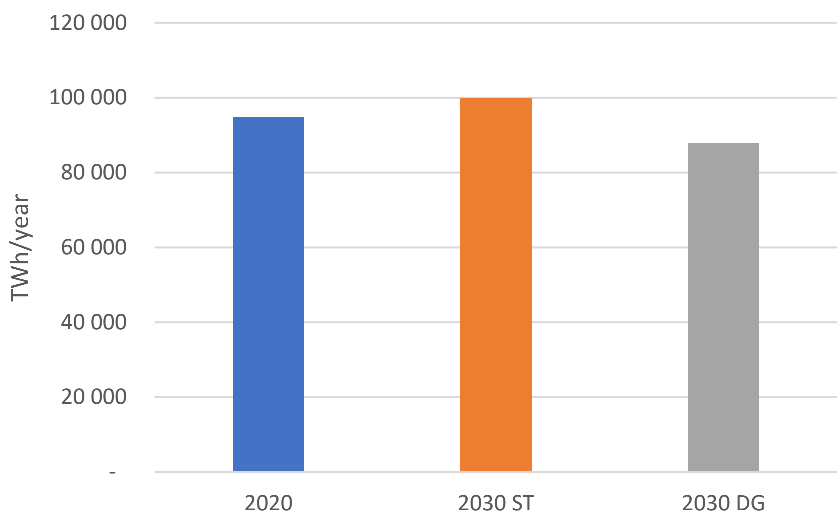
The Hungarian – Croatian interconnector cannot currently transit gas in the Hungarian direction which poses a challenge for the planned floating LNG regassification terminal at Krk island that would otherwise serve as an important natural gas source.

It is also technically possible for Hungary to import LNG from the Italian or the Polish LNG terminals, but currently they are too expensive.

3. *Risks related to other infrastructure*

Transmission & Distribution system

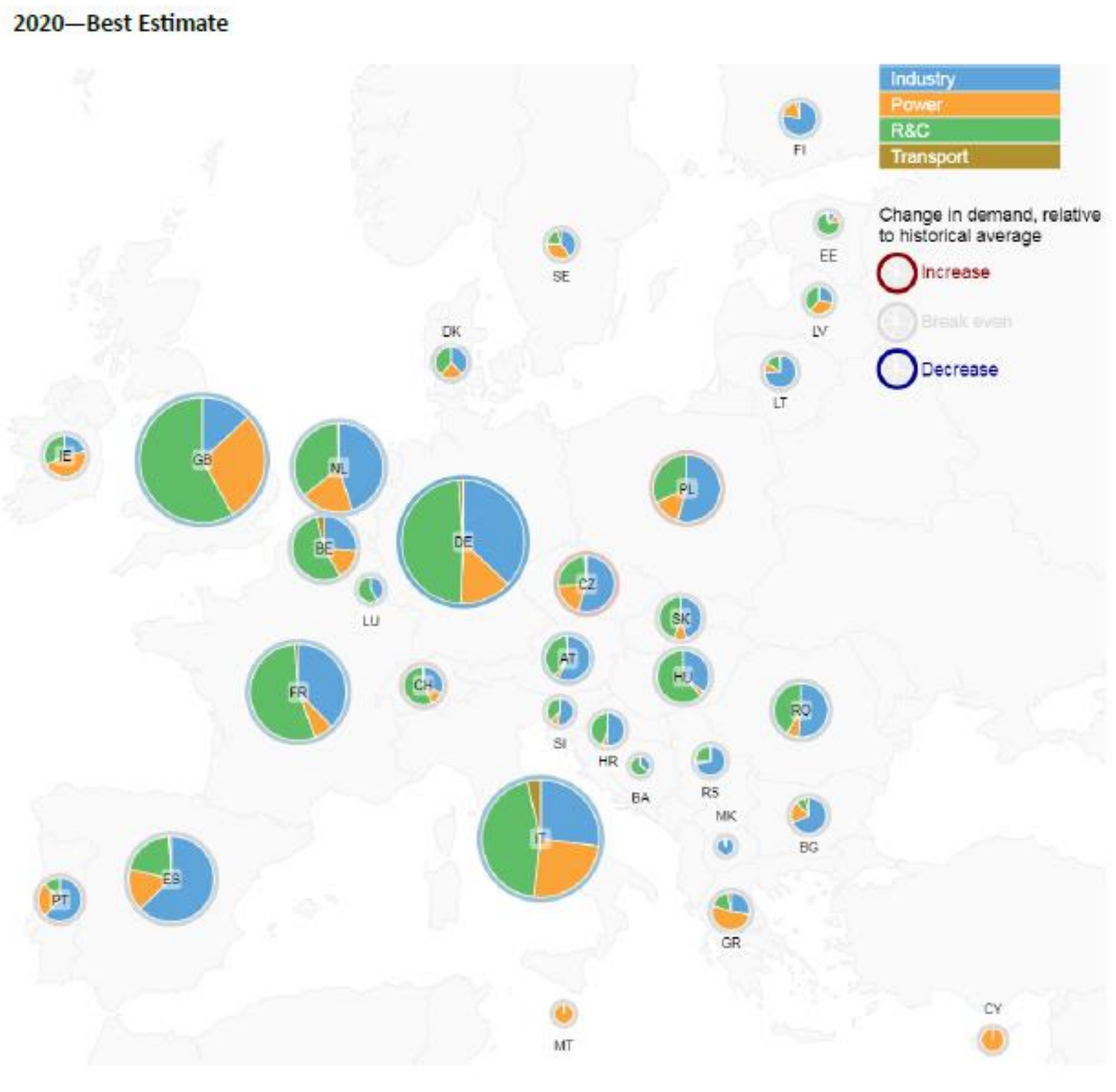
Figure 21: Hungarian natural gas consumption forecast, 2020, 2030, Source: ENTSO-G



According to the analysis of FGSZ in 2015[58], there is no important security of supply risk related to the current state of the natural gas transmission infrastructure while risk related to the distribution system infrastructure originates from the expected decline in gas consumption.

[58] https://fgsz.hu/hu-hu/Documents/Fejleszt%C3%A9si%20javaslat%20konzult%C3%A1ci%C3%B3s%20anyag_2016.pdf

Figure 22: ENTSO-E map on gas demand by 2020[59], Source: ENTSO-G TYNDP, 2018



Storages

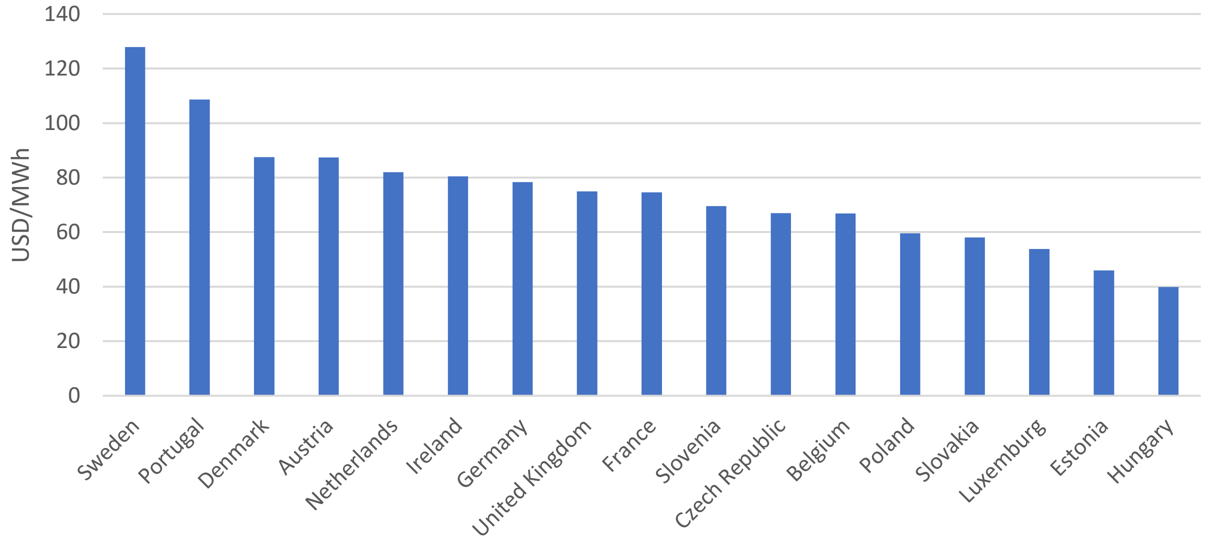
Hungary’s natural gas system is well equipped with storages including five facilities (depleted natural gas fields) with a total working gas capacity of 6.3 bcm (vs. yearly consumption). To better ensure security of supply, the national regulator enforces storage obligation on traders. In addition to this, 1.2 bcm strategic storage can only be used in case of emergency if authorized by the government.

[59] ENTSO-E Scenario Report, 2018

Security of supply issues related to domestic regulation

Similar, to the electricity sector, retail household natural prices are regulated at low levels. In 2015 for example, Hungary had the lowest household price in the EU (see Figure 23).

Figure 23. Average household natural gas price in European countries, 2015, Source: IEA



Consequently, low gas prices disincentives consumer energy efficiency investment that would contribute to energy security by reducing consumption. Furthermore, the utility lines and pipes tax might hinder investment into the infrastructure.

Section III: Poland

A. Introduction

The purpose of this text is to create a general overview of the main challenges of Polish Energy policy. The focus for the natural gas sector is security of supply and diversification, and the main threats are challenges to competition are the Nord Stream 2 project and the liberalisation process implying higher prices. In the electricity sector the main factor is EU climate policy. which pressures the viability of coal-dominted generation in Poland. Meanwhile, there is a discussion on market coupling and interconnectors. The situation in the gas sector is quite stable while the electricity sector is under threat of losing competition with external sources of energy supply. The report is based on research of the Jagiellonian Institute and the results of the interviews conducted with stakeholders of the Polish Energy sector (see Annex). The interviews are focused on long term Energy security challenges including and beyond these related to natural gas supply.

B. Domestic electricity sector

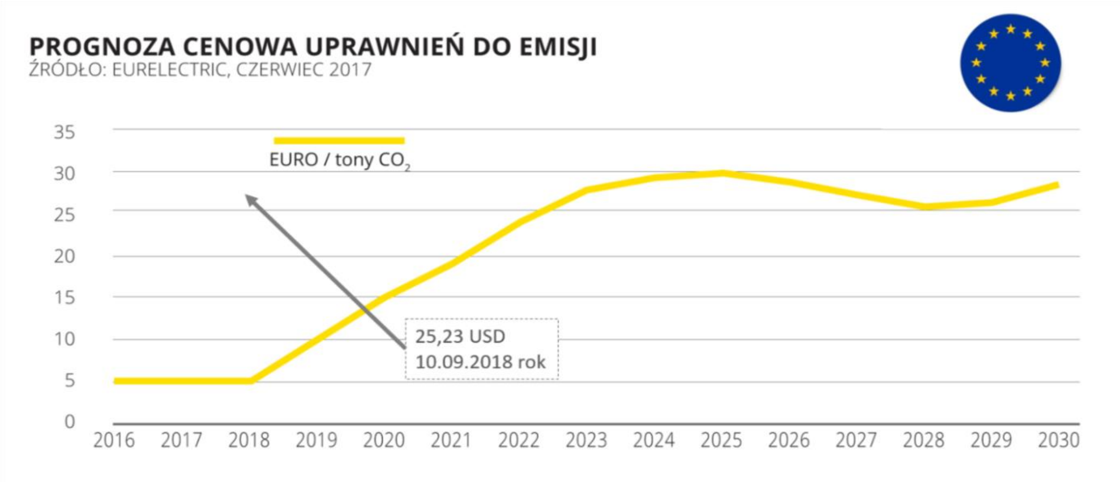
The Polish electricity sector faces several challenges requiring tremendous efforts to meet not only short term but long term market requirements. Poland is a country in which 80% of electricity production is based on coal thermal generation, making it inherently threatened by stricter energy and climate EU policy. According to the Energy Regulatory Office interviewed by Jagiellonian Institute, the risk of price fluctuation in the short term is “high” due to uncertainties over coal and CO2 trading scheme prices and the introduction of capacity market subsidies and renewables auctions.

1. *Short-term electricity market risks*

From August 2015, Polish customers got a taste of what a poorly performing electricity sector means. During that time the Polish, several elements converged and for the first time in more than 20 years, the Polish TSO needed to introduce a power consumption limit[60]. After that issue, Poland, and especially the national TSO, have been strongly focusing on avoiding such situations in the future. Foe example, now Polish Utilities have to modify maintenance plans, especially for the summer period, when there is possibility of a shortage.

While the number of electricity providers fell due to mergers, the number of market participants willing to purchase electricity on wholesales markets did not. This, along with increasing CO2 emission price (about 15 EUR/t), coal and oil prices can lead to higher electricity prices on the Polish market.

Figure 24: Eurelectric's EU ETS prices prediction. Source: Jagiellonian Institute



August 2015 was a reminder to the Polish TSO and Polish market participants must to be cautious during periods of low generation reserves especially under strenuous weather conditions, particularly during hot spells with little wind. Moreover, it is crucial to point out increasing popularity of air conditioners and electric cars in Poland and across the world. This has direct influence, spurring growth in energy demand and electricity prices on the wholesale market. Fortunately, the demand side response (DSR) products are becoming more developed in Poland[61]. As an example, the

[60] http://forum-energii.eu/files/file_add/file_add-43.pdf
[61] https://www.pse.pl/-/coraz-wieksze-zainteresowanie-swiadczeniem-uslug-dsr, http://www.vpplant.pl/pl/

national TSO now offers DSR solutions or virtual power plant startups which can be used for demand governance to minimize shocks in the energy sector to some extent.

The Energy Regulatory Office underlines that energy supply disruptions can happen in the short term in connection with unexpected temporary problems in energy system. The office mentions cyber-attack threats and points to the Country's Cybersecurity System Act from 1st of August 2018 as a foundation for dealing with cyberthreats. The office is actively engaged in cooperation with distribution system operators for increasing cybersecurity of the energy system.

2. *Long term risks*

Renewable energy source development began in Poland in the early twenties of the 20th century when the Energy Package was adopted. Under the third Energy Package, Poland's share of renewable energy sources (RES) target is set at 15 per cent.

However, during recent trilogue negotiations over the „Clean Energy for All Europeans"a new EU 32% target has been accepted for 2030[62]. In addition, there is a intermediate clause for 2023. The PKEE (Polish Electricity Association) finds this objective to be highly ambitious, with the required RES having a negative impact on electricity supply safety in the short term[63]. Fulfilling the main EU target (32% level) will require close to 50 per cent of RES in the share of total electricity production in 2030, which is a steep increase compared to current levels that could burden the economy of several countries[64]. However, according to the Energy Regulatory Office, capacity market reform should serve to adequately managem RES capacity.

Currently in Poland there is about 8.5 GW of installed RES capacity, more than 5.8 GW of on-shore wind which has increased 5 times since 2010[65]. However, according to the Polish TSO development plan, the situation for on-shore will change only slightly until 2027 with about 6 GW expected to be installed[66].

PV levels in Poland are extremely low, with only 107 MW, but the Polish TSO expects this to rise to more than 1 500 MW by (year?). This boost would help alleviate Poland's energy balance at peak periods, especially during periods of high temperatures and lack of cooling water for power plants, unplanned lack of thermal generation, lack of onshore wind generation, so nearly windless and warm weather.

According to the Energy Regulatory Office, the long term risk of energy supply disruptions in 2020-2030 is „real" due to tight capacity margins, but market reform should help to remedy this. According to the Office's data between 2020

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62 http://biznesalert.pl/ue-cel-oze-2030-32-procent/
63 http://energetyka.wnp.pl/wysokie-ambicje-ws-oze-kontra-bezpieczenstwo-energetyczne,325239_1_0_0.html
64 http://www.pkee.pl/upload/files/stanowisko_PKEE_dyrektywa_OZE_pap._firm..pdf
65 https://www.ure.gov.pl/pl/rynki-energii/energia-elektryczna/odnawialne-zrodla-ener/potencjal-krajowy-oze/5753,Moc-zainstalowana-MW.html
66 Plan rozwoju w zakresie zaspokojenia obecnego i przyszłego zapotrzebowania na energię elektryczną, https://www.pse.pl/documents/20182/2659a132-a951-4ef7-9bdb-08e1314503cd?safeargs=646f776e6c6f61643d74727565

and 2030, the Polish energy system will loose about 6,4 GW of generation to the combination of end of life cycle retirment, the derogation time limit, and inability to meet stricter CO2 emission and environmental standards.

3. *New nuclear power plants*

To date there is no clarification on prospective nuclear power plants in Poland because the government has not put forward a new energy strategy to guide energy sector development. A recent analyses from the Supreme Audit Office in Poland shows that the earliest nuclear capacity would enter the energy mix would be after 2030[67]. Initially, the official Polish Nuclear Power Programme set out in late 2010 by the Ministry of Economyland and then in approved by the Polish government in 2011 called for the construction of two nuclear power plans that would realize capacity of at least 1000 MW by 2024, 3000 MW by 2030 and over 6000 MW in 2035[68]. The official site of Polish Ministry of Energy states that the first nuclear power plant would be commissioned within ten years after this decision,[69] but because the investment process has not yet begun this timeframe seems unlikely.

The greatest concern for the nuclear programme in Poland is the financial aspect. Calculations differ from one project to another depending on localization and technology, but the Supreme Audit Office expects the first power plant in Poland to cost between 70-75 billion PLN[70].

4. *Security of supply (adequacy) and related domestic regulation (Capacity Mechanism)*

Due to availability or closure of existing conventional electricity generation capacities, Poland will be one of the most vulnerable countries in the EU to the risk of mothballing facilities. According to the ENTSO-E report, before 2025 Poland should decommissioned 6.4 GW of thermal capacity, including 3.4 GW by 2020[71]. On the other hand, before 2025 Poland plans to commission ~3.3 GW and additional ~0.4 GW of thermal capacity before 2027[72]. This 3.7 GW will be mostly baseload generation, while the biggest concern remains covering peak hours (now and in the future). It is possible that instead of quck closures, power plants will be decommissioned incrementally, working under a limited number of hours (there already are some power plants in Poland, e.g. works 1500 hours per year)[73].

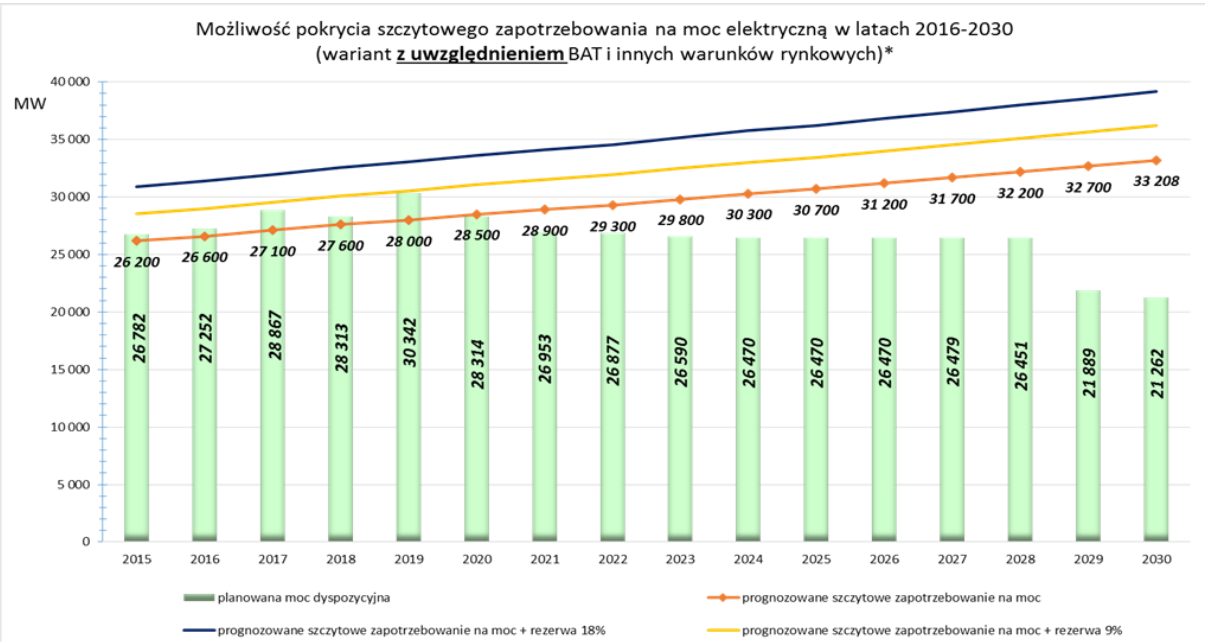
The European Commission approved the Polish electricity capacity market in February 2018[74]. Capacity mechanisms are measures designed to ensure the security of electricity supply. Typically, capacity mechanisms offer additional remuneration to electricity capacity providers, on top of income obtained by selling electricity on the market in return

[67] https://www.nik.gov.pl/aktualnosci/nik-o-realizacji-programu-polskiej-energetyki-jadrowej-ppej.html (dostęp: 18.06.2018 r.).
[68] https://www.gov.pl/energia/program-polskiej-energetyki-jadrowej1 (dostęp: 19.06.2018 r.).
[69] https://www.gov.pl/energia/energia-jadrowa (dostęp: 19.06.2018 r.).
[70] https://www.nik.gov.pl/aktualnosci/nik-o-realizacji-programu-polskiej-energetyki-jadrowej-ppej.html (dostęp: 18.06.2018 r.).
[71] ENTSO-E, Mid-Term Adequacy Forecast (2017 Edition).
[72] Plan rozwoju w zakresie zaspokojenia obecnego i przyszłego zapotrzebowania na energię elektryczną, https://www.pse.pl/documents/20182/2659a132-a951-4ef7-9bdb-08e1314503cd?safeargs=646f776e6c6f61643d74727565
[73] https://www.pse.pl/-/komunikat-osp-dotyczacy-pracy-bloku-1-w-elektrowni-belchatow-po-2016-roku
[74] http://europa.eu/rapid/press-release_MEMO-18-681_en.htm

for maintaining existing capacity or investing in new capacity. The Polish capacity market is intended to ensure the security of the electricity supply, as well as to provide incentives for investments in new capacities.

The Energy Regulatory Office mentioned that Polish OSD and OSD plan to invest over 34 bln PLN in infrastructure, of which over 21 bln in the modernization and recreation of assets. The Office provided Jagiellonian Institute with data gathered from the main utilities in Poland. According to these, Polskie Sieci Elektroenergetyczne expects that the capacity market will deliver satisfactionary generation from 2020-2035. It recommends adding new generation, DSR, and increasing the capacity of existing generation. PSE Dystrybucja reiterates this these points. Enea Operator is not expecting any security of supply threat until 2033. According to this company, security will increase because of falling dynamics of transmission system capacity development. The Office underlines that unexpected changes to energy demand and generation could undermine Enea's prediction. Energa Operator sees the main challeng for security of supply in the development of existing and new energy transmission infrastructure, especially new 110 kV WN/SN stations. Tauron Dystrybucja sets the same priority for security of supply until 2031. The main barrier would be financial resources and administrative procedures for energy system investment. The Innogy Stoen Operator expects that in the near term a major challenge to its energy system is smart grid development, though it also presents new opportunities to solve fluctuating demand and unstable RES generation. According to the Energy Regulatory Office, the introduction of the capacity market was „fully justified".

Figure 25: Capacity to fill the peak electricity demand in 2016-2030. Source: Energy Regulatory Office



5. Security concerns related to energy infrastructure

The Polish power system is an integral part of the European electricity market and it is connected via interconnectors with neighbouring countries. Since Poland is connected with other neighbouring power systems, it is connected simultaneously with almost all EU countries. Applied in Europe so-called zonal market model based on big bidding zones does not lack of problems. It is crucial to point out that in an integral part of it there are unplanned power flows, like loop flows or transit flows[75].

Unplanned power flows (unscheduled power flows) are caused by the commercial transaction (scheduled exchange). Some commercial transactions across EU Member States do not reflect the physical reality of transmission systems and the negative impact of unplanned power flows limits the potential capacity of cross-border transmission lines for the market, limiting the commercial cross-border exchange for Polish market participants. This negatively impacts social welfare in Poland.

On the other hand, in 2002 EU Member Statese adopted special targets for interconnectivity, which is currently set at 10% of installed capacity of each Member State[76]. According to the European Comission, Poland will not be able to reach this target until 2020[77]. The Polish Energy sector is lobbying for a different approach to calculate the interconnectivity that factors loopflows[78]. Then, in 2014, the European Commission proposed an increase of the interconnectivity target to 15% by 2030[79]. Still the problems created by unscheduled flows needs to be remedied: a combination of adequate bidding zone configuration, the right methodology to optimize power flows (so-called Flow-Based approach) and appropriate grid and infrastructure investment -not only cross-border but also internal (within the countries).

What is more, under the new Clean Energy for All Europeans, the European Council proposed a minimum target of 75% that for cross-border transmission lines[80]. ENTSO-E find this to be arbitrarily chosen and not reflective of the physical reality and potential of the power systems in EU[81]. To achieve this level of available cross-border capacity, TSOs need to use more re-dispatching (and other expensive remedial actions), which can increase CO2 emissions on whole EU. In addition, social welfare may be lost.

The distribution system is another integral part of all power systems. Currently, this sector also has faces several challenges, like fast-growing solar energy generation on a global scale. The growing PV sector (and other micro RES), means that more customers can generate electricity for own purpose. In Europe, some countries have high PV penetration (e.g. Italy: 8% of generation comes from PV)[82]. One of the issues is that almost half of the cost of electricity distribution comes from the variable components. In this context, more micro RES generation means less profit for

[75] Leonardo Meeus, Tim Schittekatte, The EU Electricity Network Codes, Technical Report, February 2018.
[76] http://ec.europa.eu/invest-in-research/pdf/download_en/barcelona_european_council.pdf
[77] http://www.europarl.europa.eu/legislative-train/theme-resilient-energy-union-with-a-climate-change-policy/file-15-electricity-interconnection-target
[78] http://biznesalert.pl/pkee-pakiet-zimowy-wymaga-zmian/
[79] http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145397.pdf
[80] https://www.cleanenergywire.org/factsheets/interconnectors-blockages-german-grid-odds-eu-power-market
[81] https://docstore.entsoe.eu/Documents/News/180202_ENTSO-E_public_statement_on_Art_14_Electricity_Regulation.pdf
[82] https://wysokienapiecie.pl/1863-w-europie-zaczynaja-straszyc-zombie-grids/

distribution system operators (DSO). This is a particular challenge for DSOs in Poland looking ahead to the Polish TSO forecast of PV penetration by 2027[83].

Another issue related to the distribution system in Poland is the age of the distribution network infrastructure. Analyses shows that about 30% of distribution network infrastructure needs modernization[84]. Moreover, electricity transport losses across the distribution grid are estimated up to 10%[85]. This is great concern for the future of security of supply, especially in regard to massive potential costs for new investment in distribution network infrastructure.

According to Energy Regulatory Office, the European Commision should rethink its approach to interconnectivity targets. Standard requirements for all member states does not reflect regional challenges posing different needs, costs and potential effects of increased interconnectivity for different parts of the European Union. There is a risk that a singular approach would lead to „wrong incentives for unsustainable solutins leading to over or underinvestment harmful for Energy consuments".

6. *Regional electricity challenges*

The network codes are considered to be tools that harmonize energy markets in the EU. Introduced in the Third Energy Package, network codes consist of eight legal acts published by the European Commission, which can be divided into three categories: market (I), operations (II) and connection (III). The main objective of the network codes is to facilitate the harmonization, integration and efficiency of the European electricity market.

Network Code implementation requires unification of the wholesale electricity market including, e.g. Day-Ahead Market (DAM), Intraday Market (IDM) and Balancing Market. In terms of DAM, the Multi-Regional Coupling (MRC) project is in the middle of implementation, consisting of 23 countries using the Market Coupling mechanism. Poland joined the MRC project on the cross-border interconnectors of Sweden and Lithuania and has agreed to join the initiative on synchronous borders with Germany, Czech Republic, and Slovakia.

A Cross-Border Intraday Market (XBID) project was adopted in June 2018 in 14 EU countries[86]. Both XBID and MRC are based on Market Coupling and enable coordination and harmonization of DAM and IDM in the EU. Work is also underway to include balancing markets and services due to the Electricity Balancing Guideline (one of Network Codes). Ultimately, this regulation establishes EU-wide balancing platforms for exchange of reserves enabling the development of market competition in these areas[87].

The main threats to the Polish power system under the Clean Energy for All Europeans package fall under three categories: a) related to the future shape of the energy market, b) usage of capacity mechanisms, and (c) the position

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[83] Plan rozwoju w zakresie zaspokojenia obecnego i przyszłego zapotrzebowania na energię elektryczną, https://www.pse.pl/documents/20182/2659a132-a951-4ef7-9bdb-08e1314503cd?safeargs=646f776e6c6f61643d74727565
[84] D. Ciepela, Poprawia się stan sieci elektroenergetycznej, Dziennik Gazeta Prawna, nr 52, Warszawa, 2013.
[85] http://www.kierunekenergetyka.pl/artykul,33967,jakie-wyzwania-stoja-przed-polskimi-sieciami-energetycznymi.html
[86] https://www.epexspot.com/en/press-media/press/details/press/European_Cross-Border_Intraday_XBID_Solution_and_10_Local_Implementation_Projects_successful_go-live
[87] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2017.312.01.0006.01.ENG&toc=OJ:L:2017:312:TOC

of regional operational centers. Poland believes the EU failed to include Member States in decision-making process of potential re-configuration of bidding zones. More attention should be given to increase available capacity on Poland's cross-border lines. Also capacity mechanism face some crucial risks, especially the emission limit of 550 g CO2/kWh, which denies the principle of technological neutrality. Furthermore, there is a risk connected with the proposal of the energy-only market model in EU and the guarantees of participation of foreign entities in capacity mechanisms. Finally there are risks to regional operational centers, namely related to deprivation of TSO decision-making powers in terms of system security, but also a decline in the quality of measures to ensure operational safety of national systems.

The Energy Regulatory Office states that regional operation centers can work on the basis of a compromise deal between TSOs. If ROCs are too independent and EU-oriented they can look for supervision over OSP introducing remedies not necessarily adequate for regional specifics. In the context of Regional Security Coordinators under the „Clean Energy for All Europeans," the Office proposes that the OSP should keep responsibility for security of its regulatory region. Present level of coordination is „satisfactionary".

According to Energy Regulatory Office the key factor in cross-border energy integration is recognizing the unique characteristics Member State energy systems, including necessarily cross-border trade optimalisation and minimizing security threats. The Office points out that it is especially important to Poland considering planned Baltic synchronisation in 2025.

C. Natural gas sector

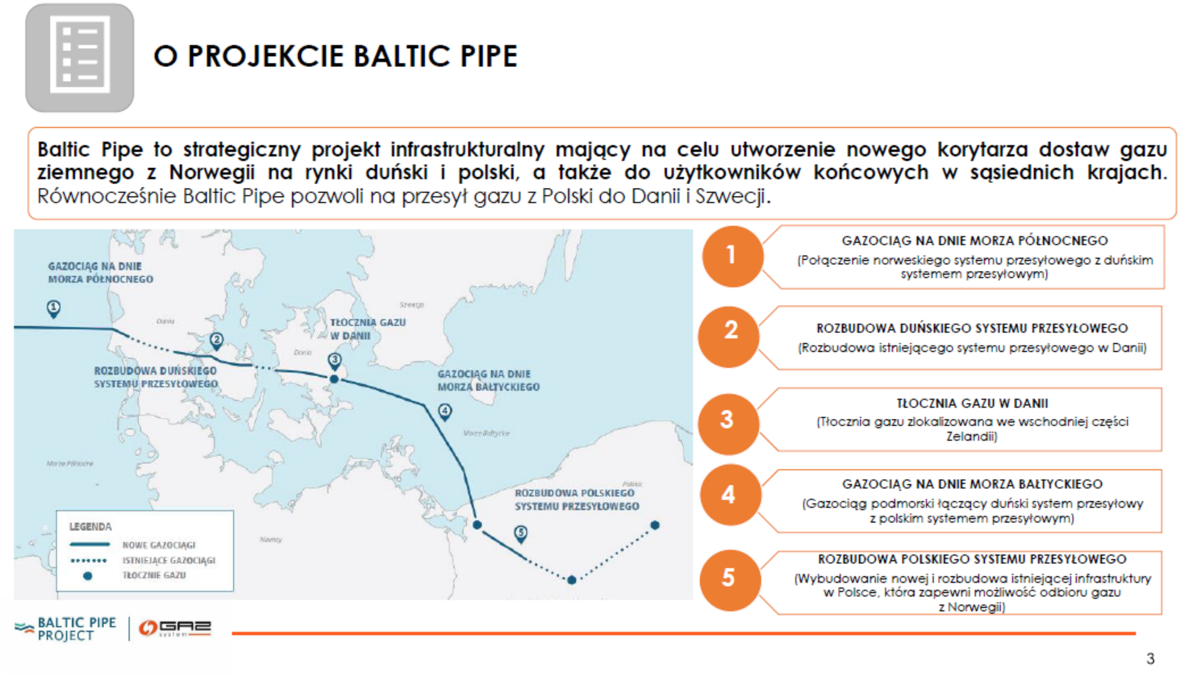
1. Production

There are no security concerns about the level of natural gas production in Poland. According to PGNiG prognosis, it should remain at 4 bcm annually thanks to revitalisation of existing fields. If the works are successful, the company expects to have almost 7 percent growth in 2019[88]. There is also a growing resource base in Norway which could serve Polish markert with the construction of Baltic Pipe via Denmark. According to the Ministry of Energy representative interviewed for this project, the plan will „limit a catalogue of crisis scenarios to technical incidents" which are easily managed in contrast to political tensions with Russia.

[88] PGNiG spodziewa się znacznego wzrostu wydobycia krajowego od 2019 r., WysokieNapięcie.pl, 23.05.2018, https://wysokienapiecie.pl/feeds/pgnig-spodziewa-sie-znacznego-wzrostu-wydobycia-krajowego-od-2019-r/

2. Infrastructure

Figure 26: Baltic Pipe project. Source: Gaz-System



Poland's strategy to diversify gas interconnections is described in the national Transmission System Operator Gaz-System's 2025 strategy[89]. The interview with a Gaz-System representative confirmed its plan to build a gas hub in Poland, using imports from Northern Gateway – LNG terminal in Świnoujscie and Baltic Pipe gas import terminal from Norway. This will contribute up to 17,5-20 bcm annually and help Poland diversifiyn from Russian gas supplies (at present: 8-10 bcm annually). Reexport could be managed using existing Germany interconnectors and planned North-South Gas Corridor interconnections with Czech Republik (second line in 2020), Lithuania (2021), and Slovakia (2021). There is also an existing connection with Ukraine and plans to build another by 2021.

The Polish government decided to prioritize the Baltic Pipe[90] to allow deliveries from Poland to transmit through Central and Eastern Europe. The alternative would be to open new interconnectors with Czechia and Slovakia and be deluged by gas imports from existing sources, mainly Russian, especially Nord Stream 2 starting in 2019.

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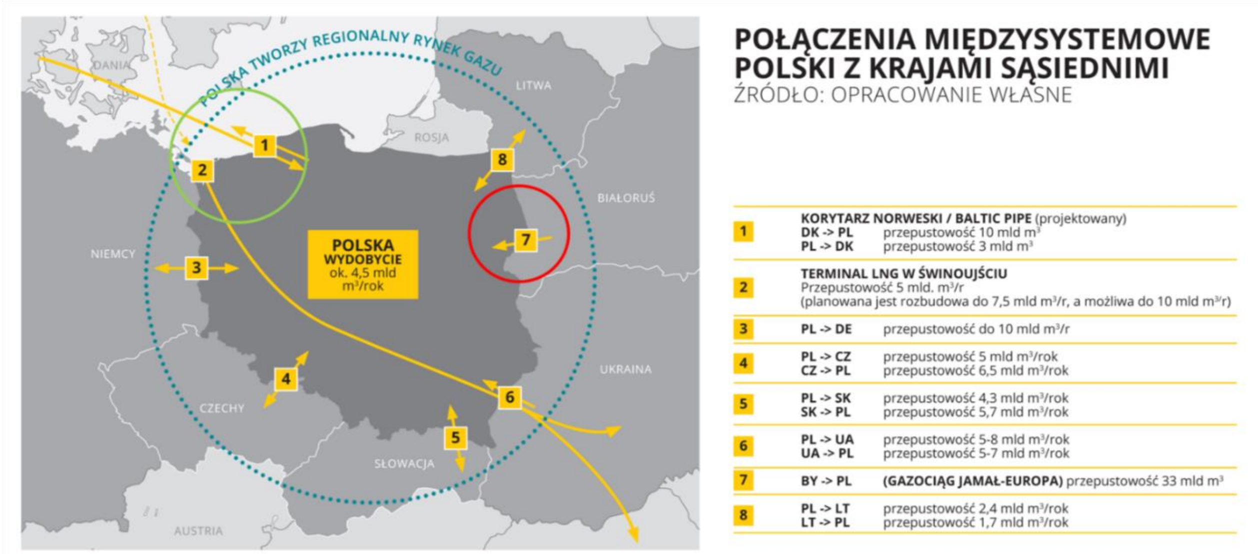
[89] Gaz-System, *Strategia Gaz-System do 2025 roku*, 17.05.2018, http://www.gaz-system.pl/centrum-prasowe/aktualnosci/informacja/artykul/202257/

[90] Gaz-System, *Baltic Pipe*, http://www.gaz-system.pl/wsparcie-z-ue/transeuropejska-siec-energetyczna-ten-e/baltic-pipe/

Figure 27: Gaz-System gas hub plan. Source: Jagiellonian Institute



The final Investment Decision for the Baltic Pipe is expected by the end of 2018[91]. If there is not a favorable decision, it could put Poland at more of disadvantage in negotiations for new gas supplies from Russia. The Polish government hopes to use this Norwegian source for leverage, and beyond this the idea of completing eliminating supplies from Russia completely has been floated.[92]

Even without Baltic Pipe (10 bcm annually) in place, their position will be much stronger than in negotiations in 1996 when the Yamal contract was signed and 2010 when it was renegotiated. The Polish government has not declared if it wants to continue gas imports from Gazprom but officials assume that ther the Yamal gas contract will not be extended.

Polish storage capacity has systematically improved, and PGNiG holds storage capacity of 2,98 bcm[93]. The company states that such capacity can cover two winter months of demand. According to gas storage system operator Gas Storage Poland, capacity will reach around 7 bcm by 2025[94].

According to the Ministry of Energy, the goal of infrastructure investment is to create a possibility for „total replacement of gas imports through Eastern border" after the Yamal gas contract concludes.

3. Security of supply

One short term risk is destabilization of gas supplies from Russia. PGNiG and Gazprom are currently in arbitration over gas price under the Yamal contract. Similar results to Gazprom's arbitration with Ukrainian Naftogaz show that even if PGNiG wins in court, Gazprom will not subdue. The court ruling in Gazprom-Naftogaz case was not followed

[91] Baltic Pipe Project, *The Baltic Pipe Project investment decision*, https://www.baltic-pipe.eu/about/investment-decision/
[92] *Naimski: Baltic Pipe nie jest przedmiotem negocjacji z Rosją*, BiznesAlert.pl, 8.02.2018, http://biznesalert.pl/polska-pgnig-gazprom-baltic-pipe-lng/
[93] *Podziemne magazyny gazu*, PGNiG, http://pgnig.pl/podziemne-magazyny-gazu
[94] Polska rozbuduje magazyny gazu, Inwestycje.pl, http://inwestycje.pl/energetyka/Polska-rozbuduje-magazyny-gazu;282465;0.html

by Gazprom in spite of the legal mandate from the court. However, this risk is already adressed by a revised Regulation on Security of Supply and Emergency action plan for Poland. In case of supply disruption from Russia, Poland will have a priority in gas supplies through interconnectors with Germany.

The Polish approach to security of gas supply is well explained by Gaz-System, whose representative was interviewed for this report. Geopolitical risks have a strong impact on energy policy, which is a part of both economic and security policy. Due to the dependence of many European countries on the supply of Russian energy resources, when analysing the geopolitical risk, one should consider the possibilities of economic and / or political destabilization of Russia and, a ceasation of the gas supplies to the region. Threats to economic security causing financial crises increase the investment risk and the risk of economic profitability, which strongly affects investors' behaviour and the demand for particular types of energy resources. As a consequence, the functioning of the fuel and energy sector is disturbed."A Gaz-System representative continued that such threat is viable after 2020 and a response should be a diversification of gas sources.

The Polish Ministry of Energy identified Nord Stream 2 as a threat not only to security of supply but also market competition. With Poland's recent and planned diversification efforts, the 55 bcm pipeline would not present an existential threat to Poland's security of supply. However Polish anti-monopoly body UOKiK warned that even if Gazprom and its Western European partners did not create a consortium for Nord Stream 2, they can still work as a gas cartel in Central and Eastern European markets, limiting market competition with oversupply of Russian gas, and undermining competetiveness of diversification projects supported by the EU, including the LNG terminal in Świnoujście[95]. While Poland has taken Gazprom to the European Court of Justice, there does not seem to be a regulatory basis for stopping the project, leaving a good possibility that Russian gas will come to Poland in 2019 not through Yamal pipeline but Nord Stream 2. The anti-monopoly survey agreement between the European Comission and Gazprom states that Russian company has to free the delivery points in gas deals, allowing customers to choose the point of delivery. Polish Ministry of Energy points out that Nord Stream 2, if built, should fully comply with European Union regulations, especially the Third Energy Package; „If it is commercially viable, Third Energy Package implementation should not be a problem" – states representative from Ministry of Energy.

According to the Energy Regulatory Office, diversification will lead to full security of supply even during the full interruption of a single source. If Nord Stream 2 becomes operational, the Office recommends legislating a higher level of solidarity between EU member states. According to the Ministry of Energy representative interviewed for this report, the history of constant Russian gas supply distruptions in 2006, 2009 and 2014 have damaged the reputation of Gazprom and led countries like Poland to seek out diversification. There is a risk of gas supply gap between 2020 and 2022 following the expiration of the transit deal between Russia and Ukraine at the end of 2019. This could create additional risks for the region in times of high demand during the winter period. That is why, according to the Ministry of Energy, security of supply through Ukraine is important for Poland and the whole of Europe. Gaz-System echoes the sentiment that a resolution of the gas transit through Ukraine after 2019 would be crucial for further development

[95] UOKiK, UOKiK przeciw Nord Stream 2, 9.05.2018, https://www.uokik.gov.pl/aktualnosci.php?news_id=14322

of the gas supply system in Central and Eastern Europe. „In case of Poland, the main challenge could be perceived with the respect of the year 2022, when the current supply LTC shall expire. By that date key infrastructure projects of Gaz-System should be completed „ – underlines Polish gas transit system operator.

Another risk highlighted by the Energy Regulatory Office and Ministry of Energy representatives is gasification in Poland, which curretly sit at at 59 percent and is only ex-ected to increase 3 percent by 2022, meaning 40 percent of Polish territory will not be gasified. Gas can help to remedy the emission challenges facing the country towards its 2030 targets under the EU climate and Energy package. That is why Ministry of Energy recommends development of small scale LNG and power-to-gas systems.

The Ministry of Energy points out that the main concern arising from EU regulation is the revised Gas Directive proposal which would be used to apply Third Energy Package rules to all pipelines, including abovementioned Nord Stream 2. However, according to the Ministry, work on revision is slowe due to lack of consensus among member states.

4. Gas price

In the short term Poland is dependent on a long term gas contract between PGNiG and Gazprom (So-called Yamal contract from 1996) on deliveries of up to 12 bcm annualy. It has a take or pay clause estimated for about 80 percent of supplies until its expiration in 2022, That is why Poland imported about 8 bcm of Russian gas in 2017 (minimum from TOP clause) and the rest was purchased on the market from LNG and Germany[96].

The short term risk related to natural gas prices is that the Yamal-Europe contract will undermine the competetiveness of Polish industry in comparison to, for example, prices for German customers. This point has been made by the national chemical champion Grupa Azoty[97]. With an Act on Stocks in place, there is a little room for independent suppliers to bring low cost natural gas to Polish customers. PGNiG can only use the gas exchange for lower priced hub indexed volumes after its obligatory offtake under the Yamal contract.

However, independent suppliers are limited by the Act on Stocks of Crude Oil, Petroleum Products and Natural Gas which makes them responsible for backing up any imports by an equivalent amount of gas in storage under the so-called ticket service. This is intended to ensure available gas supplies to the market at all times, but inherently limits the trader’s capacity for importing natural gas, especially smaller entities. In the short term, this will facilitate more market power for incumbent PGNiG and its Yamal contract, but from the government’s prospective it is necessary for energy security.

Even if diversification projects bring positive changes to the market, the costs must be bourne by Polish customers in the form of gas tarrifs. The LNG terminal in Świnoujście is subsidized by a 100 percent capacity reservation from

[96] Ministerstwo energii, Sprawozdanie z wyników monitorowania bezpieczeństwa dostaw paliw gazowych za okres od dnia 1 stycznia 2016 r. do dnia 31 grudnia 2016 r., Warszawa, lipiec 2017.

[97] *Azoty o tajemniczej sinusoidzie cen gazu*, BiznesAlert.pl, 10.05.2018, https://biznesalert.pl/grupa-azoty-1q18-ceny-gazu/

PGNiG, which must be reflected in gas prices for its customers. Its capacity is to be enlarged to 7,5 bcm annually with an option of going to 10 bcm. Baltic Pipe will be financed from EU CEF as a PCI and also gas tariffs. However, PGNiG's reservation of 80 percent of capacity could limit the amount of EU funding that is made available, and the rest would fall to customers.

According to the Energy Regulatory Office, gas prices in Poland will become more competitive with new sources of supply available. There will be also an opportunity to re-export natural gas to other countries. The long term gas contract should continue to serve as backbone of supply for Poland until 2030, but its role will be „systematically diminishing in favour of short term transactions". That should lead to „more equal" gas contracts with main suppliers like Russia.

5. *Summary*

In the short term the Polish gas market is set to change signifantly with the expiration of the Yamal contract in 2022. This will also be impacted by the diversification plan that is underway. If it succeeds, Poland will be less vulnerable to changes in the regional gas market, and furthermore LNG and Baltic Pipe would allow the country to become a more significant transit player for Central and Eastern Europe if prices are competitive. In this way, it could become an alternative to Nord Stream 2 supplies. The risks are connected to the timeline of diversification projects and lack of competition on internal market.

Table 10: Interviews

Name	Position	Institution
Piotr Sprzączak	Head of Infrastructure Unit, Oil and Gas Department	Ministry of Energy
Maciej Bando	CEO	Energy Regulatory Office
Tomasz Pietrasieński	Expert	Gaz-System

Section IV: Slovakia

A. Executive Summary

This report provides a general overview of the main energy policy dilemmas of the Slovak Republic. Although natural gas is considered to be the focal point of energy policy since the 2009 gas crisis, this report examines challenges with respect to other primary energy sources such as oil, and inputs for electricity generation. However, due to its global and flexible nature, oil is considered only to a limited degree. The report also covers more latent issues connected to energy security that will grow in prominence in the near future – for example, cyber security in relation to critical energy infrastructure. The text is based on primary data and official documents published by different Slovak authorities that are part of energy governance (ministries, regulatory authority, transmission system operator, etc.)

and series of 11 interviews with representatives of the main stakeholders (including energy companies operating on Slovak territory).

With very limited domestic production covering only approximately 2% of overall consumption, Slovakia is highly dependent on the import of natural gas. The 2009 crisis was the key action forcing event that put energy security (not only for gas, but more generally) high on the agenda of energy policy and underlined the importance of energy security for the proper functioning of Slovakia's economy. As a result, Slovakia undertook a programme of natural gas supply diversification with neighbouring countries, including several reverse flows (the Czech Republic, Austria, Ukraine) and a new interconnector with Hungary, while an interconnector with Poland that will open Slovakia to its Świnoujście LNG terminal is under construction. Another massive natural gas diversification project being considered is the Eastring pipeline, which would ultimately connect the Slovak transmission system to the envisioned Turkish gas hub (expected with the commissioning of TANAP/TAP and Turk Stream) via Bulgaria, Hungary and Romania. Along with the Polish-Slovak interconnector, Eastring is listed as a PCI (Project of Common Interest) project and thus supported by the Connecting Europe Facility (CEF).

The main short-term challenge for Slovakia's natural gas sector concerns future of transit through Ukraine and the Brotherhood pipeline. The current transit contract between Russia (Gazprom) and Ukraine (Naftogaz Ukrainy) terminates on the final day of 2019, leaving uncertainty over the nature of transit contracts thereafter if there will be any. After the commissioning of Nord Stream I in 2011 re-routed significant Russian supplies for European customers away from the Brotherhood pipeline (and thus also through Slovakia), the proposed 55 bcm/year capacity Nord Stream II has the potential to render the Brotherhood pipeline obsolete, thereby significantly altering the position of Ukraine on the traditional European gas map. As a consequence, Slovakia's status as a transit country is diminished (what is considered to be one of the main elements of energy security) leaving it as a small customer (total gas consumption is about 5 bcm/year).

The electricity sector is dominated by the nuclear industry, currently producing more than half of all electricity consumed in Slovakia. In spite of its dependency on imported fuel rods from the Russian Federation, it is considered to be a domestic source of energy, and one with minimal carbon footprint contributing to climate goals. The nuclear industry is set to become even more dominant in coming years with the two new reactors (3 and 4) at Mochovce nuclear power plant (NPP) expected to come online in 2019 and 2020, although after repeated delays these dates cannot be considered firm. There remain several unresolved, open issues in connection with commissioning, such as the price of produced electricity. Already Slovak companies are importing electricity not due to lack of domestic capacities but because the imported electricity is cheaper compared to domestic production.

The two new nuclear reactors will produce approximately 7 000 GWh/year of electricity that will have to be included in Slovakia's energy mix with an important share of (intermittent) renewables and decreasing presence of (flexible) thermal plants. This has the potential to create problems for grid stability, as can be observed at the end of January 2017. The new grid interconnector with Hungary is crucial for the development of new markets for surplus electricity, however, regional competition (the Czech Republic already exports significant amount of electricity and Hungary's

Paks 2 nuclear expansion is expected by the middle of the next decade) in energy export will be fierce. Slovakia's electricity grid stability will improve if the Malženice gas power plant is brought online by Západoslovenská energetika, which purchased the plant in August 2018. This type of flexible power plant is very suitable for grid balancing purposes and in the current market of low gas prices more financially viable.

The new power shifting transformers at the German-Polish and German-Czech borders have not been fulfilled, leaving unscheduled flows through Slovakian territory similar to 2012 levels along Czech/Slovak and Slovak/Ukrainian interconnectors. Thus loop flows from Germany are still overloading Slovakia's transmission gird and limiting the ability of cross-border trade.

An important, but relatively neglected challenge, is in the area of to cyber attacks on critical energy infrastructure. The Slovak government has not developed a comprehensive strategy in this area yet (there is, however, a general cyber security strategy) nor has there been a complex discussion on this issue. The importance of cyber security is already well acknowledged in energy security circles, and Slovakia's several nuclear facilities and important transit status should make it more of a priority even in the short-term.

B. Introduction

The purpose of this text is to provide a general overview of the main challenges the Slovak Republic is facing in energy policy area. Although following the 2009 crisis the natural gas sector receives the lion's share of attention from policymakers[98], other areas presenting short and long term challenges require more attention - namely electricity grid balancing or cyber security of energy infrastructure. These challenges are closely connected to energy transition that is the main Slovak long-term goal in energy policy area. The energy transition towards a low-carbon (an ideal model suggests carbon-free) economy requires changes in the way energy is produced, transmitted and consumed, pressuring fossil-based energy systems that are – in their various forms – fuelling the economy. As an EU member country Slovakia has set national objectives in accordance with the Energy and Climate Package[99] and the transformation of energy sector is needed to meet these goals.

This text examines the main challenges Slovakia faces in securing natural gas, electricity and (to a lesser degree) oil in the foreseeable future. It starts by providing a general overview of the Slovak energy sector before analysing each specific energy type, not only from Slovakia's national perspective, but also from a broader regional perspective that goes beyond the Visegrad Four group (V4; for example, loop flows connected to Germany's electricity market).

Although significant upgrades in natural gas infrastructure have been made contributing to Slovakia's energy security, Nord Stream II presents a challenge by reducing transit through Slovakia via the Brotherhood pipeline after 2019 (if it is completed on time) when the current transit agreement between Ukraine and Russia expires. Natural gas transit

[98] Mišík, M. (2016) On the way towards the Energy Union: Position of Austria, the Czech Republic and Slovakia towards External Energy Security Integration. Energy, vol. 111, pp. 68-81.
[99] 2020 climate & energy package. Available at: https://ec.europa.eu/clima/policies/strategies/2020_en.

is considered to be crucial for safeguarding Slovak energy security, and its termination (or significant reduction[100]) is therefore viewed as a major threat to energy security. Such position, however, does not take into consideration the existing level of diversification that guarantees physical access to alternative supplies. The country's energy security in natural gas has been significantly improved since the 2009 gas crisis to the point that a cessation of gas supplies from such a disruption will not be repeated (Interview 5).

The main challenges to the electricity sector are associated with unscheduled transit flows through Slovakia's transmission grid and the underlying issue of grid stability with high proportion of electricity generated from nuclear and renewable sources (RES). The most important current challenge in electricity generation is connected to completion of Mochovce 3 and 4 NPP which commencement has been repeatedly postponed (the original deadline for the first reactor, that is still not online, was 2012). The role of coal in electricity generation is also questionable not only from mid-term perspective, but also from short-term one.

The analysis in this report is based on primary and secondary research conducted from July to September 2018. Altogether 11 interviews were conducted with different Slovak energy sector stakeholders (10 in person and one conducted via email) listed in Appendix 1. Official documents and statistical data from Eurostat and national authorities along with secondary sources (existing analyses, academic papers, think-tank reports) are used to further strengthen the positions presented in this report.

C. General energy market statistics for Slovakia

Energy consumption[101]

Slovakia has gross inland energy consumption of approximately 16 Mtoe (million tons of oil equivalent). The consumption fell from 21.8 Mtoe in 1990 to 16.2 Mtoe in 2014. The latest data for 2016 show total gross inland energy consumption at 16.4 Mtoe, thus showing a slightly downwards trajectory of the total energy consumption of the country (see Figure 28).

Industry is responsible for the majority of the final energy consumption (43 per cent), followed by transport (24 per cent) and residential (19 per cent), and services (12 per cent). The rest (2 per cent) is consumed by agriculture and other sectors. While consumption has trended down over this period, Slovakia's energy production has plateaued since Mochovce 1 and 2 NPP was added in the late 1990s. As a result of Slovakia's falling energy imports, the gap between energy consumed and domestically produced has narrowed over this period (see also Figure 29).

[100] Sharples, J. (2018) Ukrainian Gas Transit: Still Vital for Russian Gas Supplies to Europe as Other Routes Reach Full Capacity. The Oxford Institute for Energy Studies.
[101] All data in this section, if not stated otherwise, are from „Energy datasheets: EU28 countries“, update 14 February 2018, published by the European Commission, DG Energy. Available at: https://ec.europa.eu/energy /sites/ener/files/ documents/country datasheets_feb2018.xlsx. Accessed 1 June 2018.

Figure 28: Slovak production and gross consumption of energy (in Mtoe)

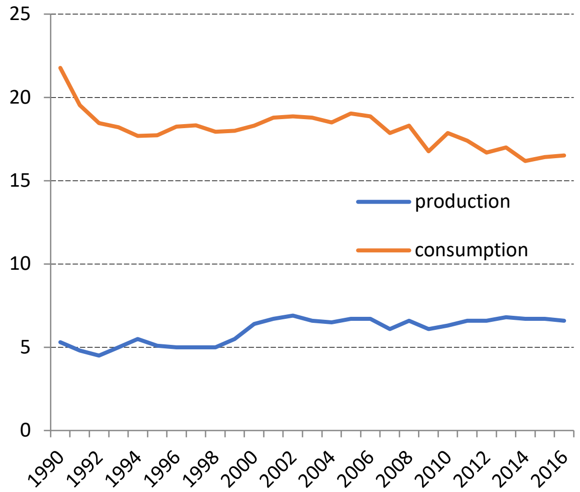
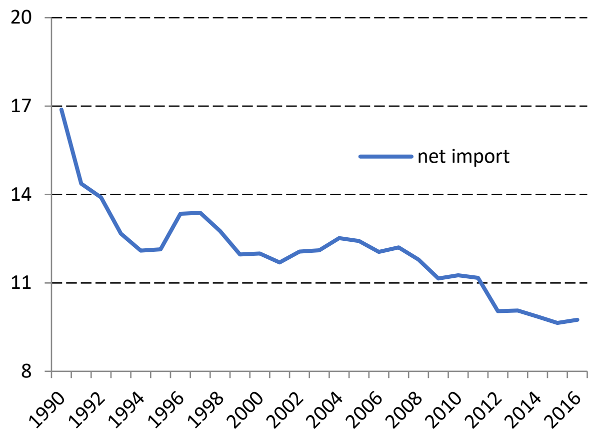


Figure 29: Slovak energy import (in Mtoe)



Most energy consumed in Slovakia is imported, including almost all natural gas and oil. The most significant national source of energy lies in nuclear power, responsible for 3.9 Mtoe out of total 6.6 Mtoe domestically produced energy in 2016. RES is the second largest domestic source with 1.6 Mtoe generated in 2016. Other domestic energy sources produce a much smaller share of total consumption (see also below).

Energy supply

Slovakia imports most energy for domestic consumption from abroad. Domestic production of solid fuels accounted only for 0.5 Mtoe in 2016, petroleum 0.4 Mtoe and natural gas 0.1 Mtoe respectively. Non-renewable waste provided altogether 0.2 Mtoe of energy. Figure 28 shows aggregate figures of gross inland energy consumption and domestic production of energy for the 1990-2016 period. The resulting fall in net imports from 16.9 Mtoe in 1990 to 9.7 Mtoe in 2016 ca be seen in Figure 29. The highest import was natural gas with 3.6 Mtoe, followed by oil and petroleum products with 3.2 Mtoe. Slovakia also imported 2.7 Mtoe of solid fuels in 2016 and 0.2 Mtoe of electricity.

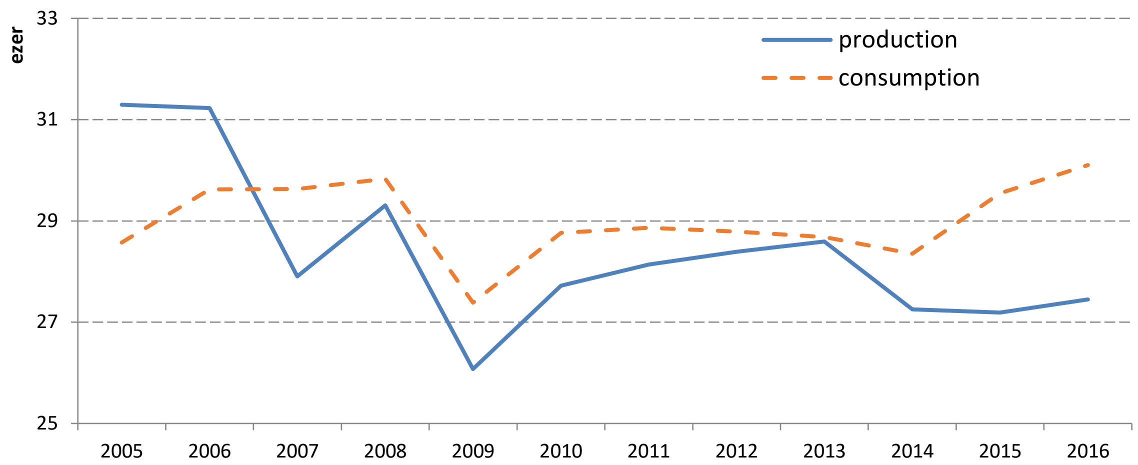
Electricity consumption and generation

When it comes to electricity generation, Slovakia's production was 27 541 GWh compared to consumption of 30 103 GWh in 2016, a record high at the time[102] before it rose again the following year to reach 31 056 GWh. The rise is attributed to a broad increase in economic activity combined with a colder than average winter. The peak load of Slovakia's electricity grid in 2016 was 4 382 MW on 7 December 2016 at 5pm, 236 MW more than the previous year[103].

[102] The data in this section are from Ministry of Economy of the Slovak Republic (2017) Správa o výsledkoch monitoro-vania bezpečnosti dodávok elektriny za 2016. Available at: http://www.economy.gov.sk/uploads/ files/ D5tgGoZt.pdf.
[103] Ibid.

Average load in 2016 was 3 427 MW and total installed capacity 7 848 MW. Figure 30 provides an overview of Slovakia's electricity consumption and production.

Figure 30: Slovak electricity production and consumption (in GWh)



There was a slight decrease in national capacity in 2015 resulting mostly from the reduction of installed capacity in two blocks of the coal-fired power plant Vojany (EVO) and one in Nováky (ENO). Moreover, gas-fired power plant Malženice was mothballed in 2013 when the production of electricity from natural gas became uneconomical. A similar energy source in Bratislava produced only a very limited amount of electricity for the same reason. Nuclear power plants produced the biggest portion of electricity in 2016 (53.8 per cent or 14 774 GWh while representing 24.7 per cent of installed capacity) followed by thermal power plants (19.4 per cent or 5 319GWh; 31.5% of installed capacity), hydro power plants (17.6 per cent of produced electricity or 4 844 GWh; 32.3 per cent of installed capacity) and (non-hydro) renewable and other sources (8.9 per cent or 2 515 GWh of electricity; 11.2 per cent of installed capacity).

Electricity import-export

Slovakia has been a net importer of electricity since 2007 after the 2006 phase out of a reactor in nuclear power plant (NPP) Jaslovské Bohunice which was followed with the phaseout of a second unit at the end of 2008 as illustrated in Figure 30; we can observe this decrease also on the overall production – see Figure 28). Imports of electricity were declining until 2014. In 2016, imports covered 8.8 per cent of total electricity consumption. Due to the low price of wholesale electricity (and high prices of fuel) it is for many stakeholders cheaper to buy electricity abroad and this has been actually identified as a reason for increase of electricity import since 2014[104].

Transit

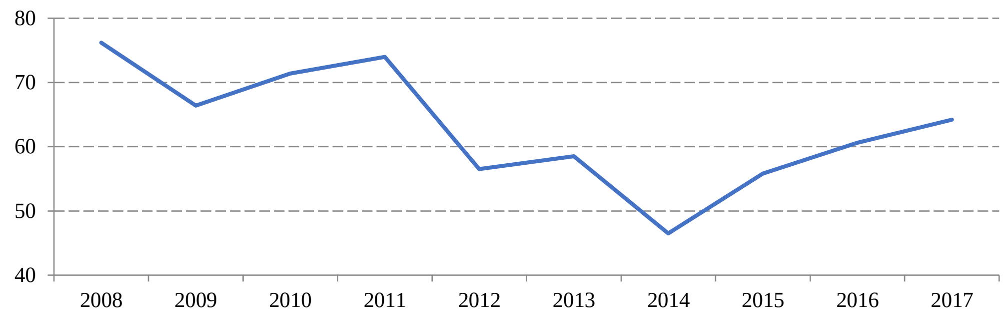
Oil is transported through Slovakia via Druzhba pipeline by Transpetrol, a.s. The amount of oil transported from the Russian Federation via Ukraine was 9 917 thousand tons in 2016. Out of this amount the biggest share was delivered

[104] Ibid.

to Slovnaft, a.s., the only refinery in Slovakia (5 747 thousand tons) and a smaller share to refineries in the Czech Republic (3 424 thousand tons). The total amount of oil transported through Slovak territory has fluctuated during the 2012-2016 period between 8 418 and 9 932 thousand tons[105]. Domestic production of oil is minimal, and the only company Nafta, a.s. produced 8 162 tons of oil and condensate in 2017[106]. The rest of oil that is consumed in Slovakia is imported via the Druzhba pipeline.

Natural gas transit has retained a crucial position in Slovak energy policy as a critical part of national energy security. Natural gas is transported via Slovakia through the Brotherhood pipeline by Eustream, a.s. (the Slovak TSO), which transported 64.2 bcm of natural gas in 2017; 5 bcm to the Czech Republic, 45 bcm to Austria (and then further to Europe) and 10 bcm to Ukraine[107] with Slovak consumption covered the rest. In 2016, the domestic consumption of natural gas was about 4.8 bcm[108]. About 98 per cent of total consumption is covered by import with domestic production amounting to only to 89 mcm in 2016[109]. Transit through Slovakia has fluctuated, with reverse flow to Ukraine significantly increasing the overall transit and utilization levels of the transmission system starting in 2014 (see Figure 31). The main reason behind the decreased transit in the east-west direction (i.e. from the Russian Federation to European countries) was the completion of the Nord Stream pipeline (first line in 2011, second in 2012) that displaced significant Brotherhood capacity, and Nord Stream 2 will further decrease the utilization rate of the pipeline not only in Slovakia but also in Ukraine (see also below).

Figure 31: Transit of natural gas through Slovakia (bcm)



Slovakia's energy policy agenda falls under the Ministry of Economy. It is guided by the main strategic document "Energy Policy of the Slovak Republic," approved in November 2014. Another important energy policy document that sets the energy security strategy is "Energy Security Strategy of the Slovak Republic" adopted in October 2008 that has not been updated since, in spite of the 2009 gas crisis that occurred thereafter. Both electricity and natural gas

[105] Annual Report. Transpetrol, a.s., available at: http://www.transpetrol.sk/wp-content/uploads/V%C3%Bdro %C4%8Dn %C3%A1-sp%C3%A1va-2016.pdf.
[106] Správa o činnosti za rok 2017 hlavného banského úradu a obvodných banských úradov Slovenskej republiky. Availbale at: http://www.hbu.sk/files/documents/spravy/2017/ro%C4%8Dn%C3%A1%20spr%C3%A1va%2020 17.pdf.
[107] eustream, a.s. Annual report 2017. Available at: http://www.eustream.sk/en_download-file/annual-report-2017/1f7852e76dd083e97a7930f319eb7439.
[108] Správa o výsledkoch monitorovania bezpečnosti dodávok plynu 2016. Available at: http://www.economy.gov.sk/uploads/files/o12GkcSI.pdf
[109] Ibid.

markets are liberalised in line with the Third Energy package, opening competition between suppliers at the wholesale market (unregulated) and at the retail level (regulation is provided by Regulatory Office for Network Industries established in 2001).

D. Security of Supply challenges related to the domestic electricity sector in Slovakia

Slovakia's electricity sector is characterised by relatively high presence of nuclear energy and declining use of coal-fired thermal power plants. Although four reactors (two reactors of V2 of Jaslovnské Bohunice NPP and two reactors in Mochovce NPP) represent 24.7 per cent of total installed capacity, they account for more than half of national production. On the other hand, coal-fired power plants accounting for more than 30 per cent of total installed capacity produced 19.4 per cent of domestic electricity. Steep development of photovoltaic power plants at the very beginning of 2010s fuelled by significant support in the form of feed-in tariffs and preferential access to the electricity grid ended abruptly in 2011, leaving 577 MW of PV installed capacity today. However, energy transition towards low-carbon economy will require further investment into RES capacities as these are supposed to, in the long-term, to replace emission producing sources like coal-fired thermal plants. Together with the increase of nuclear input after the two reactors of Mochovce NPP will be commenced (2019 and 2020 are currently set as the commencement dates for the reactors) the main challenge in electricity area will be to balance the electricity grid.

1. Short-term electricity market risks

Slovakia imports a significant and growing part of its electricity consumption from abroad (see Figure 30), for example in 2017 3 030 GWh, 378 GWh more than the previous year[110]. Slovakia has capacity to cover this difference from domestic sources, however, due to the imbalance between production costs and wholesale price of electricity, it is cheaper to import electricity from abroad (Interview 1). This situation will change with the commencement of Mochovce 3 and 4 that will bring significant amount of new electricity to the market (approximately 7 000 GWh/year). This means that the share of nuclear energy in Slovakia's energy mix will increase in the following years, putting pressure on the TSO to balance the electricity grid.

Risk of Power Outages

While the country does not experience power outages, there are challenges facing balancing of the grid. The most significant issue is connected to tertiary regulation, and to a lesser degree secondary regulation. Especially two periods during 2017 have proven to be difficult from grid balancing perspective. A cold snap in January 2017 caused increased demand from 4M MC group (market coupling between the Czech Republic, Hungary, Romania and Slovakia) leading to a shortage. This triggered a steep increase in the regulated electricity price to more than 110 euro/MWh, supporting speculative behavior of stakeholders on the market[111]. There was a general lack of electricity production in Slovakia at the time and an emergency procedure was activated on 24 January 2017 in order to get access to

[110] Ministry of Economy (2018) Správa o výsledkoch monitorovania bezpečnosti dodávok elektiny 2017. Available at: https://www.mhsr.sk/uploads/files/TZINde4d.pdf.
[111] Ibid.

emergency supplies from neighboring grids. Although all supporting services were activated (727 MW), Slovakia still needed to import increased amounts of electricity (100-350 MW) from the neighboring countries, namely the Czech Republic and Poland. Nonetheless, the situation did not lead to a power outage or any similar situation. One solution to this problem could be more flexible pricing of balancing services that would provide incentives for operators to create a reserve (Interview 1). Moreover, there is a general tendency to double the strategic components of Slovak electricity grid in order to minimize the chance of power outages.

Besides this issue another problem is connected to transit flows of unscheduled electricity from Germany through transmission grids of Central and Eastern European countries, including Slovakia. These flows overload the grid, increasing losses in the system (and thus also price of its operation) and the chance of blackouts. This problem is covered in further detail below.

2. *New generation capacity related risks (up to 2030)*

Renewable penetration

The position of RES in Slovakia until the end of 2000s was weak with the main share of hydro energy. Slovakia, however, has significant potential in RES (not all stakeholders agree), with some estimates claiming that RES potential is over 30 TWh/year, equivalent to the overall consumption of the country. The biggest potential is for biomass with more than 11 TWh/year, already the biggest share from all types of RES (Interview 4). In order to support development of RES in Slovakia and in this way contribute to country's 14% RES goal. "Act 309/2009 on the Promotion of Renewable Energy Sources and High-Efficiency Cogeneration" was adopted in 2009[112], and the fixed feed-in-tariffs and preferential access to the grid (for technical details please see the 2012 IEA report[113]) therein led to a sharp spike in photovoltaic (PV) installations. The tariffs were set for 15 years (at the level of 259,17 euro/MWh) and meant to help to establish the industry and foster research and development.

Therefore, PV power plants were developed extremely fast (not only in Slovakia, but many other countries with similar policies), labelled by the IEA the "PV boom". The "boom" can be illustrated by the fact that in 2009 there was not a single one PV power plant in Slovakia and by the next year there was 186 MW of installed PV capacity that produced 11GWh[114] of electricity. The policies were changed in 2011 to prevent further increase of large PV installations and currently there is no support for large installations, only small and rooftop PV power plants are subsidized. Currently

[112] Ministry of Economy (2015) Správa o pokroku v presadzovaní a využívaní energie z obnoviteľných zdrojov energie. Available at: http://www.economy.gov.sk/sprava-o-pokroku-oze--2015-/147583s.
[113] IEA (2012) Energy Policies of the IEA Countries. The Slovak Republic.
[114] Atlas obnoviteľných zdrojov energie na Slovensku. Available at: http://ecb.sk/fileadmin/user_upload/editors/documents/Kniha_OZE_A5_def_web.pdf.

there is altogether 530 MW of PV installed capacity (6.9 per cent of total installed capacity) that contributed 592 GWh (or 2.1 per cent) to total electricity production[115].

In 2010 the Ministry of Economy published the National action plan for energy from renewable sources[116] that currently guides the development of RES. Slovakia's goal within 2020 energy and climate package is 14 per cent of RES in total energy consumption, and it supports the indicative goal of 27 per cent EU-wide within the 2030 Energy Strategy. The Ministry of Economy claimed in April 2017 that is does not want to change the nature of the goal and is against binding goals at the national level within this strategy[117]. Currently there is a debate about what the target should be and how to contribute to it; at 18-20 per cent level, for example, a big question is what will happen to existing RES once support schemes end (Interview 1). Biomass has a significant share in RES and shows the biggest potential in heat generation, included in the official prognoses of national RES development as one of its main sources (especially when it comes to heat generation)[118].

Growth of RES in the electricity mix has increased the need for back-up sources and support (balancing) services, especially in connection to PV power stations (Slovakia has only few wind turbines with negligible production so this form of RES in not discussed). This concern has been emphasized by the Ministry of Economy, highlighting the challenge of grid stability vis-à-vis the reduction of flexible sources (like gas- or coal-fired power plants) and commencement of new (and non-flexible) nuclear sources[119]. One solution to this problem is to set new support schemes in a way that would motivate RES operators to provide part of their capacity for balancing purposes. However, not all RES are suitable for this, and one solution would be the integration of biogas power stations into grid balancing system (Interview 11).

New nuclear power plants

In 2008 the Slovak government decided to re-start work on 3rd and 4th reactor of Mochovce NPP that originally started in 1987. After a stoppage following the change of regime and ensuing economic turmoil at the beginning of the 1990s, work on Units 1 and 2 was restarted in the mid-1990s and commissioned in 1998 and 2000 respectively. It is expected that the third and fourth reactors will be connected to the grid in late 2019 and late 2020, although these dates have been moved several times from the original 2012 and 2013 targets. The original budget was set to 2.8 billion €, however, currently the total bill is estimated to be 5.4 billion €. This is a serious burden for Slovenské elektrárňe, a.s. responsible for construction of the power plant (Interview 7). Nuclear power is considered to be a secure domestic source of energy with fuel reserves for hundreds of years and a "zero" carbon footprint (interview 11). According to

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115 Ministry of Economy (2018) Správa o výsledkoch monitorovania bezpečnosti dodávok elektiny 2017. Available at: https://www.mhsr.sk/uploads/files/TZINde4d.pdf

116 Národný akčný plán pre energiu z obnoviteľných zdrojov. Available at: http://www.economy.gov.sk/narodny-akcny-plan-pre-energiu-z-obnovitelnych-zdrojov/135436s.

117 Slovenské ministerstvo pri zakladaní Energetickej únie nie so všetkým súhlasí. Available at: http://venergetike.sk/ slovenske-ministerstvo-pri-zakladani-energetickej-unie-nie-so-vsetkym-suhlasi/.

118 Národný akčný plán pre energiu z obnoviteľných zdrojov.

119 Správa o výsledkoch monitorovania bezpečnosti dodávok elektriny za 2016. Available at: http://www.economy.gov.sk /uploads/files/D5tgGoZt.pdf.

an interview from Slovenské elektrárňe, a.s. (Interview 8) the main goal of EU climate policy is decarbonisation of the economy; RES are not goals in themselves but one possible means for achieving decarbonisation in power generation, and it should be therefore up to member states which path they will choose, whether their system will be based on RES or on other sources, including nuclear.

These two new reactors (Mochovce 3 and 4) with installed capacity of 2x471 MW will turn Slovakia into net exporter of electricity. This has several consequences for the energy sector connected to safety, waste management and the possibility to sell surplus electricity (Interview 10). Although the power grid has been upgraded in order to implement the new NPP, future large sources of electricity will have to be carefully considered as there is not much room for further production capacity (Interview 1). Moreover, this will also further contribute to the existing problems with grid balancing (see above). Unstable and unpredictable (or difficult to predict) RES sources will need to be balanced in a system with a very high share of electricity from inflexible nuclear sources. These will provide baseload that will cover a significant part of the consumption, however, will not be able to cover differences between seasonal and daily load consumption patterns[120]. This will have to be done with other sources since intermittent renewable sources are not suitable for this purpose and under current subsidy schemes RES do not provide capacity reserve for balancing (Interview 11).

Even hydro plants are not always suitable for balancing purpose since they depend on the amount of water in rivers that fluctuates throughout the year and the largest facilities are not very flexible and therefore contribute predominantly to the base load. The smaller hydro plants are more flexible, however, they have limited capacity. On the one hand imports from abroad can be a suitable solution, on the other hand there can be political objections to such solution and this option does not have to be always available (plus regulatory electricity can be subject to speculation as demonstrated by the demand shock at the end of January 2017). One respondent (Interview 4) cited political pressures within the European Union as a possible challenge to long-term utilization of nuclear energy in Europe.

Moreover, it is not clear how customers will approach electricity generated from Mochovce reactors 3 and 4. Already electricity stakeholders prefer imports from abroad to available Slovak capacities that are not competitive (the ones that do not are subsidized in any way). Electricity produced by the new units will not be subsidized (although there was a discussion on guaranteed prices for produced electricity) and there will be significant competition from other major sources of electricity in the region. Electricity export will be crucial for Slovakia after Mochovce is finished as it is a small market with a high share of nuclear (Interview 9). The Slovak-Hungarian grid interconnector that is currently being developed will improve the availability of electricity export to the Western Balkan states (Hungary will not need import after Paks 2 will be finalized), however, there will be other regional players that will compete on this market currently characterized by higher electricity wholesale price. According to a respondent from Slovenské elektrárne, a.s., the dominant electricity producer, the interconnector will be crucial for its ability to sell surplus energy existing on the Slovak market after Mochovce 3 and 4 will be finalized (Interview 8).

[120] Nuclear sources have some balancing posibilities, but these are limited (Interview 11).

3. Maintenance, availability or closure of existing conventional electricity generation capacities

While nuclear and RES are being further developed in Slovakia, other sources, especially coal-fired thermal power plants (and gas-fired as well) are decreasing their capacity. This is connected to falling production of coal in Slovakia, technological obsolescence of existing coal-fired plants and the need to limit pollutants emissions (in order to meet EU goals in this area). There are two coal-powered power plants in Slovakia – in Vojany (EVO) located in the eastern part of the country with installed capacity 2x110 MW and in Nováky (ENO) in the western part with capacity of 266 MW. Other blocks of the power plants have been mothballed or de-commissioned: in 2015 two blocks in EVO and in 2016 two blocks in ENO (due to emission limits). Both power plants are used from a significant part for regulation, as their flexibility is important for the stability of electricity grid.

While nuclear is able to provide only base load and RES are intermittent by nature, coal-fired and gas-fired power plants play an important role in balancing the grid system. However, while the former group of energy sources will increase in the near future (Mochovce 3 and 4 NPP; increase of RES is probable due to need to fulfil more and more ambitious climate and energy coals at the EU level), the latter type of capacity is decreasing due to climate policy reasons (coal-fired) or high price of the commodity (gas-fired power plants). Nonetheless, these two coal-fired power plants will likely be closed down in the following decade and there is an important question as to what will happen next (Interview 1).

Malženice natural gas power plant was mothballed in 2013 after only several thousands of hours of service because the high price of natural gas compared to lower wholesale electricity prices made it economically unfeasible. A similar source in Bratislava has been mothballed too. According to a representative from the Slovak Ministry of Economy this represents one of the biggest current challenges – low wholesale electricity prices and lack of flexible electricity sources like gas-fired power plants (interview 1). The operator of Malženice power plant indicated interest in re-starting the power plant during 2018 as the price of gas decreased and the price of electricity (especially the one used for regulation) increased. It was purchased by Západoslovenská energetika, a.s., 51 per cent of which is owned by the Slovak government. One of the main reason for this step was to improve regulatory potential of Slovak electricity grid[121].

4. Security concerns related to electricity infrastructure

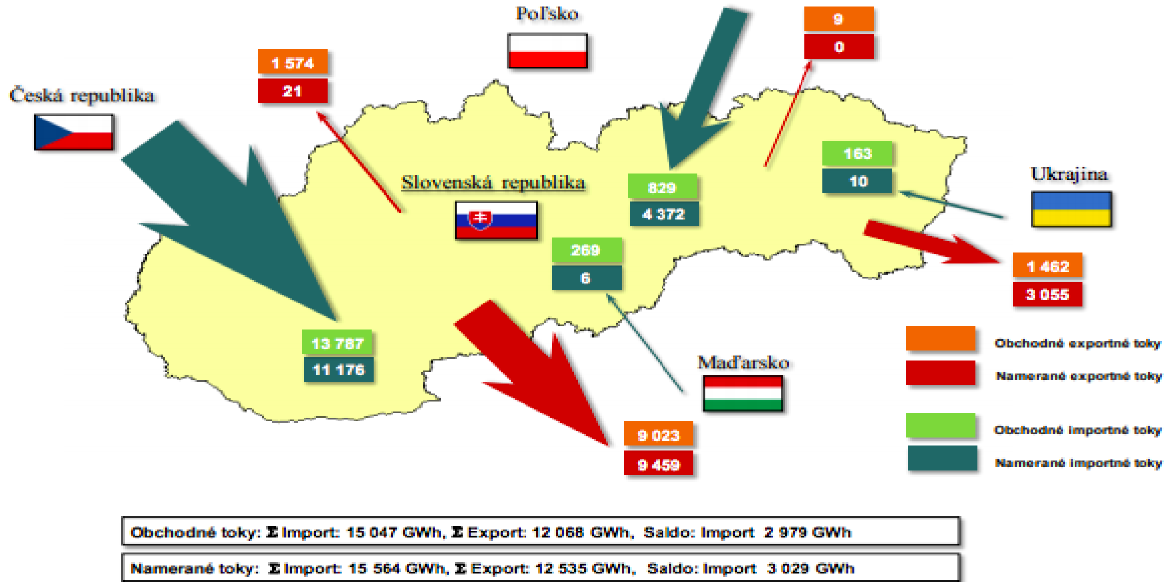
Interconnectors & Transmission system

Loop and especially transit flows have been influencing Slovakia's electricity grid since the very beginning of the 2010s when the problem began to spread throughout Central and Eastern Europe. These have been identified by several interviewees as one of the main challenges for the Slovak transmission grid. Physical unscheduled flows are entering the Slovak transmission system mostly from the north or northwest moving in the south or southeast directions. The biggest differences between scheduled and physical flows were recorded on the Polish-Slovak border (import) and

[121] Západoslovenská energetika kúpila paroplyn Malženice. Available at: https://spravy.pravda.sk/ekonomika/ clanok/481088-zapadoslovenska-energetika-kupila-paroplyn-malzenice/

on Slovak-Ukrainian border (export) in 2016. Unscheduled flows are responsible for increased operational and maintenance costs and increased risks of black-outs or other unexpected events. As a consequence, system operators tend to limit the amount of capacity for cross-border trade in order to save room for unscheduled flows, which results in sub-optimal utilisation of the grid architecture. Moreover, higher (and unscheduled) loads of the transmission grids increase losses in the system that have to be covered by the end users. The Agency for the Cooperation of Energy Regulators (ACER) estimated that between 2011 and 2013 the total loses on borders of Central and Eastern European countries amounted to 312.8 million euros[122].

Figure 32: Metered cross-border electricity flows in 2017 (in GWh), Source: Slovenská elektrizačná prenosová sústava, a.s.



Transit flows through Slovakia fell until 2016 when the amount of unscheduled flows significantly rose (by 18 per cent) and basically reached 2012 levels. While at its peak in 2012 the physical transit through the Slovak grid was 13 080 GWh, it was 10 598 GWh in 2016[123] and rose to 12 535 GWh in 2017 (see Figure 32). This increase is attributable to the largest recorded flows from the Czech Republic to Ukraine and significant flows to Hungary (although not record setting). Peak situations persist and are still problematic for the stability of the grid.

The improved situation with respect to the cross-border electricity flows in 2016 are a result of the installation of phase shifting transformers on German-Polish borders (Mikulowa – Hagenwerder line), the upgrade of Krajnik – Vierraden line between Germany and the Czech Republic to 440 kV and commencement of the 400 kV Altenfeld – Redwitz line within Germany (lack of internal electricity lines in Germany is considered to be one of the main reasons behind the unscheduled flows situation). Power shifting transformers on German-Czech borders were installed in

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[122] ACER (2015) ACER Opinion 09-2015 on the compliance of NRAs' decisions approving methods of cross-border capacity allocation in the CEE region. Available at: http://www.acer.europa.eu/Official_documents/ Acts_of_the_ Agency/Opinions/Opinions/ACER%20Opinion%2009-2015.pdf.

[123] Správa o výsledkoch monitorovania bezpečnosti dodávok elektriny za 2016. Available at: http://www.economy.gov.sk/uploads/files/D5tgGoZt.pdf.

2016 and 2017 and their positive impact on the Slovak transition grid was expected to be seen only in 2017 – this expectation was, however, not fulfilled and the situation returned to one from 2015. The Slovak Ministry of Economy believes specific use of newly built phase shifting transformers threatens fulfillment of the N-1 rule in critical situations or increase of production in neighboring countries[124].

According to Slovak authorities, the optimal solution is the development of the internal German electricity grid that will ensure the physical flows reach commercial demand areas[125].

The single bidding zone between Germany and Austria was criticized by Central European transmission system operators for perpetuating loop flows and overloading neighboring grids[126]. As a result of pressure especially from Czech and Polish grid operators supported by ACER's published opinion in September 2015 that found the bidding zone harmful to Central European markets, the German and Austrian transmission system operators announced in May 2017 that they will separate their grids from October 2018[127].

System adequacy

MAF (Mid-term Adequacy Forecast) ENTSO-E[128] report states that the generation in Slovakia is expected to be adequate to cover Slovak demand for the time horizons up to 2020 and 2025. This is a result of the two reactors in Mochovce NPP (3 & 4) and development of two new grid connections between Slovakia and Hungary (Gabčíkovo – Gönyű – Veľký Ďur and Rimavská Sobota – Sajóivánka). The report stresses that significant capacity (together more than 620 MW – including previously mentioned Malženice station) in gas-fired power plants is at risk of being mothballed due to high price of natural gas. Moreover, due to difficulties in predicting many variables factoring into this type of electricity generation (price of fuel, electricity, CO_2, etc.), the report claims that it is difficult to predict future operation of gas-fired power plants. However, in spite of this, the report claims that the Slovak system is able to sufficiently cover missing amounts due to accidental outages with imports, which happened 16 September 2016 when 450 MWh of electricity was imported to cover ancillary services for an ENO outage that lasted for approximately 20 hours[129].

Risks related to domestic regulation

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[124] Ministry of Economy (2018) Správa o výsledkoch monitorovania bezpečnosti dodávok elektiny 2017. Available at: https://www.mhsr.sk/uploads/files/TZINde4d.pdf

[125] Ibid.

[126] Unplanned flows in the CEE region In relation to the common market area Germany – Austria. Available at: https://www.pse.pl/documents/20182/51490/Unplanned_flows_in_the_CEE_region.pdf/44c6534e-a30d-4f06-9f7e-cb941b0ccf40.

[127] Germany and Austria power market split is set to start in October 2018. Available at: http://www.energy marketprice.com/energy-news/germany-and-austria-power-market-split-is-set-to-start-in october- 2018.

[128]https://docstore.entsoe.eu/Documents/SDC%20documents/MAF/MAF_2017_report_for_consultation.pdf

[129] Správa o výsledkoch monitorovania bezpečnosti dodávok elektriny za 2016. Available at: http://www. economy.gov.sk/uploads/files/D5tgGoZt.pdf.

The Slovak regulator has been using the so-called price cap method for its decisions on electricity[130]. The main challenge during 2017 was steady growth of wholesale electricity price at PXE Prague, mirroring more general trends across the region that is decisive for electricity trade in Slovakia. The low price of electricity in retail markets is considered by one interviewee (Interview 9) to be the main reason why retail markets in Slovakia is in a bad share. Energy price viewed through a social lens what creates an unbalance between production costs and retail price. Similar issue has been mentioned by other respondent (Interview 4) in connection to natural gas where not only retail prices, but also prices for small businesses are set by regulator.

E. Security of supply challenges related to the domestic natural gas sector

1. Short-term natural gas market risks (1-2 years)

Natural gas price related risks

Most natural gas is shipped to Slovakia on the basis of a long-term contract with Gazprom. The contract between Slovenský plynárenský priemysel, a.s. (SPP), the dominant energy company, and Gazprom was signed in 2008 for 20 years[131]. However, with a 56 per cent share on the gas market SPP, is not the only supplier of natural gas in a liberalized Slovak energy market[132]. Altogether there are 28 traders in Slovakia, yet, according to the Herfindahl–Hirschman Index Slovakia has a highly concentrated market (above 0.2 is considered to be highly concentrated and Slovakia is .3346). Natural gas is in general rather expensive in Europe during a period when natural gas prices world-wide are very low (Interview 2).

Risk of natural gas supply disruption

Slovakia has undergone a process of natural gas supply diversification following the 2009 natural gas crisis. It currently depends on gas supplies from the Russian Federation – however, this is a “voluntary dependency” as this is the cheapest source (several respondents including Interview 2 and Interview 3). Until 2009, however, the only source of natural gas for Slovakia was the Russian Federation. This gas flowed via Ukraine (Brotherhood pipeline) only in the east to west direction, supplying Slovakia and other European countries. This proved to be very problematic during the 2009 crisis when gas from the eastern direction was disrupted and it was not technically possible to receive gas from western Europe. One of the main lessons learnt during the crisis was the need to improve interconnectivity and develop reverse flows of natural gas. This was accomplished with the Czech Republic provisionally at the tail end of the crisis (and later a permanent upgrade was made) and also with Austria. Both reverse flows (that were supported

[130] Regulatory office for network industries. Annual Report 2017. Available at: http://www.urso.gov.sk/sites/default/files/dokumenty/URSO_VS_2017.pdf
[131] SPP podpísal s Gazpromom novú 20-ročnú zmluvu. Available at: https://ekonomika.sme.sk/c/4186731/spp-podpisal-s-gazpromom-novu-20-rocnu-zmluvu.html.
[132] Regulatory office for network industries. Annual Report 2017. Available at: http://www.urso.gov.sk/sites/default/files/dokumenty/URSO_VS_2017.pdf

financially by the European Union through the European Energy Programme for Recovery) significantly improved Slovak energy security as they enabled access to alternative gas sources.

Reverse flow with Ukraine developed in 2014 has increased utilization of the Brotherhood pipeline that is considered to be a safeguard of European energy security in the natural gas sector. The original idea to develop the reverse flow via the main Brotherhood pipeline met with opposition from Gazprom and the Russian Federation and therefore it was decided to create a "small reverse flow" by developing a new entry/exit point at Budince adjacent to Veľké Kapušany entry/exit point. This new interconnector utilised existing pipeline between Ukrainian storage facilities and Slovak power plant EVO that was gas-fired at one point. This solution required only minor changes to Veľké Kapušany compressor station, and the reverse flow has been fully utilised (for 100 per cent) ever since. This reverse flow sent an important political signal in support of Ukraine and its energy diversification, important not only for its industry but to increase utilisation of the Brotherhood pipeline that has witnessed significant decline since 2011.

The main short-term challenge to natural gas supply is connected to Russia-Ukraine (not only energy) relations. The current transit contract between Russia (Gazprom) and Ukraine (Naftogaz Ukrainy) terminates at the very end of 2019[133] and it is not clear how future transit contracts will be written (or whether there will be any). With the Nord Stream pipeline online since 2011, Russian supplies for European customers have been re-routed causing a reduction of transit via the Brotherhood pipeline (and thus also through Slovakia) further to west. Nord Stream 2 can make the Brotherhood pipeline obsolete (or at least significantly decrease the amount of shipped gas[134] to levels insufficient for proper maintenance of the pipeline) and thus significantly change the position of Ukraine on the European gas map. The tension from last winter (2017-2018) together with the continuous development of the second phase of the Nord Stream pipeline (Nord Stream 2) suggests that the transit through Ukraine is not guaranteed for the future, which can be problematic also for Slovakia. A respondent from Slovakia's gas TSO argued that there is a chance that Slovakia will be in a similar situation circa 2009 if transit via Ukraine is terminated, dependent on only one direction of gas flow, only this time from west and not from east (Interview 5).

There have been other infrastructure projects that have improved interconnectivity of Slovakia's gas transmission system and in this way contributed to increasing energy security. The interconnector with Hungary was built (commenced in July 2015) thanks to strong political support by both governments In spite of low utilization rates, it had a positive impact on the Hungarian market as gas prices fell (Interview 2). An interconnector with Poland has been in development since a 2013 agreement between Slovak and Polish governments was signed. After receiving funding for preparation of the project as a listed PCI in 2015, it gained further support in 2017 to cover construction costs (108 mil. €). Physical construction of this pipeline commenced in September 2018[135].

[133] Pirani, S., Yafimava, K. (2016) Russian Gas Transit Across Ukraine Post-2019: pipeline scenarios, gas flow consequences, and regulatory constraints. The Oxford Institute for Energy Studies

[134] Sharples, J. (2018) Ukrainian Gas Transit: Still Vital for Russian Gas Supplies to Europe as Other Routes Reach Full Capacity. The Oxford Institute for Energy Studies.

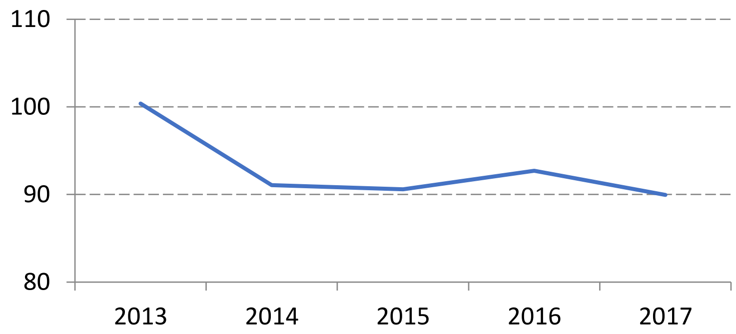
[135] Začala sa výstavba plynovodu medzi Slovenskom a Poľskom. Available at:https://www.mhsr.sk/top/zacala-sa-vystavba-plynovodu-medzi-slovenskom-a-polskom.

There is a very little chance that the devastating consequences of the 2009 gas crisis would be repeated in Slovakia. Thanks to diversification, Slovak gas companies have access to alternative sources (and also routes) of supplies. A positive externality of the crisis was realisation of energy security challenges across different energy sectors. As a consequence of the crisis an oil pipeline between Slovakia and Hungary has been upgraded allowing Slovakia to fully compensate an oil supply cut from Russia (Interview 3). However, the future of the Brotherhood pipeline remains uncertain. Natural gas can help Slovakia cope with its emissions problem, especially with particulate matter which it has been criticised for by the Commission (Interview 2).

Security concerns related to natural gas production

Slovakia produces only very limited amount of natural gas. The production has oscillated around 100 mcm of natural gas per year (approximately 2 per cent of total consumption) and thus does not contribute in a significant way to Slovak energy security. Moreover, it is expected that the production will further decline in coming years.

Figure 33: Natural gas production in Slovakia (mcm)



2. *Natural Gas Supply source diversification (up to 2030)*

Although Slovenský plynárenský priemysel, a.s., the Slovak gas company with the biggest market share, has a long-term contract with Gazpom export until 2028 (the company signed a 20-year long contract in 2008), the future of the supplies via Ukraine is still not clear. Other companies are being supplied by short-term contracts or are buying natural gas on spot markets. However, there is cross-border capacity that can fully replace supplies for Slovakia coming from Ukraine from other directions. The Slovak government is interested in maintaining the country's transit which is an important part of its perceived energy security. The argument that is used to support transit nature of Slovakia is that transit increases the importance of given country for the supplying country. The transit country is not thus interesting only as an importer of natural gas, but also as a country transiting gas to other customers. However, as one interviewee noted, the 2009 gas crisis has shown, that this argument is not fully valid (Interview 5).

This argument was used to support the new pipeline proposed by Eustream (Slovak TSO) -Eastring that is supposed to connect the Slovak transit system with Southern and Eastern Europe. This bi-directional pipeline received support as a PCI candidate (to develop a feasibility study) is meant to supply Balkan countries with gas coming from Western European hubs or to provide gas to Europe from a hub that will be developed after the South Corridor will be completed (especially TANAP, but also other sources). However, the main point of the pipeline seems to be safeguarding the Brotherhood pipeline utilisation after transit through Ukraine will eventually cease. It's current utilisation (63.8 bcm in 2017) is below its total capacity of 90 bcm a year.

The planned interconnector between the Czech Republic and Austria is viewed negatively by Slovak authorities as they believe it will decrease energy security of the country by circumventing Slovak transition system. The Czech and Austrian transmission systems are currently connected through Slovak territory and thanks to reverse flow between all three countries gas can flow in any direction.

Storage

Slovakia has a significant storage capacity of 3.4 bcm, but the 2009 gas crisis demonstrated their insufficient deliverability. They have since been upgraded based on this experience and now can deliver up to 45 mcm of natural gas per day. While storage facilities in the Slovak territory are utilised also by foreign companies, a storage facility in the Czech Republic with capacity of 0.57 bcm is used for the purposes of Slovak distribution system.

Regional challenges

In the area of electricity, the regional challenges are similar at the country level. The Visegrad Four (V4) region is supportive of nuclear energy – Slovakia and Hungary are expanding nuclear power plants, the Czech Republic is currently thinking about re-starting a public procurement procedure for a new NPP, and Poland is also thinking about building one. The V4 region thus stands out within the European Union, when it comes to nuclear energy, and with the United Kingdom leaving the EU, there will be fewer countries sharing similar support for nuclear energy within the Union. UK was one of the very few pro-nuclear "Western" EU members currently building a new power plant. Long-term disagreement with Austria on the nuclear issue (especially with the Czech Republic, but also Slovakia) can thus gain new impetus after Brexit. Although the Czech Republic and Slovakia with the support of the European Commission established European Nuclear Energy Forum in 2007, this platform is not very publicly visible and currently serves more like an expert platform[136]. However, public support is very important to continue with the development of nuclear after Fukushima accident.

Cyber security of critical infrastructure

One issue, that is currently not included in Slovak energy security documents or discourse in discussion on cybernetic threats of critical energy infrastructure. This discussion should be included in energy security discourse due to important position of two types of critical energy infrastructure that have already been objects of cybernetic attacks:

[136] 13th European Nuclear Energy Forum. Available at: https://ec.europa.eu/info/events/13th-european-nuclear-energy-forum-2018-jun-04_en.

nuclear facilities and the transmission system[137]. Moreover, high dependency is sometimes considered to be a hybrid thread (a cyber security is part of hybrid threads)[138]. The cyber security strategy of the Slovak Republic includes energy among critical infrastructure and so do other strategic documents dealing with cyber security[139]. However, energy policy strategic documents do not mention cyber security at all.

Several stakeholders developed their own cyber security strategies. For example, Slovak electricity TSO Slovenská elektrizačná prenosová sústava, a. s. is actively following cyber security issues and has developed an internal procedure (Interview 11).

[137] Polityuk, P., Vukmanovic, O., Jewkes, S., Ukraine's power outage was a cyber attack: Ukrenergo, Reuters, 2017, https://www.reuters.com/article/us-ukraine-cyber-attack-energy-idUSKBN1521BA

[138] Institute for Security Studies, Hybrid threats and the EU. Available at: https://www.iss.europa.eu/sites/default/files/EUISSFiles/EE%20hybrid%20event%20report.pdf

[139] Koncepcia kybernetickej bezpečnosti Slovenskej republiky na roky 2015 – 2020, available at: http://www.nbusr.sk/wp-content/uploads/kyberneticka-bezpecnost/Koncepcia-kybernetickej-bezpecnosti-SR-na-roky-2015-2020-A4.pdf; Akčný plán realizácie Koncepcie kybernetickej bezpečnosti Slovenskej republiky na roky 2015-2020, available at: http://www.nbusr.sk/wp-content/uploads/kyberneticka-bezpecnost/Akcny-plan-realizacie-Koncepcie-kybernetickej-bezpecnosti-SR-na-roky-2015-2020.pdf

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