Centre for Economic and Regional Studies of the Hungarian
Academy of Sciences – Institute of World Economics

MTA Közgazdaság- és Regionális Tudományi Kutatóközpont
Világgazdasági Intézet

Working paper 254.

June 2019

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REVISITING THE MANAGEMENT OF STATIONARY FUEL SUPPLY SECURITY AND GAS DIVERSIFICATION IN HUNGARY

WP

Centre for Economic and Regional Studies HAS Institute of World Economics
Working Paper Nr. 254 (2019) 1–44. June 2019

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ISSN 1215-5241
ISBN 978-963-301-684-8

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Institute of World Economics
Working Paper 254 (2019) 1–44. June 2019

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Abstract

This paper aims to assess the security of stationary fuel supply in Hungary by applying the three-dimensional approach, encompassing availability, affordability and sustainability. The main focus is on primary energy fuels in relation to electricity, but the approach is also applied, in part, to electricity itself. It is shown how select influencing factors affect the choices made from among security of supply dimensions. Although providing a source-by-source review, special attention is paid to nuclear energy and natural gas. For a long time, natural gas has been the fuel that Hungary is particularly sensitive to in terms of security of energy supply. Thus, gas diversification has become a key issue, analysed here also by using my own gas diversification scheme. I find that considerable progress has been made in this area. However, along with the 2014 decision on the construction of new units at the Paks Nuclear Power Plant (Paks II), aimed at achieving self-sufficiency in Hungarian electricity supplies, the energy agenda has changed considerably. With Paks II, Hungary's dependence will both decrease and increase – as new types of risks emerge. In such circumstances, a Nuclear–Solar/Biomass–Natural Gas concept of the electricity mix seems to be emerging in Hungary.

JEL: L71, L95, O13, P28, Q4

Keywords: Hungary, Russia, energy security, security of supply, gas diversification, stationary fuels

* This paper is a significantly revised and extended version of Weiner (2017b), and was completed on 20 April 2019. A shorter version of this paper has been submitted to the Journal of International Relations and Development. I would like to thank the editor and three anonymous reviewers for their useful comments and suggestions on an earlier version of this paper. In addition, many thanks go to Jonathan Stern for helpful feedback on the first draft. For proofreading help, I thank David Ellison.

ǂ This paper was supported by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences. Additional financial support was provided by the ÚNKP-18-4-BGE-4 New National Excellence Program of the Ministry of Human Capacities of Hungary. The work is also connected to the scientific program of the Centre of Excellence on Cyber-economy of the Budapest Business School University of Applied Sciences.

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1. Introduction

Energy affairs are the most important element of EU–Russia relations. This also applies to Central and East European (CEE) EU member states, which have common concerns, primarily linked to being dependent on Russia for energy supplies. Gas is the most sensitive issue despite changing European gas markets (Weiner 2016), and also despite the many years that have passed since the 2009 Russian–Ukrainian gas crisis, which was the most serious gas supply security incident ever experienced in Europe and one of the most serious energy supply security incidents in general (Stern 2009). This warning signal has prompted EU countries to truly address the issues of security of supply and diversification, with the latter seen as a key to enhancing the former. However, EU countries have different circumstances, various priorities, and thus differing energy policies. Again, this also applies to EU-member CEE countries. Since the 2009 Russian–Ukrainian gas crisis, not only the EU member states but also the EU itself have been focusing strongly on supply security and establishing cooperation aimed at enhancing supply security. Therefore, the different energy polices of EU member states have broad policy-oriented implications. Due to the cross-border implications of energy policy decisions, one cannot ignore the energy policies of other countries. Conflicting energy policies can lead to conflicts and become barriers to regional cooperation.

Since 2009, the EU has shown a gradual change in its approach to the issue of supply security. Security considerations have gained prominence in official EU documents, despite persistent and explicit references to market integration, the liberal principle and related regulatory measures (Boersma and Goldthau 2017: 103). The EU has faced increasing geopolitical instability in its neighbourhood (Franza and van der Linde 2017). The 2011 Arab Spring was followed by the 2014 events in Ukraine, which became a turning point, changing the EU's approach to energy policies and Russia. The EU has come to see Russia as a growing threat. The Energy Union plan[1] marks a fundamental shift from a liberal approach towards a liberal mercantilist[2] one (Andersen et al. 2017a). The

[1] In February 2015, the European Commission released a package of three communications on the EU's Energy Union. One of them is the framework strategy for the Energy Union (European Commission 2015).
[2] Mercantilism means the political use of trade and economic power to enhance the wealth and power of a state at the cost of rival powers (Andersen et al. 2017b: 6).

European Commission has responded to the Russian geopolitical challenge by deploying its full regulatory toolbox as well as by a more direct and interventionist use of the EU's economic power (Andersen et al. 2017b: 14).

In contrast, the subject of this case study, Hungary, seems not to consider Russian energy relations as a threat. The current Hungarian government – led by Prime Minister Viktor Orbán, who served first from 1998 to 2002 and returned to power in 2010, after eight years of leftist/liberal governments – maintains increasingly closer ties with Russia. Prime Minister Orbán, who for two decades was a former staunch critic of Russia, has in recent years completely changed his attitude towards Russia, turning into one of Moscow's most vocal defenders (Deák and Weiner 2019: 136). As part of this approach, in January 2014 Hungary concluded a huge nuclear deal with Russia, leading to Russia's State Atomic Energy Corporation Rosatom participating in the design and construction of the future fifth and sixth units of the Paks Nuclear Power Plant (Paks II).[3] Thus, in addition to gas, another sensitive issue was added to the Hungarian–Russian energy agenda. This indicates that, without a complex assessment of the particular circumstances of the CEE countries, one cannot understand the reasons behind energy policy decisions, security of supply, diversification achievements, or be able to influence these processes.

Energy policy decisions have long-term implications and entail enormous costs. Complex decisions need to be made, while simultaneously – for an observer – it is not easy to evaluate security of supply and diversification decisions and achievements. I suggest that the three-dimensional approach, encompassing availability, affordability and sustainability, is appropriate for assessing the security of the supply of stationary fuels.[4] In this approach, the main focus is on primary energy fuels – coal, natural gas, renewables

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[3] The Hungarian–Russian intergovernmental agreement on cooperation on the peaceful use of nuclear energy was signed on 14 January 2014. This was followed by the financial intergovernmental agreement (on the intergovernmental loan to be provided to Hungary for the financing of the nuclear power plant construction) concluded on 28 March 2014. On 9 December 2014, Hungary's MVM Paks II Nuclear Power Plant Development and Russia's NIAEP of the State Atomic Energy Corporation Rosatom signed the engineering, procurement and construction (EPC) contract, the operation and maintenance (O&M) contract and the fuel supply contract. These three contracts are called implementation contracts.

[4] The International Energy Agency (IEA) defines energy security as "the uninterrupted physical availability at a price which is affordable, while respecting environment concerns" (IEA n.d.). Hughes (2012) also argues in favour of using this method, though he applies the term 'acceptability' instead of 'sustainability'.

and nuclear fuel[5] – in relation to electricity as a secondary energy source,[6] but the three-dimensional approach is also applied, in part, to electricity (i.e., in relation to specific primary energy).[7] Due to its sensitivity, gas is subjected to more critical scrutiny. For this reason, I have developed and use a methodology that allows for cross-country comparisons across different CEE diversification options for Russian gas imports (Figure 1). I illustrate that the degree of complexity of CEE choices is high. Even within one country, there may be several options as regards the type of diversification. Among these options, I include the role of nuclear energy, the other sensitive issue, in the gas diversification scheme. I argue that decisions on security of supply and gas diversification should be regarded as the consequences of choices among security of supply dimensions, in other words, the prioritisation of different dimensions. These choices should be made on the basis of such influencing factors as the following: (1) the energy perspective (energy market supply, demand and price conditions); (2) the overarching institutional context (the role of the EU); and (3) the national government's approach to dependence, perceived threats, and relations with Russia. When evaluating the security of stationary fuel supply and gas diversification, I review energy policies and related national and EU documents, as well as statements made by governments and other stakeholders on security of supply (threats) and gas diversification. I also analyse the stated aspirations and progress made towards enhancing the security of stationary fuel supply and gas diversification over the past ten years, as well as the reasons behind the results. However, I would like to emphasize that although diversification is seen as key to enhancing security of supply, diversification alone does not inevitably achieve this goal.

This paper is structured as follows. After providing a snapshot of the characteristics of the Hungarian electricity balance (Section 2), I assess the security of supply of nuclear power, renewables, coal and gas in Hungary (Section 3). The section on gas also focuses on Hungary's gas diversification options and achievements (Section 3.4). Finally, a summary is provided and conclusions drawn at the end of the paper (Section 4).

[5] Oil is not discussed here as it is principally a transportation fuel.
[6] Heat is only partially covered here. However, regarding gas diversification, all domestic gas consumption is taken into consideration.
[7] Thus, exports, imports, electricity transmission infrastructure, and so on, are not in the forefront of the issues I consider.

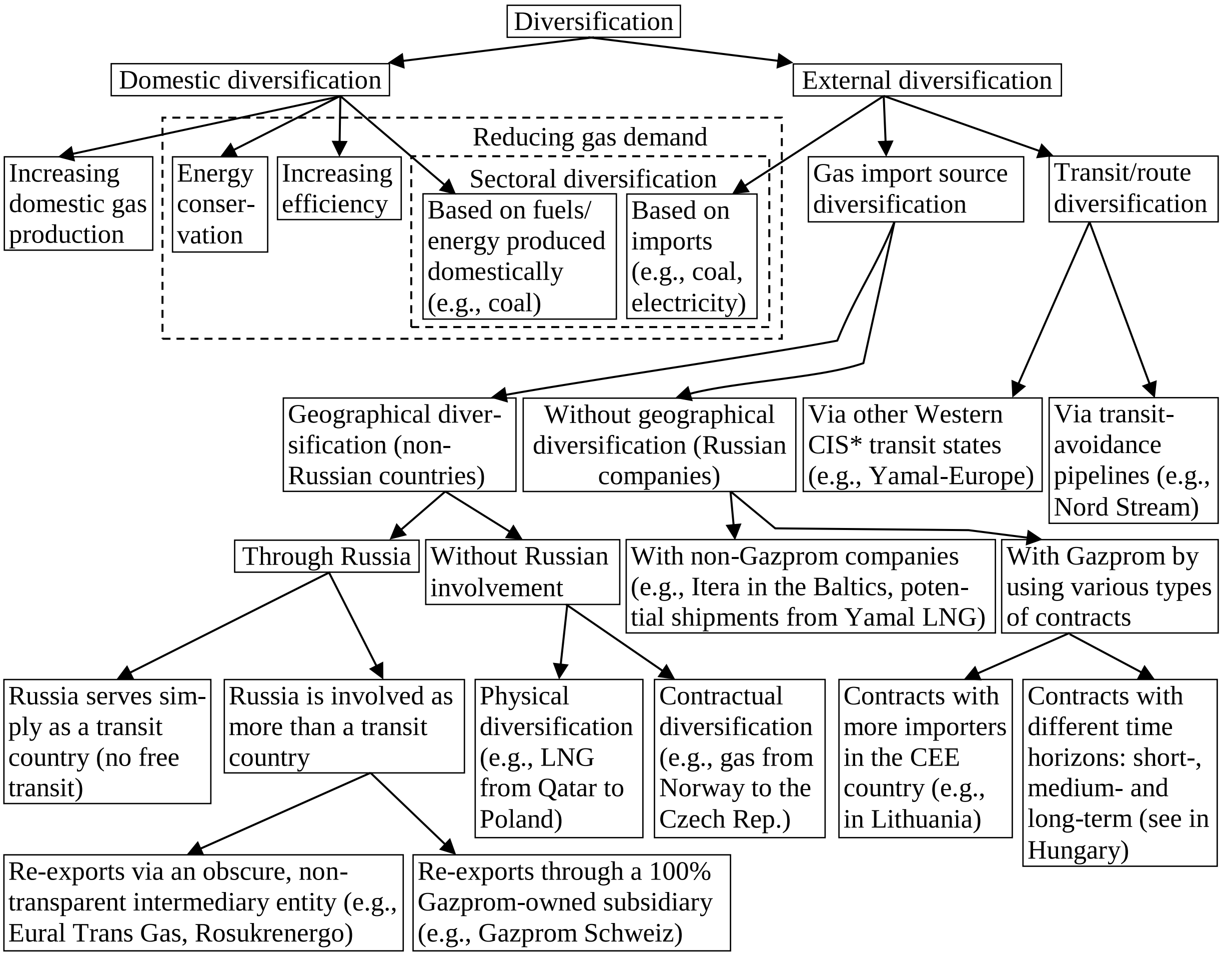

Figure 1. A Central and East European diversification scheme for gas
*The 12 non-Baltic former Soviet republics still tend to be referred to as the countries of the Commonwealth of Independent States (CIS), though currently it is a regional organisation consisting of only ten post-Soviet republics, since Georgia and Ukraine are not members of the CIS.
Source: Own compilation, partly based on Balmaceda (2008, 2013) and Stern (2002). An earlier version was published in Weiner (2016).

2. The changing electricity mix in Hungary

The total installed capacity of the Hungarian electricity system was 8,617 MW at end-2017, of which large power plants (>50 MW) had a capacity of 6,996 MW. Out of the 8,617 MW total installed capacity, constant available capacity reached 7,117 MW (MEKH–Mavir 2018: 38, 42–43). In 2018, the Hungarian electricity transmission system operator Mavir, a subsidiary of Hungary's state-owned energy group MVM, analysed medium- and long-term supply capacity development to the year 2033, and found that the installed capacity of large power plants would fall from 6,996 MW in 2017 to 5,797 MW in 2023, 4,815 MW in 2028 and 3,971 MW in 2033. Small power plants were projected to decline from 1,621 MW in 2017 to 943 MW in 2023, 786 MW in 2028 and 530 MW in 2033 (Mavir 2018: 13).

In the 2000s, total electricity consumption increased until 2007 (and reached 43.9 TWh), followed by a fall in 2009. The years 2010–2014 witnessed stagnation, with annual demand ranging from 42 to 43 TWh. Since 2015, however, consumption has remained above the level of 2007, reaching over 44 TWh (Table 1) (Eurostat 2018b; MEKH–Mavir 2018: 70).

Table 1. Hungary's electricity balance, 2006–2016 (GWh)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Imports	15 393	14 680	12 774	10 972	9 897	14 664	16 970	16 635	19 079	19 935	17 951
Exports	8 186	10 694	8 871	5 459	4 702	8 021	9 003	4 758	5 689	6 249	5 240
Net imports	7 207	3 986	3 903	5 513	5 195	6 643	7 967	11 877	13 390	13 686	12 711
Total gross production	35 859	39 960	40 025	35 908	37 371	36 019	34 635	30 294	29 392	30 342	31 859
Total net production*	33 345	37 220	37 383	33 344	34 613	33 533	32 351	28 031	27 131	28 132	29 506
Available for final cons.	33 240	33 744	34 327	33 150	34 207	34 574	35 238	34 877	35 728	36 975	37 541
Final consumption	33 238	33 744	34 327	33 150	34 207	34 540	35 004	34 873	34 737	36 291	37 118
Total consumption**	43 066	43 946	43 928	41 421	42 566	42 662	42 602	42 171	42 782	44 028	44 570
Net imp./total cons. (%)	16.7	9.1	8.9	13.3	12.2	15.6	18.7	28.2	31.3	31.1	28.5

* Total net production = total gross production – own consumption of power plants.
** Total consumption = net imports + total gross production.
Source: Eurostat (2018b) and own calculations.

In Hungary, two power plants – the Paks Nuclear Power Plant and the lignite-fired Mátra Power Plant – provide the bulk of electricity generation. More than half of Hungary's electricity is generated by Paks. Nuclear energy is followed by natural gas and coal. As Table 2 indicates, the shares of these three energy sources have changed significantly over the past ten years. In 2007 and 2008, gas still comprised the largest share, peaking at 38.1 per cent in 2007. Gas was followed by nuclear energy with approximately a 37 per cent stake in 2007 and 2008, whereas over the past ten years coal has maintained a relatively stable share, fluctuating between 17 and 21 per cent, except for 2017. Meanwhile, the share of renewables in electricity generation increased, except for decreases in 2011 and 2012 (Table 3). However, market trends have changed. By the mid-2010s, the share of nuclear power increased to over 50 per cent, while the share of

Table 2. Gross electricity and heat production in Hungary, by fuel, 2006–2017 (%)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Electricity												
Nuclear	37.5	36.7	37.0	43.0	42.2	43.5	45.6	50.7	53.2	52.2	50.4	49.0
Coal and coal products	19.8	18.7	18.0	17.9	17.0	18.3	18.7	21.1	20.8	19.5	18.1	15.5
Natural gas	36.7	38.1	37.9	29.0	31.0	29.8	27.1	18.3	14.4	16.8	20.3	23.8
Oil products	1.5	1.3	0.9	1.8	1.3	0.4	0.5	0.3	0.3	0.3	0.2	0.3
Other combustible fuels*	0.4	0.4	0.3	0.3	0.4	0.4	0.3	0.4	0.6	0.7	0.9	0.9
Biomass (solid biofuels)	3.2	3.4	4.4	5.9	5.4	4.2	3.8	4.7	5.8	5.5	4.7	5.0
Biogas	0.1	0.1	0.2	0.3	0.3	0.6	0.6	0.9	1.0	1.0	1.0	1.0
Renew. municipal waste	0.3	0.4	0.3	0.3	0.4	0.3	0.3	0.4	0.5	0.7	0.8	0.5
Hydro	0.5	0.5	0.5	0.6	0.5	0.6	0.6	0.7	1.0	0.8	0.8	0.7
Wind	0.1	0.3	0.5	0.9	1.4	1.7	2.2	2.4	2.2	2.3	2.1	2.3
Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.6	1.1
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Heat												
Nuclear	1.0	0.9	1.0	1.0	0.9	1.0	1.1	1.0	1.6	1.5	1.6	1.6
Coal and coal products	16.0	18.1	17.0	12.5	13.2	14.3	13.5	11.0	10.8	10.7	9.9	8.3
Natural gas	78.9	77.4	77.3	77.3	78.3	76.1	77.4	74.8	71.6	69.4	65.9	68.2
Oil products	1.4	0.2	0.9	4.6	0.4	0.5	0.5	0.5	0.7	0.6	0.2	0.3
Other combustible fuels*	0.8	0.9	1.0	1.0	1.0	1.0	1.0	2.9	4.7	4.7	6.5	6.5
Biomass (solid biofuels)	0.8	1.3	1.5	2.2	4.5	5.3	5.0	7.8	7.2	8.5	9.6	8.9
Biogas	0.0	0.0	0.0	0.0	0.2	0.5	0.1	0.2	0.2	0.3	0.3	0.1
Renew. municipal waste	0.8	0.9	1.0	1.0	1.0	0.8	0.6	0.6	0.8	0.9	0.9	0.9
Solar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Geothermal	0.3	0.3	0.4	0.4	0.4	0.6	0.8	1.2	2.4	3.4	5.0	5.2
Total	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*

* Other combustible fuels = industrial waste + non-renewable municipal waste + other sources.
Source: Own calculations based on Eurostat (2018b, 2018c) and MEKH (2019b, 2019c).

gas fell below 20 per cent. Between 2013 and 2015, coal even preceded gas in electricity generation (Eurostat 2018b; MEKH 2019b). Simultaneously, the share of net imports in total electricity consumption increased and was above 30 per cent in 2014 and 2015, compared to around 9 per cent in 2007 and 2008 (Table 1) (Eurostat 2018b).

These developments are typically due to three main market factors. Gas prices were at a serious competitive disadvantage compared with those of coal between 2011 and 2014 (Stern 2017: 3, 9), carbon prices were mostly very low in the 2010s and there was a downward trend in electricity prices (Sandbag n.d.; KWK-Index n.d.). However, since the mid-2010s coal is no longer cheap compared to gas (Jonathan Stern, email communication, 7 February 2018; BP 2018). Carbon prices started to rise in 2017 and an increase in European electricity market prices has also materialized since 2017 (Sandbag n.d.; KWK-Index n.d.). As a result, the share of gas has increased and the role of nuclear energy and coal in electricity production, as well as that of electricity imports, has declined (Eurostat 2018b; MEKH 2019b).[8]

These market changes are reflected in power plant utilization rates in Hungary. While the Paks Nuclear Power Plant and the Mátra Power Plant operate at high utilization rates, natural gas was a big loser, despite an increase in its utilization rate. In 2017, the average capacity utilisation rate for power plants in Hungary was 45 per cent (Mavir 2018: 12). By 2008, the utilization rate of the Paks Nuclear Power Plant rose above 90 per cent and it has been operating with a load factor of around 90 per cent ever since. For a long time, the Mátra Power Plant was running with a load factor of around 75 per cent. But its utilization rate has been decreasing since 2014 and stood at only 64.2 per cent in 2017. By contrast, the load factor at the Gönyű combined-cycle power plant, the third-largest[9] power station by generating capacity and the most modern and efficient gas-fired power plant in Hungary, was 40.3 percent in 2016 and 55.2 per cent in 2017, compared to 7.4 per cent in 2013 (Mavir 2016: 14; MEKH–Mavir 2018: 50).

Regarding security of supply, increased electricity imports are advantageous from the perspective of both affordability and environmental sustainability.[10] But the government sees them as a risk in terms of availability, especially if the share of net electricity imports continues to grow in the future. The government believes that electricity supply should not be dependent on imports, which could be curtailed in a crisis situation. This strong priority with respect to availability likely stems from the current political leadership's insistence on sovereignty, though it may seem strange at a time of integrated electricity markets under the EU's regulatory authority.[11] However, at present, a high import ratio is not something that threatens Hungary, because current installed capacity allows for complete self-sufficiency. Thus, from this perspective, the real question is whether the installed capacity will be enough to meet Hungary's future electricity demand. The

[8] In 2017, natural gas provided 68.2 per cent of derived heat production (Table 2) (MEKH 2019c). In 2017, household gas consumption constituted roughly 35 per cent of Hungarian total gas consumption (MEKH 2019a: 28, 43).
[9] In fact, the third largest one is a power plant with a 900 MW capacity having a so-called 'constant non-operational' status (MEKH–Mavir 2018: 46).
[10] Naturally, this is only true if we do not take into account imported electricity generated by polluting power plants.
[11] This contradiction was brought to my attention by an anonymous reviewer.

government insists the only plausible solution for maintaining its ability to satisfy electricity demand through domestic production is the Paks II project.

Since the fall of the communist regime, Hungary has had three energy strategies. The first was approved in 1993 and remained valid for one and a half decades. Approved in 2008, the second energy strategy, for the 2008–2020 period, was short-lived compared to the first one. The third, Hungary's National Energy Strategy 2030 (with an outlook to 2050), was approved in 2011, one year after the new government took office (NFM 2011).[12] A new energy strategy should be ready in 2019.

The 2011 energy strategy has two primary goals: (1) increasing the direct state presence and (2) economic development based on cheap nuclear energy (Felsmann 2011). Among the six scenarios for Hungary's electricity mix by 2030 and 2050, the government chose the so-called Nuclear–Coal–Green concept, referring to the new units at the existing Paks Nuclear Power Plant, a new coal power plant and the utilisation of renewables as a linear extension of the planned trajectory set in 2010 in Hungary's National Renewable Energy Utilisation Action Plan for 2010–2020. However, the energy strategy claims this does not mean that elements of the other scenarios are unrealistic. This, to some extent, contradicts the government's statement that Paks II is indispensable, as two of the above-mentioned six scenarios are opposed to further nuclear expansion.[13]

3. A review of primary energy sources

3.1. Nuclear energy: creating multiple dependence on Russia

Hungary is a notorious nuclear supporter. It has four Soviet-designed units (500 MW each) in state ownership (through MVM) that were commissioned in the 1980s for a design life of 30 years and will be phased out in the 2030s, after the end of their 20-year lifetime extension programme. In 2014, it was expected that two new units would be commissioned in 2024 and 2026, respectively, with a slightly higher combined capacity

[12] In 2015, the strategy's energy consumption projections were recalculated.
[13] The government taking office in 2010 seemed to focus on nuclear energy from the very beginning.

(two units of 1,200 MW each) than that of the four old units.[14] Due to delays, it is unknown when the new units will be online, but it seems certain that the parallel operation of the old and new units will continue for years. The new nuclear units will be owned by the Hungarian state and are projected to cost around EUR 12.5 billion, accounting for more than 12 per cent of the Hungarian GDP. The Russian budget provides a EUR 10-billion credit line for the project, and Russia's state-owned Vnesheconombank (VEB) is acting as the principal agent for the Russian government. The line of credit is available from 2014 to 2025. A 3.95 per cent interest rate applies until the new units start operation, but no later than March 2026. The 21-year repayment period should start at the latest in March 2026. Hungary has to pay a 4.5 per cent interest rate in the first seven years, followed by 4.8 per cent in the second seven-year period, and 4.95 per cent in the final seven years (Portfolio.hu 2014). While much criticism has emerged against the interest rate level on the loan, in 2014 Hungary's debt rating was junk or below investment-grade and the international financial market situation has also changed. However, there is a possibility of early payment, and the government has already seized upon this opportunity. Nevertheless, the contractual regime has serious deficiencies, which is not surprising as the deal was negotiated in total secrecy, without proper policy and political preparation and without the involvement of the state administration. The critical management risks for a nuclear power investment and those who bear responsibility are unknown. The major questions here are who will bear the responsibility if construction is halted or delayed, and how the penalties to be paid by Russia will affect ongoing loan and interest payments. The article in the loan agreement on dispute settlement is just as vague, as it does not incorporate a mechanism for international arbitration. This is complicated by another article in the loan agreement, which states that if the Hungarian party is in financial arrears for over 180 days, Moscow is entitled to ask for an immediate lump sum repayment of the remaining unpaid debt. As the Hungarian side would obviously be unable to fulfil this condition, the Russian party would, therefore, always have the upper hand in any dispute resolution process (Deák and Weiner 2016). In addition, the Paks II project will swallow up almost all accessible public funds for the generation of energy in the years to come (Deák and Weiner 2019: 142).

[14] The 2011 energy strategy suggested two 1,000 MW units each.

When considering the Russian influencing factor, one should note that the list of nuclear fuel and reactor suppliers is very limited (Deák 2018). The nuclear industry seems to be in trouble in the West, as reflected by the French Areva's virtual bankruptcy and the US Westinghouse's bankruptcy proceedings. Nonetheless, Russian Rosatom has improved its performance (Minin and Vlček 2018: 98). Commitment to one type of reactor assumes a very long-term cooperation between the supplier and the host state. There is a one-and-a-half-decade-long licensing and construction period for new reactors, and a reactor might work for 50-60 years (Deák 2018). Until 2013, it was planned that the reactor supplier would be selected in an open tender (Pcblog.atlatszo.hu 2018). But the government later argued that only one Russian-type reactor (VVER 1200) met the Hungarian criteria (HVG.hu 2017b). Seemingly, the geopolitical influencing factor has no negative impact on the project.

Regarding the availability dimension, the government contends Paks II will also increase security of supply, as nuclear fuel will be available in sufficient quantities at the site. But there is no possibility of the diversification of nuclear fuel supplies for this type of reactor. With renewables, the greater level of flexibility is appreciated, while nuclear plants are basically inflexible. This highlights another aspect of the availability dimension. A further availability problem for large nuclear units is that problems with a unit or units could cause the loss of a large amount of generation capacity for a certain period of time. Delays in the construction of new units can also be interpreted as the loss of large amounts of expected generation capacity.[15] Previous forecasts indicated that, with Paks II, Hungary would become a net exporter of electricity (REKK 2011). Thus security of demand, i.e., a market for excess electricity, would also have to be ensured. However, newer forecasts suggest Hungary will likely remain a net importer on a yearly basis (ENTSO-E 2015). Again, the main issue is the length of parallel operation of the old and new units. Nonetheless, security of demand is still a challenge for shorter time periods. Another problem linked to the availability of electricity arose in August 2018 when the low-level and warming of the Danube, from which cooling water is taken, posed a significant risk, both to the operation of the Paks Nuclear Power Plant, as well as to the Danube itself. This problem will be much more pronounced during the parallel operation of the new and old

[15] These aspects of availability were brought to my attention by one of the anonymous reviewers.

units. Moreover, it is debatable how this problem could be addressed without cooling towers.

The affordability of electricity from Paks II, which hinges on two promises made by the Hungarian government, cheap electricity and a profitable project, will hardly be fulfilled. The European Commission concludes that the internal rate of return of the project will be lower than the weighted average cost of capital. Thus, it will not be profitable on a market basis (Fabók 2017). For the project to pay off, a substantial price increase is needed. The government anticipates that because of the investment gap in the electricity generation sector under cheap electricity, European electricity prices will increase to such an extent that they can accomplish both goals. In contrast, others warn that electricity from Paks II will not be cheap and such long-term price growth in the European market is unlikely to materialize. Price increases of such magnitude would provide incentives for innovation in other energy-generation technologies and energy efficiency, ultimately leading to lower prices (Felsmann 2015). The European Commission requires Paks II to sell at least 30 per cent of its total electricity output on the open power exchange, and the rest “on objective, transparent and non-discriminatory terms” via auction. The Paks Nuclear Power Plant and Paks II will be potential competitors, since Paks II should be functionally and legally separated from the existing Paks Nuclear Power Plant operator (European Commission 2017). These are the results of the EU institutional influencing factor.

Compared to a gas-fired power station, nuclear fuel has a relatively low share in the total cost structure of a nuclear power plant. The development of a nuclear power plant requires a large amount initial investment but can then produce for a long time and cheaply (Deák 2018). Renewables have the lowest variable costs, followed by nuclear energy, after which comes coal, while gas-fired units have the highest variable costs (Székffy 2014: 723). This means that if one commits to power generation units with low variable costs, once these capacities have been constructed, expectations exist for the units to continue operating. This approach in turn has a serious impact on energy sources already in use, or for which plans exist, while significant changes can also always occur in energy markets. With Paks II, the Hungarian government has also made a decision in favour of centralised energy production, and thus against decentralised, local energy. Nevertheless, according to Mezősi’s (2016) calculations, nuclear energy and renewables can co-exist in Hungary. Among power plants based on non-renewable energy resources (such as fossil fuel power plants and nuclear power stations), nuclear and coal-fired power plants typically provide baseload power, while natural gas is a much more flexible power resource and can provide power on-demand (Gonzalez-Salazar et al. 2018). Renewables are also different in terms of dispatchability. Wind and solar photovoltaic (PV) power are non-dispatchable. Their intermittency and variability have long been debated. The main argument used to justify nuclear energy is that, along with hydropower, it is the only low-carbon power source that can supply reliable baseload electricity on a large scale (Diesendorf 2016).

The 2014 decision concerning Paks II was unexpected and early. This might turn out to be disadvantageous due to a lack of knowledge of how renewable markets will develop and as nuclear energy innovation could also significantly lower investment and operating costs (Felsmann 2015). The 2011 Hungarian energy strategy considers the construction of new nuclear capacities at a new site after the shutdown of the four old units. At the beginning of October 2017, the minister in charge of Paks II made the first references to the possibility of building these new units (Kormany.hu 2017). The Paks deal will increase Hungary’s reliance on Russia and raises many questions related to the future of Hungarian–Russian political and economic relations (Weiner 2017a: 212). This outcome will define the nuclear energy sector and to some extent even the financial landscape in the country for the long term (Deák and Weiner 2019: 137). While the initiation of loan repayment will occur in 2026, the nuclear power plant will definitely not begin operating in 2026. Thus, the government is now working on modifying the loan agreement.

Finally, regarding the sustainability dimension, nuclear energy contributes a very small amount of emissions to the atmosphere. Nonetheless, handling nuclear waste remains an expensive challenge. European energy sector trends are against nuclear energy. In addition, attitudes towards nuclear energy have changed since Japan’s 2011 Fukushima nuclear accident. The likelihood of accidents similar to Chernobyl and Fukushima are very small, but are high-intensity events when they occur (Deák 2018). Hungarian public opinion is against both the Paks II project and Russian participation (Hargitai 2018).

3.2. Renewables: a focus on biomass and solar PV

Regarding renewables, as mentioned above, because the electricity sector is a network industry where system balance needs to be maintained, the availability dimension focuses on issues of intermittency, variability and non-dispatchability. Further, technology imports and the availability of certain raw materials are also issues (Deák 2018). Regarding the former, the question is how high a share renewables can occupy in the electricity mix. Many still believe that renewables, other than large-scale hydropower plants, can only supplement the established electricity system. Thus many believe there is an inherent upper limit on the share of renewables (Hinrichs-Rahlwes 2013: 90). At one end of the spectrum, stands the old model with baseload power provided by large, inflexible power plants, while at the other end stands a new model with a dominant share of renewables that is flexible according to demand. Advocates of the latter argue it is feasible and supported both by practical experience and computer simulations (Diesendorf 2016).[16] Seemingly, the Hungarian government does not believe that renewables will have a powerful role to play. Obviously, the government views renewables more as a problem than an opportunity. This seems to stem from the need for subsidies to develop this energy option (affordability) and from the challenge it poses for transmission and distribution system operators (availability). However, flexibility in power grids is often underestimated and the question of subsidies should be seen in light of the sizeable state aid for the Paks II project. Further, data collected by the International Renewable Energy Agency (IRENA) shows that the levelised cost of electricity (LCOE) for bioenergy-for-power, hydropower, geothermal and onshore wind projects commissioned in 2017, occupied the lower end of the LCOE range for fossil fuel options (IRENA 2018: 16). Lazard (2017) states that "in some scenarios the full-lifecycle costs of building and

[16] Diesendorf (2016) discusses the four main conditions that make this possible. Firstly, the fluctuations in wind and solar PV can be balanced by flexible, dispatchable renewables, such as by hydropower with dams, open cycle gas turbines (OCGTs) fuelled by green gas and concentrated solar thermal power (CSP) with thermal energy storage (TES). Secondly, one should rely on diverse renewables (i.e., multiple technologies and spreading out wind and solar PV farms geographically). Thirdly, new transmission lines may be needed to achieve this wide geographic distribution of renewables. Fourthly, smart demand management can shave the peaks in electricity demand and manage periods of low electricity supply. Smart meters and switches are controlled by both electricity suppliers and consumers, and programmed by consumers to switch off when demand on the grid is high and/or supply is low. Stern (2017: 6) warns that progress in relation to demand-side management would not only further reduce the problem of renewable intermittency, but also reduce the need for backup from gas (or other fossil fuel) generation.

operating renewables-based projects have dropped below the operating costs alone of conventional generation technologies such as coal or nuclear".

Regarding sustainability, the situation is not so clear-cut. Non-fossil-fuel power technologies also induce life-cycle greenhouse gas (GHG) emissions. However, according to Pehl et al. (2017), life-cycle emissions from solar, wind and nuclear power are many times lower than from coal or gas with carbon capture and storage (CCS). Though highly uncertain and variable, life-cycle emissions from hydropower and bioenergy are substantial, and comparable in scale to those generated by fossil fuel CCS plants (higher than from gas CCS, but lower than from coal CCS) (Evans 2017). Sustainability questions also arise in the case of backup power and energy storage. In the old model, backup power is derived from the combustion of fossil fuels, typically natural gas, which cause GHG emissions. However, energy storage also increases emissions.

With the exception of solid biomass, mostly woody biomass (firewood), renewables continue to play a minor role in Hungary. However, solar PV has recently become a new favourite of the Hungarian government, while geothermal energy could play a greater role in heat production (Nagy 2016).

Based on the newest statistics, at first glance, the share of renewables looks favourable (Table 3). Under the 2009 EU Renewable Energy Directive, the national target of 13 per cent of renewables in gross final energy consumption was already achieved in 2011 (European Parliament and Council 2009).[17] However, two important remarks should be made in relation to this ratio. On the one hand, this ratio has been declining since 2013; on the other, this higher ratio is only the result of a very recent advantageous change in the statistical methodology pertaining to woody biomass (REKK 2017).[18] The growth of renewables should be increased according to both the EU and geopolitical influencing factors. The former is associated with EU commitments and incentives, while the latter

[17] In contrast, Hungary's National Renewable Energy Utilisation Action Plan for 2010–2020 sets a target of 14.65 per cent by 2020 (NFM 2010). The other target, namely the 10 per cent share of renewables in the transport sector by 2020 still needs to be reached. The share of solid biomass in renewable energy consumption was 80.8 per cent in 2017 (MEKH 2019e).

[18] When the national energy regulator moved from using supply-side statistics to statistics referring to household energy consumption, the shares drastically increased. The 2014 share of renewables in gross final energy consumption increased from 9.5 per cent to 14.6 per cent (Eurostat 2016).

Table 3. Share of energy from renewable sources in Hungary, 2006–2017 (%)

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Share of energy from renewables in gross final energy consumption	7.4	8.6	8.6	11.7	12.7	14.0	15.5	16.2	14.6	14.4	14.3	13.3
Share of electricity from renewables in gross electricity consumption	3.5	4.2	5.3	7.0	7.1	6.4	6.1	6.6	7.3	7.3	7.3	7.5
Share of renewables in heating and cooling	11.4	13.5	12.0	17.0	18.1	20.0	23.3	23.7	21.2	21.2	20.9	19.6
Share of renewables in transport	1.1	1.5	5.1	5.8	6.1	6.1	5.9	6.2	6.9	7.1	7.6	6.8

Source: MEKH (2019f).

refers to the possibility of reducing dependence on Russia through increasing the role of renewables. Nevertheless, the statistical change has hindered EU incentives and the geopolitical influencing factor seems to have no effect on this issue.

Despite developments in the LCOE for renewables, affordability and the realisation of renewable electricity is still strongly affected by support schemes. Recently, there have been changes in this respect. The first support scheme (abbreviated as "KÁP" in Hungarian) operated between 2003 and 2007, followed by the second one ("KÁT") between 2008 and 2016. The third generation of support schemes ("METÁR") was launched in 2017 (Haffner 2018).

3.2.1. Biomass: an easy way to increase the role of renewables

Regarding availability, one should first dispel the myth that Hungary is a great power in terms of biomass. Further, while biomass is a renewable resource, it is both renewable and exhaustible (Dinya 2010: 913, 916). As opposed to other renewables, one of its benefits is its role as a buffer, as it can be stored and dispensed, making it more controllable than other renewables (Dinya 2018: 1187).

As to the sustainability dimension, many refer to energy from biomass as "green energy". But not all bioenergy is green because, as emphasized above, based on a life-cycle analysis, a significant share of bioenergy technologies are not so environmentally friendly (Dinya 2018: 1186–1187). Replacing coal or gas with biomass theoretically results in reduced carbon emissions, since, by law, burning wood is "carbon neutral", as carbon emitted by its combustion is equal to the amount of carbon absorbed from the atmosphere during plant growth. Also, the emitted pollution is reabsorbed by newly planted trees.[19] Similarly, biogas represents a carbon-neutral fuel source. Regarding this issue, in June 2018, the European Academies' Science Advisory Council (EASAC) published a commentary highlighting the concept of all bioenergy being carbon-neutral as "too simplistic and does not offer any general context-independent justification to increase forest utilisation". EASAC claims that the so-called payback period (the time needed for forests to reabsorb the carbon dioxide emitted during biomass combustion) ranges from decades to hundreds of years (EASAC 2018). The distances for biomass transportation and imports to energy plants also contribute to global warming potential and other environmental impacts (Bowyer 2012).

The dominant role of firewood in the biomass segment requires reconsideration. Dinya (2018: 1187) recommends not giving preferential treatment to the production of biomass for energy purposes and concentrating instead on the energy utilization of by-products produced when making biomass (and by human activity), as there is always a by-product. Biomass (as raw material) cannot be used for energy purposes without significant expenditure, which should be taken into consideration when evaluating the affordability dimension of security of supply. Therefore, within the biomass potential, Hungary's National Renewable Energy Utilization Action Plan for 2010–2020 aims at promoting the use of by-products and residues both for biogas and incineration applications. The Action Plan intends to base the use of biomass for energy generation on new premises. Rather than large power plant capacities, it would support biomass use for the local generation of heat. With respect to electricity, low to medium capacity plants with a local regional development impact should be supported (NFM 2010: 170). Similarly, Büki and Lovas (2010: 26) recommend that in order to achieve the greatest possible natural gas substitution, biomass should primarily be used for direct heat supply and cogeneration. Due to their low efficiency, direct electricity production from wood and straw-fired power plants are bad solutions.

[19] GHG emissions from energy generated using biomass are generally lower than those from fossil fuels, but not always. According to the UK Environment Agency, using short rotation coppice chips to generate electricity can produce 35 to 85 per cent fewer emissions per unit of delivered energy than a combined cycle gas turbine power station, while using straw can, in some cases, produce over 35 per cent more (Bates et al. 2009).

3.2.2. Solar PV: a booming industry

The availability dimension of solar PV energy supply security consists of both the amount of solar radiation and technology imports. Solar radiation conditions are considered to be very favourable in Hungary, better than in Germany, a world leader in terms of installed PV capacity (Munkácsy et al. 2014: 67). Nonetheless, the load factor of electricity generation from solar PV was only 15.2 per cent in 2017. At end-2017, the installed capacity of licensed and non-licensed PV generation amounted to 314.4 MW (of which the capacity of non-licensed microgeneration, i.e., small-scale household installations was 221.2 MW), compared to just 2 MW at end-2010 (MEKH–Mavir 2018: 36, 52; IRENA 2018: 25). These figures are still very low. But the industry is currently experiencing rapid growth. In July 2018, the government predicted that by 2022 3–4 GW installed PV capacity, including 600 MW of microgeneration, could be achieved (Király 2018). This is a realistic target despite negative developments that include long and cumbersome licensing and a tax on solar PV panels. Regarding the former, in some cases, the permitting process for installations, encompassing approximately 40 permits, may take up to one year. As for the tax on solar PV panels, it was introduced in 2015. Although it was halved in 2018, it is still high compared to the European average (HVG.hu 2017a). Positive changes in the solar PV sector are mainly linked to the subsidy system. Some believe that solar PV energy has become a priority because of EU subsidies and the possibility of installing small units for households and public institutions (Nagy 2016). In contrast, failures are detected in the production of solar PV panels in Hungary. According to the Hungarian Photovoltaic and Solar Collector Association, solar PV panel production in Hungary is almost impossible without state support (Szabó, D. 2017). Büki and Lovas (2010: 84) claim that in the domestic PV program, research and development plays an important role, and the Hungarian PV industry has significant scientific background support and can provide high value added. Regarding sustainability, the environmental impacts of solar power include land use in the case of large utility-scale PV and hazardous materials resulting from the PV cell manufacturing process (Union of Concerned Scientists n.d.). Although there are no concentrated solar thermal power projects in

Hungary, it is important to note that water use for cooling purposes is also a sustainability issue in the case of CSP.[20]

3.2.3. Wind: blocked by law

In contrast to solar PV, wind power is a big loser in Hungary. In 2016, a *de facto* ban was introduced on new wind projects, with no new permits issued since 2006. When evaluating the availability dimension of the Hungarian wind sector, I concentrate on the wind potential and equipment/technology imports. It is true that it is worth installing wind turbines only in 5.5 to 6 per cent of Hungary's territory. But this potential has so far not been exploited (Munkácsy n.d.: 14). Earlier calculations showed that wind potential was between 7,623 MW and 10,694 MW, while fresh figures indicate that the amount of capacity that can be installed by 2050 is 9,517 MW (±15%) (Munkácsy et al. 2014: 147). In contrast, the last turbine was launched in 2011. By that time, there were 37 wind farms in operation with 172 towers and a total capacity of only 329 MW. At end-2017, the installed capacity was 324.9 MW (Illés 2017; MEKH–Mavir 2018: 53). The annual load factor of the Hungarian wind fleet was 25.9 per cent in 2017 (MEKH–Mavir 2018: 53, 55), a good rate as compared to other European countries (Tóth and Schrempf 2013: 15). Currently, the government claims wind is not optimal for Hungary and thus wind energy has no place in the Hungarian energy system (Német 2016). Their approach to this issue was quite different in 2010. Hungary's National Renewable Energy Utilization Action Plan for 2010–2020 declared that capacity could grow to 740 MW by 2020, which is the manageability limit of the power system (NFM 2010: 202). However, according to the Hungarian Wind Energy Industry Association, the capacity could be increased to 1,200 MW without jeopardizing the operation of the electricity system. The association argues that the issue of balancing could have been a real problem one and a half decades ago. But since then there has been a great deal of progress in the electricity grid and controllability (Illés 2017). In 2009, the left-wing government launched a tender for the development of wind farms with a total capacity of 410 MW, which was almost three times oversubscribed

[20] Compared to GHG emissions, far less attention is paid to the water footprint. Water is used as a source that is converted to steam to turn turbines (a working fluid); for flue gas desulphurization in coal facilities; for cooling; and for cleaning. Water is also used for growing energy crops for biopower facilities. For the water consumption of different types of power plants, see Macknick et al. (2012).

(Tóth et al. 2011). But this was then cancelled by the new Orbán government in 2010, quoting errors with the justification behind the decision (Nagy 2016). According to the Hungarian Wind Energy Industry Association, there was a short period of time after the cancellation of the tender procedure when it even seemed that existing wind plants were also targeted for elimination (Energiaskanzen.hu 2012).

There have been various explanations for the Orbán government's anti-wind approach. The government's first argument points to the already mentioned issue of balancing. Wind energy is highly dependent on weather conditions and the wind is usually stronger at night when less power is required (Szalai et al. 2010: 956). Since wind energy output cannot be forecast precisely, it has the highest balancing cost. The government contends that overproduction could lead to unintended flows, causing extra costs for the electricity system. These fears are relevant but exaggerated, taking into account the previously planned relatively low capacity. Again, the Hungarian authorities do not trust renewables, and overly decentralized and fragmented systems are contrary to their approach. It is also an exaggeration to say that a pumped-storage hydropower plant is needed to increase wind capacity in Hungary. This argument has also already been raised in relation to Paks II. A further argument is the preservation of the natural landscape (the aesthetic effect on the local landscape) (Nagy 2016). This is actually a sustainability issue. Other sustainability problems include high land-use intensity (Swain at al. 2015), shadow-flickers from wind turbines, mechanical and aerodynamic noise, negative effects on the flora, physical contact with birds, as well as icing problems on turbine blades as fragments could fall off the blades (Szalai et al. 2010: 953–955). Also, allegations have been made regarding the political aspects of the wind issue, as Hungary's wind power sector is linked to the left-wing government. Wind plant construction quotas were allocated under scandalous conditions in 2006, and, as indicated above, the 2009 tender was also tied to the Socialist government. Another problem could be the high share of foreign ownership, low employment in the sector, foreign turbines and low participation by domestic manufacturing companies. Finally, another explanation could be avoiding disruptions for the Paks II electricity market (Szabó, M. 2006).

As the fuel for wind farms is free, affordability questions point to the price of electricity from wind. The lifetime of a wind turbine is around 25 years, and the payback period can vary. However, after the investment is paid off, generation costs are very low. Although no investment aid (capital subsidy) has been provided for wind projects, operators receive a higher-than-market price under the KÁT Feed-in Tariff scheme until the return on investment is achieved, after which they sell their electricity on the free market. In 2011, the Hungarian Wind Energy Industry Association argued that paid-off wind power plants sold their electricity on the free market at a net price of 8–12 HUF/kWh, which is the same order of magnitude as the price of the electricity produced by the Paks Nuclear Power Plant, a written-down asset. Also, it insisted that the wind energy subsidy only put a very small financial burden on consumers (MSZIT 2011).

3.2.4. Hydropower: domestically politically sensitive

Hydropower is an old power source that can also be a tool used to control the power system. At end-2017, Hungary's installed hydropower capacity amounted to only 57.5 MW, excluding small-scale household power plants (MEKH–Mavir 2018: 56). Hungary is not rich in hydropower potential due to the lack of mountains, low rainfall, and the fact that rivers flow in flat areas. Although limited, hydropower opportunities do exist in Hungary. The hydropower potential is calculated at 989 MW. The Danube offers almost three quarters of this potential, followed by the Tisza and the Dráva. The Tisza continues to have the most installed capacity. Hydropower production on the Danube is negligible, while the Dráva has not been exploited at all (Büki and Lovas 2010: 94). While both principal types of hydropower plant – run-of-river hydropower and storage hydropower – operate in Hungary, pumped-storage hydropower, a special type of hydropower plants, does not. Larger-scale projects have been politically unacceptable since the Gabčíkovo (Slovakia)–Nagymaros (Hungary) Dam issue on the Danube, which became a symbol of regime change in Hungary. The construction on the Hungarian side was stopped in 1989 as a result of protests by environmentalists and civilians, and Hungary decided to terminate the 1977 treaty in 1992. After that, the Czechoslovaks diverted the majority of the Danube to the Gabčíkovo Hydropower Plant. The conflict between Hungary and Slovakia has so far not been solved, despite the 1997 ruling of the International Court of Justice in The Hague, which required meeting the objectives of the 1977 treaty. Until a bilateral compromise is reached, Hungary does not even receive its share of the electricity production from the Gabčíkovo Hydropower Plant, which has been operating for more than two and a half decades (Szeredi et al. 2010: 970–971). Thus, Hungary's National Renewable Energy Utilisation Action Plan for 2010–2020 includes only small and medium hydropower plants (Gerse 2014: 783, 785). A significant part of the Hungarian section of the Danube (140 out of the total of 417 kilometres) forms the common border between Hungary and Slovakia. Here, the use of hydropower cannot be carried out without Slovakia's consent. The utilization of the Danube section between the Danube Bend (a curve of the Danube) and the southern border is not restricted by the laws of other countries. However, constraints arise from the plan of the Danube Commission, an international intergovernmental organization, in which the locations of the dams necessary for navigation have been designated as the city of Adony and the village of Fajsz (Szeredi et al. 2010: 970–972). At the southern border, neighbour-related problems also affect the possibility of the existence of a hydropower plant. Investigating the economic feasibility of hydropower plants at Nagymaros and Fajsz, Kerényi and Szeredi (2012) found that they could be implemented and did not require subsidies. However, sustainability arguments have the upper hand over both the availability and affordability dimensions. As mentioned, the question of pumped-storage hydropower arises occasionally, but advocates of environmental sustainability also oppose this initiative, despite the existence of pumped-storage hydropower stations in many countries in Europe (Büki and Lovas 2010: 96). Two possible locations are the Danube Bend and the Zemplén Mountains in Northeast Hungary. But these locations would trigger protests from environmentalists.

3.3. Coal: a sunset fuel

Coal is an energy source for which the dimensions of availability and sustainability strongly collide. While coal has favourable properties regarding availability, the opposite is true for sustainability. Coal held a prominent position in the national energy policy discourse in the 1990s due to coal-fired power plants and coal mines. As far as the availability dimension is concerned, domestic coal production is currently centred around two open-pit lignite mines that supply the Mátra Power Plant. In addition, there are a few other insignificant coal mines. Lignite is abundantly available in the two mines.

Sustainability issues linked to lignite mining include environmental impacts, such as noise and dust, changes in the geological and hydrogeological conditions in the area, and the creation of external dumps for storing overburden (Widera et al. 2006: 156). While lignite exports to Romania have ceased, the population is still supplied with lignite, which has very serious sustainability consequences because lignite is typically burned in stoves without filters. Lignite is the lowest grade coal with a very high sulphur content. The Mátra Power Plant is outdated, with massive emissions of harmful substances, even though it currently meets existing requirements. The Mátra Power Plant is Hungary's single largest emitter of carbon dioxide: approximately 10 per cent of current emissions. While affordability is not an issue for domestic lignite, it can easily become a problem for the electricity produced by the Mátra Power Plant, because of its emissions. Due to its two mines, the Mátra Power Plant is not dependent on lignite price fluctuations. Profitability thus depends primarily on electricity and carbon prices. The power plant buys 100 per cent of its carbon dioxide quotas (Mert.hu n.d.-b). Furthermore, controlling emissions of other harmful substances, such as sulphur dioxide, nitrogen oxides and dust, would require additional costly investment (Forbes.hu 2017).

The power plant's licenses will expire by the mid-2020s. However, according to end-March 2019 company news, out of the current 884 MW of lignite-based capacities, 600 MW are intended to remain in use until 2029. This would require the extension of the relevant licenses (Portfolio.hu 2019). However, building a new lignite-fired unit is unlikely, despite statements in Hungary's 2011 energy strategy. Biomass co-firing and the company's solar PV activity indicate a move towards sustainability. But the appearance of a new controlling owner raises new issues. The power plant was controlled by German owners after its privatization, with the government acting as a minority shareholder through MVM. Since 2018, the company has been under the control of Lőrinc Mészáros, a friend of the prime minister, a former gas fitter, and the richest or one of the richest men in Hungary. According to the power plant's plans, the Mátra Power Plant will be a 1,600 MW-capacity power plant by 2030. Out of these capacities, the aim is to achieve the following structure: 500 MW of gas capacity (compared to the current 66 MW), 100 MW of biomass capacity, 31 MW of refuse-derived fuel (RDF) capacity, 600 MW of power storage capacity, and 400 MW of solar PV energy capacity (Portfolio.hu 2019). The Mátra Power Plant is not a completely separate facility but is part of an industrial park. In order to process the power plant's by-products, several industries have settled in its immediate vicinity (Kurucz 2014: 2). The power plant and its two mines hold a significant employment position in the region with 2,100 employees plus external contractors for maintenance, construction and production (Mert.hu n.d.-a). The number of employees of the industries built around the power plant should be added to this figure.

Besides the Mátra Power Plant, there are only two power stations in Hungary that burn coal. According to 2017 data, the Ajka Power Plant uses Czech brown coal for up to 10 per cent of its electricity and heat production (personal communication, 29 June 2017), while in the case of the Hamburger Hungária Power Plant the share of coal exceeded one third of its energy sources in 2017.[21] But the coal's origin remains unknown (Hamburger Hungária 2018). Thus, there does not appear to be any dependence on Russian coal in the stationary sector. In euro terms, 5.9 per cent of Hungary's total coal and coal product imports came from Russia in 2017 (2.6 per cent in 2016 and 12.7 per cent in 2018) (Comext 2019).

The 2011 energy strategy provides two reasons for why coal-based energy production should be maintained in Hungary: (1) in the case of an energy crisis related to availability and affordability (e.g., gas price explosion and nuclear disruption), coal is the only internal reserve which could be rapidly mobilised;[22] and (2) to prevent losing the professional culture of such energy production, which might be necessary in an emergency and due to greater potential coal use in the future if sustainability and emissions criteria (carbon capture and storage, as well as clean coal technologies) can be met (NFM 2011). The problem with these arguments is that it is more than questionable that substantial additional coal volumes can be mobilised and utilised in an emergency.[23] In 2016, Mavir argued that coal power plants would almost completely disappear in Hungary. Coal may only play a role post-2031, due to the availability of the technologies mentioned in the 2011 energy strategy (Mavir 2016: 20).

[21] The Hamburger Hungária Power Plant belongs to Hamburger Hungária, a leading corrugated base paper manufacturer in the city of Dunaújváros.
[22] According to Hungary's 2013 Reserve Management and Utilisation Action Plan, the amount of primary energy currently available from domestic coal could practically be doubled (NFM 2013: 6).
[23] This was brought to my attention by an anonymous reviewer.

3.4. Natural gas: becoming more diversified and less Russia-dependent

For a long time, Hungarian gas consumers evaluated gas very positively from the point of view of availability, affordability and sustainability. In terms of availability, the turning point was the 2009 Russian–Ukrainian gas crisis. The issue of affordability has influenced residential and non-residential consumers. While market developments could affect the non-residential sector, the increase in residential gas prices has remained taboo. At the same time, the sustainability image of gas has not been damaged.

With a couple of exceptions, gas consumption grew until 2006. The decline started in 2007, and gas consumption had diminished to 57.7 per cent of its 2006 peak level by 2014. Since 2015, demand has been increasing again (Table 4) (Eurostat 2018a; MEKH 2019d). Gas consumption reached 10.3 bcm in 2017 (MEKH 2019a: 28). Consequently, as indicated, the role of gas in the energy/electricity/heat mix significantly decreased, though recently an increase has taken place. The sharp decline in gas consumption between 2007 and 2014 was mainly due to the evolution of (relative) gas prices and the 2008–2009 economic crisis. These have been reflected in the gas consumption of both the energy transformation sector and end users, such as industry and the populace. In the case of power plants, the already described substitutions have taken place based on different energy, carbon and electricity prices. Regarding power plants, there are examples when switching from gas to domestic biomass is explained not only with affordability considerations, but also for availability reasons. In other cases, biomass replaces coal in power plants. Among the population, some increase has also been observed in energy conservation and efficiency, as well as sectoral diversification through the substitution of gas for coal and firewood. Some gas consumption reduction has been linked to services being turned off due to non-payment and illegal household connections. Foreign employment and emigration have also reduced household gas consumption to some extent. On the other hand, there are only a few new consumers connected to the network (Szilágyi 2013, 2014).

Another means of domestic diversification would be to increase domestic gas production. Hungarian gas production was declining rapidly until 2015. Since then, it has grown slightly. But currently it is basically stagnating. In 2017, gas production increased

Table 4. Hungary's gas balance, 2006–2017 (TJ)

	2006	2007	2008	2009	2010	2011
Primary production	99 734	83 926	83 981	95 764	93 570	88 562
Imports	394 454	358 995	390 442	331 059	331 283	276 281
Exports	185	716	787	2 955	7 801	19 495
Stock changes	-14 330	5 985	-31 475	-40 697	-6 097	46 282
Gross inland consumption	479 672	448 190	442 161	383 171	410 955	391 630

	2012	2013	2014	2015	2016	2017
Primary production	74 027	64 656	60 177	57 319	59 821	59 064
Imports	282 398	283 348	311 343	237 669	302 508	467 390
Exports	28 915	50 703	25 860	19 184	37 380	123 173
Stock changes	23 216	25 253	-53 354	37 780	11 155	-45 652
Gross inland consumption	350 726	322 554	292 306	313 585	336 104	357 629

Source: Eurostat (2018a) and MEKH (2019d).

to around 2.5 bcm (MEKH–FGSZ 2018: 33). In the early 2010s, domestic gas production accounted for more than 20 per cent of gas consumption. At that time, declining production (up until 2015) was associated with declining consumption (up until 2014). However, since 2015, consumption has been increasing, so the production-to-consumption ratio has fallen below 20 percent. This type of production comes from conventional sources. There were significant hopes for unconventional gas. But this has proved to be an illusion.

As indicated, four types of diversification aim at reducing gas demand: energy conservation, energy efficiency, as well as domestic and external sectoral diversification. In Hungary, there is room for both energy conservation and energy efficiency. The significance of these ways of introducing domestic diversification tends to be underestimated. Households are the largest energy users, and the greatest potential for energy savings lies here. The EU influencing factor plays a key role in improving energy efficiency. This refers to the implementation of the 2012 EU Energy Efficiency Directive and the availability of EU funding. In doing so, Hungary did not choose the standard programme of annual final energy by energy distributors or retail energy sales companies, but rather the implementation of alternative policy measures.

The diversification scheme (Figure 1) indicates that a further option lies in sectoral diversification, either domestic or external. As mentioned, biomass is an easy solution for replacing gas. In contrast, the role of domestic lignite in the stationary sector will be diminished by the end of the 2020s and it is undesirable to increase its role among the population. It should preferably be eliminated. In residential heating, the increased role of firewood and coal due to affordability considerations has serious consequences for the dimension of environmental sustainability.[24] In contrast, the role of solar PV energy will increase. But as with any other energy source, the question here is what it would replace. High capacity utilization at Paks, the Paks II project, as well as increasing electricity imports, coal and biomass imports could all belong to external sectoral diversification. As discussed, decreasing gas demand has partly been offset by growing electricity imports. But increasing electricity imports cannot be considered an option in Hungary because the government sees them as a risk. Similarly, as indicated, the role of nuclear power has increased. Although the role of nuclear energy and solar PV energy will shrink, the role of gas in electricity production is unlikely to decrease,[25] partly because coal power plants will soon disappear almost completely, and partly because the electricity system requires this flexible resource due to the intermittency and variability of renewables.

In Hungary, the bulk of gas imports continues to consist of long-term, Russian gas supply contracts. As a result, some non-geographical diversification is also provided. Currently, Hungary has two long-term gas import contracts, both with Gazprom Export, Gazprom's export arm. The major one is with MVM's Hungarian Gas Trade (formerly Mol Natural Gas Supply and then E.ON Natural Gas Trade), Hungary's leading gas trader, and are managed through Panrusgáz, the Russian–Hungarian gas intermediary joint venture.[26] This contract was signed by Hungarian oil and gas company Mol.[27] Concluded in 2007 for the period 2008–2028, a small contract has been entered into with Centrex Hungary, an affiliate of the Gazprombank-owned and Vienna-based Centrex Europe Energy & Gas.[28] Although the major long-term gas supply contract was to expire in 2015, unused gas will be available until 2021.[29] The Hungarian government intends to sign a new long-term gas supply contract with Gazprom for post-2021.

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[24] Naturally, firewood does not fall in the same category as coal.
[25] Annual electricity generation from gas may decrease, but the installed capacity will not.
[26] With this contract, Gazprom Export sells gas not only from the eastern direction but also from the western direction via Slovakia and Austria.
[27] Mol's wholesale, marketing and trading business Mol Natural Gas Supply was taken over by Germany's E.ON Ruhrgas in the mid-2000s. E.ON Natural Gas Trade, the new name for Mol Natural Gas Supply, was subsequently acquired by MVM in 2013 and renamed Hungarian Gas Trade.
[28] Gazprom has not had control over Gazprombank for many years.
[29] The contract was divided. As a consequence, Gazprom and Panrusgáz currently have four contracts. Two contracts are effective until 2019 and two until 2021 (Gazprom 2016).

Among external diversification options, geographical gas import source diversification implies both contractual relations for the sale, purchase and construction of the appropriate infrastructure.[30] By now, Hungary has pipeline links with all neighbouring countries – Ukraine, Serbia, Austria, Romania, Croatia and Slovakia – except Slovenia (Figure 2).[31] The first to be built was the Ukrainian pipeline. The link with Serbia, dedicated for transit purposes, carries gas in the direction of Serbia, Bosnia and Herzegovina via Hungary. Up until 1996, only one import option was in place for Hungary. For gas imports from the west, the Austrian–Hungarian interconnection was built in the 1990s. By 2009, significant capacity expansion was undertaken at the Ukrainian–Hungarian border, which was partly necessary because of the new strategic gas storage facility in Hungary. The Hungarian–Romanian interconnection was launched in 2010, the Hungarian–Croatian one in 2011, followed by the Hungarian–Slovakian one in 2015. The problem, however, is that Croatia and Romania have not fulfilled their obligations regarding the joint gas interconnections. They must ensure the physical transportation of gas to Hungary as well. On the other hand, in line with preliminary expectations, the Hungarian–Slovakian pipeline is not used in any direction at all, though it principally has a security interconnector character for crisis situations,[32] and some argue that the pipeline itself had an impact on Hungarian gas price negotiations with Gazprom (Beöthy et al. 2016: 3). In contrast, due to increased interest, the capacity of the western (Austrian) entry point was expanded. This was related to cheaper gas imports from Western Europe, which have been available in large quantities since the late 2000s. As a result, for the first time in 2011 and then in 2012 (but not in subsequent years), Hungary imported more gas through the western entry point than through the eastern (Ukrainian) one. However, as mentioned, Gazprom supplies gas from both directions. Again, this means that some of the western deliveries involve Russian long-term contract gas, and the remainder probably consists of Russian molecules but not from a Russian seller. This increased

[30] Underground gas storage facilities also play an important role in security of supply, but they are not regarded as diversification. Hungary is a great power in the field of gas storage. After the 2006 Russian–Ukrainian gas crisis, Hungary also set up a strategic storage facility. Meanwhile, all the facilities are now state-owned. Nonetheless, there was a time when storage units did not hold satisfactory quantities of gas, which was risky and thus reduced security of supply.
[31] There is an intention to create a Hungarian–Slovenian–Italian gas corridor.
[32] This point was brought to my attention by an anonymous reviewer.

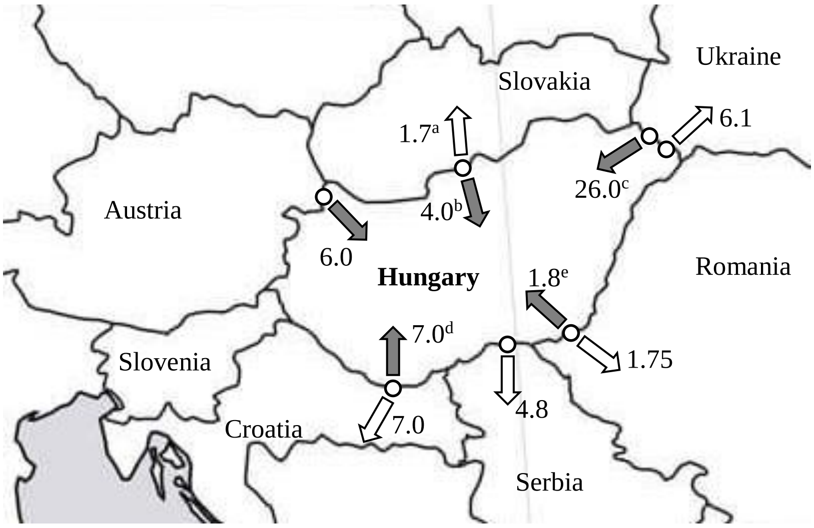

Figure 2. Cross-border entry/exit points on the Hungarian borders and capacity data (bcma)
[a] In contrast, MEKH–FGSZ (2018: 26) suggests 1.8 bcma of capacity.
[b] In contrast, MEKH–FGSZ (2018: 26) suggests 4.4 bcma of capacity.
[c] This figure also includes gas transit to Serbia, Bosnia and Herzegovina.
[d] Because of the lack of a compressor station in Croatia, only minor capacities can be utilised via the compressor station on the Hungarian side. The Croatian gas pipeline system also requires further development.
[e] Currently, only a symbolic quantity can be transported to Hungary. Developments are ongoing to enable full capacity utilization.
Source: Own compilation based on FGSZ (2018: 10) and Hungarian Gas Transit (2018: 6), the latter for the Hungarian–Slovakian interconnector.
Blank map: http://www.freeworldmaps.net/europe/europe-blank-map-hd.jpg.

amount of non-Russian gas has only appeared in the statistics to a limited extent (Weiner 2016).

The Hungarian–Romanian and Hungarian–Slovakian gas connections are currently to be seen in light of two competing gas corridors, the Bulgarian–Romanian–Hungarian–Austrian (ROHUAT/BRUA) one and the Bulgarian–Romanian–Hungarian–Slovakian–Austrian (BRUSKA) one, that will partly be based on already existing infrastructure and will provide Hungary and others access to Black Sea gas. However, Hungary is not interested in the development of the Hungarian–Austrian direction and further transport of gas to Austria.[33] Hungary hopes to purchase Romanian Black Sea gas that could reduce the volumes of the future Russian long-term gas supply contract. The Hungarian government apparently wanted to get all the volumes of this offshore gas. But this goal will not be achieved. Hungary intends to access this gas at a price that is competitive with

[33] In April 2019, the EU Agency for the Cooperation of Energy Regulators (ACER) claimed that the Hungarian–Austrian project should be tested on the market and thus the decision on the two competing directions should be determined by the market demand for capacity (ACER 2019).

Russian gas prices, thus availability and affordability of gas could also be improved. At the end of 2017, the Romanian–Hungarian pipeline was booked for the period 2022–2037, and it turned out that the two biggest winners were MVM's Hungarian Gas Trade and the Austrian subsidiary of MET, essentially a Hungarian interest energy company. But in December 2018, both companies withdrew (Erdélyi and Magyari 2019).

The Croatian–Hungarian pipeline is important for gas deliveries from the future Croatian LNG regasification facility, a floating storage and regasification unit (FSRU), for which the final investment decision was made in early 2019. Building an LNG regasification facility in neighbouring countries (in Croatia or Romania) is a very old idea, and it now seems to be materialising in Croatia. While the FSRU will have lower capacity than a land-based facility, the price is expected to be the real problem here and not the available quantities.

The above projects have typically been supported by EU funds, which means the institutional context also plays an important role in market creation (László Miklós, personal communication, 30 August 2018).

Non-Russian gas supplies were initiated in the 1990s. These supplies included those from Germany's Ruhrgas (later E.ON Ruhrgas, then E.ON Global Commodities, and now Uniper Global Commodities) and from the French Gaz de France (later GDF Suez, now Engie) through the Austrian–Hungarian gas interconnection on the one hand, and those from Ukraine and then from Central Asia on the other. The contract with GDF expired in 2012, while the contract with E.ON Ruhrgas was successfully terminated well before the 2015 expiration date.[34] Thus, these contracts were not handed over in 2013 when MVM bought E.ON Natural Gas Trade. It is true that as contractual diversification and not physical, gas was not physically delivered to Hungary from Germany and France via Austria. Moreover, gas under western contracts was more expensive than with Russian ones. However, the benefits of the western contracts were apparent during the January 2009 gas crisis when this scheme worked well and Hungarian (and other foreign) consumers benefitted from this option. Naturally, in order for this scheme to work, many conditions (such as interconnections and available gas supplies) must be met at a given location and time. As mentioned above, Central Asian imports via gas intermediaries were

[34] There was no need for these quantities, especially at such high prices.

stopped at the end of 2008. However, Gazprom Schweiz AG, exporting Central Asian gas to CEE, is present in Hungary through its Hungarian subsidiary WIEE Hungary.

Thus far, large gas pipeline projects – either aimed at source diversification or transit avoidance – have failed. On the Southern Gas Corridor, the Nabucco West pipeline project, a scaled-down version of Nabucco "classic" based on Azeri gas and aimed at geographical diversification without Russian involvement by transporting gas from the Turkish–Bulgarian border through Bulgaria, Romania and Hungary into Austria, was shelved in June 2013.

In turn, South Stream, essentially a transit diversification project planned to run under the Black Sea to Bulgaria and then onwards, was terminated in December 2014. South Stream was then replaced by the TurkStream pipeline project, stretching from Russia to Turkey across the Black Sea. The first pipeline is intended for Turkish consumption, and Europe will source gas from the second line. Nonetheless, it has not yet been decided where the continuation of TurkStream will arrive in Europe. Options include routes to either South Italy or CEE. Initially, the Tesla pipeline, to be installed from the Turkish–Greek border through Greece, Macedonia, Serbia and Hungary to Austria, was proposed by Hungary. Later, a Bulgarian–Serbian–Hungarian pipeline was put on the agenda. Recently, this pipeline has been discussed as a system of separate interconnections and national networks. However, virtually any pipeline plan should conform to EU legislation.

In addition to the option of the southern gas transit diversification, the Hungarian government would retain the Ukrainian corridor. Hungary was among those CEE countries that in March 2016 signed a letter objecting to Nord Stream 2, a trans-Baltic Sea pipeline project under construction between Russia and Germany, also aimed at diverting gas from the Ukrainian gas corridor. One problem is that Nord Stream 2 would increase Russian gas prices for Hungary (Viland 2018; Kotek et al. 2017). A further problem is that, compared to Russian gas imports, the capacities represented by western and northern interconnectors are preferable for import source diversification strategies.

While steps have been taken towards increasing the physical availability of gas, there has been a shift in domestic energy policy towards the affordability dimension reflected in a major utility rate cut campaign. This shift was to some extent imminent in most of the region's countries. For large segments of society, the regular payment of gas and electricity bills has become an everyday challenge. Utility prices belong to the top issues on people's minds. The government started cutting regulated gas prices in January 2013, followed by the second cut in autumn 2013, then the third in 2014. Declining regulated gas prices were first supported by Gazprom's concessions on gas volumes and prices in 2013 and 2014 (Deák and Weiner 2019: 144–145). Then the decline in oil prices began in mid-2014.[35] However, two comments have to be made. On the one hand, the same government raised gas prices before the rate cut campaign (Ember 2018), and, on the other, regulated gas prices have remained unchanged, despite the fact that market developments would have justified further cuts. Further, affordability considerations contributed to the politically-driven regulatory squeeze on the profitability of the utility sectors and on the partial renationalization at the corporate level. Utility rate cuts have weakened security of supply due to the lack of investment (LaBelle and Georgiev 2016), and also because declining household energy prices have increased energy use in Hungary (Sebestyén Szép 2017).

4. Summary and conclusions

Over the next one and a half or two decades, significant amounts of installed capacity will be mothballed in Hungary. But it is not completely clear how much new capacity should be built to achieve the self-sufficiency in electricity supplies called for by the Hungarian government. This amount also depends largely on the type of energy source the government encourages, as their annual load factor could be different. However, despite the decision on Paks II, there is great uncertainty about the future role of renewables and gas in the energy/electricity/heat mix. Their future might be chiefly dependent on purely political decisions rather than energy market factors. Nevertheless, the energy mix is not entirely determined by autonomous decisions, as various EU requirements – environmental obligations and renewable targets – should be met. In

[35] I do not know how important a role oil product prices are now playing in gas pricing, though it has surely decreased drastically.

Hungary's case, the institutional factor plays an important role, as opposed to the geopolitical influencing factor. Indeed, there is no universally optimal choice or mix for enhancing security of supply and gas diversification. There are only different sets of choices and large variation in the influencing factors that impact the prioritisation of different security of supply dimensions, with differing and uncertain rewards, both in the short and long term. The 2011 energy strategy selected the Nuclear–Coal–Green concept that, surprisingly, does not reflect the role of natural gas.

Nuclear energy plays the largest role in the Hungarian electricity balance, and this role will continue to grow, thus making Hungary more dependent not only on nuclear energy, but also on Russia. Paks II represents an unexpected turn regarding Hungary's energy dependence. With Paks II, Hungary's dependence will both decrease and increase as new types of risks appear. The Paks II decision came about at a time when Hungary was following a declining trajectory regarding its energy dependence, notwithstanding certain negative developments. The decision was surprising despite telling references in the 2011 energy strategy. One would have expected a very different strategy when making decisions for many decades ahead. Nonetheless, this was a legitimate decision that also won EU approval. Paks II can be understood as a form of external sectoral diversification and it has its own place in the gas diversification scheme. It is unlikely, but not impossible, that Paks II will pay off if electricity prices keep going up. Nonetheless, cheap electricity is not expected from Paks II. Therefore, affordability is very doubtful, while the issues of availability and sustainability are also not free of contradictions.

At present, coal still enjoys a solid position, though it is likely to fall out of the energy mix by the end-2020s, as no decision has been made to continue its use and no new lignite unit will presumably be introduced. From the perspective of sustainability, this is good news. At the same time, this could be considered negative in terms of availability, whereas the affordability dimension depends on the actual energy market and environmental factors.

Based on installed capacity, thus far, the "Green" component of the 2011 energy strategy has primarily focused on biomass and wind energy.[36] But solar PV energy will soon dominate the renewable sector. Biomass, a contradictory renewable energy source,

[36] Based on annual electricity production, biomass is much more important than wind.

can also continue to expand and may provide an easy way to increase the role of renewables. In general, the political environment for renewables has remained a big challenge in Hungary, as the Hungarian government supports a centralized approach and does not believe in the reliability of intermittent and variable renewables due to fears concerning the availability and affordability dimensions. However, solar PV has been selected for expansion, and is ready to take off. The anticipated rapid spread of solar PV across Hungary will strengthen decentralized energy system structures. Solar PV will certainly squeeze profitability rates in the electricity generation sector: it has very low marginal cost and is therefore at the bottom of the merit order curve. Moreover, these investments are not only made on a market basis. Once capacities are in place, they will certainly be used. Therefore, non-solar investors should take into account how much solar PV will be installed. On the other hand, the Hungarian government does not intend to exploit the remaining wind potential due to the availability and sustainability dimensions. Nevertheless, solar PV and wind complement each other well, which is an argument for eventually reconsidering the wind issue. Hydro potential is also not likely to be utilised to a much larger extent because of the sustainability dimension and political sensitivity and only minimal growth should be expected.

Finally, despite the deteriorating effects of high gas prices between 2011 and 2014, gas will continue to play an important role in electricity generation as a flexible peaking resource or a standby reserve in an electricity system with increasing amounts of intermittent and variable renewables. In addition, while decentralised biomass-based heating and geothermal could gain more focus in the heating sector, the future of gas, the cleanest fossil fuel, is not disputed in Hungary. Therefore, in the foreseeable future, a Nuclear–Solar/Biomass–Natural Gas focus in the electricity mix will emerge. Since the January 2009 Russian–Ukrainian gas crisis, Hungary's dependence on both gas in general and Russian gas in particular has decreased, while Hungary's gas security has increased. This has been the result of a combination of the declining gas demand (due to sectoral diversification and some energy conservation and efficiency measures), gas market integration and connections, as well as decreasing gas production, the last of which is a negative factor. While attempts to overcome decreasing gas production have so far failed and current technological means, oil prices and environmental regulations do not support unconventional gas, there is still room for improvement concerning the other issues that could enhance the availability and affordability of gas imports. The future of the (major), Russian, long-term gas supply contract is of particular importance. Gazprom has practically extended it until 2021, which is not only currently economically significant for Hungary, but which has provided the Hungarian government with more time prior to signing a new contract that could take into account both the progress made in gas diversification and the latest developments in the gas and other energy markets. Among the geographical source diversification plans, Romanian offshore gas can be decisive for this issue. However, previous expectations seem to have been abandoned. Another option, a long-awaited one, could be imports from a Croatian LNG regasification plant. The EU institutional influencing factor plays a major role with respect to gas, as activities such as encouraging physical infrastructure development, enhancing liberalization and market integration, as well as using antitrust measures against Gazprom, increase security of supply through both availability and affordability. EU measures also have direct market creation effects. Finally, it is important to ask what will happen with Ukrainian transit and how the elimination of the Ukrainian corridor will affect Russian gas import prices and gas prices in general, in particular if Russia reserves such pipeline capacities that the CEE region could use for importing gas from Western gas hubs and not for Russian long-term contract gas. Nord Stream 2 will most certainly be built. But the future of the European continuation of TurkStream is still uncertain.

From the point of view of dependence on Russia, the expected Nuclear–Solar/Biomass–Natural Gas focus in electricity generation means there will be two sources (solar and biomass) independent of Russia, as opposed to two Russian-dependent energy sources (nuclear and natural gas). Though coal has been the most important Russian-independent source thus far, its future disappearance will alter this balance. The strongest dependence will be observed for nuclear energy, since the nuclear fuel, the technology and the loan will all be or have been provided by Russia. At the same time, Paks II is the single most solid element of the Russian presence in Hungary. Therefore, Paks II stretches Moscow's influence well beyond the tenure of the incumbent government and will determine Russian–Hungarian relations for a long time to come.

Several years have passed since the last energy strategy was adopted in 2011. Energy market changes are prompting the government to rethink this strategy and its review is ongoing.[37] To what extent these uncertainties will be addressed remains to be seen.

[37] The new strategy should be ready by 1 September 2019.

References

ACER (2019) 'ACER Adopts Decision on Gas Interconnection between Hungary and Austria', *News*, 11 April, available at https://acer.europa.eu/Media/News/Pages/ACER-adopts-Decision-on-gas-interconnection-between-Hungary-and-Austria-.aspx (13 April 2019).

Andersen, Svein S., Andreas Goldthau and Nick Sitter (2017a) 'Conclusion: Liberal Mercantilism?', in Svein S. Andersen, Andreas Goldthau and Nick Sitter, eds. *Energy Union: Europe's New Liberal Mercantilism?*, 237–242, London: Palgrave Macmillan.

Andersen, Svein S., Andreas Goldthau and Nick Sitter (2017b) 'Introduction: Perspectives, Aims and Contributions', in Svein S. Andersen, Andreas Goldthau and Nick Sitter, eds. *Energy Union: Europe's New Liberal Mercantilism?*, 1–10, London: Palgrave Macmillan.

Balmaceda, Margarita M. (2008) *Energy Dependency, Politics and Corruption in the Former Soviet Union: Russia's Power, Oligarchs' Profits and Ukraine's Missing Energy Policy, 1995–2006*, London: Routledge.

Balmaceda, Margarita M. (2013) *The Politics of Energy Dependency: Ukraine, Belarus, and Lithuania between Domestic Oligarchs and Russian Pressure*, Toronto: University of Toronto Press.

Bates, Judith, Oliver Edberg and Chris Nuttall (2009) 'Minimising Greenhouse Gas Emissions from Biomass Energy Generation', Bristol: Environment Agency, available at http://www.globalbioenergy.org/uploads/media/0904_Environment_Agency_-_Minimising_greenhouse_gas_emissions_from_biomass_energy_generation.pdf (20 July 2018).

Beöthy, Ákos, Borbála Takácsné Tóth, Péter Kaderják and Péter Kotek (2016) 'Was It worth Building the SK–HU Natural Gas Interconnector?', Budapest: Regional Centre for Energy Policy Research (REKK), *REKK Policy Brief*, No. 06/2016, available at http://rekk.hu/downloads/academic_publications/rekk_policybrief_06_en.pdf (20 April 2019).

Boersma, Tim and Andreas Goldthau (2017) 'Wither the EU's Market Making Project in Energy: From Liberalization to Securitization?', in Svein S. Andersen, Andreas Goldthau and Nick Sitter, eds. *Energy Union: Europe's New Liberal Mercantilism?*, 99–114, London: Palgrave Macmillan.

Bowyer, Jim (2012) 'Life Cycle Impacts of Heating with Wood in Scenarios Ranging from Home and Institutional Heating to Community Scale District Heating Systems', Dovetail Partners, Inc., available at https://www.lccmr.leg.mn/projects/2011/finals/2011_07_rpt_life_cycle_impacts_heating_with_wood.pdf (11 July 2018).

BP (2018) 'BP Statistical Review of World Energy', June.

Büki, Gergely and Rezső Lovas, eds. (2010) *Megújuló energiák hasznosítása* [Utilizing Renewable Energies], Budapest: Hungariain Academy of Sciences.

Comext (2019) EU Trade since 1988 by SITC (DS-018995), available at http://epp.eurostat.ec.europa.eu/newxtweb/ (29 March 2019).

Deák, András (2018) 'Energiabiztonság' [Energy Security], manuscript.

Deák, András and Csaba Weiner (2016) 'Country Report: Hungary', Manuscript prepared for the project 'Russian economic influence in new Europe', Center for the Study of Democracy (Sofia) and Center for Strategic and International Studies (Washington, D.C.).

Deák, András and Csaba Weiner (2019) 'Hungary: Leveraging Political Influence', in Ognian Shentov, Ruslan Stefanov and Martin Vladimirov, eds. *The Russian Economic Grip on Central and Eastern Europe*, 136–150, Abingdon – New York: Routledge.

Diesendorf, Mark (2016) 'Dispelling the Nuclear 'Baseload' Myth: Nothing Renewables Can't Do Better!', *The Ecologist*, 10 March, available at https://theecologist.org/2016/mar/10/dispelling-nuclear-baseload-myth-nothing-renewables-cant-do-better (5 July 2018).

Dinya, László (2010) 'Biomassza-alapú energiatermelés és fenntartható energiagazdálkodás' [Biomass-Based Energy Production and Sustainable Energy Management], *Magyar Tudomány* 171(8): 912–925.

Dinya, László (2018) 'Biomassza-alapú energiahasznosítás: a múlt és a jövő [Biomass-Based Energy Utilization: Past and Future], *Magyar Tudomány* 179(8): 1184–1196.

EASAC (2018) 'Commentary by the European Academies' Science Advisory Council (EASAC) on Forest Bioenergy and Carbon Neutrality', 15 June, available at https://easac.eu/fileadmin/PDF_s/reports_statements/Carbon_Neutrality/EASAC_commentary_on_Carbon_Neutrality_15_June_2018.pdf (30 July 2018).

Ember, Zoltán (2018) 'Bemutatjuk a rezsicsökkentést, az elmúlt nyolc év legnagyobb szemfényvesztését' [We Introduce the Utility Rate Cut Campaign, the Biggest Window-Dressing Operation of the Last Eight Years], *24.hu*, 24 March, available at https://24.hu/fn/gazdasag/2016/11/17/szamlakkal-bizonyitjuk-hogy-kamu-a-reziscsokkentes/ (24 March 2018).

Energiaskanzen.hu (2012) 'Kínos szélcsendben a szélenergia-szektor' [Wind Energy Sector in Awkward Doldrums], available at http://energiaskanzen.hu/cikk/energiatoblet/kinos-szelcsendben-a-szelenergia-szektor.html (2 January 2017). This link does not exist anymore.

ENTSO-E (2015) 'TYNDP 2016 Scenario Development Report', Brussels: ENTSO-E, 3 November, available at https://www.entsoe.eu/Documents/TYNDP%20documents/TYNDP%202016/rgips/TYNDP2016%20Scenario%20Development%20Report%20-%20Final.pdf (17 September 2017).

Erdélyi, Péter and Péter Magyari (2019) 'Milliárdos gázüzlet miatt került Magyarország az orosz és az amerikai érdekek ütközőzónájába' [Billion-Dollar Gas Business Leads Hungary into Conflict Zone between Russian and American Interests], *444.hu*, 11 February, available at https://tldr.444.hu/2019/02/11/milliardos-gazuzlet-miatt-kerult-magyarorszag-az-orosz-es-az-amerikai-erdekek-utkozozonajaba (11 February 2019).

European Commission (2015) 'Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank: A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy', COM/2015/080 final, available at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2015%3A80%3AFIN (9 May 2017).

European Commission (2017) 'State Aid: Commission Clears Investment in Construction of Paks II Nuclear Power Plant in Hungary', *Press release*, 6 March, available at http://europa.eu/rapid/press-release_IP-17-464_en.htm (7 August 2018).

European Parliament and Council (2009) 'Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the Promotion of the Use of Energy from Renewable Sources and Amending and Subsequently Repealing Directives 2001/77/EC and 2003/30/EC' (Text with EEA relevance), available at http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A32009L0028 (17 October 2017).

Eurostat (2016) 'Renewable Energy in the EU: Share of Renewables in Energy Consumption in the EU Rose Further to 16% in 2014: Nine Member States Already Achieved Their 2020 Targets', *Eurostat news release*, 10 February, available at http://ec.europa.eu/eurostat/documents/2995521/7155577/8-10022016-AP-EN.pdf/38bf822f-8adf-4e54-b9c6-87b342ead339 (28 May 2017).

Eurostat (2018a) 'Simplified Energy Balances – Annual Data' [nrg_100a] (Last update: 31-05-2018), available at http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_100a&lang=en (20 April 2019).

Eurostat (2018b) 'Supply, Transformation and Consumption of Electricity – Annual Data' [nrg_105a] (Last update: 04-06-2018), available at http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_105a&lang=en (20 April 2019).

Eurostat (2018c) 'Supply, Transformation and Consumption of Heat – Annual Data' [nrg_106a] (Last update: 04-06-2018), available at http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_106a&lang=en (20 April 2019).

Evans, Simon (2017) 'Solar, Wind and Nuclear Have 'Amazingly Low' Carbon Footprints, Study Finds', *Carbon Brief*, 8 December, available at https://www.carbonbrief.org/solar-wind-nuclear-amazingly-low-carbon-footprints (30 June 2018).

Fabók, Márton (2017) 'Valótlant állít az illetékes államtitkár Paks II nyereségességéről' [Secretary of State Making False Statement on Paks II's Profitability], *Energiabox*, 10 October, available at https://energiabox.blog.hu/2017/10/10/valotlant_allit_az_illetekes_allamtitkar_paks_ii_varhatoan_nem_lesz_nyereseges (15 October 2018).

Felsmann, Tamás (2011) 'Állam és atomenergia' [The State and Nuclear Energy], *Világgazdaság*, 19 May, available at http://vg.hu/velemeny/publicisztika/allam-es-atomenergia-349184 (5 August 2017).

Felsmann, Tamás (2015) 'Can the Paks-2 Nuclear Power Plant Operate without State Aid? A Business Economics Analysis', Budapest: Energiaklub, available at https://energiaklub.hu/files/study/study_can_paks-2_operate_without_state_aid_energiaklub_2015.pdf (2 August 2017).

Mezősi, András (2016) 'Elfér-e egymás mellett a megújuló és atomenergia. A megújulók hatása az atomerőművi kihasználtságra és profitra Magyarországon' [Enough Space for Renewables and Nuclear Energy? The Impact of Renewables on Nuclear Power Plant Production and Profit in Hungary], Budapest: Regional Centre for Energy Policy Research, *Jelentés az energiapiacokról*, No. 2016/4: 17–19.

FGSZ (2018) 'FGSZ Ltd's Annual Report 2017', available at https://fgsz.hu/file/documents/1/1161/fgsz_annual_report_2017.pdf (11 March 2019).

Forbes.hu (2017) 'Nagyon ráfaraghat Mészáros Lőrinc a Mátrai Erőmű megvásárlására' [Lőrinc Mészáros May Fare Badly with Purchase of Mátra Power Plant], 8 May, available at https://forbes.hu/uzlet/meszaros-lorinc-matrai-eromu/ (5 June 2017).

Franza, Luca and Coby van der Linde (2017) 'Geopolitics and the Foreign Policy Dimension of EU Energy Security', in Svein S. Andersen, Andreas Goldthau and Nick Sitter, eds. *Energy Union: Europe's New Liberal Mercantilism?*, 85–98, London: Palgrave Macmillan.

Gazprom (2016) '20 Years of Reliable Russian Gas Supplies to Panrusgas, Hungary', *News and events*, 5 December, available at http://www.gazprom.com/press/news/2016/december/article294894/ (11 October 2017).

Gerse, Károly (2014) 'A vízenergia-hasznosítás hozzájárulása a fenntarthatósághoz' [Hydropower Utilization's Contribution to Sustainability], *Magyar Tudomány* 171(7): 779–789.

Gonzalez-Salazar, Miguel Angel, Trevor Kirsten and Lubos Prchlik (2018) 'Review of the Operational Flexibility and Emissions of Gas- and Coal-Fired Power Plants in a Future with Growing Renewables', *Renewable and Sustainable Energy Reviews* 82 (Part 1): 1497–1513.

Haffner, Tamás (2018) 'A megújuló energia termelés támogatásának intézményi változásai – a Megújuló Energia Támogatási Rendszer bevezetése' [Institutional Changes in Support of Renewable Energy Production: Introduction of Renewable Energy Support Scheme], *Közép-Európai Közlemények* 11(2): 17–29, available at http://vikek.eu/wp-content/uploads/2018/05/KEKNo412018.2.sz%C3%A1m.pdf#page=17 (19 November 2018).

Hamburger Hungária (2018) 'Összefoglaló jelentés 2017' [Summary Report 2017], Dunaújváros, 21 April, available at https://www.hamburger-containerboard.com/fileadmin/Hamburger_Containerboard/Hungary/Sustainability/HH_Eromu_Eves_oesszefoglalo_jelentes_2017.pdf (10 December 2018).

Hargitai, Miklós (2018) 'Hatástalan a propaganda: nem akarjuk Paks 2-t' [Ineffective Propaganda: We Do Not Want Paks 2], *Népszava*, 23 July, available at https://nepszava.hu/3002452_hatastalan-a-propaganda-nem-akarjuk-paks-2-t (29 October 2018).

Hinrichs-Rahlwes, Rainer (2013) 'Feature: System Transformation', in REN21: *Renewables 2013 Global Status Report*, 90–92, Paris: REN21 Secretariat, available at http://hub.globalccsinstitute.com/sites/default/files/publications/137988/renewables-global-status-report-2013.pdf (1 August 2018).

Hughes, Larry (2012) 'A Generic Framework for the Description and Analysis of Energy Security in an Energy System', *Energy Policy* 42: 221–231.

Hungarian Gas Transit (2018) 'Magyar Gáz Tranzit Zártkörűen Működő Részvénytársaság 2017. évi Éves Beszámolójának Kiegészítő Melléklete' [Supplementary Annex to 2017 Annual Report of Hungarian Gas Transit Ltd.], Budapest, 27 April, available at http://www.gaztranzit.hu/hu/balmenu/dokumentumtar/Documents/Magyar%20G%C3%A1z%20Tranzit%20ZRt._kieg%C3%A9sz%C3%ADt%C5%91_mell%C3%A9klet_2017.pdf (19 April 2019).

HVG.hu (2017a) 'Enyhít a napelemekre kivetett sarcon a kormány' [Government to Reduce Tax on Solar Panels], 27 December, available at http://hvg.hu/gazdasag/20171227_Enyhit_a_napelemekre_kivetett_sarcon_a_kormany (31 October 2018).

HVG.hu (2017b) 'Itt „a" magyarázat: miért fogadta el az unió a paksi atomalkut?' [Here Is "The" Explanation: Why Has the EU Accepted the Paks Nuclear Deal?], 26 September, available at https://hvg.hu/gazdasag/20170926_Itt_a_magyarazat_Miert_fogadta_el_az_unio_a_paksi_atomalkut (31 October 2018).

IEA (n.d.) 'Energy Security', International Energy Agency (IEA), available at http://www.iea.org/subjectqueries/keyresult.asp?KEYWORD_ID=4103 (3 January 2011). This link does not exist anymore.

Illés, József (2017) 'Akár háromszor annyi turbina is működhetne, de nem engedik az építésüket' [There Could Be up to Three Times More Turbines, but Their Construction Is Not Allowed], 27 September, available at https://mno.hu/gazdasag/akar-haromszor-annyi-turbina-is-mukodhetne-de-nem-engedik-az-epitesuket-2418865 (17 November 2018).

IRENA (2018) 'Renewable Capacity Statistics 2018', Abu Dhabi: International Renewable Energy Agency (IRENA), available at https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Mar/IRENA_RE_Capacity_Statistics_2018.pdf (30 November 2018).

Kerényi, A. Ödön and István Szeredi (2012) 'A vízenergia-hasznosítás vizsgálata II.' [Assessment of Hydropower Utilization II], *Magyar Energetika* 19(5): 37–41.

Király, István Dániel (2018) 'Elindul Magyarországon a megújuló energiaforrások térnyerése' [Renewable Energy Sources to Start Expanding in Hungary], *Infostart/InfoRádió*, 6 July, available at https://infostart.hu/belfold/2018/07/05/elindul-magyarorszagon-a-megujulo-energiaforrasok-ternyerese (24 November 2018).

Kormany.hu (2017) 'Újabb blokkok tervezését kellene mérlegelni' [Planning New Units Should Be Considered], *Website of the Hungarian Government*, 5 October, available at http://www.kormany.hu/hu/tarca-nelkuli-miniszter/hirek/ujabb-blokkok-tervezeset-kellene-merlegelni (16 October 2017).

Kotek, Péter, Adrienn Selei and Borbála Takácsné Tóth (2017) 'The Impact of the Construction of the Nord Stream 2 Gas Pipeline on Gas Prices and Competition', Budapest: Regional Centre for Energy Policy Research (REKK), available at https://rekk.hu/downloads/academic_publications/NordStream2_REKK.pdf (25 April 2019).

Kurucz, Boglárka (2014) 'A Mátrai Erőmű intézkedései a szigorodó károsanyag-kibocsátási határértékek betartása érdekében' [Mátra Power Plant Measures to Comply with Stricter Emission Limits], Student Association of Energy, March, available at https://www.eszk.org/attachments/l190/besz/matra_beszamolo.pdf (11 November 2018).

KWK-Index (n.d.) 'Quarterly Prices According to CHP Law', European Energy Exchange, available at https://www.eex.com/en/market-data/power/spot-market/kwk-index (24 April 2019).

LaBelle, Michael and Atanas Georgiev (2016) 'The Socio-Political Capture of Utilities: The Expense of Low Energy Prices in Bulgaria and Hungary', Manuscript prepared for 'Energy Law and Energy Infrastructure Development for a Low-Carbon World', edited by Raphael Heffron, Darren McCauley, Angus Johnston and Stephen Tromans to be published by Cambridge University Press, available at http://energyscee.com/wp-content/uploads/2016/10/HU-and-BG-chapter-final-v3.pdf (11 November 2017).

Lazard (2017) 'Levelized Cost of Energy 2017', *Insights*, 2 November, available at https://www.lazard.com/perspective/levelized-cost-of-energy-2017/ (7 April 2018).

Macknick, Jordan, Robin Newmark, Garvin Heath and Kathleen C. Hallett (2012) 'Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies: A Review of Existing Literature', *Environmental Research Letters* 7(4), available at http://iopscience.iop.org/article/10.1088/1748-9326/7/4/045802/pdf (27 May 2018).

Mavir (2016) 'A magyar villamosenergia-rendszer közép- és hosszú távú forrásoldali kapacitásfejlesztése 2016' [Medium- and Long-Term Supply Capacity Development of the Hungarian Electricity System, 2016], Budapest: Mavir, available at https://www.mavir.hu/documents/10258/15461/Forráselemzés_2016.pdf/462e9f51-cd6b-45be-b673-6f6afea6f84a (22 August 2017).

Mavir (2018) 'A magyar villamosenergia-rendszer közép- és hosszú távú forrásoldali kapacitásfejlesztése 2018' [Medium- and Long-Term Supply Capacity Development of the Hungarian Electricity System, 2018], Budapest: Mavir, available at https://www.mavir.hu/documents/10258/15461/Forr%C3%A1selemz%C3%A9s_2018_IG.pdf/fc043982-a8ea-e49f-6061-418b254a6391 (7 March 2019).

MEKH (2019a) '2017 Évkönyv' [2017 Yearbook], Budapest: Hungarian Energy and Public Utility Regulatory Authority (MEKH), available at http://www.mekh.hu/download/5/63/60000/mekh_evkonyv_2017_hu.pdf (20 April 2019).

MEKH (2019b) 'Annual Data on Gross Electricity Production, 2014–2017' (Date of the last update: 31 January 2019), available at http://www.mekh.hu/download/a/13/90000/4_2_gross_electricity_production_2014_2017.xlsx (20 April 2019).

MEKH (2019c) 'Annual Data on Heat Production, 2014–2017' (Date of the last update: 31 January 2019), available at http://www.mekh.hu/download/b/13/90000/5_1_thermal_energy_production_2014_2017.xlsx (20 April 2019).

MEKH (2019d) 'Annual Natural Gas Balance, 2014–2017' (Date of the last update: 31 January 2019), available at http://www.mekh.hu/download/9/13/90000/3_2_annual_natural_gas_balance_2014_2017.xlsx (20 April 2019).

MEKH (2019e) 'Production and Consumption of Primary Renewable Energy Sources, 2014–2017' (Date of the last update: 31 January 2019), available at http://www.mekh.hu/download/d/13/90000/6_2_primary_renewable_en_sources_2014_2017.xlsx (20 April 2019).

MEKH (2019f) 'Share of Renewable Sources in Gross Final Energy Consumption, 2005–2017' (Date of the last update: 31 January 2019), available at http://www.mekh.hu/download/c/13/90000/6_1_share_of_renewable_en_sources_2005_2017.xlsx (20 April 2019).

MEKH–FGSZ (2018) 'Data of the Hungarian Natural Gas System, 2017', Budapest: MEKH–FGSZ, available at http://www.mekh.hu/download/f/29/60000/a_magyar_foldgazrendszer_2017_evi_adatai.pdf (10 March 2019).

MEKH–Mavir (2018) 'Data of the Hungarian Electricity System, 2017', Budapest: MEKH–Mavir, available at https://www.mavir.hu/documents/10258/154394509/MEKH+MAVIR+VER+2017_kiadvany_vegleges_20181116.pdf/d345fdb8-7048-4af2-9a63-1d7415bb84c9 (15 March 2019).

Mert.hu (n.d.-a) Mátrai Erőmű. Cégtörténet [Mátra Power Plant: History], available at http://www.mert.hu/cegtortenet (30 September 2017).

Mert.hu (n.d.-b) Mátrai Erőmű. Köszöntő [Mátra Power Plant: Greetings], available at http://www.mert.hu/hu/elnoki-koszonto (9 November 2018).

Minin, Nikita and Tomáš Vlček (2018) 'Post-Fukushima Performance of the Major Global Nuclear Technology Providers', *Energy Strategy Reviews* 21: 98–110.

MSZIT (2011) 'A szélenergia támogatásáról, és a fogyasztói árakra gyakorolt hatásáról' [On Wind Power Support and Its Impact on Consumer Prices], Hungarian Wind Energy Industry Association (MSZIT), 26 April, available at http://www.mszit.hu/hirek/hirek/article/a-szelenergia-tamogatasarol-es-a-fogyasztoi-arakra-gyakorolt-hatasarol/ (17 November 2018).

Munkácsy, Béla (n.d.) 'Háttérinformációk és szempontok a szélerőművekkel kapcsolatos szabályozás tárgykörében' [Background Information and Considerations on Wind Power Regulation], available at http://munkacsy.web.elte.hu/szelenergia-hatter.pdf (15 November 2018).

Munkácsy, Béla, Fanni Sáfián, Ádám Harmat and Sándor Németh (2014) 'Hazai megújuló potenciálok és hasznosításuk jövőképünkben' [Domestic Renewables Potential and Their Utilization in Our Vision], in Béla Munkácsy, ed. *A fenntartható energiagazdálkodás felé vezető út* [The Way to Sustainable Energy Management], 143–152, Budapest: ELTE Universtiy, Faculty of Science, Department of Environmental and Landscape Geography – Environmental Education Network National Association, available at http://ktf.elte.hu/wp-content/uploads/2014/09/ERRE-VAN-ELORE-2.0.pdf (6 November 2018).

Nagy, Gergely Miklós (2016) 'Csak ne a szél! Miért sorvasztja el a kormány a szélerőműveket?' [Anything but Wind! Why Is the Government Winding down Wind Power Plants?], *Magyar Narancs*, No. 2016/35, 1 September, available at https://m.magyarnarancs.hu/belpol/csak-ne-a-szel-100654 (15 November, 2018).

Német, Tamás (2016) 'Csepreghy: a szélenergiának nincs helye a magyar energiarendszerben' [Csepreghy: No Place for Wind Energy within the Hungarian Energy System], *Index.hu*, 8 October, available at http://index.hu/belfold/2016/10/08/csepreghy_a_szelenergianak_nincs_helye_a_magyar_energiarendszerben/ (5 March 2017).

NFM (2010) 'National Renewable Energy Action Plan 2010–2020', Budapest: The Deputy Secretariat of State for Green Economy Development and Climate Policy for the Ministry of National Development (NFM), available at http://2010-2014.kormany.hu/download/6/b9/30000/RENEWABLE%20ENERGY_REPUBLIC%20OF%20HUNGARY%20NATIONAL%20RENEWABLE%20ENERGY%20ACTION%20PLAN%202010_2020.pdf (10 November 2018).

NFM (2011) 'National Energy Strategy 2030', Budapest: Ministry of National Development (NFM), available at http://2010-2014.kormany.hu/download/7/d7/70000/Hungarian%20Energy%20Strategy%202030.pdf (29 August 2017).

NFM (2013) 'Ásványvagyon-hasznosítási és készletgazdálkodási Cselekvési Terv' [Reserve Management and Utilisation Action Plan], Budapest: Ministry of National Development (NFM), February, available at http://2010-2014.kormany.hu/download/c/6a/c0000/ÁCsT_02%2012.pdf (5 October 2017).

Pcblog.atlatszo.hu (2018) 'Orosz befolyás Magyarországon (2. rész): Paks II.' [Russian Influence in Hungary (Part 2): Paks II], 5 March, available at https://pcblog.atlatszo.hu/2018/03/05/orosz-befolyas-magyarorszagon-2-resz/ (29 November 2018).

Pehl, Michaja, Anders Arvesen, Florian Humpenöder, Alexander Popp, Edgar G. Hertwich and Gunnar Luderer (2017) 'Understanding Future Emissions from Low-Carbon Power Systems by Integration of Life-Cycle Assessment and Integrated Energy Modelling', *Nature Energy* 2, 939–945.

Portfolio.hu (2014) 'Kiderült: így vesszük fel a Paks-2 hitelt az oroszoktól' [Uncovered: This Is How We Will Receive a Loan for Paks II from Russia], 28 May, available at https://www.portfolio.hu/gazdasag/energia/kiderult-igy-vesszuk-fel-a-paks-2-hitelt-az-orszoktol.199481.html (30 November 2018).

Portfolio.hu (2019) 'Nagy dobásra készül a Mátrai Erőmű. Teljes átalakulást terveznek' [Mátra Power Plant Prepares for Big Move: They Are Planning a Complete Transformation], 25 March, available at https://www.portfolio.hu/vallalatok/energia/nagy-dobasra-keszul-a-matrai-eromu-teljes-atalakulast-terveznek.318559.html (25 March 2019).

REKK (2011) 'A Nemzeti Energiastratégia 2030 gazdasági hatáselemzése' [Economic Impact Analysis of the 2030 National Energy Strategy], Budapest: Regional Centre for Energy Policy Research (REKK), April, available at http://2010-2014.kormany.hu/download/9/87/70000/ESTRAT%20Gazdasági%20Megvalósíthatósági%20Tanulmány.pdf (3 June 2017).

REKK (2017) 'Meg-megújuló statisztikák' [Revised Renewable Statistics], Budapest: Regional Centre for Energy Policy Research (REKK), *REKK Policy Brief*, No. 01/2017, available at http://rekk.hu/downloads/academic_publications/rekk_policybrief_hu_2017_01.pdf (30 May 2017).

Sandbag (n.d.) 'EUA Price', available at https://sandbag.org.uk/carbon-price-viewer/ (24 April 2019).

Sebestyén Szép, Tekla (2017) 'The Effects of Utility Cost Reduction on Residential Energy Consumption in Hungary: A Decomposition Analysis', *International Journal of Sustainable Energy Planning and Management* 13: 61–78.

Stern, Jonathan (2002) 'Security of European Natural Gas Supplies', London: Royal Institute of International Affairs.

Stern, Jonathan (2009) 'The January 2009 Russia–Ukraine Gas Crisis: Implications for Europe', Presentation at IMEMO, Moscow, 26 March, available at https://www.imemo.ru/files/File/ru/conf/2009/26032009/26032009_prz_STE.pdf (9 January 2017).

Stern, Jonathan (2017) 'The Future of Gas in Decarbonising European Energy Markets: The Need for a New Approach', Oxford: Oxford Institute for Energy Studies, *OIES Paper*, NG 116, available at https://www.oxfordenergy.org/wpcms/wp-content/uploads/2017/01/The-Future-of-Gas-in-Decarbonising-European-Energy-Markets-the-need-for-a-new-approach-NG-116.pdf (15 May 2018).

Swain, Marian, Jessica Lovering, Linus Blomqvist, Ted Nordhaus and Rebecca R. Hernandez (2015) 'Land-Use Intensity of Electricity Production: Comparison across Multiple Sources', American Geophysical Union, Fall Meeting 2015, abstract id. GC51C-1098, available at http://adsabs.harvard.edu/abs/2015AGUFMGC51C1098S (13 April 2018).

Szabó, Dániel (2017) 'Elbukik a nagy terv. Magyarországra nem süt már a Nap' [The Big Plan Fails: The Sun Is Not Shining on Hungary Anymore], *Napi.hu*, 21 May, available at https://www.napi.hu/magyar_vallalatok/elbukik_a_nagy_terv_magyarorszagra_nem_sut_mar_a_nap.638095.html (18 November 2018).

Szabó, M. István (2006) 'Energiaipari változások II. Bolond szél fúj' [Energy Industry Changes II: Crazy Winds Coming], *Magyar Narancs*, No. 2006/15, 13 April, available at https://magyarnarancs.hu/belpol/energiaipari_valtozasok_ii_-_bolond_szel_fuj-65386 (27 November 2018).

Szalai, Sándor, Iván Gács, Károly Tar and Péter Tóth (2010) 'A szélenergia helyzete Magyarországon' [Status of Wind Energy in Hungary], *Magyar Tudomány* 171(8): 847–958.

Székffy, Klára (2014) 'Az európai villamosenergia-piac átalakulása a megújuló energiaforrások térnyerésének hatására' [Transformation of the European Electricity Market Due to Renewable Energy Expansion], *Közgazdasági Szemle* 61(6): 719–745.

Szeredi, István, László Alföldi, Gyula Csom and Csaba Mészáros (2010) 'A vízenergia-hasznosítás szerepe, helyzete, hatásai' [Role, Status and Impacts of Hydropower Utilization], *Magyar Tudomány* 171(8): 959–978.

Szilágyi, Zsombor (2013) 'Robbanáspont. Az állami beavatkozás hatásai a földgázpiacon' [Flashpoint: Effects of State Intervention on the Natural Gas Market], *Mérnök Újság* 20(2): 34–35.

Szilágyi, Zsombor (2014) 'Változások a földgázpiacon' [Changes in the Natural Gas Market], *Magyar Épületgépészet* 63(9): 25–27.

Tóth, László and Norbert Schrempf (2013) 'Szélerőművek szerepe „A megújuló energia hasznosítása" Nemzeti Cselekvési Tervben' [The Role of Wind Power Plants in the Renewable Energy Utilisation Action Plan], *Mezőgazdasági Technika*, August, available at http://technika.gmgi.hu/uploads/termek_341/szeleromuvek_szerepe_a_nemzeti_cselekvesi_tervben_13_08.pdf (27 November 2018).

Tóth, Péter, Miklós Bulla and Géza Nagy (2011) *Energetika* [Energy], available at https://www.tankonyvtar.hu/en/tartalom/tamop425/0021_Energetika/ch04s03.html (25 November 2018).

Union of Concerned Scientists (n.d.) 'Environmental Impacts of Solar Power', available at https://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/environmental-impacts-solar-power.html (22 November 2018).

Viland, Gabriella (2018) 'Az atomenergia-termelés összhangban van az uniós klímapolitikával' [Nuclear Power Production in Line with EU Climate Policy], *Magyar Hírlap*, 31 July, available at http://magyarhirlap.hu/cikk/124638/Az_atomenergiatermeles_osszhangban_van_az_unios_klimapolitikaval (20 November 2018).

Weiner, Csaba (2016) 'Central and East European Diversification under New Gas Market Conditions', Budapest: Institute of World Economics, MTA KRTK, *IWE Working Papers*, No. 221, available at http://real.mtak.hu/33784/ (10 December 2016).

Weiner, Csaba (2017a) 'Energy Once Again in the Spotlight: New Forms of Russian Investment Presence in Hungary', in Lyubov N. Shishelina, ed. *Rossiya i Tsentralnaya Yevropa v novykh geopoliticheskikh realnostyakh: Sbornik statey uchastnikov XI mezhdunarodnoy nauchnoy konferentsii, Moskva, 1–2 dekabrya 2016 goda* [Russia and Central Europe in the New Geopolitical Realities: Proceedings of the XI International Scientific Conference], 194–214, Moscow: Institute of Europe RAS, available at http://real.mtak.hu/80442/7/195_PDFsam_Rossiya_i_Tsentralnaya_Evropa__2018.pdf (27 November 2018).

Weiner, Csaba (2017b) 'Managing Energy Supply Security and Gas Diversification in Hungary: Putting Theory into Practice', Budapest: Institute of World Economics, MTA KRTK, *IWE Working Papers*, No. 238, available at http://real.mtak.hu/73435/ (31 January 2018).

Widera, Marek, Zbigniew Kasztelewicz and Miranda Ptak (2016) 'Lignite Mining and Electricity Generation in Poland: The Current State and Future Prospects', *Energy Policy* 92: 151–157.