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Hungary's Hydrogen Strategy

Ambition for Innovation within Political Confines

John Szabo

Part of a series edited by Yana Zabanova and Rainer Quitzow

Summary

Hydrogen is a much-discussed facet of Hungary's energy transition that has seen little progress, but offers an important tool to extend the government's foreign and energy policy. Policy-making in Hungary is highly centralised and government ambitions have prioritised the continued role of nuclear power, natural gas, and a solar PV boom. These closely trace foreign policy priorities as well, given that the former two entrench relations with Russia, while the latter enhances self-reliance while allowing the country to meet EU renewable energy targets. A hydrogen economy supports such ambitions, while the government has also welcomed EU funds and foreign investment into novel (green) technologies that increase the value added in the economy. Domestic demand offers a secondary, but nonetheless important, push for the uptake of hydrogen in industry and transportation. Hungary's case shows how pre-existing political economic confines shape the uptake of hydrogen, as governments and other key actors take action while disrupting pre-existing practices to the least extent possible.

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1. Introduction

Hungary has been a frontrunner in articulating hydrogen ambitions. The government and a number of companies were quick to jump on the “hydrogen train”, with the former taking the lead by publishing the National Hydrogen Strategy (henceforth, simply Strategy) in May 2021 (Government of Hungary, 2021). This followed the European Commission’s (2020) ‘A hydrogen strategy for a climate-neutral Europe’ and other strategies relatively quickly (World Energy Council, 2021), which may be surprising given the size of Hungary’s hydrogen market and the relatively moderate climate and renewable ambitions. This paper explores the roots of Hungary’s interest in hydrogen and pieces together the role international forces play in shaping this energy carrier’s and related technology’s role in the country’s energy system and, more broadly, the economy.

The paper suggests that hydrogen’s uptake largely responds to external forces and how a relatively small economy takes decisions within pre-existing confines. It shows how the European Union’s (EU) climate goals alongside the funds made available for the development and diffusion of new technologies is a powerful force from Western Europe and EU institutions with political, economic, and technological implications. Meanwhile, energy relations with Russia lend further support to hydrogen. At the intersection of these forces is a country that deeply relies on natural gas and nuclear power with little appetite to change its energy system and break its ties with Russia; albeit, in parallel, it has welcomed energy-hungry multinational corporations and sought to capture any support from the EU that could increase the added value of domestic economic activity. This paper explores the autonomy and structural constraints of small countries and how they may approach the unfolding energy transition.

Following this introduction, section two discusses demand- and supply-side drivers, actors, research and innovation, as well as hydrogen’s link to the automotive sector. Section three then moves on to explore the international facet of hydrogen affairs by assessing strategy and the interlinkages between domestic and international policy. The final, fourth section, draws conclusions.

2. Domestic drivers: enchantment with nuclear, natural gas, and solar PV

2.1 National strategies and their demand-side drivers

Hungarian government policy first engaged with hydrogen in the early 2010s which then took on renewed momentum in the early 2020s, but tangible results have been slow to follow. The Ministry for National Development’s (2012) ‘Energy Strategy 2030’ already discussed hydrogen’s potential role in the transportation sector and as a form of energy storage in the early 2010s. Ambitions did not materialise, as initial enthusiasm toward hydrogen fizzled out in Europe and the USA with the decline in oil and natural gas prices (Szabo, 2020). Hungarian interest towards hydrogen rekindled with rising climate ambitions and the general discussion on the matter throughout the EU following the publication of the ‘Clean Energy for All Europeans’ (European Commission, 2016). As EU-level decarbonisation became a top-priority and experts pointed out the limitations to electrification (Eurelectric, 2018), policy-makers in Hungary began to explore the potential of hydrogen, yet again. Support for the energy carrier was foreshadowed in the 2019 National Energy Climate and Energy Plan (NECP) (Government of Hungary, 2019a), which projected that Hungary may consume as much as 51 ktoe of hydrogen by 2030.

The NECP indicates that Hungary’s energy system will rely on hydrogen to decarbonise transportation and natural gas consumption, store energy, as well as balance the electricity grid. Albeit, the Plan does not indicate specific volumes. Enthusiasm towards hydrogen emerged in a setting where Hungary’s single aging coal plant was bound to be retired and decarbonisation policy would have to tackle transportation as well as natural gas consumption in the industrial and household sectors. What is more, there was a Europe-wide “hype” around hydrogen backed by policy-makers and natural gas interests, since the former saw it as a “silver bullet” in the transition while the latter as a tool for the survival of their industry (Szabo, 2020). The Government of Hungary (2021) was relatively quick to publish its ‘National Hydrogen Strategy’, in which it refined its ambitions included in the NECP and ideas for hydrogen’s applications became more circumspect. It still discusses hydrogen as the “Swiss army knife” of the energy transition, but it shifted emphasis to meeting demand in the industrial sector alongside transportation and balancing the electricity grid.

Hydrogen already plays an important role in Hungary’s industrial sector. The country consumed 160,000 tonnes of hydrogen in 2020, which was driven by fertiliser production (115,000 t), oil refining (25,000 t), and the chemical industry (20,000 t). These industrial actors currently consume emitting methane-based hydrogen at the fertiliser plant in Pétfürdő, the Danube Refinery in Százhalombatta, and the chemical plant in Kazinbarcika. The Strategy proposes that this demand should be met via a combination of low-carbon hydrogen[1], carbon-free[2], or green hydrogen[3] by forming two “hydrogen valleys”: a “Northeast hydrogen valley” and the “Transdanubia hydrogen ecosystem”. The former is based on existing heavy-, petrochemical-, and chemical industry, while the latter builds on existing

[1] Low-carbon hydrogen in this case is understood as blue (natural gas-based and paired with carbon capture and storage) or turquoise (natural gas-based using pyrolysis) hydrogen.

[2] Carbon-free hydrogen refers to pink hydrogen (nuclear-based).

[3] Green hydrogen refers to renewable-based hydrogen.

demand (fertiliser production and oil refining) as well as potential demand from an iron mill (Dunaújváros) and cement production facilities (Beremend and Királyegyháza). These sources of demand could be paired with the Paks nuclear power station and additional green electricity providing input for electrolysis, underpinning the formation of a complete ecosystem.

Table 1: Hungary's 2030 hydrogen plans

Category	*Production*	*Demand*		
		Industrial Demand	*Transport*	*Balancing the electricity grid*
Low-carbon H_2	20k tonnes	20k tonnes		
Carbon-free and renewable H_2	16k tonnes	4k tonnes	10k tonnes	
Additional infrastructural plans	240 MW electrolysis capacity		20 charging stations / 40 charging points 4,800 fuel cell vehicles	60 MW balancing capacity 2% blending (where reasonable)

Source: Government of Hungary, 2021

The Strategy indicates that only a portion of future hydrogen demand will be met via renewable, carbon-free, or low-carbon hydrogen by 2030 (see table 1). It proposes that 24,000 tonnes of green, low-carbon, or carbon-free hydrogen per annum will substitute emitting (grey) hydrogen in the industrial sector. Moreover, the transportation sector’s demand will reach 10,000 t by 2030, which will grow to 65,000 t by 2040 and 212,000 t by 2050. Heavy-duty transportation is the driver of the latter’s growth as the diesel engines of trucks, buses, and garbage trucks are phased out. The Strategy envisions a need for twenty charging stations by 2030, which would optimally be distributed along highways near larger cities (Szabó et al., 2022). The Strategy also envisions that hydrogen be blended into the natural gas grid to decarbonise natural gas, which plays an important role in meeting household and commercial energy needs – 73% of households used natural gas directly throughout the country (KSH, 2019). It also presents hydrogen as a tool that could support balancing the grid by helping meet peak electricity demand and store energy when necessary. Thus, future consumption has four pillars: (1) industry, (2) transportation, (3) balancing the electricity grid, and (4) decarbonising gas consumption by blending. That is, most demand originates from the decarbonisation of natural gas (heating, industry, electricity generation) and petroleum products (transportation).

A force that is set to alter the Strategy is the government’s recent pivot to support battery manufacturing. Industrial policy has shifted to welcome the development of battery-related megaprojects undertaken by a host of multinational companies, including South Korean Samsung or Chinese CATL. Battery production is a tremendously energy-intensive activity and current estimates suggest that projects in the pipeline will increase domestic electricity demand by 3.5 TWh, which equates to approximately 8%–9% of 2021 total demand (Bucsky, 2023). Government policy has sought to facilitate this expansion and state-owned energy enterprises will invest in capacities to substantially increase electricity generation. Measures that can help dampen the mismatch between supply and demand include three natural gas combined cycle gas turbines with a total installed capacity of 1650 MW. These can both help meet peak demand and the baseload demand of battery manufacturing facilities from the mid-2020s onwards. They are also planned to be hydrogen-ready, further increasing hydrogen’s potential role.

2.2 Supply-side drivers

Hydrogen's uptake is also supported by supply-side factors, given the infrastructure disposition and energy politics of Hungary. The country's long-term hydrogen ambitions emphasise a gradual shift to green hydrogen, while relying on low-carbon and carbon-free hydrogen in the interim. Green ambitions are premised on the continued boom of solar photovoltaics. The installed capacity of solar PV rapidly rose over the course of the past 6–7 years, from effectively nil to nearly 4 GW by December 2022 (MAVIR, 2022). This is especially substantial when considering the size of the electricity market, where peak demand highs were just over 7 GW in 2022 (MAVIR, 2023). The solar boom led a lopsided development, as government policy effectively banned the construction of wind installations that would have been able to balance some of solar PV's intermittency. Meanwhile, the grid has become saturated and pilot projects that connect batteries to the grid are only being introduced by the regulator. The intermittency stemming from solar output and limitations for the grid to absorb generation underpins the case for project developers to explore hydrogen production, but the economic case is not there just yet according to developers.

The Paks nuclear power station is a further driver of zero-carbon hydrogen. The four reactors that began operations in the 1980s have a total installed capacity of 2 GW and provide approximately half of Hungary's domestically generated electricity. They will remain operational into the 2030s and, in parallel, the government began to explore the option to build a nuclear power station – Paks 2 – that would substitute the existing one. Initial plans indicated that the two power stations' operations would overlap, leading a number of experts to propose that surplus electricity be used to produce hydrogen. Delays in the construction of Paks 2 make overlapping operations increasingly unlikely, but nuclear is still framed as a mainstay in Hungarian energy affairs and there is still a push from the government and private actors' interest to construct an electrolyser that would harness abundant baseload electricity from the plant to produce hydrogen (Balogh, 2021). This introduces a feedback loop whereby nuclear-based electricity underpins a case for hydrogen and interest in hydrogen underpins the case for nuclear generation.

The third supply-side driver for hydrogen is the extensive role natural gas plays in Hungary's energy system. Hungary has an extensive gas grid, large natural gas storage facilities, and natural gas infrastructure developed by end-users to meet energy needs (e.g., household heating or industrial demand). This enables the uptake of low-carbon hydrogen in a number of ways. The gas grid could be converted to support the blending of hydrogen which can either be domestically produced or imported. If domestically produced, Hungary can continue to import natural gas, which it can convert into hydrogen via steam methane reforming paired with CCS. Hungary's geological potential for CCS is held to be good, but projects have not yet been implemented (CCS4CEE, 2023). MOL – a regionally important oil and gas company – has experience with CO_2 injection for enhanced oil recovery (EOR), and Hungarian stakeholders have participated in three large EU projects on CCS (EU GeoCapacity, CGS Europe, and CASTOR). Despite limited experience, stakeholder involvement in projects alongside common discourse and objectives in the Strategy indicate that there is an interest to produce blue hydrogen and utilise the stakeholders' experience with natural gas.

2.3 Public and private stakeholders

Decision-making in Hungary's energy system is centralised in the hands of the government and the largest stakeholders align their decisions with state-objectives (Szabo, Weiner & Deák, 2020). The government follows a top-down approach to decision-making, whereby political directions are set at the highest levels of government – generally by Prime Minister Viktor Orbán – which then provide the basis for the policy ministries develop. Ministries play a role in identifying newly emerging issues and objectives that can be translated into policy, if these align with high politics. High politics' approach to hydrogen largely derives from foreign and energy policy – the two are closely linked – and a bid to boost innovation in the domestic economy. The government's foreign policy orientation includes maintaining close ties with Russia based on energy trade (e.g., natural gas and nuclear technology) and a general interest to explore whether emergent technologies can help increase the added value and technological sophistication of the country, especially if that links to the automotive sector or manufacturing sectors and is financed by external actors (e.g. the EU).

Hydrogen's recent emergence on the EU level coincided with the centralisation of most energy as well as innovation and development-related topics in the Ministry of Innovation and Technology between 2018–2022. This ministry explored hydrogen's role in the context of a generally ambitious research and development agenda and it was also able to include it into energy planning – the NECP and the National Hydrogen Strategy offer a testament to this. Following the 2022 elections and with the emergence a global energy crisis, the government dissolved this Ministry and created a stand-alone Ministry of Energy, while moving roles pertinent to a hydrogen ecosystem to the Ministry for Culture and Innovation, the Ministry for Construction and Transport, as well as the Ministry for Economic Development. Hydrogen-related issues that rely on energy, innovation, education, infrastructure, transport, economic, and development policy are now splintered between these ministries, ultimately, slowing the adoption of the technology.

Supply-side actors involved with hydrogen affairs tend to be linked to one of two energy champions: the Hungarian Public Utility (Magyar Villamos Művek i.e. MVM) or MOL. MVM is an entirely state-owned public utility holding that has a broad portfolio ranging from power generation to natural gas storage. Hungarian Gas Storage (Magyar Földgáztároló i.e. MFGT) is the MVM subsidiary responsible for the latter and plays a key role in exploring hydrogen storage at scale. Its strategy is typically subjugated or closely guided by government policy, including natural gas storage level targets or exploring hydrogen storage to enhance the energy security of the country in the future. MOL is a publicly traded company and therefore enjoys somewhat more autonomy. However, shareholders include state-aligned foundations that were directly owned by the state until relatively recently and personal ties have underpinned a close working relation between the government and the company. Both companies are key players in the hydrogen ecosystem that respond to European trends but take action in close coordination with the state.

MOL, Nitrogénművek, and Wanhua–BorsodChem consume the overwhelming majority of hydrogen making them key players in shaping the domestic market. They have also all begun to explore options for low-carbon hydrogen. Nitrogénművek is a privately owned company that is the largest domestic producer of various fertilisers, for which it produces substantial amounts of hydrogen-intensive Calcium Ammonium Nitrate (CAN). Its owner is among the wealthiest individuals in Hungary, but one that falls outside of PM Orbán-aligned businesspersons and he has conflicted with the government on numerous occasions. Its leadership's involvement in policy is inhibited by personal relations, but it has to be taken into account thoroughly given that it is the largest consumer of hydrogen. Wanhua–BorsodChem is a producer of isocyanates, PVC, and other vinyl products. It is owned by a Chinese holding company and fortifies China-Hungary business and political ties, but its impact on policy is limited to the government considering that they will need to cooperate in the future to meet hydrogen demand. MOL tends to coordinate with the government, but it being an international oil company has engaged in piloting green hydrogen alone. All three of these companies began to explore non-emitting hydrogen, but have done so largely independently; albeit, while coordinating with the government on strategy.

Hydrogen associations, discussion platforms, and organisations have been active in supporting the diffusion of hydrogen. However, their role in policy is muted, as foreign and energy policy alongside investment tends to drive policy in Hungary. Nonetheless, the Hungarian Hydrogen and Fuel Cell Association has been active since 2011, while the Hungarian Hydrogen Technology Association was established in 2020 and became a member of Hydrogen Europe and Global Hydrogen Industrial Association Alliances. Through Hydrogen Europe, Hungary's hydrogen industry is also represented at UNIDO's International Hydrogen Energy Centre. The country is a member of the International Energy Agency (IEA), but is only represented in the IEA's Hydrogen Technology Collaboration Programme through the European Commission. Finally, the second Budapest Hydrogen Summit was organised in

2023, with high-level participants from the public and private sector indicating the general interest towards the matter. These offer important platforms for discussion that can then be incorporated into policy, but their impact is limited in comparison to the effect high politics has on decisions.

2.4 Research and innovation on hydrogen

Hungarian stakeholders launched a number of innovative projects that support the development of hydrogen. A grand undertaking and one deemed strategically important by the state is MFGT's endeavour to explore large-scale hydrogen storage. The company's preliminary study found that "[h]ydrogen is a long-term solution and a pathfinder for the decarbonisation objective" (MFGT, 2019, p. 64) leading the company to develop the 'Aquamarine' pilot project. This explores how it can store the hydrogen produced from a 2.5 MW electrolysis system in the underground storage facility at Kardoskút – a 280 Mm3 natural gas storage site. The project is financed by the Ministry of Innovation and Technology, the National Research, Development and Innovation Office, and MFGT. The company recently completed on-site construction in March 2023 and began to run test operations prior to the pilot. Tests have potentially regional implications, since Hungary's gas storage capacities are substantial in a regional context and especially when compared to demand. In principle, it could offer sites for storing hydrogen, as it does for natural gas, if this becomes technologically feasible. And, with this, it can play a regionally strategic role by storing hydrogen.

FGSZ – the natural gas transmission system operator (TSO) and a subsidiary of MOL – is exploring the transit of hydrogen in its pipeline infrastructure system. It joined the European Hydrogen Backbone (EHB) initiative, a cooperation among 32 energy infrastructure operators, most of which are natural gas grid operators. FGSZ (2022) indicated in its 2022 ten-year development plan that it plans to facilitate the uptake of hydrogen by adapting pipelines and compressor stations during the 2026–2032 period. Hungary's location at the intersection of a number of natural gas markets entails that plans to develop hydrogen compatible and dedicated hydrogen infrastructure are at the top of the company's agenda, as FGSZ can position itself as an important hydrogen transit country in the future.

Large-scale demand-side developments are also on the way in the Hungarian hydrogen sector. Nitrogénművek has teamed up with the European Bank for Reconstruction and Development (EBRD) to explore emission reduction opportunities (Nitrogénművek, 2023). The project aims to enhance energy efficiency at Nitrogénművek's Pétfürdő fertiliser plant and use a renewable energy-powered electrolyser to produce ammonia. Meanwhile, MOL announced in 2022 that it will invest €22 million to develop a 10 MW electrolyser in Százhalombatta near the Danube Refinery (MOL, 2022). This will produce 1,600 t of green hydrogen per annum, but this is only a fraction of the company's demand. The electrolyser is not directly paired with the development of a renewable energy plant, but will connect to the grid and the company will procure green electricity by purchasing green certificates. This practice is questionable in that it draws green electricity from a not fully renewable mix, prioritising hydrogen production over consuming the green electricity where possible. Nitrogénművek's and MOL's endeavours signal interest and some action to green their activities, but remains a marginal fraction of their overall portfolio.

Basic research has also been ongoing on hydrogen in Hungary. A consortium of nine university and research institutes won a €17 million project to establish a 'National Laboratory for Renewable Energies', which will prioritise hydrogen technologies and carbon capture and utilisation (CCU) (ELKH TTK, 2023). The endeavour is financed by government and EU funds, and also seeks to support future international research collaborations and applications for funding (e.g. Horizon). Further resources for research, development, and innovation will be made available through GINOP+, IKOP+, KEHOP+, Modernisation Fund, and national budget programmes in the forthcoming years. These continue to heavily draw on EU funds with a general focus on developing the domestic hydrogen scene (Kaderják, 2022).

Domestic actors were involved with their European counterparts in developing a number of so-called Important Projects of Common European Interest (IPCEI) (Government of Hungary, 2021). Projects include: Blue Danube @ Green Hydrogen, Black Horse, and Silver Frog. Blue Danube @ Green Hydrogen is a cooperation between Austria, Germany, Romania, Netherlands, EU and targets the production of large-scale green hydrogen in Southeastern Europe and its subsequent transport to industrial actors along the Danube river (Verbund, 2020). Black Horse tackles the diffusion of hydrogen-fuelled heavy-duty transport and the development of requisite fuelling infrastructure through a cooperation between Visegrád countries (REKK, 2021). Finally, Silver Frog aims to develop a 2 GW per annum solar module factory, which will help the deployment of 10 GW of solar PV capacity to produce green hydrogen. The consortium is composed of Hungarian heterojunction PV module manufacturer Ecosolifer, Swiss mechanical engineering company Meyer Burger, the Belgian-based unit of Canadian hydrogen business Hydrogenics, and Danish renewables developer European Energy (Enkhardt, 2019). Hungarian companies and research entities are thus involved in international research throughout the entire supply-chain, but results of these projects are yet to materialise.

2.5 Hydrogen fuel cells and the transportation sector

The automotive sector has a long-standing tradition in Hungary. The country was an important producer of especially heavy-duty vehicles and buses during the communist era, which, paired with low wages, offered an attractive location for original equipment manufacturers primarily from Western Europe to establish operations. Audi, Mercedes Benz, Stellantis, Suzuki have major production capacities in the country and BMW is constructing a plant as well. In addition, Credobus, ITE Bus & Truck, BYD, Volvo, and Ikarus manufacture buses and other heavy-duty vehicles. Electrification is at the top of the agenda for most companies active in Hungary, but some have suggested that they will produce vehicles propelled by hydrogen fuel cells as well. Passenger vehicle manufacturers Audi (h-tron), Mercedes Benz (GLC F-CELL), and BMW (iX5) piloted hydrogen cell-propelled vehicles, but there is no indication that these will be manufactured in Hungary. Bus producers also tend to focus on electrification, as Credobus was the only one with plans to launch the Econell 12 Next with fuel cells in 2023–2024 (Credobus, 2022). Meanwhile, a handful of hydrogen fuel cell propelled buses were added to the Budapest and Paks fleets (Zomborácz, 2022; e-cars, 2023). Thus, the technology has only begun to penetrate the transportation market and vehicle manufacturing in Hungary. The government – drawing on EU funds – has launched programmes to support the uptake of buses with alternative propulsion systems (HUMDA, 2023), including hydrogen, but domestic automotive manufacturing is largely shifting to the production of electric vehicles.

3. International approach

3.1 Strategic objectives and energy relations

Hungary's government strategy ties the country politically and economically to both the "West" and the "East". Its ties to the "West" were fast-tracked with the collapse of the Eastern bloc, which would set the country on a path to join the North Atlantic Treaty Organization (NATO) and the EU. Political integration was paired with deepening economic ties, as Western capital flowed into the country and into sectors such as the automotive or electronics industries. The second Orbán government took office in 2010 and shortly launched its "Eastern Opening", as a part of which it began to strengthen ties with Eastern powers. This included deepening energy-based relations with Russia and attracting investment from Far Eastern partners (e.g. China or South Korea) (Bernek, 2018). Subsequent Orbán governments have maneuvered between these two poles, seeking to become a bridge between the two while reaping the economic and political benefits of respective diplomacy.

Foreign relations in both directions are closely linked to the energy sector. Hungary has been reliant on energy imported from the Soviet Union since the middle of the 20th century, as demand far outpaced domestic energy produced from a limited hydrocarbon and lignite resource base. The government developed a reliance on Soviet imports, by first importing crude oil, then electricity, followed by natural gas, and, finally, nuclear technology (Szabo & Deák, 2020). The order of these and their availability was dictated by leaders in Moscow; thus, Hungary's energy mix was essentially externally imposed. The dissolution of the Soviet Union did not dissipate reliance on imports, as Hungary continues to import the overwhelming majority of its crude oil and natural gas from Russia in addition to having commissioned the Paks 2 nuclear power station by Russia's Rosatom. It integrated its natural gas and electricity grid into the European system upon joining the EU, but sustained most of its reliance on Russian resources. This was essential to politics that ensured low energy prices for domestic consumers, which was a key pillar of the government's domestic policy and a force that helped Fidesz secure electoral wins (Weiner & Szép, 2022; Szabo, Weiner & Deák, 2020).

The Hungarian government has indicated little propensity to substantially change the structure of its energy mix. If it does change, this tends to unfold along a politics-determined path where the state opts for the lowest cost option. Historically, the inexpensive resources offered by the Soviet Union drove change, while the EU now plays this role by mandating renewable energy targets and offering funding to support their diffusion. The 2019 NECP and the 'National Energy Strategy 2030, with an Outlook to 2040' (Government of Hungary, 2019b) offer a glimpse of future plans, emphasising the need to reduce natural gas and electricity imports. The government plans to tackle the former through energy efficiency measures while still leaving room for imports, while the latter is based on nuclear ambitions and the continuance of the solar PV boom. The direction of change – energy efficiency and renewables – draw on EU support, be that directly through EU funds (e.g., energy efficiency programmes) or by developing essential auxiliary technologies (e.g., the grid, electricity storage, etc.) that enable the renewable energy's expansion. With this, the government continues a balancing act whereby it leaves room for EU funds and Western investment into renewables, while maintaining close energy-based ties with Russia through cooperation on nuclear power as well as sustained natural gas and oil imports.

3.2 The link between international and domestic strategy

Government strategy that prioritises Russian nuclear power- and natural gas-based cooperation in addition to attracting EU funds for renewable-related innovation prefigure hydrogen ambitions. Simply put, there are two dominant geopolitical forces driving a hydrogen economy: Russia and the EU.

Natural gas trade with Russia enables low-carbon hydrogen and Rosatom's role in Paks 2 that of its nuclear-based variant. The EU plays a role in driving Hungary's transition to renewables and promoting innovation in the energy sector, which increasingly includes support for green hydrogen as well. The government transposes these external drivers – international relations and funding – into domestic policy, which is met by demand from a handful of industrial actors, alongside prospective consumption from by transportation, heating, and electricity generation.

A fixture in Hungarian energy affairs is nuclear power. The government and key stakeholders have discussed this as a source of electricity for zero-carbon hydrogen production. The Paks power station is of Soviet design, tying Hungary to Russia with the latter providing fuel rods and storing nuclear waste. The sanction imposed by Western powers due to Russia's war in Ukraine have not yet targeted nuclear power but have discussed such measures, and the government is exploring alternative fuel rod supplies. Westinghouse may offer a compatible solution, which may be essential in the long-term as the government announced that it will explore whether the reactor's operational lifetime can be extended into the 2040s. In parallel, MVM and Rosatom signed an agreement under the auspices of their respective governments, renewing the two countries' nuclear-based cooperation by pursuing the project.

Initial nuclear plans suggested that the operations of the Paks and Paks 2 projects would overlap. Delays have forced the latter's planned completion into the late 2020s or early 2030s. The government continues to argue that the operation of these projects will overlap – even if this seems increasingly unlikely – and the surplus electricity it generates can either be exported or used to run an electrolyser. This underpins the economic rationale of the project and allows for Hungary to develop hydrogen production capacities that can be based on Paks 2 generation and renewable electricity once MVM retires Paks. Thus, the supply-side of the Transdanubia Hydrogen Ecosystem would be solved. However, many raised concerns over the need for a new nuclear power station (Sáfián, 2015) and the opacity of the contract (Erdélyi, 2021). Moreover, the war in Ukraine and related sanctions undermine the viability of Paks 2 as key suppliers, such as Siemens or General Electric, are forced to reconsider their involvement (Szabó, 2023). Moreover, there is substantial political pressure from EU institutions to consider imposing sanctions on Russian nuclear projects, obstructing the completion of Paks 2. Despite risks of completion and potential further delays, government support has not wavered as the project is a prominent component of Hungary-Russia cooperation and neither party is willing to outright abandon it.

The other mainstay of Hungarian energy affairs is the government's reluctance to shift away from Russian natural gas. Hungary – like most countries in the region – diversified natural gas import routes since joining the EU and especially following the shock of the 2009 supply crisis. However, it continues to largely rely on Russian supplies, irrespective of the war in Ukraine. It has largely done so, because this was the cheapest source of energy with which the Orbán-led governments could pursue their "utility price reduction" programmes to secure electoral victories and maintain close ties with Russia. It re-committed to Russian natural gas when inking a fifteen-year contract in September 2021 (euronews, 2021), which it expanded – against EU ambitions to move away from Russian resource reliance amidst the war – in 2023 (VG, 2023). The Kremlin may have halted most supplies to Europe, but the Orbán government discusses Russian natural gas as a pillar of energy security, which it presumes will sustain given the stability of imports through the Balkan Stream pipeline. Strategic cooperation based on this energy carrier's trade has not wavered nor is there indication that the government plans to substantially reduce the country's dependence through 2035 and low-carbon hydrogen extends demand further into the future.

The other leg of hydrogen developments is the green transition led by the EU and a number of Western member states. The recent solar PV boom in Hungary emerged as a combination of EU climate and energy policy, market forces, as well as domestic drivers. The EU's climate objectives and renewable energy targets provided support through incentives, such as those allocated from EU cohesion policy or income from selling carbon quotas. These also stimulated government to take action, as a part of which it rolled out a generous feed-in tariff system until relatively recently and a net-metering that was simply accessible for household consumers, hence the solar PV boom. Alongside the diffusion of solar PV, new frontiers of green technologies paves the way for the state and a handful of enterprises to pursue “technological opportunism” (Chen & Lien, 2013). These overwhelmingly draw on EU funds which underpins further decarbonisation and enhances the competitiveness of domestic firms, while also allocating substantial wealth to national entities. However, these have not yet materialised in the field of hydrogen as most projects are still in their infancy.

A key vehicle in Hungary’s green transition plans is based on the EU’s Recovery and Resilience Facility (RRF). This provides the country with just over €7 billion in grants and nearly €10 billion in loans. The plan for grants was approved and its energy chapter generally focuses on electricity. Meanwhile, loans have not been officially approved, but proposals overwhelmingly target energy sector investments, including CCS projects, the construction of electrolysers, industrial application of hydrogen, and purchasing hydrogen-propelled buses and other large vehicles (Brückner, 2023). Note that the details are unclear as the official request was not made public at the time of writing. Nonetheless, hydrogen sections are set to feature prominently in the RRF Plan of Hungary in response to the general promise of the technology and the availability of grants for the cause.

4. Conclusion

Hungary's approach to hydrogen reflects its general engagement with new green technologies: it conveys enthusiasm and seeks to attract as much foreign funding as possible, but it adapts its actions to pre-existing political confines. At the policy-level hydrogen has been oft-discussed and included into various planning documents, but action is yet to materialise. Only the largest industrial consumers and natural gas infrastructure actors have begun to explore the role hydrogen can play. MOL's refinery, Nitrogénművek's fertiliser plant, the pipeline system operated by FGSZ, and the natural gas storage facility operator MFGT are experimenting how a transition to hydrogen may take shape. There is some pressure to explore these alternatives due to Hungary's deep reliance on natural gas and the extensive grid that can become an asset in a low-carbon setting. Action is usually limited to areas where foreign grants and financing is available, with actors involved typically large consumers that need to convey a convincing plan on how they will sustain their businesses. Thus, hydrogen endeavours tend to reflect corporations seeking to convince investors and clients that they are preparing for a low-carbon future, while state-led action has been largely limited to planning.

The supply-side of the hydrogen story tends to be more important in the government's hydrogen ambitions. Producing the energy carrier aligns closely with its energy politics. Natural gas and nuclear power are bedrocks of the government's energy plans, and with these leaders sustain the country's close relation to Russia. Pivoting away is a non-option, as it is deemed costly and the government claims that Russian energy offers stable and inexpensive resources that allows for the government to maintain its low utility price policy. Low-carbon hydrogen can continue the country's dependence on overwhelmingly Russian natural gas and offer a relatively low cost, low CO_2 emission energy resource in difficult to decarbonise sectors. In similar vein, nuclear-based hydrogen lends rationale to pursuing the Paks 2 project, which is a strategic project for both parties that neither wants to forfeit due to the high economic and political costs. Hydrogen sustains nuclear ambitions, and nuclear ambitions underpin hydrogen, offering a loop that favours the country's pro-Russia foreign policy. Diplomacy is thus important in Hungary's hydrogen affairs, but it tends to be indirect as the basis of discussion are the energy carriers that underpin the current energy system and hydrogen is a hypothetical discussed to extend their role into the future.

There is also ample room for green hydrogen in Hungary's energy system, especially given the prospects EU funds offer. Hydrogen can dampen the lopsided focus on a solar boom since 2016 that has left experts in the energy sector scurrying to solve the issue of storage and grid-related bottlenecks. It can help store surplus electricity generated by renewables, while depleted hydrocarbon fields could play a role in storing renewable hydrogen. All in all, Hungary's hydrogen ambitions – covering production, storage, CCS, etc. – allow for the state to continue manoeuvring between the Western Europe/European institutions and Russia, by maintaining ties with the latter through nuclear and natural gas while meeting EU goals, attracting funds and investment, and facilitating hydrogen-related cooperation with Western counterparts.

5. Literature

Balogh, Ádám (2021). Atomerőmű-kapacitások és a karbonsemleges hidrogénelőállítás lehetőségei Magyarországon – Green Policy Center, 28 April 2021, available at: https://www.greenpolicycenter.com/2021/04/28/atomeromu-kapacitasok-es-a-karbon-semleges-hidrogeneloallitas-lehetosegei-magyarorszagon/.

Bernek, Á. (2014). Hazánk keleti nyitás politikája és a 21. századi geopolitikai stratégiák összefüggései. Külügyi Szemle, 17(2), pp. 122–144. Available at: https://kki.hu/assets/upload/06_Bernek_Agnes.pdf.

BMWI (2020). The National Hydrogen Strategy. Available at: https://www.bmwk.de/Redaktion/EN/Publikationen/Energie/the-national-hydrogen-strategy.pdf?__blob=publicationFile&v=6.

Brückner, Gergely (2023). Lantos Csaba és Navracsics Tibor soha nem látott, közel 6000 milliárd forintos energiatervet készít. – Telex, 06 February 2023, available at: https://telex.hu/gazdasag/2023/02/06/lantos-csaba-es-navracsics-tibor-soha-nem-latott-kozel-6000-milliard-forintos-energiatervet-keszit.

Bucsky, Péter (2023). A Magyar cégek is megfizetik az új akkumulátorgyárak árát – G7, 15 May 2023, available at: https://g7.hu/vallalat/20230515/a-magyar-cegek-is-megfizetik-az-uj-akkumulatorgyarak-arat/.

Chen, C.-W., Lien, N.-H. (2013). Technological opportunism and firm performance: Moderating contexts. Journal of Business Research, 66(11), pp. 2218–2225. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0148296312000331.

Credobus (2022). Megérkezett az econell 12 next. Available at: https://credobus.hu/media/2022/08/31/megerkezett-az-econell-12-next/.

e-cars (2023). Hidrogén-üzemanyagcellás busz közlekedik Pakson – e-cars, 18 January 2023, available at: https://e-cars.hu/2023/01/18/hidrogen-uzemanyagcellas-busz-kozlekedik-pakson/.

ELKH TTK (2023). Nemzeti Laborok. Available at: http://www.ttk.hu/nemzeti-laborok/mel.

Enkhardt, Sandra (2019). Operation Silver Frog: Innovative 2 GW solar production plan for green hydrogen in Europe – pv magazine, 11 October 2019, available at: https://www.pv-magazine.com/2019/10/11/operation-silver-frog-innovative-2-gw-solar-production-plan-for-green-hydrogen-in-europe/.

Erdélyi, Katalin (2021). Az Alkotmánybíróság szerint rendben van, hogy a kormány 30 évre titkosította a Paks2-projektet – Átlátszó, 25 January 2021, available at: https://atlatszo.hu/kozugy/2021/01/25/az-alkotmanybirosag-szerint-rendben-van-hogy-a-kormany-30-evre-titkositotta-a-paks2-projektet/.

Eurelectric (2018). Decarbonisation Pathways. Available at: https://cdn.eurelectric.org/media/3457/decarbonisation-pathways-h-5A25D8D1.pdf.

Euronews (2021). 15 évre kötött gázvásárlási szerződést a Gazprommal Magyarország – euronews, 27 September 2021, available at: https://hu.euronews.com/2021/09/27/15-evre-kotott-gazvasarlasi-szerzodest-a-gazprommal-magyarorszag.

European Commission (2016). Clean Energy for All Europeans. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1582103368596&uri=CELEX:52016DC0860.

European Commission (2020). A hydrogen strategy for a climate-neutral Europe. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0301.

FGSZ (2022). 10 Éves Fejlesztési Terv. Available at: https://fgsz.hu/file/documents/2/2308/2022_10_eves_fejlesztesi_terv.pdf.

Government of Hungary (2019a) National Energy and Climate Plan. Available at: https://energy.ec.europa.eu/system/files/2020-01/hu_final_necp_main_hu_0.pdf.

Government of Hungary (2019b). Nemzeti Energiastratégia 2030. Available at: https://www.enhat.mekh.hu/strategiak.

Government of Hungary (2021). Magyarország Nemzeti Hirdogénstratégiája. Available at: https://cdn.kormany.hu/uploads/document/6/61/61a/61aa5f835ccf3e726fb5795f766f3768f7f829c1.pdf.

HUMDA (2023). Zöld Busz Program. Available at: https://humda.hu/green/zold-busz-program.

Kaderják, P. (2022). Magyarország hidrogén stratégiája, különös tekintettel a távhőszektorra. Presentation at XXI. Távhőszolgáltatási Konferenciát és Szakmai Kiállítás in Eger, Hungary. Available at: https://tavho.org/uploads/rendezvenyeink/Konferencia%202022/Magyarorsz%C3%A1g%20hidrog%C3%A9n%20strat%C3%A9gi%C3%A1ja%2C%20k%C3%BCl%C3%B6n%C3%B6s%20tekintettel%20a%20t%C3%A1vh%C5%91szektorra%20-%20Dr.%20Kaderj%C3%A1k%20P%C3%A9ter.pdf.

KSH (2019). A települések infrastrukturális ellátottsága, 2019. Available at: https://www.ksh.hu/docs/hun/xftp/stattukor/telepinfra/2019/index.html.

MAVIR (2022). PV Statisztika. Available at: https://www.mavir.hu/documents/10258/245542105/PV+STATISZTIKA_HU_20221201_ig_v1.pdf/27a7db3b-040a-c84b-4084-572cae3aaed5?t=1670837611498.

MAVIR (2023). Rendszerterhelés. Available at: https://www.mavir.hu/web/mavir/rendszerterheles.

MFGT (2019). Energy Storage Danube Region Study. Available at: https://mfgt.hu/-/media/MFGT/P2G/MFGT_EnergyStorageDanubeRegionStudy_2019.pdf?la=hu-HU.

Ministry for National Development (2012). National Energy Strategy. Available at: https://2010-2014.kormany.hu/download/7/d7/70000/Hungarian%20Energy%20Strategy%202030.pdf.

MOL (2022). Újabb Lépés az Energiafüggetlenség Felé: Zöld Hidrogén Gyártásába Kezd a Mol. Available at: https://molgroup.info/hu/media-kozpont/sajtokozlemenyek/ujabb-lepes-az-energiafuggetlenseg-fele-zold-hidrogen-gyartasaba-kezd-a-mol.

Nitrogénművek (2023). EBRD and Nitrogenmuvek To Start Study On Energy Improvement And Green-Ammonia Development In Hungary. Available at: https://www.nitrogen.hu/en/news/328-ebrd-and-nitrogenmuvek-to-start-study-on-energy-improvement-and-green-ammonia-development-in-hunagry.

REKK (2021). V4 Hydrogen Cooperation Opportunities. Available at: https://rekk.hu/downloads/events/V4_hydrogen_cooperation_opportunities.pdf

Sáfián, Fanni (2015). Paks Nélkül a Világ – energiaklub, January 2015, available at: https://energiaklub.hu/files/study/paksii_nelkul_a_vilag_web.pdf.

Szabó, Á., Orosz, L., Borsi, Z., Telekesi, T., Főglein, K., Faragó, G., and Schváb, Z. (2022). Hidrogén Tüzelőanyagcellás Nehézgépjárművek Hidrogéntöltő Állomásainak Optimális Helymeghatározása – Külügyi Műhely, 2022(1). Available at: http://real.mtak.hu/143666/1/04_KulugyiMuhelySzaboAdam.pdf.

Szabó, Dániel (2023). Szankciós kereszttűzbe került Paks II. – portfolio, 10 February 2023, available at: https://www.portfolio.hu/gazdasag/20230210/szankcios-kereszttuzbe-kerult-paks-ii-595504.

Szabo, John, Weiner, Csaba, and Deák, András (2020). Energy Governance in Hungary. In Knodt, Michele and Kemmerzell, Jörg (eds.) Handbook of Energy Governance in Europe. Available at: https://link.springer.com/referenceworkentry/10.1007/978-3-319-73526-9_13-1.

Szabo, J. (2021). Fossil Capitalism's Lock-ins: The Natural Gas-Hydrogen Nexus. Capitalism Nature Socialism, 32(4). Available at: https://www.tandfonline.com/doi/full/10.1080/10455752.2020.1843186.

Verbund (2020). Green Hydrogen Blue Danube. Available at: https://www.verbund.com/en-de/about-verbund/news-press/press-releases/2020/11/17/greenhydrogenbluedanube

VG (2023). Szijjártó Péter Moszkvából üzeni: biztosítva van Magyarország földgáz- és kőolajellátása, megújult a paksi beruházásról szóló szerződés – Világgazdaság, 11 April 2023, available at: https://www.vg.hu/vilaggazdasag-magyar-gazdasag/2023/04/szijjarto-peter-moszkvaban-biztositott-magyarorszag-foldgaz-es-koolaj-ellatasa.

Weiner, Cs. and Szép, T. (2022). The Hungarian utility cost reduction programme: An impact assessment. Energy Strategy Reviews, 40. Available at: https://www.sciencedirect.com/science/article/pii/S2211467X22000177?via%3Dihub.

World Energy Council (2021). Working Paper: National Hydrogen Strategies. Available at: https://www.worldenergy.org/assets/downloads/Working_Paper_-_National_Hydrogen_Strategies_-_September_2021.pdf.

Zomborácz, Iván (2022). Ilyen a budapesti hidrogénes busz – Totalcar, 11 February 2022, available at: https://totalcar.hu/magazin/kozelet/2022/02/11/ilyen-a-budapesti-hidrogenes-busz/.

6. About the author

John Szabo is a Fellow at the Centre for Economic and Regional Studies as well as an Assistant Professor at Eötvös Loránd University, both of which are in Budapest. His interests focus on the society-environment nexus in energy affairs.

The **Research Institute for Sustainability (RIFS)** conducts research with the aim of investigating, identifying, and advancing development pathways for transformation processes towards sustainability in Germany and abroad. The institute was founded in 2009 as the Institute for Advanced Sustainability Studies (IASS) and has been affiliated with the Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences under its new name since 1 January 2023 and is thus part of the Helmholtz Association. Its research approach is transdisciplinary, transformative, and co-creative. The Institute cooperates with partners in science, political and administrative institutions, the business community, and civil society to develop solutions for sustainability challenges that enjoy broad public support. Its central research topics include the energy transition, climate change and socio-technical transformations, as well as sustainable governance and participation. A strong network of national and international partners and a Fellow Programme supports the work of the Institute.

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Contact:
John Szabo: szabo.john@krtk.hu

Address:
Berliner Strasse 130
14467 Potsdam
Tel: +49 (0) 331-28822-340
Fax: +49 (0) 331-28822-310
Email: media@rifs-potsdam.de
www.rifs-potsdam.de

ViSdP:
Prof. Dr Mark G. Lawrence,
Scientific Director, Speaker

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