HYDROGEN IN CENTRAL AND EASTERN EUROPE

Perspectives for development of hydrogen economy in Visegrad Group and Ukraine

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Perspectives for development of hydrogen economy in Visegrad Group and Ukraine

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EMPTY PROMISES OR FULL-FLEDGED PLANS?

Politicians from the Central and Eastern Europe region are increasingly signalling that the hydrogen economy will be an important element of the climate transformation. Therefore, this study is a review of the most important activities in this direction carried out by individual countries in the region.

> **Unfortunately, most of the declared intentions still remain at a very early stage: the first pilot projects are only now being launched and the foundations for hydrogen strategies are being established.**

Hydrogen as an element of the energy transformation has currently became a fashionable topic in the region of Central and Eastern Europe. Although most governments point to the importance of the hydrogen economy and many companies announce plans to include hydrogen in their business models, the initiatives of the region's countries so far indicate that still not all countries have adopted their own strategies in this area, not to mention that there are no major projects hydrogen installations.

However, it should be remembered that some of the hydrogen technologies still require refinement and the investments carry a high business risk. Therefore, there is no doubt that it is the EU funds that will provide the key impulse for the development of the hydrogen economy. This applies both to Ukraine, which, compared to the region, is distinguished by considerable determination of its hydrogen plans, and to the Visegrad Group countries (Czechia, Hungary, Poland, Slovakia)

When considering the regional opportunities for the hydrogen economy, it is worth noting that its development requires a comprehensive strategy that covers all sectors and levels of the economy. Also, it requires a well-developed regulatory system, stable public support and private financing focused on technologies matching local needs. The strategy must take into account the specificity of the energy and transport sectors of individual countries, because in this case there are no "one size fits all" solutions.

One of the strengths of the Visegrad Group countries and Ukraine are fairly robust academic centres, which provide an opportunity to research and develop new hydrogen technologies. On the other hand, however, the weakness of local financial markets, bureaucratic barriers for business and the lack of cooperation between business and academia will probably once again hinder the development of domestic technologies. Moreover, industrial hydrogen installations require very advanced technologies (high pressures, cryogenics) and overcoming the competitive advantage of Western and Asian competitors, e.g. in the field of fuel cells or high-power electrolysers, will be highly problematic.

> **The development of the hydrogen economy requires cooperation with foreign companies, especially in the field of fuel cells, high-power electrolysers or the production of hydrogen passenger cars.**

In the future, negotiations at the government level can be expected, when, in return for entering the market, foreign companies will be ready to invest in production plants in a given country. Politicians in some countries of the region have already signalled the need to cooperate with foreign suppliers.

At this stage, it can be concluded that many of the promises regarding the hydrogen economy have no backing in actual policies, effective regulation, support systems, or a large number of pilot projects. On the other hand, the development potential is significant, especially since the high dependence on fossil fuels requires large-scale energy transformation, which generates significant opportunities for the water sector. In the years to come, an intensification of activities and the first stage of the hydrogen economy development should be expected.

In our study, wherever possible, we focused on hydrogen produced from low-emission sources, because only this type is being treated seriously by decision-makers and business.

UKRAINE: HIGH AMBITIONS BURDENED BY POLITICAL WEIGHT

Ukraine seems to be the most interested in H2 economy in the entire region. The country is developing its RES capacity, while also considering employing the power of Zaporozhye nuclear plant for production of low-emission (purple) hydrogen, as well as testing its gas network for blending.

Ukraine seeks better cooperation with Germany, aiming to become the designated hydrogen supplier as envisioned by the European Commission's (COM) hydrogen strategy. The main barriers for Ukraine are its political instability and persistent conflict in Donbas, which discourage foreign investors.

Ukraine – a leader in hydrogen exports?

In the European Union's plans, the role of Ukraine as H2 supplier could be at least on par with the Northern African states. Good base for RES development, significant domestic deposits of natural gas and potential for CCS might allow Ukraine to fulfil these expectations. In addition, the country seeks new purpose for its existing nuclear reactors, which could be used to produce purple H2. For Ukraine, hydrogen is there-fore a tempting export resource, especially since Kiev can potentially take advantage of the existing gas export routes running through Czechia and Slovakia – these pipelines might be repurposed for transport H2.

As early as 2019 Ukraine has entered the talks with European Commission and German institutions regarding the possibilities of zero-emission H2. Plans have been put in place for a German-Ukrainian cooperation, with Ukrainian governmental advisers mentioning possible transfers of up to 600 mln EUR for Ukrainian hydrogen projects. Coordination with the EU is an important political project for Kiev, which sees in it an opportunity to modernise Ukrainian energy sector and pipeline network, as well as a chance to establish successful strategic partnership with Europe. By 2030, Ukrainians plan to install up to 10 GW for green H2 electrolysis. Supply via Transbalkan Pipeline to Galati in Romania could be among the first possible export projects.

Official Kiev develops pilot projects for 100-megawatt electrolysers as the basis for cooperation with EU (comparable to the ongoing Moroccan project)

Transmission – first blending tests in the region

In order to fulfil the COM's plans, Ukraine needs to ensure reliable logistics based on existing gas pipeline infrastructure, Governmental activities in this field are supported by Energy Association Ukrainian Hydrogen Council, which has provided analysis of blending operations and potential exports to the EU. Action plan for 2035 developed on the basis of its conclusions has been approved by COM, According to EAUHC analysis, a 10-20% blend of hydrogen could be safely transported to the EU, but to achieve this, public funding must be secured. Regionalnaya Gazovaya Kompania has conducted first blending trials in the Ukrainian distribution network during the summer and autumn of 2020. Initial reports indicated that the results of using 99% mixture of hydrogen were less than satisfactory.

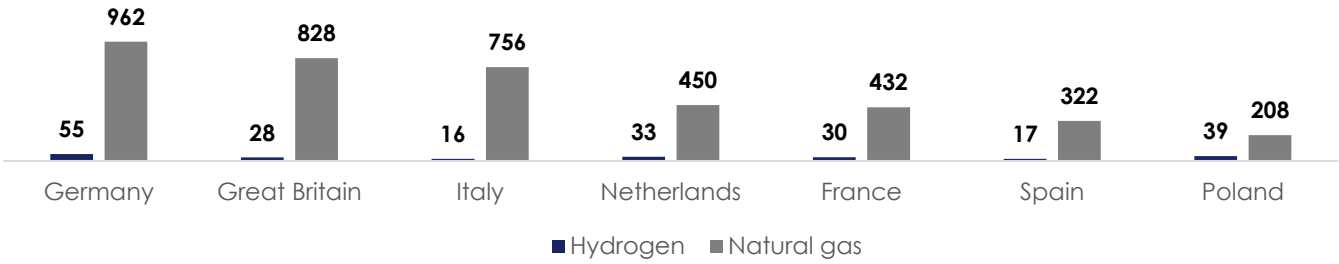
UKRAINE'S GAS TRANSMISSION SYSTEM

POLAND: HYDROGEN STRATEGY – WHAT IS NEXT?

Poland is a significant prospective market for hydrogen due to its large population and developed industry, whose demand for energy can no longer be fulfilled by an out-dated energy sector based on fossil fuels. Dominance of Polish transport companies on the European market might also drive the demand for low-emission H2 as a transport fuel.

Poland is currently one of the leading producers of grey H2 in Europe (app. 1 mln tonnes/year), mostly as a by-product of petrochemical industry and fertilisers production. For Polish economy, these features could be both blessings and burdens.

DEMAND FOR H2 AND NATURAL GAS IN LEADING EU ECONOMIES IN 2019 (TWh)



Polish transition towards hydrogen economy could be an escape window from growing emission costs in transport, industry and building heating. In the face of the growing EU climate ambitions and their impact on energy prices for end users, Poland needs to rapidly transform its economy and energy generation. This, however, requires large amounts of money, acquisition of foreign technology (electrolysers, power cells) and fast deployment of RES/CCS, or even nuclear power. Growing public debt and unfavourable macroeconomic environment hinders these efforts, even if Poland can still count on significant EU funds.

Besides improved regulation and funding, the main impulse for H2 should stem from the leading producers of grey H2: mostly large SOEs (Azoty, PKN Orlen, Lotos, PGNiG, JSW), which only start the first pilot projects in public transport and production of green H2 for internal use. Their output might cover the demand of a small H2 public transport fleet, but is insignificant compared to the grey H2 (1 mln t/year).

Additional companies seem interested in low-emission hydrogen generation. For example, an offshore wind company Polenergia plans to produce H2 in partnership with Siemens. Lotos and electric transmission system operator PSE are planning a project involving RES and a hydrogen purification plant. (currently seeking funding from the Innovation Fund).

The demand side for green hydrogen in Po-land will be determined by the communes (gminas). National Fund for Environmental Protection (NFOŚiGW) develops a funding scheme for 2022, offering up to 90% for H2 buses and up to 3 mln PLN for H2 refuelling stations. This would allow communes to buy at least several dozen of buses – possibly hundreds if the scheme is extended. The costal Tri-City of Gdańsk, Gdynia and Sopot is expected to be the pioneer of this program, with Warsaw and Silesian agglomerations negotiating their participation. More local governments are expected to express their interest.

SELECTED H2 PILOT PROJECTS IN POLAND

ORLEN

- H2 production in Włocławek for commercial use in public transport. First stage to commence in 2022;
- Target: 4000-5000 t/year. Initial hourly rate: 170 kg/h, target rate: 600 kg/h

PGNiG

- Exploring the possibilities for pipeline transmission and storage of hydrogen;
- Pilot green hydrogen production plant in Odolanów.

PAK

- Power Plant Complex Pątnów Adamów Konin - (ZE PAK SA);
- Electrolysers and a photovoltaic farm, expected power of 70 MW , target production rate: 63 kg H2/h.

POLAND: HYDROGEN STRATEGY – WHAT IS NEXT?

Poland has recently seen a few research projects regarding H2 technologies. Aside from the NCBR-funded projects, significant initiatives are attempted by major state-owned companies, which highlights the importance of these companies in creating the hydrogen economy

SELECTED POLISH HYDROGEN PROJECTS

	H2 bus will be subsidised by the government. By 2025 250-500 such vehicles could enter the market, depending on the scenario.
	Hydrogen bus production is already possible (Autosan, Solaris)
	ZE PAK – refuelling station (Nel Hydrogen), GZOG as part of the Hydra Tank project (scientific purposes))
	Three refuelling stations under development – PGNiG/Toyota, Orlen, Lotos/Toyota, ZE PAK and other companies willing to build more
	First designs of hydrogen-powered locomotives (Hy-way to Hel and Greater Poland Voivodeship)

	Publicly funded projects (NCBR) – mobile hydrogen storage unit and a design of a H2-powered van
	Research project on coal gasification by JSW, (similar to the Azoty/Tauron project)
	Possibilities for hydrogen storage in salt caverns or as metal hydroxide
	Hydrogen locomotive project (Lotos/Pesa/ Orlen, PKP also declares similar interests
	small-scale research projects, including low-power electrolysers (Sescom) and H2 generation from waste

Perspectives for hydrogen economy

Successful growth of hydrogen sector in Poland is hard to imagine without an active role of the state. The draft hydrogen strategy scheduled for adoption by 1Q 2021 lays out the following assumptions:

- deployment of P2G technology (1MW), use of H2 as a stabiliser for electro energetic networks and for synthetic fuel production
- deployment of 500 H2 buses by 2025 and up to 2000 buses by 2030;
- construction of at least 32 hydrogen refuelling stations;
- development of H2-powered locomotives;
- creation of 5 „hydrogen valleys", promoting hydro-gen use in i.a. petrochemical industry and fertiliser production;
- enabling CFD contracts supporting energy transition;
- installation of 2 GW electrolyser capacity by 2030;
- gradual development of transmission and distribution network for H2;
- creation of regulatory framework.

Anticipated support will target both green and blue (natural gas + CCSU) H2 projects. Despite a lack of clear declarations, any planned nuclear installations should also be used to power the hydrogen production. Overall, however, the strategy does not provide clear details or deadlines for many of the proposed actions.

The shape of the planned regulations and the amount of financial resources involved that will show the true level of determination of the Polish government. The strategy itself is very ambitious. The creation of 5 hydrogen valleys, or clusters in which companies would cooperate within the value chain, is an ambition on a European scale. The intended scenario involves creating 5 such areas in a longer period of time (e.g. until 2040). The plan to build 2 GW of electrolyser capacity is equally ambitious. In comparison, Germany plans to reach 5GW of electrolyser power by 2030, with a more advanced hydrogen economy.

If the government fails to deliver on these assumptions, there is little hope for fast development of H2 economy. The most pressing issues seem to be the creation of regulatory framework (especially regarding safety standards) and fiscal stimuli.

CZECHIA: TRANSMISSION, START-UPS AND AMBITIOUS PLANS

Czechia is well-positioned for the development of the hydrogen economy. As a result, grey hydrogen producers are currently preparing pilot projects in the transport sector. The main Czech energy producer, CEZ, invests in start-ups developing hydrogen technologies, and the gas operator, Net4Gas, has long-term plans to convert its infrastructure.

Hydrogen production – state of play and new projects

Currently, grey hydrogen is obtained mainly as a by-product of chemical processes. One of its main producers is Spolchemie.

However, the main players on the energy market, especially the CEZ concern, do not currently have advanced H2 production projects. Moreover, the ČEZ Group took steps in this direction only in 2020. The company ÚJV Řež, responsible for research and development in the holding, has established a team for the commercial development of hydrogen technologies.

> **Potentially, CEZ may be primarily interested in H2 production using its nuclear power plants (it has plans to further engage in this sector). The company is also considering introducing hydrogen in the transport sector.**

Thanks to foreign investments, CEZ is already gathering know-how for the needs of the hydrogen economy. Through Inven Capital, it holds shares in electrolyser developer Sunfire, (including an electrolyser in Rotterdam, and an installation in Norwegian Herøya for the production of H2-based aviation fuel is being prepared). As a result, compared to its competitors in the Visegrad Group, the holding is gradually emerging as a regional leader in hydrogen.

In the Czech Republic, the H2 electrolysis for the purpose of methane production (with an oversupply of energy on the market) is also being considered by the gas pipeline operator Net4Gas, together with GasNet (distribution system operator).

A RES H2 storage pilot project is carried out by UJV Řež (in cooperation with CEZ). Jablotron and its partner Leancat currently produce fuel cells and the so-called powerboxes (electricity generators from H2) and they intend to create a "storehouse" of hydrogen for their own needs and for distribution to smaller consumers currently having problems with energy supply.

Another company from Jablonca – Devinn – offers a similar solution: H2Base mobile generators. However, there is no information about major plans for fuel cells from such giants as CEZ and EPH.

Transmission – conversion plans by 2040

Czech TSO Net4Gas participates in European Hydrogen Backbone initiative (with Fluxys, Gasunie, ontras, Energinet and other European TSOs), aimed at coordinated development European of H2 transmission infrastructure, By 2040 such a network should have at least 23 thousand km, 75% of which would be the converted natural gas pipelines. These plans include conversion of selected Czech pipelines.

Transport sector

There is noticeable interest in hydrogen-powered transport in Czechia, although this sector is only in nascent stage of development. Between 2009-2014 Czechs tested a H2 bus, but decided against wider implementation. The only operating H2 refuelling station was set up by UJV/CEZ in 2018. Unipetrol has announced plans to build 3 additional stations in Prague, Brno and Litvinov by 2021. These investments will be financed from Sectoral Operational Programme: Transport. The grey hydrogen is to come from Unipetrol's own production, which will probably require further purification of the raw material obtained from refining.

> **Unipetrol signed a hydrogen distribution agreement with Bonett (currently the leader on the Czech CNG market). Bonett has also expressed interest in the development of hydrogen stations in Poland and Slovakia.**

The township of Usti on Elbe considers a transition towards hydrogen-powered public transit and construction of a H2 station in partnership with Spolchemie (H2 producer) and Cheminvest. In 2019 the parties signed a memorandum on hydrogen use in public transport. Similarly, Moravian-Silesian region, , wants to buy at least 10 hydrogen buses and establish first H2-powered train connections by 2025, in cooperation with Vitkovice Cilinders.

According to National Action Plan for Clean Mobility, in mid-term perspective (by 2025) there should be 3 or 5 hydrogen stations fuelling the heavy duty transport to Germany and H2 transport in major cities (Prague, Ostrava, Brno).

SLOVAKIA: TRANSIT COUNTRY, OR MORE?

Hydrogen economy in Slovakia shows potential mainly in the possibility of long-term transit from Ukraine to EU post-2030. Domestic market cannot generate significant demand compared to the rest of the region. On the other hand, large concentration of automotive industry in Slovakia makes it an important link in the value chain of European hydrogen car manufacture.

Production: plans across the H2 "colour palette"

Similarly to Poland, current producers of grey hydrogen (chemical firms Duslo Šaľa and Fortischem) reserve it for exclusive internal use. at the same time, these companies seek to lower their emission rate for H2 production. A power-to-gas project is underway at Duslo, using wind farm power to produce hydrogen

Slovnaft explores the idea of blue hydrogen production from natural gas (with CCS), initially to be used for de-sulhpurisation at Slovnaft's refinery. The next stage could be production aimed at transport sector. Target power level of the Slovnaft's installation is 60 thousand Nm3/h.

There are some consideration regarding the possibility to use nuclear power to generate low-emission purple hydrogen, but no concrete actions have been taken yet, and the issue seemingly de-pends on the direction of hydrogen regulation and policy at the EU level. Slovakian plans to further develop nuclear energy should be noted in this context.

> **Unless Poland builds hydrogen ready pipeline connections with Ukraine (which is currently unlikely) or technological innovations eliminate the need for pipeline transit altogether, Slovakia and Czechia will be the sole transit countries for Ukrainian- and potentially Russian - hydrogen to the EU.**

Transmission – key position in future transit?

Slovakia is clearly well-positioned to reap the benefits of Ukrainian hydrogen transit, should this project become reality. This is reinforced by the initial Czech considerations to convert several transmission pipelines to hydrogen transit post-2030, which gives Slovakia a decent opportunity moving towards 2040.

Slovakian TSO for gas, Eustream (EP Infrastructure Group) has not, at the time of writing of this report, made any announcements regarding blending or pipeline conversion projects, although it is know that such options are being analysed by both Eustream and SPP.

Meanwhile, another part of the EP Group, Nafta anticipates the option for storage of hydrogen-natural gas blend in its upcoming storage facility UGS Veľké Kapušany near the Ukrainian border. Nafta is also a partner in the Underground Sun Storage project in Austria, the purpose of which is to use the H2/natural gas blend for storage of RES energy.

Transport sector – possible cooperation with Kia

Slovakia is taking its first steps in this sector. Currently there ar no refuelling stations, although declarations have been made to create them in the next few years, e.g. by converting CNG stations operated by SPP.

> **Kia Motors and Hyundai produce hydrogen cars and both are present in Slovakia. Kia has already declared that some of their future H2 car production could take place in Slovakian facilities.**

According to journalists, Slovakian Ministry of Economy plans to build a railway connection using H2 locomotives (Nové Zámky-Nitra-Prievidza), but no timeline or details have been release at the time until the publication of this report, This project will likely require EU funding to take off. Minister of Economy declares that hydrogen economy is treated as a priority and that the research centres (such as Hydrogen Technology Centre in Kosice) will be provided with adequate funding for H2-related research.

Publication of national hydrogen strategy is scheduled for 2021. For the moment, situation is similar to Poland, with the market waiting for government's action. In this regard, the situation is highly similar to Poland, where the market is also announcements from the government.

HUNGARY – HUMBLE BEGINNINGS

Hungarian efforts in the hydrogen sector are currently limited. The country has a potential to produce hydrogen using nuclear power and this is the option currently being considered by the government. National hydrogen strategy is being drafted, but without a set publication date. No pilot projects have yet been started by businesses.

> **Hungary seems to be promoting mainly the production of hydrogen from nuclear energy as an element of the climate transformation.**

Production – hydrogen powered by atom

Budapest sees purple hydrogen as an acceptable energy source in short and medium perspective. Considering this position, and adding the existing plans of expanding nuclear capacity it can be expected that the state-owned consortium MVM will seek new ways to use that capacity, including hydrogen projects.

MVM's subsidiary MFGT started the „Aquamarine" project to analyse the options for electrolysed H2 storage in former gas storage units and for blended distribution. MVM also took part in creation of the Hydrogen Technologies Platform

Yet, there are no concrete plans for construction of major production installations. Several small-scale projects are being run, including green hydrogen installation in off-grid areas by E.ON Hungaria and JKH, aimed at generating energy from solar panels and storing it in either accumulators or as H2 in pressured containers (E.on Solar Container).

Transport sector

The Hungarian fuel concern MOL, in addition to the production of hydrogen for refining processes, in 2019 started cooperation with the Slovak company InoBat, the aim of which is the development of fuel cells, There are some early plans to supply the market with hydrogen (probably from refining after purification), but no concrete steps have been taken in this direction.

> **For now, Hungary has no H2 fuelling stations. Despite MOL's previous announcements, the company has not even started to deploy such infrastructure. Likewise, the local governments stay quiet on the issue hydrogen-driven modernisation of public transport.**

Hydrogen Technologies Platform was created to drive the development of H2 technology in Hungary. The body is currently assessing the potential for production, use and storage. Szeged University conducts research on electrolysis, but no other research projects are know at this time.

CONCLUSIONS

Not enough innovative projects

On one hand, scientific potential in the CEE region is sufficient and the governments are willing to finance further technological research. On the other, the region struggles with bureaucratic barriers and lack of experience and know-how (compared to the West) in market implementation of innovative tech. What is more, there is a visible competence gap in large-scale H2 projects, such as electrolysers or fuel cells. Over the years Western European, American and Asian competitors have accumulated impressive know-how and competitive production costs in i.a. cryogenics and high-pressure technologies - CEE stakeholders are unlikely to catch up with them anytime soon.

CEE-based companies will have to cooperate with foreign suppliers of technology - this trend is already visible in the on-going and planned projects, many of which run on German technology. Due to already existing business connections, Germany seems to be the natural partner, although diversification of suppliers would benefit the region. Strategic partnerships including for production transfer to CEE states should be sought out actively.

This does not preclude local innovation as an extension of Western stakeholders' value chains (dedicated chargers, compressors, H2 car parts) or as the source of niche technological advantage (synthetic fuel production/petrochemical industry, vehicle production based on imported fuel cells and small scale electrolysers, H2 purification, measurement stations, household appliances, IT systems for distributed energy generation)

Purple hydrogen – regional flavour?

There are already existing nuclear power plants in the region, along with the plans to further develop this sector. As a result, nuclear energy could become an important source of (purple) hydrogen in the next decade, as it is easier to scale the production. Natural gas production with the option for CO2 storage and use from the perspective of the region can also be scaled up if regulations and the necessary infrastructure are created.

Green hydrogen production (water electrolysis using electricity produced from RES) is tested, but it will only expand if provided with public support and if production costs decrease. Currently, it seems that only the massive rollout of the renewable energy sources (offshore winds, rooftop photovoltaic) would ensure the domination of green hydrogen.

CONCLUSIONS

EU regulation and funding – key to CEE hydrogen economy

Over the next decade, hydrogen economy in CEE will be driven mainly by EU decarbonisation requirements and will rely on EU funding. The greater the financial stimulus, the swifter the resulting development, but one should not ignore the local factors in each state – existing grey H2 production, structure of industrial sectors, RES rollout rate. The shape of EU legislation might prove essential – whether it will give priority to green hydrogen (very likely) or take a more technology-neutral approach, leaving more space for blue and purple variants. If the nuclear lobbying states, led by France, fail to secure support for purple H2, it will likely constrain the production potential in CEE, with limited local sources of capital.

Despite its, ambitions, Ukraine's limited access to EU funding is likely to hinder its progress in comparison to V4 countries.

Currently, there are at least three promising applications for low-emission H2 seem in CEE region: public transport, P2G and replacement of grey H2 in fossil fuel refinement. **However, there is no sufficient regulation, support schemes and major pilot projects which would give hope for a serious kick-off for hydrogen economy.** Political declarations, such as Polish national hydrogen strategy, might seem ambitious, but only time will tell to what extent the governments fulfil their promises. **In practice, EU remains the pacemaker for hydrogen economy in CEE region.**

East-West hydrogen transit

CEE countries are natural transit countries for Ukrainian and Russian hydrogen. Repetition of the model of development of early natural gas transit seems logical. Thus, it would be worthwhile to consider the development of North-South transit corridor based on the Three Seas Initiative Initial transit should be conducted with Hydrogen-natural gas blend through gas transmission lines (Ukraine via Slovakia and Czechia). Unless an alternative for blending emerges soon, new blending capacity will be installed in other countries, including Poland.

CONCLUSIONS

Conclusions for Poland

Poland is a latecomer to an already long-running technological race. This is an obstacle, as Polish industry is lacking many competences that are essential for hydrogen economy. In a wider hydrogen economy, however, there are niches that Polish companies might fill,. **Hydrogen economy will likely be one of the leading drivers of Polish economy towards 2050.**

Production scale of grey hydrogen in Poland (about 1 mln tonnes/year) is both an opportunity and a liability. It can drive demand for domestic technologies, but it is likely to fall out of favour once EU standards for hydrogen become stricter. At the initial stage of developing EU-wide regulatory framework, the key objective for Poland is to ensure the level playing field, i.e. to prevent solutions that would favour the already more technologically advanced Western companies, which already enjoy greater governmental support and easier access to green hydrogen. Level playing field would also include: tech neutrality and equal support for both national and cross-border projects. Poland should seek support from other CEE countries, which generally share the same circumstances. **In addition, lobbying for support for H2 production from biogas and waste on the EU level would support Polish agricultural sector.**

Support instruments for hydrogen economy outlined in the Commission's strategy (demand side support policies, Carbon Border Adjustment Mechanism) should take into account the interests of Polish petrochemical industry (ammonia production) if this industry is to remain competitive. **Nonetheless, Polish law and decisions of the Treasury as the owner of these companies should ensure their genuine commitment to developing Polish hydrogen technology.** The pace of hydrogen transition rests on the efforts of petrochemical industry.

Building Polish hydrogen economy requires a comprehensive and multi-faceted approach, starting with establishment of systemic solutions, precise timetable of investments, support schemes and regulatory instruments as well as clearly defined roles for all stake-holders (in particular state companies and public officials). To ensure accountability, a system of yearly reporting and review of the national H2 strategy system should be established, allowing the public, the experts and the legislative to follow the developments.