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Hydrogen use in Poland in the light of EU policy to move away from coal: the concepts of hydrogen valleys and smart and sustainable cities

Introduction

Hydrogen, due to its prevalence, generates many opportunities for the energy sector. It should be emphasised that the reaction of hydrogen with oxygen does not produce carbon dioxide. For this reason, one often encounters the term 'clean energy carrier'. This fact generates not only economic benefits, but also, for example, environmental or social benefits. Hydrogen valleys in Poland are expected to contribute to achieving climate neutrality and maintaining the competitiveness of the Polish economy, but the question is whether this will be possible. The essence is cooperation between individual participants in the energy market promoting hydrogen-based solutions, e.g. between enterprises, within clusters, or between enterprises and the public.

The aim of this study is to show the prospects for the realisation of so-called hydrogen valleys and smart sustainable cities as an alternative to EU guidelines. For the purpose of this analysis, a hypothesis was formulated, which assumes that the use of hydrogen in the economy will significantly improve Poland's energy security in the long term. The following research question was asked: Will Poland use hydrogen as a solution to meet EU requirements for a zero-carbon economy?

The article is divided into two parts. The first describes the energy and climate policy framework of the EU and Poland, the second describes hydrogen valleys – the current status of projects and the use of green hydrogen as part of the creation of the so-called smart cities idea. In summary, the article is of a mixed nature, in which the governance aspect and the policy decision aspect will be included. In addition, it will discuss an issue relevant to Poland's energy security concerning on the latest news and developments.

This article uses the method of content analysis of press release documents or websites. The methods used included empirical methods, i.e. observation, description and general methods, i.e. analysis, synthesis, induction and deduction. Primary sources, monographs, articles and publications on the websites of individual ministries, organisations, entities, etc. were used in this article.

The EU energy and climate policy framework and Poland's energy and environmental security strategy

In December 2019, the European Commission presented the so-called Green Deal strategy, i.e. a map of actions to ensure that Europe is, among other things, climate-neutral by 2050. It was proposed to tighten the EU's carbon reduction targets from 40% to 50–55%. The EU emphasises the need for close cooperation for a modern and competitive economy and therefore encourages changes at the level of national legislation. It is important to develop new technologies, while protecting the environment at the same time e.g. green hydrogen or electromobility.¹

In response to EU regulations, the *National Energy and Climate Plan for 2021–2030* was adopted by Poland on 18 December 2019, confirming the implementation of the so-called Energy Union. It assumes that RES (Renewable Energy Sources) in gross final energy consumption will account for approximately 21–23%. It is also planned to create around 300 sustainable energy areas at local level. The solution supports the EU guidelines for increasing the share of renewable energy in the overall energy mix: RECs – Renewable Energy Communities, and ECs – Energy Communities. Hydrogen is mentioned several times in the document, as an example for the possibilities of developing the Polish economy, e.g. for the natural gas network, as an input for chemical processes, for changing carbon dioxide

¹ Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, *The European Green Deal*, COM/2019/640 final, <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52019DC0640> [accessed: 7 April 2022].

into methane so that the resulting gas can be used to produce electricity, or for upgrading the quality of biogas.²

In 2020, a document developed by the Polish side appeared on a SWOT analysis of the Green Deal strategy. Weaknesses were identified as: the lack of an energy strategy, the lack of decisions on the transition towards green energy or the significant share of coal in the energy balance, and administrative issues – an insufficient number of people working on this issue. As strengths were indicated: the potential of regions for future modernisation, e.g. Wielkopolska, Silesia, Lower Silesia (mining), support instruments, e.g. the *Mój Prąd* programme, the *Czyste Powietrze* programme or the *Fundusz Niskoemisyjny*, and the potential for development of low-emission transport – the lithium-ion battery factory, LG Chem for electric cars.³

In 2020, the *Hydrogen Strategy for a climate-neutral Europe* was presented. Among other things, it proposed installing 40 GW of electrolyzers by 2030. The essence, therefore, is the creation of a so-called ‘hydrogen eco-system’ in Europe by 2050, based on cooperation between, among others, public authorities, industry, business or society. The EU’s goal is to produce renewable hydrogen using wind and solar energy. However, this requires time, probably a time horizon of about 25 years. The document stresses that there are different examples of hydrogen: electrolytic hydrogen (electrolysis of water – whatever the energy source), renewable hydrogen – electrolysis of water, electrolysis powered by electricity from renewable sources, pure hydrogen is renewable hydrogen, hydrogen from fossil fuels and hydrogen from fossil fuels using carbon dioxide (greenhouse gases are captured).⁴ The creation of a European alliance for clean hydrogen is an opportunity is the creation of a so-called inventory-list of investments and the identification of opportunities to finance them (e.g. the NEXT Generation EU Recovery Plan, or InvestEU).

In 2021, the Directive of the European Parliament and of the Council on the promotion-application of energy from renewable sources (2018) entered into force. The directive indicates how the consumption of renewable energy sources should develop between 2021 and 2030 (RES 32% – by 2030). In addition, it emphasises that

² “Krajowy plan na rzecz energii i klimatu na lata 2021–2030 przekazany do KE”, Ministerstwo Aktywów Państwowych, 13 December 2019, <https://www.gov.pl/web/aktywa-panstwowe/krajowy-plan-na-rzecz-energii-i-klimatu-na-lata-2021-2030-przekazany-do-ke> [accessed: 8 April 2022].

³ Kancelaria Senatu, *Polska w Zielonym Ładzie – korzyści, możliwości i ocena SWOT*, Opinie i ekspertyzy, OE–307, Warszawa 2020, https://www.senat.gov.pl/gfx/senat/pl/senatekspertyzy/5619/plik/oe_307.pdf [accessed 8 April 2022].

⁴ Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, *A hydrogen strategy for a climate-neutral Europe*, COM/2020/301 final, <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0301&from=pl> [accessed: 8 April 2022].

the participation of local actors, including, for example, prosumers, is important. They should have the right, to: generation, storage and sale of generated energy. The document also stresses that the so-called guarantees of origin used for renewable electricity, should be extended to e.g. biomethane. This would be a further step towards the introduction of guarantees of origin for hydrogen.⁵

The response from the Polish side was a *Draft Law on amendments to the law on Renewable Energy Sources and certain other laws*. It was indicated that a 14% share of RES in transport by 2030 was possible. The new regulations were to unify the issues of generation, sale, transmission and storage of energy in the activities of entities at the local level. At the same time, consultations are being carried out within the framework of the draft law on biocomponents and liquid biofuels, in order to implement the RED II directive in transport.⁶

In July 2021, *Fit for 55* was published, a document consisting of 13 legislative proposals. These must be accepted by the European Parliament and the individual Member States. Indications are that this process will last until 2023. An important solution is to limit the registration of combustion vehicles in 2035 (within the EU). In addition, Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 has also been repealed, changing AFID (Alternative Fuel Infrastructure Directive) to AFIR (Alternative Fuels Infrastructure Regulation). Zero-emission vehicles will therefore be promoted, which require the creation of an appropriate charging infrastructure. Thus, by the end of 2030, a hydrogen charging infrastructure should already be in place on the TEN-T network. Such solutions require legal regulations, e.g., for payment, information on charging costs, payment by card at the terminal or contactless. In addition, there are expected to be around 1 million charging points across the EU in 2025 and 3 million in 2030.⁷

On 7 December 2021, the *Polish Hydrogen Strategy until 2030 with an outlook until 2040* was published. It was pointed out that hydrogen is the right path to decarbonisation and can be applied in many areas of the economy, from energy to heating, industry or, for example, transport. So-called 'hydrogen valleys' are to appear in Poland, i.e. places for future investments that are convenient for stakeholders, for creating potential for investments, for the scientific and research environment, etc. The strategy is a way to use hydrogen on an industrial scale. In addition, jobs will be

⁵ Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast), OJ L 328/82, <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=PL> [accessed: 7 April 2022].

⁶ Rządowy projekt ustawy o zmianie ustawy o odnawialnych źródłach energii oraz niektórych innych ustaw, Draft No. 1129, 26 April 2021, <https://www.sejm.gov.pl/sejm9.nsf/PrzebiegProc.xsp?nr=1129> [accessed: 7 April 2022].

⁷ European Commission, *Fit for 55*, <https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55-the-eu-plan-for-a-green-transition> [accessed: 7 April 2022].

created, which will significantly increase the attractiveness of the region. The document emphasises the importance of the entire value chain from production, transmission to storage and use, with regulations in line with EU guidelines and attracting potential investors.⁸

In March 2022, Poland updated the assumptions of *the Polish Energy Policy until 2040*. The change is a result of the ongoing war between Russia and Ukraine. Therefore, it was emphasised that it is important to minimise crisis situations, which involves intensifying efforts to diversify directions and sources of energy acquisition, while maintaining the competitiveness of the economy and limiting environmental impact. It was pointed out that decarbonised gas or hydrogen-based technologies could be a solution to natural gas. Additionally, in the case of transport, there is talk of clean public transport, i.e. the use of bio-components in liquid fuels.⁹

The above documents indicate the EU's promotion of hydrogen investments, which fits in with the zero-carbon strategy. In addition, with the spectre of further war in Ukraine, hydrogen provides an additional alternative to fossil fuel supplies. Poland supports these solutions, emphasising that hydrogen can become a permanent part of the energy mix and participate effectively in it, e.g. by increasing the competitiveness of the economy in the long term.

Hydrogen valleys and the idea of the Smart City

There are many ways to produce hydrogen. The so-called steam reforming of the gas, i.e. converting it under the influence of heat, is mentioned as the most economical way. Another way is the so-called electrolysis of water, i.e. splitting it into hydrogen and oxygen, using an electric current. In the case of hydrogen, the terms grey, green, blue, violet are also used, but this refers to the way it is obtained, e.g. gas, water, etc. The term biohydrogen is mentioned, which refers to the involvement of micro-organisms (fermentation and photolysis). In the case of vehicles, hydrogen can be used to power internal combustion engines and in fuel cells to generate electricity. These solutions offer a number of opportunities when it comes to the energy market, especially in an ever-changing environment where energy and

⁸ "Polska Strategia Wodorowa do roku 2030 z perspektywą do roku 2040 opublikowana w Monitorze Polskim", Ministerstwo Klimatu i Środowiska, 9 December 2021, <https://www.gov.pl/web/klimat/polska-strategia-wodorowa-do-roku-2030-z-perspektywa-do-roku-2040-opublikowana-w-monitorze-polskim> [accessed: 7 April 2022].

⁹ "Założenia do aktualizacji Polityki Energetycznej Polski do 2040 r. (PEP2040) – wzmocnienie bezpieczeństwa i niezależności energetycznej", Kancelaria Prezesa Rady Ministrów, 29 March 2022, <https://www.gov.pl/web/premier/zalozenia-do-aktualizacji-polityki-energetycznej-polski-do-2040-r-pep2040--wzmocnienie-bezpieczenstwa-i-niezaleznosci-energetycznej> [accessed: 29 March 2022].

environmental security issues are constantly being redefined.¹⁰ If photolysis is used, it is possible to generate hydrogen, which contains about 10–20% carbon dioxide, so that the gas does not need to be purified. Another solution can be so-called dark fermentation, where organic compounds, polymers e.g. starch or cellulose, are used. This technology was used by Prof. Jacek Dach from the Poznań University of Life Sciences.¹¹

In Poland, five hydrogen valleys (Pol. dolina wodorowa, DW) were planned: Dolnośląska DW, Wielkopolska DW, Mazowiecka DW, Podkarpacka DW and Śląskie Zagłębie Wodorowe. With the support of, among others, the Ministry of Climate and Environment and the Industrial Development Agency, they are to become part of the European system. A hydrogen valley is a geographical area, so it can be a city, a region or e.g. a transmission area, where hydrogen is embedded in the so-called supply chain from production, storage, distribution to its use. Which affects the efficiency and competitiveness of the area. However, a number of investments are needed to make this happen, and this is where the EU can be of help, e.g. under the National Recovery Plan (NRP, Pol. Krajowy Plan Odbudowy, KPO), where EUR 23.850 billion is available in the form of grants and EUR 12.112 billion in the form of loans, including for green energy and mobility. In order to obtain the funds, the Polish side sent the document (in May 2021) to the European Commission (EC), but so far it has not been accepted.¹² The lack of agreement is due, among other things, to the divergence of Polish and EU objectives. Poland indicates that a mutually acceptable solution is still being worked on, e.g. on the issue of justice. The KPO points out the so-called challenges for the sector, highlighting that Poland's hydrogen production in 2020 was 1 million tonnes. This was hydrogen from fossil fuels. Low-carbon hydrogen production facilities are appearing in Poland, but they are of a test nature.

The first hydrogen valley was inaugurated in May 2021 in Jasionka, the so-called Podkarpacka DW.¹³ In January 2022, the Śląsko-Małopolska DW was established. According to Paweł Kolczyński, Vice President of the Industrial Development Agency (ARP S.A.), it is necessary to base the industry on hydrogen and support this solution in order to be able to use hydrogen effectively in the energy sector in the

¹⁰ A. Chodyński, *Dynamika przedsiębiorczości i zarządzania innowacjami w firmach. Odpowiedzialność – prospołeczność – ekologia – bezpieczeństwo*, Kraków: Oficyna Wydawnicza KAAFM, 2021, pp. 165–169.

¹¹ “Kierunek przyszłości – biometan i biowodor”, Portal Komunalny, 1 December 2021, <https://portalkomunalny.pl/kierunek-przyszlosci-biometan-i-biowodor-428075/> [accessed: 7 April 2022].

¹² Portal Funduszy Europejskich, 1 September 2021, <https://www.funduszeuropejskie.gov.pl/strony/o-funduszach/fundusze-na-lata-2021-2027/konsultacje-spoleczne-kpo/o-kpo/> [accessed: 7 April 2022].

¹³ “Rzeszów sercem Podkarpackiej Doliny Wodorowej”, Ministerstwo Klimatu i Środowiska, 18 May 2021, <https://www.gov.pl/web/klimat/rzeszow-sercem-podkarpackiej-doliny-wodorowej> [accessed: 7 April 2022].

future.¹⁴ At the end of February 2022, the Dolnośląska DW was established. KGHM Polska Miedź S.A. is the business partner. According to KGHM vice-president Adam Bugajczuk, hydrogen can be used as a fuel and as a reducing agent in smelter furnaces. However, this is not possible without building a base, i.e. infrastructure, creating a network of links and relations with stakeholders, with the support of scientific and research facilities, etc. An important element in the creation of hydrogen valleys is cooperation between research institutes, universities, enterprises – from startups, clusters (so-called local content), to entities that have been on the market longer and have a stable financial position, such as local government units or, for example, State Treasury companies.¹⁵ Also established are: Mazowiecka DW, Zachodnioeuropejska DW, Wielkopolska DW oraz Pomorska DW coordinated by the Hydrogen Technology Cluster. Within the latter, several projects are being implemented (as shown in Table 1).

Table 1. Projects implemented within the Hydrogen technology cluster

Project name	Area of activity
NeptHyne	Hydrogen production – wind farms in the Baltic Sea – seawater desalination project
PDA Support	Hydrogen vehicles in public transport, LOTOS Group, initially 10–15 buses, then more than 40
Pomeranian Hydrogen Valley	Hydrogen Technology Cluster Project
PCHET	Conference on coal technology
H2GLOBAL	Within the framework of the COSME – Programme for the Competitiveness of Enterprises and small and medium-sized enterprises 2014–2020 – the pursuit of cooperation with other European clusters.

Source: author's own elaboration based on: *Klaster Technologii Wodorowych*, <https://klasterwodorowy.pl/nepthyne,127.pl> [accessed: 22 March 2022].

Deputy Minister of Climate and Environment Ireneusz Zyska announced at the 14th TIME Economic Forum (March 2022) that a concept is being developed to establish a so-called hydrogen valley ecosystem operator in Poland. According to the minister, it is important that: “the valleys should not compete with each other exchange the knowledge and experience gained, and not duplicate the same projects

¹⁴ “Powstała Śląsko-Malopolska Dolina Wodorowa”, Agencja Rozwoju Przemysłu, 31 January 2022, <https://arp.pl/pl/o-arp/dla-mediow/aktualnosci/powstala-slaskomalopolska-dolina-wodorowa> [accessed: 8 April 2022].

¹⁵ “Powstała Dolnośląska Dolina Wodorowa”, KGHM Polska Miedź, 25 February 2022, <https://media.kghm.com/pl/informacje-prasowe/powstala-dolnoslaska-dolina-wodorowa> [accessed: 8 April 2022].

concerning the development of the hydrogen economy in Poland.”¹⁶ He also mentioned that a Polish centre for hydrogen technology and a Polish centre for hydrogen certification should be established, so that we can talk about an orderly structure for building a stable hydrogen market in Poland. Moreover, appropriate legal regulations are needed to define the framework for the activities of entities in the sector – work on the so-called ‘constitution for hydrogen’ is currently underway. This is a continuation of activities resulting from the *Polish Hydrogen Strategy until 2030 with an outlook until 2040*. Work is also underway on regulations on refuelling infrastructure (hydrogen can be used as fuel for fuel cell engines), i.e. hydrogen stations including their operation, modernisation, repair, inspection, or charging.¹⁷ At the beginning of February 2022 PKN Orlen announced that it had signed an agreement with 17 cities to build hydrogen charging stations, including Krakow. In 2022, the first four are to be built, while by 2030, there is talk of 100.¹⁸ It should be noted that according to the Polish Alternative Fuels Association, there were more than 70 vehicles in Poland that run on hydrogen in 2021. However, there is not a single station for charging them to date. This situation significantly limits the possibilities for the development of this sector.¹⁹

In 2017, the standard PN-ISO 37120:2015-03 *Sustainable social development – Indicators of urban services and quality of life* was made public. It addresses the so-called integrated approach to sustainable development. The aim is to measure the quality of life over a certain time horizon, the effects of activities, the exchange of information on applied solutions within the framework of reducing or changing consumption to an environmentally compatible style. For cities, the most important objective is to meet energy demand in a competitive, secure, low-carbon and affordable manner. Attention should therefore be focused on improving efficiency in transport, communication, transmission, etc.²⁰

Warsaw and Krakow appeared in the *Smart Cities Index 2021*, which lists 118 cities. The preparatory work rested with two entities: Lausanne Business School

¹⁶ “Zyska: Powstała koncepcja powołania operatora dolin wodorowych”, Świat Rolnika, 9 March 2022, <https://swiatrolnika.info/ekologia/oze/zyska-powstala-koncepcja-powolania-operatora-dolin-wodorowych-w-polsce.html> [accessed: 12 April 2022].

¹⁷ Projekt rozporządzenia Ministra Klimatu i Środowiska w sprawie wymagań technicznych dla stacji wodoru, Rządowe Centrum Legislacji, 10 February 2022, <https://legislacja.rcl.gov.pl/projekt/12356050/katalog/12851708#12851708> [accessed: 8 April 2022].

¹⁸ M. Pokorzyński, “Orlen zbuduje stacje tankowania wodoru. Pierwsze powstaną w tym roku”, *Auto Świat*, 2 February 2022, <https://www.auto-swiat.pl/cv/wiadomosci/orlen-zbuduje-stacje-tankowania-wodoru-pierwsze-powstana-w-tym-roku/m3bz72g> [accessed: 8 February 2022].

¹⁹ Polskie Stowarzyszenie Paliw Alternatywnych, <https://pspa.com.pl/aktualnosci/> [accessed: 8 April 2022].

²⁰ *Smart Cities*, Polski Komitet Normalizacyjny, <https://www.pkn.pl/smart-cities> [accessed: 12.03.2022].

(IMD) and the Singapore University of Technology and Design. Aspects such as technology, transport, science, infrastructure, among others, were taken into account. A scale was created: from A to D, where the letter A indicates the best score. The 2021 report highlights health care issues as a consequence of the COVID-19 pandemic.²¹

Within the framework of Smart Cities in Poland, Białystok, Gdańsk, Gdynia, Kielce, Poznań, Rzeszów, Szczecin, Wrocław should also be mentioned. In these cities, investments are mainly focused on (building roads, car parks, constructing sports facilities, paving roads) promoting entrepreneurship and investments in environmental protection. In addition, cities are creating a policy of incorporating hydrogen as a solution to reduce carbon dioxide emissions, e.g. in Białystok, the Agricultural Hydrogen Valley was created to intensify activities in this area. On the other hand, Gdynia, Kielce, Gdańsk, Lublin and Warsaw have certificates for the ISO-37120 standard.²² The concept of Smart Cities is not easy to define, one way is to identify the so-called versions: Smart City 1.0, Smart City 2.0 and Smart City 3.0. In version 1.0, the initiators of change were entities known in the IT or telecommunications industry, the essence was to increase demand for the modern products and solutions offered. In the next stage, 2.0, the focus was on local authorities, where the main objective was to improve the quality of life of the inhabitants, e.g. by promoting ecological solutions, universal accessibility to various amenities, e.g. the Internet. Version 3.0 is intended to respond to societal needs and, on the other hand, should implement top-down objectives, such as low-carbon. The relationship between the actor, the society and the local authority will be crucial here in building the country's energy security (by ensuring local security).²³ In Poland, cities are at the 2.0 stage, which gives rise to some optimism (number of ideas, cooperation within clusters), but on the other hand shows how much still needs to be done to be able to speak of stability, e.g. the legal environment and regulations to structure investments within clean hydrogen.

Urban development, raises issues of population movement, whether by public transport or one's own means of transport. This is why intelligent traffic planning (e.g. roads, bridges, tunnels, airports) and the appropriate connection of potential participants (by rail, air or car) is so important. This situation is not only the result of a progressive urbanisation process, but is also due to the bluntness of the environment, its unpredictability and its complexity, in terms of development. On the one hand, there is the technological development and increased consumption for products and

²¹ *SCO Smart City Observatory*, <https://www.imd.org/smart-city-observatory/home/> [accessed: 8 April 2022].

²² P. Szepecht, "Idea smart city kuleje w Polsce. Może być źródłem oszczędności dla miast", 10 January 2022, <https://www.wirtualnemedial.pl/arttykul/smart-city-polska-zrodlo-oszczednosci-dla-miast> [accessed: 8 April 2022].

²³ M. Zysk, "Idea Smart City 3.0, czyli inteligentne miasta w Polsce", 20 May 2021, <https://cityislife.pl/design-i-sztuka/idea-smart-city-3-0-czyli-inteligentne-miasta-w-polsce> [accessed: 8 April 2022].

services, and on the other, the growing awareness of resource depletion and the issue of environmental protection, the control and monitoring of processes and, consequently, the need to store large amounts of data.

Hydrogen is a solution to the Smart Cities idea, this is confirmed by investments in, among other things, hydrogen-powered buses. In Poland, the first examples are Gdansk and Gdynia, which tested Solaris Trollino 18 hydrogen trolleybuses in 2017. Manufacturers emphasise their greater efficiency than electric vehicles (longer range and cheaper servicing). In Krakow, for example, the Solaris Urbino 12 hydrogen bus was tested. In January 2021, cities were able to apply for project funding for the purchase of green and zero-emission buses from the *Green Public Transport* programme of the National Fund for Environmental Protection and Water Management. There was a huge amount of interest, with more than 100 applications for the use of hydrogen in public transport. These investments will exceed PLN 1 billion.²⁴ It should be noted that such solutions are already in use, e.g. Toyota's Woven City in Japan (as part of a collaboration between Toyota and Isuzu and Hino Motors).

Conclusions

To sum up the above considerations, green hydrogen is an important solution for creating a so-called zero-carbon economy. The events in Ukraine have accelerated the debate on the diversification of directions and sources of energy not only in the EU, but also worldwide. Energy independence is also essential and significantly enhances national security. There is no single solution for diversification from the monopoly supplier of raw materials to the European market – Russia. Each country has a different energy mix, a different policy, a differently developed industry, which significantly complicates rapid change. In addition, the EU's low-carbon strategy has long put pressure on countries where coal occupies a significant part of the energy mix, such as Poland. The examples cited above confirm the significant impact of hydrogen valleys on improving the competitiveness of the Polish economy and the possibilities within the creation of solutions in line with the Smart City idea. Investments in green hydrogen offer the possibility of generating energy in a way that is independent of other countries, which significantly improves Poland's energy security, first at the local level, and consequently for the whole country, these premises can be seen in government documents, statements by politicians or publications by individual entities. Which confirms the hypothesis assumed in the introduction. In addition, it is a solution that supports the EU's zero-carbon strategy. To the question of whether Poland will use hydrogen as a solution to meet EU requirements?

²⁴ "W polskich miastach pojawi się ponad 100 autobusów na wodór", Gramwzielone.pl, 14 March 2022, <https://www.gramwzielone.pl/woddor/107489/w-polskich-miastach-pojawi-sie-ponad-100-autobusow-na-wodor> [accessed: 22 April 2022].

It is difficult to answer in the affirmative at the present time. Poland has a so-called hydrogen strategy, so-called hydrogen valleys are being created cooperating with energy clusters and creating a whole network of cooperation at the local level. In order to achieve climate neutrality, legal regulations and an amendment to the RES Act are needed. The situation is similar here, investments need the support of the government not only in words (public statements), but appropriate legal regulations are required for this. This is the key to success, due to the visible bottom-up initiative, e.g. of companies at the local level.

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*Hydrogen use in Poland in the light of EU policy to move away from coal:
the concepts of hydrogen valleys and smart and sustainable cities*

Abstract

Hydrogen can be used in several ways, including as a raw material, fuel or as an energy carrier. Therefore, hydrogen becomes an object of interest not only to companies, but also to individual governments. The European Union (EU) promotes low-emission solutions, which entails giving up fossil fuels and adapting the energy mix to renewable energy. In addition, the war in Ukraine is reshaping relations on the energy market in Europe and beyond. The well-known concept of diversification takes on a new meaning, it is combined with efficiency and competitiveness in the event of a change in the directions and sources of energy. It should be emphasized that no CO₂ emissions are generated when using hydrogen. This fact becomes a passport to the implementation of the EU's low-emission goals by 2050. Poland is not energy self-sufficient, additionally it still bases its energy mix on fossil fuels, which consequently raises concerns about meeting the EU guidelines. Therefore, the aim of the study is, inter alia, showing the prospects for the implementation of the so-called hydrogen valleys and sustainable smart cities, as alternatives to, for example, EU guidelines, dependence of supplies on the Russian monopoly, inefficiency and inactivity of the energy sector in the long term. For the purposes of this analysis, a hypothesis has been formulated, which assumes that the use of hydrogen in the economy will significantly improve Poland's energy security in the long term. The following research question was asked: Will Poland use hydrogen as a solution to meet the EU requirements for a zero-emission economy?

Key words: EU, Poland, management, hydrogen valleys, Smart City, clusters, competitiveness, low-emission