energies

MDPI

Article

Hydrogen Technology on the Polish Electromobility Market. Legal, Economic, and Social Aspects

Wojciech Drożdż [1], Filip Elżanowski [2], Jakub Dowejko [1,*] and Bartosz Brożyński [1]

[1] Department of Logistics, Institute of Management, University of Szczecin, 70-453 Szczecin, Poland; wojciech.drozdz@usz.edu.pl (W.D.); bartosz.brozynski@usz.edu.pl (B.B.)
[2] Faulty of Law and Administration, University of Warsaw, 00-927 Warsaw, Poland; filip.elzanowski@uw.edu.pl
* Correspondence: jakub.dowejko@usz.edu.pl

Abstract: The aim of this study was to evaluate the motorization market of electric vehicles powered by hydrogen cells in Poland. European conditions of such technology were indicated, as well as original proposals on amendments to the law to increase the development pace of electromobility based on hydrogen cells. There were also presented economic aspects of this economic phenomenon. Moreover, survey research was conducted to examine the preferences of hydrogen and electric vehicle users in 5 primary Polish cities. In this way, the level of social acceptance for the technological revolution based on hydrogen cells and taking place in the motorization sector was determined.

Keywords: electromobility; hydrogen cells; energy law; customer preferences

Citation: Drożdż, W.; Elżanowski, F.; Dowejko, J.; Brożyński, B. Hydrogen Technology on the Polish Electromobility Market. Legal, Economic, and Social Aspects. *Energies* **2021**, *14*, 2357. https://doi.org/10.3390/en14092357

Academic Editor: Hai-Wen Li

Received: 12 March 2021
Accepted: 12 April 2021
Published: 21 April 2021

1. Introduction

Electromobility as part of the alternative fuel market, also embracing hydrogen technologies, can currently be called a megatrend on the global and European scale both on the motorization market and on the electric energy market. On the one hand, the development of the alternative fuel market is a market trend whereas, on the other hand, this trend mainly arose from the promotion of the development of this market by the energy policy and climate change policy of the European Union (EU), which is not only reflected in the strategic and program documents of the European Union [1] but, first of all, in the form of legal acts.

The primary objectives of the climate and energy policy of the EU are to reduce the emission of greenhouse gases, to increase the percentage of renewable energy sources in the final consumption of energy gross leading to the decarbonization of the power industry, and to increase the energy efficiency, which in consequence shall result in climatic neutrality, which is the purpose of the energy and climate policy of the European Union, expressed in a Communication of the European Commission—European Green Deal [2]. The said primary objectives shall also be achieved in the transportation sector with the aim to use zero-emission and low-emission technologies and fuels. The legal framework for the development of alternative fuels in the EU law was constituted, in the current legal state, by the directive of the European Parliament and of the Council 2014/94/EU of 22 October 2014 on the development of alternative fuel infrastructure (Directive 2014/94) [3].

Electrical energy and hydrogen are alternative fuels that are now the object of high interest on the market of transport. It must be noted that electric vehicles and vehicles driven by hydrogen cause a smaller emission of CO2, specks of dust, and gases harmful to the health and the environment. It must be taken into consideration that reduced emission of contaminants depends on the sources which generate the electric energy used for charging the electric vehicles—a considerable percentage of renewable sources increased the ecological value of electric and hydrogen drives.

The term electromobility, including hydrogen technologies, may be understood as a combination of two segments of this market: the charging or refueling stations (component

of infrastructure) as well as the electric and hydrogen vehicles (component of infrastructure and vehicle users).

Consequently, in the market of electromobility, as a new market of electric energy, one can separate a segment of vehicles and a segment of infrastructure, which are inseparable and cannot function independently of each other. With the increase in the number of charging or refueling stations, the number of electric vehicles and vehicles driven by hydrogen will be on the rise, which will lead to significant growth of the market of alternative fuels sensu largo. As indicated in a justification to the Act of 11 January 2018 on electromobility and alternative fuels—alternative fuels require a unique infrastructure used for refueling and charging motor vehicles driven by these fuels. Without creating appropriate infrastructures, consumers would not be interested in changing motor vehicles driven by conventional fuels (e.g., petroleum, diesel oil) into vehicles using alternative fuels as a drive. In turn, entrepreneurs would not be interested in carrying out economic activities related to alternative fuels since there are no customers [4].

On 8 July 2020, communication between the European Commission and the European Parliament, Council, European Economic and Social Committee, and Committee of the Regions was published—a strategy within the scope of hydrogen for the benefit of a neutral Europe for the climate (hydrogen strategy) [5] that must be deemed a derivative of provisions of the European Green Deal, and a starting point for an analysis contained herein. Hydrogen, including, particularly, the one obtained from renewable sources—so-called green hydrogen—was mentioned as one of the vital energy media which may contribute to the achievement of the assumptions of the European Green Deal. The primary objective of the published strategy was to stimulate and enlarge the renewable sector with green hydrogen so that it would be an entirely zero-emission, generally available source of energy in the EU until 2050. The hydrogen strategy also indicated that investments in hydrogen would contribute to sustainable economic growth and to the creation of jobs, which will be of vital importance in the context of coming out of the crisis connected with COVID-19. The hydrogen strategy also emphasized the reconstruction plan [6] presented by the European Commission, in which the necessity of unblocking the investments in pure technologies and the value chains of vital significance was highlighted. The plan underlined that clean hydrogen is one of the significant areas which must be dealt with in the context of the energy transition and indicated many possibilities and ways of supporting this process [7].

The hydrogen strategy also described hydrogen production methods (types of hydrogen), possible exploitation of hydrogen in the industry and transport, and a plan of support of this fuel by the EU.

The primary types of hydrogen in the hydrogen strategy were as follows:

- Electrolytic hydrogen—hydrogen generated within the electrolysis of water (in an electrolyzer powered by energy) regardless of the source of electric energy. The emissions of greenhouse gases of the whole life cycle related to the production of electrolytic hydrogen depending on the method of production of electric energy.
- Renewable hydrogen (pure hydrogen)—hydrogen generated within the electrolysis of water (in an electrolyzer powered by electric energy) with the reservation that electric energy comes from renewable sources. The emissions of greenhouse gases of the whole life cycle related to the production of renewable hydrogen are close to zero.
- Hydrogen of fossil fuels—hydrogen generated within various processes in which fossil fuels are used as raw materials (natural gas reforming or coal gasification). It accounts for a more significant part of hydrogen produced now. The emissions of greenhouse gases of the life cycle related to the production of hydrogen from fossil fuels are high.
- Hydrogen of fossil fuels with carbon capture—a subtype of hydrogen of fossil fuels with the reservation that the greenhouse gases emitted in the production process of this hydrogen are captured. The emissions of greenhouse gases connected to the production of hydrogen of fossil fuels with carbon capture or with the use of pyrolysis

are lower than in the case of hydrogen of fossil fuels, but the changeable effectiveness of greenhouse gas capture must be taken into consideration (maximum 90%).

- Synthetic hydrogen derivatives—various gas and liquid fuels based on hydrogen and coal. A hydrogen fraction of the synthesized gas should be renewable so that synthetic fuels can be considered renewable. For example, renewable fuels include synthetic naphtha in aviation, synthetic diesel oil for cars, and different molecules used for the production of chemicals and fertilizers. With regard to air pollution, the combustion of synthetic fuels generates similar levels of emission of contaminants as fossil fuels [8].

As indicated in the hydrogen strategy, now-renewable hydrogen, electrolytic hydrogen, and hydrogen of fossil fuels with carbon capture are not competitive in terms of costs compared to the hydrogen of fossil fuels (the current estimated price of hydrogen of fossil fuels is approximately EUR 1.50/kg. To a large extent, the price depends on the prices for natural gas and does not include CO_2 costs. The estimated price of hydrogen from fossil fuels with carbon capture and storage is around EUR 2.00/kg, whereas the price of renewable hydrogen is between EUR 2.50 and EUR 5.50/kg–Hydrogen strategy, page 5 of the report of the International Energy Agency, the Future of Hydrogen pertaining to hydrogen for 2019, page 42: https://www.iea.org/reports/the-future-of-hydrogen# [accessed on 4 March 2021]. The calculations were based on the assumed natural gas prices for the EU of the amount of EUR 22.00 per MWh, the electric energy prices between EUR 35.00 and 87.00/MWh, and the costs of the production capacity coming to EUR 600.00/kW) [9]. However, in the long run (years 2030–2050), the priority of the EU is the development of the production of renewable hydrogen with the use of wind and solar energy mainly. The renewable hydrogen is most consistent with the long-run objective of the EU within the scope of the climatic neutrality and with the aim to achieve zero-emission of contaminants, and most coherent with the integrated energy system.

It was indicated in the hydrogen strategy that increased production of hydrogen is combined with the creation of new pioneer markets; two primary pioneer markets of which include industrial uses and mobility, which can be gradually developed to exploit the potential of hydrogen reasonably in terms of costs for the benefit of the economy neutral for the climate. Hydrogen may be applied in the transportation sectors in which electrification procures difficulties. In the initial period of implementing hydrogen technology solutions, hydrogen may be used in local city buses, in commercial fleets (e.g., taxis), or components of railway networks, in the cases in which electrification is unfeasible or unprofitable. At the subsequent stages of implementing hydrogen as a fuel in transport, it is necessary to propagate using hydrogen fuel cells in heavy road vehicles—coaches, special purpose vehicles, and vehicles for long-distance road transport—due to a high emission level of CO2 thereof. Hydrogen may also become an alternative low-emission fuel in the case of inland shipping, short sea shipping and may contribute to decarbonization of the aviation and maritime sectors (hydrogen strategy, pages 12–13. In the case of aviation and sea transport, hydrogen may help to decrease the emission of greenhouse gases and air pollutants thanks to the production of synthetic liquid naphtha or other synthetic fuels. The long-term potential option for aviation may also be hydrogen fuel cells which require the adaptation of the construction of an aircraft or jet engines propelled by hydrogen) [10].

Adoption of the hydrogen strategy by the European Commission must be treated as another argument for assuming that hydrogen technologies and hydrogen as a chemical component have become the object of interest not only in Europe but also all over the world, because they may be used as raw material, fuel or as an energy medium and energy storage facility, including on the market of electromobility transport.

As indicated in the literature, it is needed to develop a cheap, fast, and efficient method of production of hydrogen so that it can replace the current energy media. At present, approximately 48% of the produced hydrogen is formed due to methane reforming with the use of water vapor, 30% crude oil (mainly in refineries), 18% of coal, and the remaining 4% comes from the electrolysis of water. The best-known methods of obtainment of hydrogen include:

- natural gas reforming,
- coal or coke gasification,
- plasma technology,
- electrolysis of water,
- photo-electrolysis,
- biological methods [11].

It is also worth noting that, already now, Poland—with the production at the level of approximately 1 million tons per annum (globally approximately 74 million tons)—is an essential player on the market of so-called grey hydrogen manufactured from fossil fuels. It is mainly used as a raw material in chemical production processes (e.g., from ammonia) and refinery processes [12].

Data obtained at the end of 2018, classified Poland as one of the primary producers of hydrogen in the EU, generating 1.3 million tons of hydrogen per annum in total. The most significant Polish producers are Grupa Azoty S.A. (approximately 420 thousand tons), PKN Orlen S.A., Grupa Lotos S.A. and, JSW S.A. [13]. However, this hydrogen is not currently used as a fuel for vehicles in transport.

It must be noted that the objectives of the energy and climate policy of the EU may be achieved, first of all, by the so-called pure hydrogen—renewable hydrogen produced from renewable energy sources. Now, it accounts for approximately 5% of the total global production of this raw material—generation of green hydrogen is still more expensive than other forms of production thereof. The progress of this market's segment is, for the time being, in the initial phase of evolving but, to stimulate innovations and reduce emissions, Poland should also commence research, adopt the strategies, implement legal regulations and incentives, and conduct programs of support to increase the use of hydrogen in transport and to be able to compete with other countries.

Hydrogen is perceived as a fuel of the future for the transport and power industry. The current sources of hydrogen are mainly based on fossil fuel processing technologies (natural gas, crude oil, coal). The prosperity of the technologies for the obtainment of hydrogen, with the use of renewable sources, is very intense, and it is forecast that in 2050 approximately 25% of hydrogen will be reached through electrolysis or directly through the gasification of biomass. In a more extended perspective, the blossom of electric transport, particularly long-distance transport, will be based on hydrogen drives with the use of fuel cells. The spread of high-power fuel cells is a barrier in energy uses on a considerable scale. The fact that, as already said above, one of the significant sources of hydrogen in Poland is the excessive coke oven gas, which contains more than 55% of hydrogen, is essential information too [14].

The subject matter of the analysis in this publication was hydrogen technology and hydrogen as one of the types of alternative fuels being part of the electromobility market in line with the classification adopted both in strategic documents and in the European Union law, and in Polish national law. Using the hydrogen technologies term in the definition of electromobility was also justified for the second reason. Hydrogen as a transportation fuel may be used in two ways:

(1) as a fuel which was combusted in an engine bay and
(2) with the use of fuel cells, generating energy driving an electric motor.

Due to many advantages (lightness, easy and fast filling of tanks) and specific problems with the use in a combustion engine (e.g., pre-ignition, hydrogen storage energy consumption in a liquid aggregate state), particularly the technology which uses hydrogen for the generation of electric energy through fuel cells is being developed now [15]. Therefore, hydrogen-driven vehicles and hydrogen-fueling infrastructure may be considered a part of the electromobility term, in which alternative fuel is not electric energy but hydrogen.

2. Methodology

In order to fulfill the purpose of the article, a comprehensive analysis of the legal acts of the polish and European legislation was carried out in the context of their impact on hydrogen technology in electromobility. In order to investigate the economic and social aspects, a questionnaire was created. To determine the preferences of potential users of electric vehicles based on hydrogen cells, survey research was conducted amongst users of hybrid and electric vehicles of 4 motorization companies (2 German and 1 French, and 1 Japanese). The group of respondents was selected not accidentally, since, based on results from earlier original research of November 2019, it was found that by far the largest interest in the hydrogen technology in motorization was demonstrated by the current users of vehicles with an electric drive or a combustion-electric drive (more than 77%), whereas the coefficient of interest in the hydrogen technology in motorization amongst users of traditional combustion vehicles came to only 35%. The research was carried out in 5 primary cities of Poland: Gdansk, Kraków, Szczecin, Warsaw, and Wroclaw, where the percentage of electric vehicles in the overall number of registered vehicles and pro-ecological awareness was the highest. In total, 171 users of hybrid and electric vehicles responded to 10 survey questions. A starting point for an analysis of the matters related to the hydrogen technology and maturing thereof should be the strategic documents adopted at the EU level and reflected in the legal acts of the EU, which would be either binding directly in the Member States of the EU (laws) or would have to be transposed into domestic law orders (directives), under Article 288 of the Treaty on the Functioning of the European Union (TFEU) [16].

In the European Green Deal it was indicated that the "achievement of climatic neutrality also requires a smart infrastructure. Closer cross-border and regional cooperation will help to benefit from transformation into pure energy at moderate prices. It will be necessary to review the frameworks regulating the energy infrastructure to ensure cohesion with the climatic neutrality objective. The said frameworks should be conducive to the use of innovative technologies and infrastructures, such as smart networks, hydrogen networks, and carbon capture, storage and utilization, storage of energy and should also enable integration of the sector" [17].

The consequence of implementing the European Green Deal was the adoption of the Hydrogen Strategy of the most significant assumptions presented in Chapter 1 of the publication.

The energy and climate policy of the EU and the legal acts entered into force at the level of the EU law should be reflected in policies and domestic law orders of the EU Member States. It is worth reminding that under Article 288 of the TFEU, a directive is binding in every Member State to which it is addressed regarding the result that shall be achieved. However, it leaves the freedom of choosing the form and means, and measures of domestic bodies. Therefore, the manners of implementing the Directive 2014/94 in the individual EU Member States may differ.

So far, Poland has implemented the Electromobility Development Program within the framework of the Strategy for Responsible Development until 2020 (with an outlook to 2030) [18]. Achievement of its objectives was the basis for the implementation of a regulatory package, which incorporated the matter of electromobility into the Polish policy and domestic law order, and, in principle, the problem related to the alternative fuel market, of which electromobility is a part. The Electromobility Development Program consists of the following strategic documents:

- the Development Plan of Electromobility in Poland Energy for the Future adopted by the Council of Ministers on 16 March 2017 [19]:
- the National frameworks of the policy for the growth of alternative fuel infrastructures, which have to be developed under the Directive 2014/94, adopted by the Council of Ministers on 29 March 2017 (national frameworks of the policy for development of alternative fuel infrastructure) [20].

In principle, the previous documents did not refer to hydrogen technology and hydrogen as an alternative fuel, mainly focusing on electric energy and gas fuels.

The draft document of the Energy Policy of Poland until 2040 along with updates (PEP 2040) [21] and the national plan for the benefit of energy and climate for 2021–2030, enlarged of which until the end of 2019 arose from the obligation imposed on the EU Members States by way of the Regulation of the European Parliament and of the Council (EU) 2018/1999 of 11 December 2018 on the management of the Energy Union, and activities in the area of climate [22] indicating the guarantee of functioning conditions and instrumentation of support of the alternative fuel market, particularly electromobility, as the strategic project. It was emphasized in the national plan for the benefit of energy and climate for the years 2021–2030 that the potential of using hydrogen should not be searched for only in the car transport but also in the railway, air, and sea intended use [23].

The PEP2040 project indicated that, due to the vast possibilities of using and the considerable interest in the technology, special attention should be paid to the production and use of hydrogen in transport and in other sectors. At present, hydrogen is applicable in the refinery industry, metallurgy, and during the production of fertilizers; however, the demand for this gas will be increased if it is possible to introduce it to the gas networks and to use it in fuel cells for the production of electric energy. Thanks to it, apart from the existing uses, it will be able to be successfully used in the transportation sector (cars, trucks, public transport, shipping, aviation), heat, and electrical power sectors (in fuel cells and gas turbines).

In PEP 2040, attention was paid to the fact that, due to the hitherto prevailing unprofitability of using hydrogen for energetic purposes, this technology was at a low level of development. However, because of the physical properties of hydrogen (it is light, reactive, it can be stored, it has high energy content per unit of mass), the ecological character (its combustion product is water vapor only), the problem of using hydrogen for energetic purposes became a point of the increasingly common interest. It would be a desirable situation, if the production of hydrogen in the future was carried out with the use of renewable energy sources, also as a way of managing energy production surpluses. In PEP 2040, it was also indicated that research projects and exchange of the hitherto prevailing experiences of interested entities and creation of a regulatory zone regarding the use of hydrogen in the transportation sector and power industry would serve the purpose of stimulating this market. The legal frameworks to use hydrogen shall be drawn up until 2021 so that the market can be developed entirely in the perspective of 2030 [24].

As it results from the above, the progressing of the energy markets including electromobility, which also comprised hydrogen technology and hydrogen as an alternative fuel, was one of the strategic projects of draft PEP 2040, which indicated that hydrogen technology should be at the center of interest of bodies competent to implement the energy policy. Ipso facto, the strategic projects should be transformed into legal regulations that would include standards assigning rights and obligations of particular entities to support the development of the electromobility market. Here, it must be reserved that it was necessary to specify that the planned policy within the scope of supporting the hydrogen technologies—which may take place, e.g., in the published hydrogen strategy, which, as it arose from communications of the Ministry of Climate and the Environment, the ministry is currently working on—shall be presented in a broader scope below.

However, it must be noted that the PEP 2040 project was adopted and announced under the provisions of the Act of 10 April 1997—Energy Law (Energy Law Act) [25]. According to Article 15a (1) and (2) of the Energy Law Act, the Council of Ministers—upon request of the minister in charge of energy affairs—adopted the energy policy of the country, and the minister in charge of energy affairs announced the energy policy of the country under an announcement in the Official Journal of the Republic of Poland Monitor Polski. Therefore, it must be considered now that PEP 2040 was not a binding document but only a draft document of the country's energy policy. Notwithstanding the above, one could put forward a thesis that hydrogen technology was part of the strategic documents and

policies of the European Union and the PEP project until 2040 and the National Plan for the benefit of energy and climate. The development of the electromobility and alternative fuel markets could be considered a priority objective of the Polish energy and climate strategy.

At present, works on creating the Polish hydrogen strategy, which is to be adopted under a resolution of the Council of Ministers, are pending in the Polish Ministry of Climate and the Environment. A starting point to the works on the hydrogen strategy was the fact of signing a letter of intent by representatives of the Ministry of Climate and the Environment, and the most significant and strategic companies of the energy and transportation sectors, on the establishment of partnership for the benefit of building the hydrogen economy and entering into a sectoral hydrogen agreement.

In line with the published heralds, the primary objectives of the hydrogen strategy were based on:

1. creating a value chain for low-emission hydrogen technologies;
2. strengthening the role of hydrogen in building Polish energy safety and security;
3. implementing hydrogen as a transportation fuel;
4. preparation of new laws for the hydrogen market [26].

Going on to the analysis of binding legal provisions concerning hydrogen technology and hydrogen both at the level of the EU law and at the domestic level, Directive 2014/94 must be taken as a starting point.

According to Article 2 point 1 of Directive 2014/94, alternative fuels were fuels or sources of energy, which were used at least partially as a substitute for the sources of energy coming from raw crude oil in transport and which may potentially contribute to the decarbonization of transport and improvement of the greenness of the transportation sector. They included, among other things, electric energy, hydrogen, bio-fuels defined in Article 2 (i) of the Directive 2009/28/EC of 23 April 2009 on the promotion of using energy from renewable sources [27], synthetic and paraffin fuels, natural gas including bio-methane in the form of gas (compressed natural gas—CNG) and in the liquid form (liquefied natural gas—LNG), and liquefied petroleum gas (LPG). Thus, hydrogen was deemed an alternative fuel.

Motor vehicles driven by hydrogen, including vehicles of category L (motor vehicles having two or three wheels, some motor vehicles having four wheels and mopeds—Appendix No 2 of the Act of 20 June 1997; Road Traffic Law (consolidated text: (Journal of Laws) OJ of 2020, item 110) [28]—driven by hydrogen, as indicated in point 37 of the introduction to Directive 2014/94, are currently characterized by a very low market penetration coefficient. Therefore, an extension of a sufficient hydrogen-refueling infrastructure was an indispensable condition making it possible for motor vehicles driven by hydrogen to be spread on a considerable scale.

Point 38 of the introduction to Directive 2014/94 indicates that the Member States, which decide to cover hydrogen-refueling points with national frameworks of the policy, should ensure that publicly available hydrogen supply infrastructure for motor vehicles shall be created, ensuring that motor vehicles driven by hydrogen would move within the networks specified by the Member States. In the relevant cases, it was necessary to take into consideration cross-border connections, which would allow motor vehicles driven by hydrogen to move around the whole Union. According to Article 3 of Directive 2014/94, Member States were obliged to adopt the national frameworks of the policy concerning the development of the market regarding alternative fuels in the transportation sector and to the development of proper infrastructure. The national frameworks of the policy should have been adopted by 18 November 2016. The introduction to Directive 2014/94 and Article 3 showed that taking into consideration hydrogen-refueling points in the national policies and provisions was optional and depended on the decision of the given Member State, whereas Directive 2014/94 requireed taking into account publicly accessible electric vehicle charging points in the national frameworks of the policy and legal regulations (Article 3 (8) and Article 4), and publicly accessible gas-fuel-refueling points—LNG and CNG for motor vehicles (Article 3 (8) and Article 6).

A reference to hydrogen was also made in Article 5 of Directive 2014/94 in accordance with which the Member States, which would decide to include publicly accessible hydrogen-refueling points in their national frameworks of policies, shall ensure the accessibility of an appropriate number of such points until 31 December 2025 to guarantee that motor vehicles driven by hydrogen, including vehicles driven by fuel cells, shall move within the limits of the networks specified by the said Member States including, in relevant cases, cross-border connections.

According to Article 11 (1), Directive 2014/94 should have been implemented by 18 November 2016. Poland adopted provisions of the Directive 2014/94 with more than one -year delay and, as indicated above, the adopted national frameworks of the policy and provisions did not take into consideration the creation of the publicly accessible hydrogen supply infrastructure for motor vehicles, which proved that, at the date of implementing the EU law provisions concerning electromobility and alternative fuels, hydrogen was not a priority objective for the Polish legislator. At that time, much more significant pressure was put on the infrastructure for charging electric vehicles, among other things, due to the fact that the obligation to take into consideration electric vehicle charging points and stations in the national frameworks of the policy arose out of provisions of the Directive 2014/94.

Apart from the Directive 2014/94, it was also necessary to invoke the Regulation of the European Parliament and of the Council (EC) No 79/2009 of 14 January 2009 on the type-approval of motor vehicles driven by hydrogen and amending Directive 2007/46/EC (regulation on type-approval) [29] which had a technical nature. The regulation on the type-approval established requirements for the type-approval of motor vehicles regarding the hydrogen driven and type-approval of hydrogen components and installations. The laws also established requirements for the assembly of such components and installations. Significant provisions of the regulation on the type-approval included the indication of obligations of hydrogen vehicle manufacturers and general and detailed requirements for hydrogen components and installations. The said legal act indicated that vehicles driven by hydrogen had already been an object of interest of the EU legislator over 10 years ago. A broader analysis of the regulation on the type-approval, which had an overly technical nature, went beyond the frameworks and subject matter hereof (beyond the scope of this publication was also an analysis of Directive 2009/31/WE of 23 April 2009 on the geological storage of carbon dioxide, and amending the Council Directive 85/337/EEC, Euratom, Directives of the European Parliament and of the Council 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC, and Regulation (EC) No 1013/2006 (OJ of EU of 5.6.2009 L 140/114) concerning CCS (carbon capture and storage) technology, i.e., CO2 sequestration. The CCS technology was the process of preventing the emission of carbon dioxide (CO_2) being released into the atmosphere from power stations and heavy industry factories. Directive 2009/31/EC was implemented to the Energy Law Act and the Act of 9 June 2011—Geological and Mining Law (consolidated text: OJ of 2020, item 1064) [30].

Going on to the national law, it must be indicated that within the framework of transposition of the Directive 2014/94, primarily two statutory regulations, along with implementing acts, were implemented, i.e.:

- the act of 11 January 2018 on electromobility and alternative fuels, which came into force on 22 February 2018 (Electromobility Act) [31];
- acts establishing the Low-Emission Transport Fund (FNT), i.e., the Act of 6 June 2018 on the amendment to the Act on bio components and liquid biofuels, and some other acts, which came into force on 28 July 2018 [32].

The Act on electromobility left both the hydrogen-refueling infrastructure and hydrogen vehicles on the margin of laws compared to the electric vehicle charging infrastructure and gas-fuel-refueling infrastructure; therefore, the provisions referred to hydrogen only in several places. This mainly arose from provisions of the Directive 2014/94, which provided the Member States with the right not to take into consideration the hydrogen-refueling

infrastructure in national policies and provisions, differently than in the case of the electric vehicle charging infrastructure and gas-fuel-refueling infrastructure—LNG and CNG.

An analogous description of alternative fuels (identical in terms of scope) to the description included in the Directive 2014/94 was stipulated in Article 2 point 11 of the Act on electromobility, where alternative fuels were considered fuels or electric energy used for driving engines of motor vehicles or vessels, constituting a substitute for fuels derived from crude oil. Thus, hydrogen was deemed one of the types of alternative fuel.

Moreover, hydrogen as an alternative fuel was part of several statutory definitions:

(1) a zero-emission bus was also considered a bus using electric energy as a drive generated from hydrogen in fuel cells installed in it (Article 2 point 1 of the Act on electromobility);
(2) the scope of the road-public-transport-charging infrastructure, including hydrogen charging or refueling points along with the accompanying infrastructure necessary for them to function, intended for charging or refueling, particularly zero-emission buses used in public transport (Article 2 point 3 of the Act on electromobility).

The said laws indicated that the legislator treated hydrogen equally to electric energy considering them as emission-free alternative fuels.

The definition of vehicles driven by hydrogen was vital for the hydrogen technology, i.e., the motor vehicle within the meaning of Article 2 point 33 of the Act of 20 June 1997—Road Traffic Law—using electric energy as a drive, generated from hydrogen in fuel cells installed in it. A significant provision indicating that the legislator included hydrogen technology in the market of alternative fuels was Article 32 (6) of the Act on electromobility. According to this regulation, the General Director of National Roads and Motorways (GDDKiA) may include the location of hydrogen-refueling points in the location plan of generally accessible charging stations and natural gas stations along roads of the Trans-European transport network (TEN-T), base network remaining under their management, i.e., a set of devices used for supplying hydrogen to vehicles driven by hydrogen to drive engines of these vehicles if the location of such points was justified by the needs for the development of the alternative fuel market. The plan was developed for a period of not less than 5 years.

A provision of Article 39 (1) point 2 of the Act on electromobility also indicated that limitations on the entry into clean transport zones in city centers having more than 100 thousand residents should not be binding on vehicles driven by hydrogen.

As a result of an analysis of the aforementioned regulations of the Act on electromobility, one can put forward the thesis that the regulation of hydrogen technology in transport-refueling infrastructure and hydrogen vehicles was residual compared with the laws implemented within the scope of electric energy and gas fuels. Such a legal state should be changed if the legislator intends to promote using hydrogen in transport. Here, it was necessary to go on to an analysis of legal regulations within the scope of the electromobility support system, including hydrogen technologies.

In consequence of establishing the FNT, based on a delegation for issuance of the laws contained in the Act of 25 August 2006 on bio components and liquid biofuels (Act on biofuels [33]), the following implementing acts were issued:

- the regulation of the Minister of Energy of 5 November 2019 on the detailed conditions for providing support for the purchase of new vehicles from FNT resources to natural persons not carrying out economic activities and conditions for settlement of the said support [34];
- the regulation of the Minister of State Assets of 23 December 2019 on the detailed criteria for the selection of projects to provide support from FNT resources [35];
- the regulation of the Minister of State Assets of 23 December 2019 on the detailed conditions for the provision of and method of settlement of support given from FNT resources [36].

By way of a provision of Article 10 of the Act of 14 August 2020 on the amendment to the Act on bio components and liquid biofuels and some other acts (Amending Act [37]), the FNT was liquidated, thereby changing the model of support and co-financing of electromobility and alternative fuels resigning from a separate fund, i.e., the FNT, which was managed by the National Fund for Environmental Protection and Water Management (NFOŚiGW; Pursuant to Articles 400 and 400b of the Act of 27 April 2001—Environmental Protection Law (consolidated text: OJ of 2020, item 1219), the NFOŚiGW is a state legal entity responsible and liable for financing environmental protection and water management within the scope stipulated in this act) [38] and handing over the competencies with regard to supporting the co-financing of electromobility and alternative fuels directly to the NFOŚiGW.

The forms of supporting electromobility and alternative fuels, and funds for financing the support were slightly modified. Repealed provisions of the Act on biofuels were transferred to the Environmental Protection Law Act dated 27 April 2001 (EPL Act) [39].

For this analysis, it was significant that the Amending Act incorporated a new form of support, i.e., the support in the form of co-financing the purchase of new M1 category vehicles (M category vehicles are motor vehicles designed and constructed mainly for the transport of people and baggage thereof. The M1 category includes vehicles having not more than eight seats apart from the driver's seat) [40] referred to in appendix No 2 of the Act of 20 June 1997—Road Traffic Law [41]—using electric energy as a drive, generated from hydrogen in fuel cells or using only electric energy as a drive (Article 401c (9c) point 12 of the EPL Act). Adding this form of support emphasized the fact that the legislator wanted to support vehicles driven by electric energy generated from hydrogen or only driven by electric energy, i.e., the broadly understood electromobility in a special way. The currently binding provisions which regulate the forms of supporting electromobility and hydrogen technologies, i.e., Article 401c (9c) points 1–13 of the EPL Act, also maintained the support in the form of co-financing construction or extension of the infrastructure for the distribution or the sale of hydrogen, and co-financing for manufacturers of means of transport using hydrogen as a drive including enterprises carrying out activities within the scope of production of components for means of transport driven by hydrogen. Such a range of support in the statutory provisions, which maintained and which, in the case of hydrogen technology, even extended the scope of support, and which allowed the NFOŚiGW to commence the construction and implementation of support programs could be considered satisfactory.

According to Article 28ze (1) of the Act on biofuels (currently Article 401c (9c) of the EPL Act) repealed on 1 October 2020, resources of the FNT (at present resources of the NFOŚiGW) could be allocated, among other things, for:

- supporting the construction or extension of the infrastructure for distribution or sale of compressed natural gas (CNG) or liquefied natural gas (LNG) including gas derived from biomethane or hydrogen, or construction or extension of the infrastructure for charging vehicles with electric energy, used in transportation;
- supporting the manufacturers of means of transport using electric energy, CNG or LNG as a drive including gas derived from biomethane or hydrogen and entrepreneurs within the meaning of provisions of the Act of 6 March 2018—Law on entrepreneurs—carrying out activities within the scope of production of components for the said means of transport;
- supporting the public-collective transport functioning particularly in urban agglomerations, health resorts, on areas where nature protection forms were established under the environmental protection provisions;
- supporting the research connected with the development of new types of bio components, liquid biofuels, other renewable fuels, or with the use of CNG or LNG, including gas derived from biomethane or hydrogen, or electric energy, used in transportation or the new construction solutions related to this and the support of exploitation implementations of research results;

- supporting the educational programs;
- supporting the purchase of new vehicles and vessels;
- supporting the activities related to analysis and survey of the market of bio components.

According to Article 28ze (3) of the Act on biofuels, the support for the aforementioned projects given from FNT resources, including the purposeful grant, could have the following form:

(1) grants;
(2) loans, including those given to territorial self-government units and other returnable financial support;
(3) taking up or acquiring by the FNT disposer, i.e., the minister in charge of energy affairs, for the benefit of the state treasury:
    a. stocks or shares of companies;
    b. bonds issued by entities other than the State Treasury or territorial self-government units, which carry out activities within the scope covered by the support.

In the current legal state, the ways of financing electromobility and alternative fuels, taking into consideration the previous forms of support, were specified in Article 411 of the EPL Act. A provision of Article 28zd (1) of the Act on biofuels also ensured financing the FNT. The revenues of the FNT were:

(1) purposeful grants from the state budget of up to 1.5% of proceeds from the excise duty on motor fuels planned in the previous fiscal year; the amount of the purposeful grant was specified by the Budgetary Act in the budgetary part of the disposer, of which was the minister in charge of energy affairs;
(2) interest on the free resources of the FNT handed over for the management under the provisions on public finance;
(3) resources handed over by the power transmission system operator of 0.1% of the justified return on capital involved in the conducted economic activity within the scope of the transmission of electric energy, referred to in Article 16b (3) of the Energy Law Act;
(4) proceeds from the substitution fee referred to in Article 23 (1a) of the Act on biofuels;
(5) proceeds from the emission fee referred to in Article 321a of the EPL Act, in part falling on the FNT;
(6) other revenues.

In the current legal state, revenues of the NFOŚiGW, including the previous categories of resources, were specified in Article 401 of the EPL Act. As the aforementioned analysis showed, the forms of supporting alternative fuels including the hydrogen technologies and revenues of the NFOŚiGW, which are allocated for granting this support, were transferred in principle in whole to the EPL Act. The change above, i.e., liquidation of the FNT, was difficult to be assessed now because provisions of the Act on biofuels regulating the support from the FNT and provisions of the EPL Act determining the support given directly from the NFOŚiGW were not binding in a more extended period. Indeed, this change must be assessed negatively in part due to the fact that no change for the NFT to the function was given, and afterward, no assessment of the support system operation was carried out. Not earlier than after the entry into the force of the statutory provisions, along with implementing acts and conducting at least several competitions for the obtainment of a particular type of support, one could think about making a correction of the provisions in force. Furthermore, there were statutory provisions regulating the rules on the functioning of the FNT, revenues of the fund, and supported activities. There were also issued extensive implementing acts, which allowed to conduct competitions for the support of individual activities, which, de facto, were not applied in practice owing to the liquidation of the FNT. Indeed, such activity had no positive influence on taking up actions, including investments aimed at developing the infrastructure of alternative fuels and vehicles driven by these fuels, including the commencement of investments in hydrogen technologies. The competitions for the support due to an amendment of the provisions were not announced

and carried out. Not earlier than after the amendment of the provisions, the NFOŚiGW could commence work on the announcement of calls within the scope of supporting electromobility and alternative fuels, which considerably delayed the start of the works on implementing the hydrogen technologies on the Polish transportation market.

On the other hand, the implementation of the provisions, which incorporated the basis for granting support by the NFOŚiGW based on provisions of the EPL Act and the calls within the framework of the announced programs, ensured the cohesion of the law system in this respect because the NFOŚiGW provided support for the development of electromobility and alternative fuels in the same way as for other environmental protection projects—we did not have to do with a fund functioning on the basis of a separate act, which may make the management of the support by the NFOŚiGW easier. Similarly, the determination of the rules on calls for individual types of support within the framework of the programs announced by the NFOŚiGW directly based on the provisions of the act may be more flexible than in the case of the regulation of the principles on calls in the form of laws to the act. Incorporating the modifications in the rules of support, e.g., favorable to beneficiaries, would require changing the regulation or laws, which would indeed last longer than the change of the rules on calls within the framework of the program implemented by the NFOŚiGW.

The currently binding statutory provisions, along with the programs of support implemented by the NFOŚiGW, should be assessed after implementing at least several co-financing programs and granting support for given projects.

It was necessary to pay attention to the fact that, at present, there were pending works on implementing the priority program New Energy within the performance of the provisions of the PEP 2040, the objective of which would be to support projects aimed at developing emission-free hydrogen technologies and production, and the technologies for transmission and the use of hydrogen, including, among other things, the following technologies:

- adaptation of the infrastructure to transportation of hydrogen;
- storage of hydrogen;
- use of hydrogen in the road, railway, or water transport;
- using synergic effects between the linking of sectors.

As indicated in a communication of the NFOŚiGW and in the available presentation, the budget of the New Energy amounts to PLN 2.5 billion—PLN 2.3 billion for loans and PLN 200 million for grants. The program included:

- a possibility of obtaining an innovative bonus up to 20% of the amount of the loan; however, not more than PLN 10 million for the achievement of the tangible effect of a given project;
- a potential grace period in repayment of the loan (18 months from the project completion date);
- a potential grace period in repayment of interest (for projects which last shorter than 2 years);
- a possibility of canceling up to 25% of the loan amount decreased by the amount of an innovative bonus provided that the amount of cancellation was allocated for the next project concerning the implementation of the same technology [42].

Moreover, the programs financing electric vehicles, activated by the NFOŚiGW, may be a model for implementing the system of support for hydrogen technologies:

- eVAN—co-financing of the purchase of an electric delivery van (N1);
- green car—co-financing of the purchase of an electric passenger car (M1);
- Koliber—a taxi good for the climate pilot project;
- green public transport [43].

3. Proposals of Amendments to the Legal State and Programs of Support of the Legislation in the Context of Optimization of the Development Process Electromobility Based on Hydrogen Cells in Poland

As the analysis conducted above showed, the EU and, first of all, the Polish legal regulations included residual provisions on hydrogen technology and hydrogen as a fuel compared to alternative fuels, such as electric energy, gas fuels (CNG, LNG, LPG), or biofuels.

It would be necessary to construct and implement legal regulations which, firstly, describe the rules of the creation and growth of the hydrogen technology infrastructure, including entities, which are to participate in the development of hydrogen technology.

A starting point should be the approval of the PEP2040 so that the draft would finally become a binding document. Afterward, it would be necessary to specify the policy on the support of electromobility and alternative fuels through the implementation of the hydrogen strategy by imitating the strategy adopted by the European Commission, which would be an addition to the draft PEP2040 and national plan for the benefit of energy and climate for the years 2020–2030, and which would be the basis for the implementation of the legal regulations and the incorporation of the systems for support of hydrogen technologies in transportation. Moreover, it would be required to update the national frameworks of the policy on the alternative fuel infrastructure to take into consideration the hydrogen-refueling infrastructure in the document.

In September 2020, a press release of the Vice-Minister of Climate Ireneusz Zysk, who heralded the creation of the draft hydrogen law act (W. Jakóbik; The Ministry of Climate was already drawing up the hydrogen law. It will be ready in the third quarter of 2021; https://biznesalert.pl/ustawa-prawo-wodorowe-prace-ministerstwo-klimatu-trzecikwartal-2021-energetyka-wodor-innowacje/, accessed on 12 January 2020), [44] appeared. The act's task was to implement the assumptions of the energy strategy within the scope of using hydrogen technologies. Based on this legal act, energy purposes until 2030 and until 2050 shall be determined. This project is to be ready already until the third quarter of 2021. As indicated in the Second Chapter of the publication, there were pending works on implementing the Polish hydrogen strategy. Thus, the heralds showed that the Polish Ministry of Climate and the Environment intended to implement the hydrogen strategy and draw up the draft hydrogen law act. The announcement of the adoption of a separate act pertaining only to hydrogen shall be treated as another argument for the thesis that the Polish legislator planned to implement the hydrogen technology into the transportation market and intended to activate the programs of the support for hydrogen. Both of these intentions, in terms of direction, must be assessed positively. At present, we do not know the details of the said activities; thus, we cannot analyze and assess them.

Going on to the postulates of the authors hereof, first, it was necessary to indicate that a very significant aspect would be to create a legal environment for the functioning of the hydrogen technology infrastructure—including hydrogen-refueling stations in imitation of the provisions on charging stations, and CNG- and LNG-refueling stations in the Act on electromobility, without which it would be difficult to commence the investments and commence the implementation of the support programs by the NFOŚiGW and other institutions. One may take into consideration the implementation of the new Act on hydrogen technology (Act on hydrogen) or the amendment of the Act on electromobility and alternative fuels by adding solutions concerning the hydrogen-refueling infrastructure. Because of the cohesion of the law system—arising, among other things, from Polish legislative technique principles [45]—where it was indicated in § 2, among other things, that the act should exhaustively regulate a given field of matters, not leaving beyond the scope of its regulation of significant fragments of the said field; it would be necessary to declare an amendment of the Act on electromobility and alternative fuels so that the provisions on all alternative fuels would be in one legal act.

Therefore, it would be necessary to postulate the introduction of the laws within the scope of the hydrogen infrastructure, which were at least analogous as in the case of the charging stations and gas-fuel-refueling stations, for example:

(1) introduction of the definition of a generally accessible hydrogen-refueling station and hydrogen charging points;
(2) introduction of the definition of an operator of a generally accessible hydrogen-refueling station and an indication of what entity may be or will be an operator of a hydrogen-refueling station;
(3) adding provisions specifying the rights and obligations of an operator of a generally accessible hydrogen-refueling station;
(4) introduction of provisions specifying the obligation to draw up a construction plan and schedule for generally accessible hydrogen-refueling stations along with the indication of an entity obliged to draw it up for a given area (e.g., territorial self-government unit body—in the case of the municipality: commune head, mayor, president of the city);
(5) potential indication of an entity obliged to construct generally accessible hydrogen-refueling stations if the number of stations built on a given area is not achieved within the indicated deadline and indication of sources of financing these investments;
(6) introduction of provisions along with implementing acts determining an obligation and scope of technical tests of hydrogen-refueling stations and an entity entitled to conduct the said tests (e.g., the Office of Technical Inspection (UDT) or the Transport Technical Supervision (TDT));
(7) taking into consideration generally accessible hydrogen-refueling stations, apart from charging stations and CNG- and LNG-refueling stations, in the Alternative Fuel Infrastructure records [46].

It would also be essential to indicate the role of public institutions in the implementation of hydrogen technology. Similarly, as in the case of electric vehicles, one might take into consideration the incorporation of an obligation to have a particular share of hydrogen vehicles in the company car fleets used in central offices of public administration bodies and bodies of territorial self-government units.

It would also be significant to take into account the role of public collective transport in the increased use of alternative fuels and to introduce an obligation in collective transport fleets concerning a particular share of zero-emission buses driven by hydrogen.

It would be essential to promote hydrogen vehicles by introducing incentives into the tax law. It would be necessary to preserve an exemption from the excise duty on passenger cars being hydrogen vehicles (Article 109a (1) of the Act of 6 December 2008 (consolidated text OJ of 2020, item 722)) [47]. Additionally, there should be introduced, in analogy to the case of electric vehicles, increased amortization and depreciation allowances on the wear of hydrogen vehicles in the acts regulating income taxes (amendments in the Act of 26 July 1991 on personal income tax (consolidated text: OJ of 2020, item 1426) and Act of 15 February 1992 on corporate income tax (consolidated text: OJ of 2020, item 1406)) [48].

Facilities in the building law would be another measure that might facilitate and accelerate the investments into the hydrogen-refueling infrastructure. One of the favorable solutions, like in the case of electric vehicle charging stations was the introduction of an exemption from the obligation to obtain a decision on the permit for building hydrogen-refueling stations, in Article 29 of the Act of 7 July 1994—Building Law (consolidated text OJ of 2020, item 1333.) [49].

It would also be necessary to postulate maintaining the provisions in force, or extending the scope thereof, which introduce the incentives for acquiring and moving vehicles driven by hydrogen, like in the case of the privileges incorporated for electric vehicles, for example: free of charge parking in city centers, the right to enter low-emission transport zones, the right to move along traffic lanes intended for urban communication and taxies (bus passes), and distinguishing hydrogen vehicles through different registration plates (green registration plates).

Within the scope of the provisions on support of electromobility and alternative fuels, including hydrogen, as it arose from the previous analysis, in the current legal state there are provisions in the EPL Act which formed the basis, among other things, for supporting

activities related to an analysis and study of the hydrogen market and implementation of this fuel in transportation, providing grants and loans both for the construction of the hydrogen-refueling infrastructure and for the purchase of vehicles driven by hydrogen, supporting manufacturers of vehicles driven by hydrogen and co-financing of public collective transport to acquire vehicles driven by hydrogen. Maintenance of said laws in force, despite the liquidation of the FNT, must be assessed positively. The presented laws must remain in force and, on their basis, the NFOŚiGW should commence calls for the programs of support in individual scopes for the hydrogen technologies. By this time, as indicated above, it would be necessary to extend the laws pertaining at least to the functioning scope of the hydrogen-refueling infrastructure.

As it arose from the entire analysis carried out above, the implementation of hydrogen technology in transportation by the time when it could compete with conventional fuels—i.e., the price of hydrogen and the investments in the infrastructure would be comparable to solutions of the currently existing technologies—it seems necessary to implement adequate systems of support, which would allow for the gradual implementation of hydrogen as a fuel not only into the transportation market—electromobility market—but also into the entire economy.

4. Economic Aspects of Motorization Based on Hydrogen Cells

A modern energy system should take into consideration the possibilities of obtaining energy from renewable sources to the maximum possible extent. Those obviously include solar energy, wind energy, water (i.e., rivers, sea forces), but also nuclear energy, biomass, biogases, and bioliquids, geothermal energy, aerothermal energy, hydrothermal energy, and biomass combustion processes. In numerous aspects, hydrogen is also an excellent fuel. It is an overly efficient fuel, does not emit waste gases (in a combustion process), and is not a greenhouse gas itself. Thus, it is not toxic, and, apart from the common neutral occurrence, it can be generated without limit from renewable energy sources. As the European Commission claims, hydrogen will help to decarbonize the industry and transport; to generate energy in the whole of Europe; and the entire strategy will be based on the investment potential, regulation, and the new market based on innovations and research of the research and development (R+D) sector. Hydrogen can be a source of energy in sectors that, so far, have not been fitted for electrification and which can enable the storage of energy to balance the flows of energy from renewable sources. The achievement of this result requires the coordination of actions between the public sector and private sector at the EU level, and a special priority is the production of the so-called clean hydrogen, mainly from wind and solar energy. As mentioned before, the energy reformation process does not take place at once; thus, it requires a process-based attitude, and the EU policy classifies it in the following manner:

- in the years 2020–2024, the support for the installation of hydrogen electrolyzers powered by energy from renewable sources, with the power of at least 6 gigawatts, producing up to one million tons of renewable hydrogen;
- in the years 2025–2030, hydrogen must become an integral part of a modern energy system, with electrolyzers characterized by the power of at least 40 gigawatts and the production of up to 10 million tons of renewable hydrogen in the EU;
- in the years 2030–2050, the technologies for the production of renewable hydrogen should achieve maturity and be implemented on a considerable scale in all sectors that are difficult to be decarbonized.

The initiated European Clean Hydrogen Alliance, which united representatives on the social side, and leaders of the industry, national ministries, and the European Investment Bank (EBI), created a specific kind of institution for the support of investments, aimed at developing the production of the so-called green hydrogen and at stimulating the demand for implementation of hydrogen in countries of the EU community. According to reports of the European Commission, every week, new projects appeared for the benefit of developing hydrogen energy (frequently already even with the power of 1 gigawatt), and

from November 2019 to March 2020, the list of planned global investments was increased from 3.2 GW to 8.2 GW of electrolyzers with the realization period until 2030 (57% of which were located in countries of the EU). Analysts of the European Commission also noted down a considerable increase in the number of entities acceding to the International Hydrogen Council, i.e., from 13 units (2017) to 81 as of today. Thus, in accordance with forecasts, more and more entities discerned the energy potential of hydrogen as an energy medium, possible to be applied on a vast scale. In its strategic vision of an energetically neutral Europe, in November 2018, the European Parliament published information on a planned change of the community's energy mix in which the percentage of hydrogen, from the level of 2-4%, shall account for 13–14% until 2050.

The energy revolution also pertained to other sectors. They included, e.g., the motorization sector in which an electromobility development trend is currently noticeable. It seemed that the electromobility term itself had already had a different influence for some time on social awareness, and this idea was positively received. First, people had to get acquainted with bases of such a progressive direction, accept it, and afterward, popularize such a trend in the motorization sector, and become users of vehicles with a non-conventional drive of their own. Advantages of an electric car were already commonly known, but still, there are many types of barriers having an influence on customers' preferences. First of all, the cost of the purchase influenced the popularity of these types of vehicles. Furthermore, these vehicles have a smaller range than models with a combustion drive and a relatively long charging time. Still, the most significant manufacturers from the sector cope with technical exploitation aspects. This data was reflected in the number of vehicles moving today on European including Polish roads.

A report of the International Council on Clean Transportation—the European Electric Vehicle Factbook (2019/2020)—presented, in detail, the 16 most significant domestic markets in the European Union and European Free Trade Association (EFTA). In every country, there were identified metropolitan regions and areas where electric vehicles were most popular, including battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV), and the market dynamics were described in terms of the best models of electric vehicles and manufacturers. In 2019, in the whole of the EU, more than 560 thousand electric vehicles were registered, which was reflected in the final cumulative result at the level of 1.8 million registered vehicles at the end of 2019 and the second place in terms of sales in the world. In contrast, it was still China that was a power in this sector, with general sales at the level of 3.5 million since the beginning of the existence of the electromobility sector. Whereas, in the third place of the podium, United States were classified with the number of 1.4 million vehicles. According to the authors of the report, sales of electric vehicles had still been on the rise since 2010 (with an average annual increase of 50% over the last five years). A share of vehicles in the European motorization market was dispersed, and other countries with the highest percentage in 2019 were Norway (56%), the Netherlands (15%), and Sweden (11%). Unfortunately, the percentage of other representatives of the EU community still remained at the level of 1–2%.

However, the technology is still being perfected, and the most significant motorization groups are searching for newer and newer solutions concerning drives. Additionally, the increasingly strict EU provisions on the emission of CO_2 increased the orientation of production towards vehicles with an alternative hydrogen drive. However, it was worth emphasizing already at the start that the so-called hydrogen vehicles were also electric cars, but they did not store energy in a battery but in a specially adapted tank with compressed hydrogen. From the said tank, hydrogen was sent to the cells, where it generated energy with an admixture of oxygen. Regardless of the model, it was necessary to pay attention to the fact that the costs of the exploitation of the vehicles would be lower than in the case of a car with a combustion engine. It involved a much smaller number of construction components and such, which required necessary replacements after a particular number of kilometers, were covered; thus, servicing costs would considerably decline. Additionally, the cost of obtaining the fuel itself was lower compared with fuels

intended for conventional vehicles. Another aspect was also the potentially lower failure frequency of such a vehicle (it had fewer components exposed to damage). However, in a social aspect, there was still the fear of small or untrue distance (faster loss of the reach caused, e.g., by weather conditions), which could be covered by the vehicle with an alternative drive. Additionally, the energy efficiency aspect must be mentioned. In the case of electric vehicles, 8% of the loss was generated by the transmission moment of the energy to the battery itself. Next, as much as 18% was lost by the vehicle during the conversion of power necessary for the generation of the drive. That means that, while using a new, entirely operational car, already at the start, we could only use 70–80% of its efficiency (depending on the model). As a rule this vehicles are definitely exceptionally technologically advanced, various advantages and dis advantages are included in Table 1. However it cannot be clearly indicated that cars powered by renewable sources will be vastly popular, because there are a number of factors, including personal ones, that might determine it.

Table 1. Disadvantages and advantages of using the hydrogen drive.

Disadvantages	Advantages
Smaller efficiency in relation to the electric drive	Zero-emission of exhausted gases (formation of water steam)
Lack of available charging infrastructure	Resource of which the availability is unlimited
High flammability	Relatively fast vehicle charging process
High costs of maintenance and purchase of vehicle	Considerable range
Requires using even more specialized technical solutions than the standard electric vehicle charging points	Lack of noise when the engine works

Source: own study.

5. Results and Discussion

As a result of the research on the research sample, the following results were obtained in response to individual questions from the survey.

To the question: Are you interested in novelties in the area of electromobility based on hydrogen cells?—see Figure 1: almost 2/3 of the respondents answered rather yes. Next, 17% gave a definite confirming answer, which, in total, accounts for 82% of the researched sample group interested in novelties in this respect. Further, 15% of the interviewees indicated rather a lack of interest; and a definite lack of interest was expressed by only 2% of the researched sample group. The number of those who were indecisive was minimal, with 1% of the overall number of respondents. Such a distribution of answers confirmed the earlier original research stating that the group of drivers using hybrid and electric vehicles was a group with well visible preferences, as far as interest in another electromobility technology based on hydrogen cells was concerned.

With regard to the opinion of the respondents about electric vehicles based on hydrogen cells, over 2/3 of the interviewees stated that they would be, or would rather be, the future of motorization. Less than 1/5 of the respondents had a different standpoint, and 13% did not mind this respect—see Figure 2. Here, you could see an explicit correlation between the interest in novelties concerning hydrogen cells in motorization and the conviction of their indispensable domination in the future.

An indispensable topic discussed, while talking about development of electromobility based on hydrogen cells, was the matter related to the safe use of such vehicles—see Figure 2.

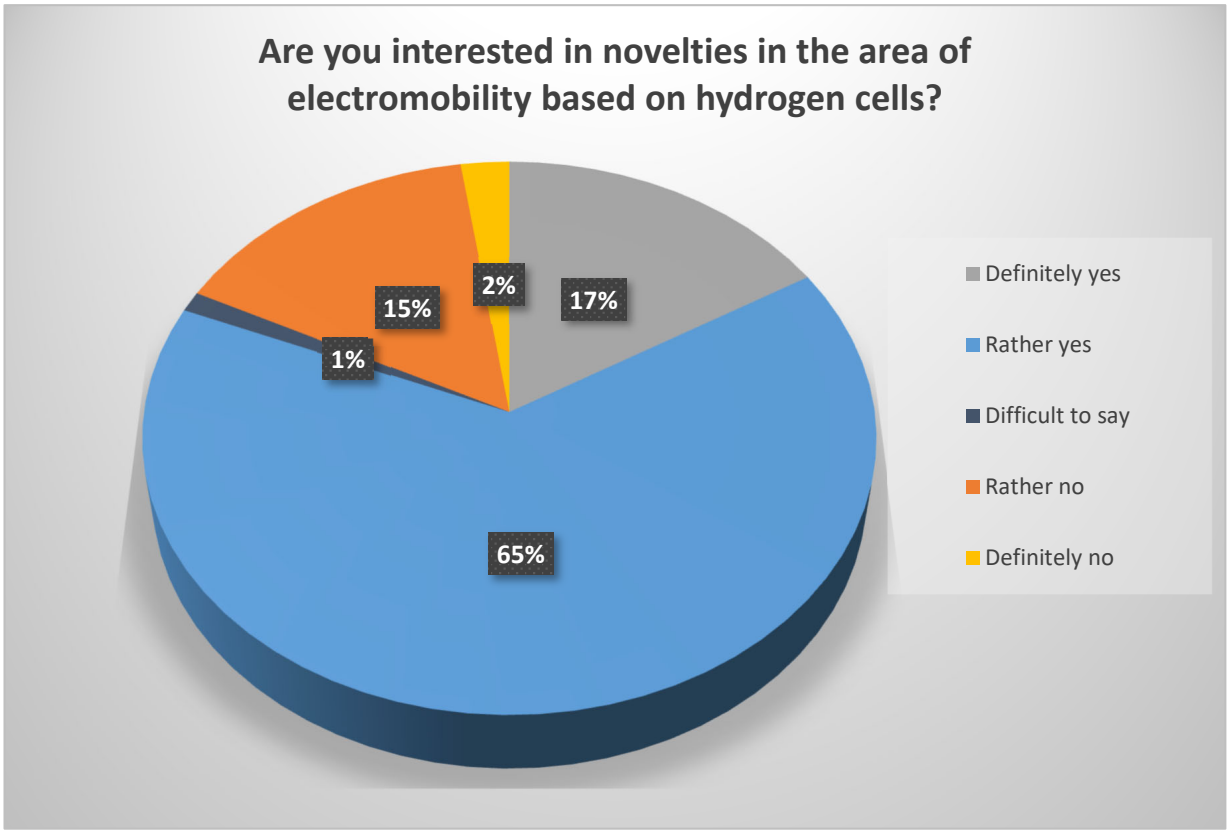

Figure 1. Survey question number 1. Source: own study.

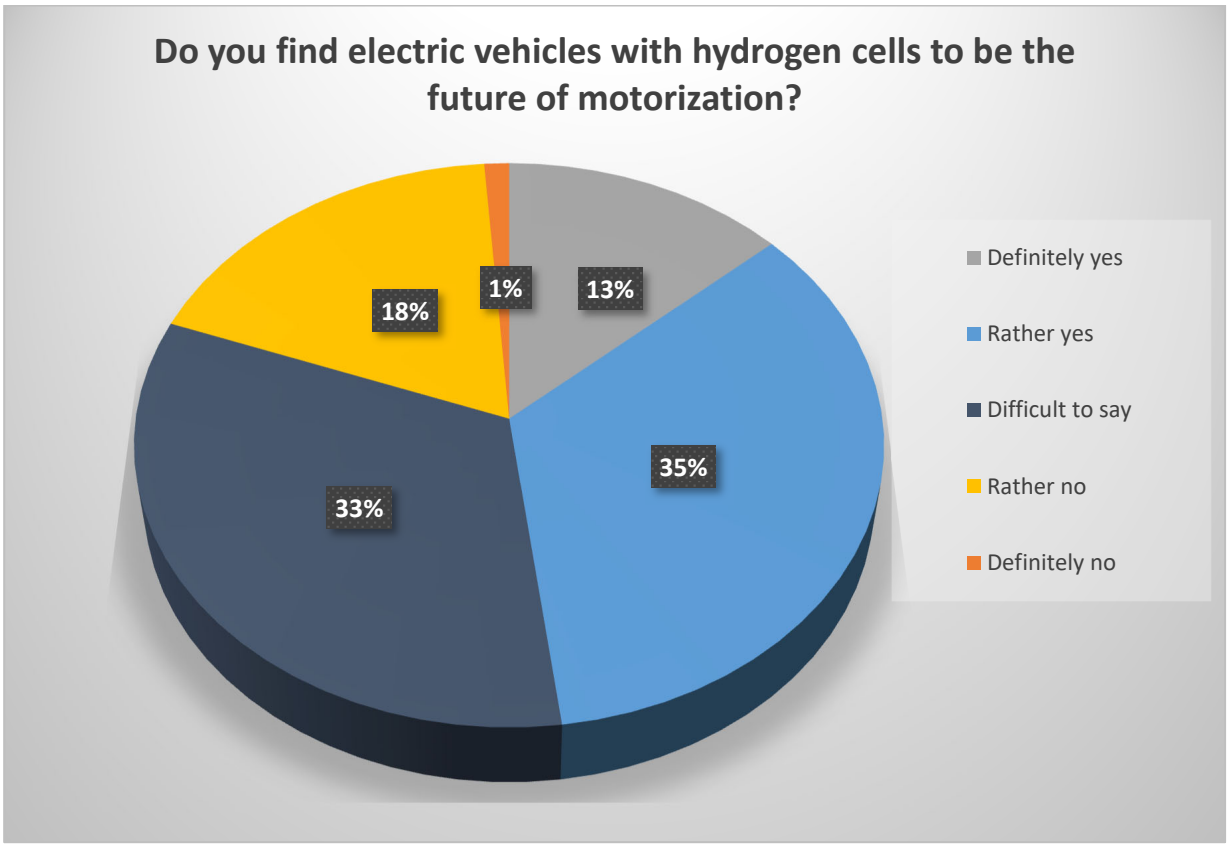

Figure 2. Survey question number 2. Source: own study.

Only 12% of the respondents definitely found them to be safe for users, whereas nearly 40% of the interviewees did not mind this respect. A comparable number of respondents—42%—indicated that such vehicles are rather safe. Such a high percentage of respondents who did not mind and those who found vehicles with hydrogen cells to be rather safe showed that there is a need to carry out a more effective information campaign about this technology and a necessity to indicate assets thereof in the area of safety. It must be remembered that the group of respondents was, anyway, the most positively oriented group of car users towards novelties in motorization.

Apart from the safety of use, an increasingly significant role in the choices concerning mobility was played by the problem related to the protection of the natural environment. In this respect, in total, 82% of the interviewees indicated that electric vehicles based on hydrogen cells were definitely or rather friendly to the environment. In total, 11% of the respondents had an opposite standpoint—see Figure 3. One can assume that such a high percentage of the respondents convinced of the friendly impact of the hydrogen technology in motorization arose from the shared knowledge of modernity of the said technology and, in consequence, of its greenness.

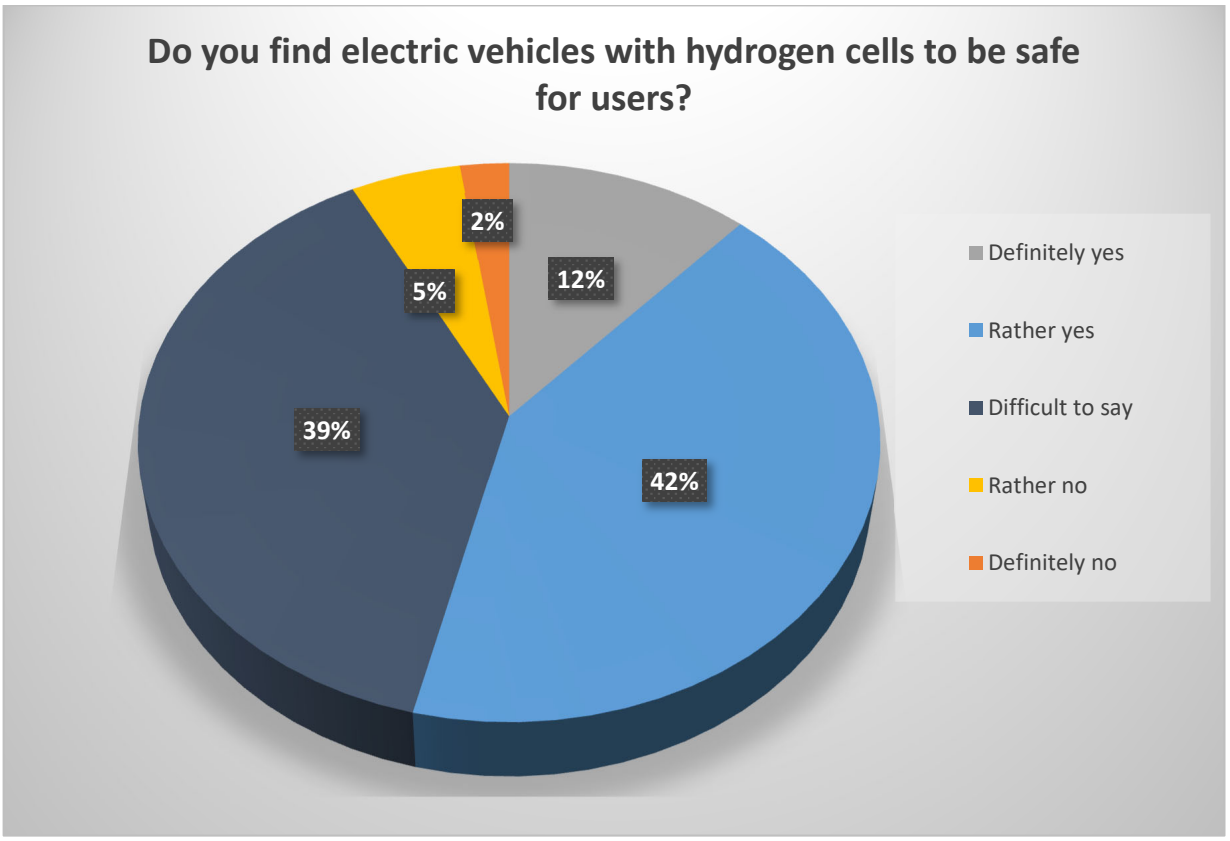

Figure 3. Survey question number 3. Source: own study.

Amongst users of hybrid and electric vehicles, in Poland, there was very high uncertainty in regard to the purchase of an electric vehicle with the technology of hydrogen cells. Nearly 60% of the respondents could not express their standpoint in this respect. Only 4% of the interviewees were decided to purchase such a vehicle, and $\frac{1}{4}$ of the respondents took such a possibility into consideration. Further, 12% of the respondents did rather not take into consideration or were definitely not interested in such a purchase—see Figure 4. This distribution of answers may indicate that the hydrogen technology in motorization is still a matter that is too distant for car users, and its real commonness in the upcoming years is still small.

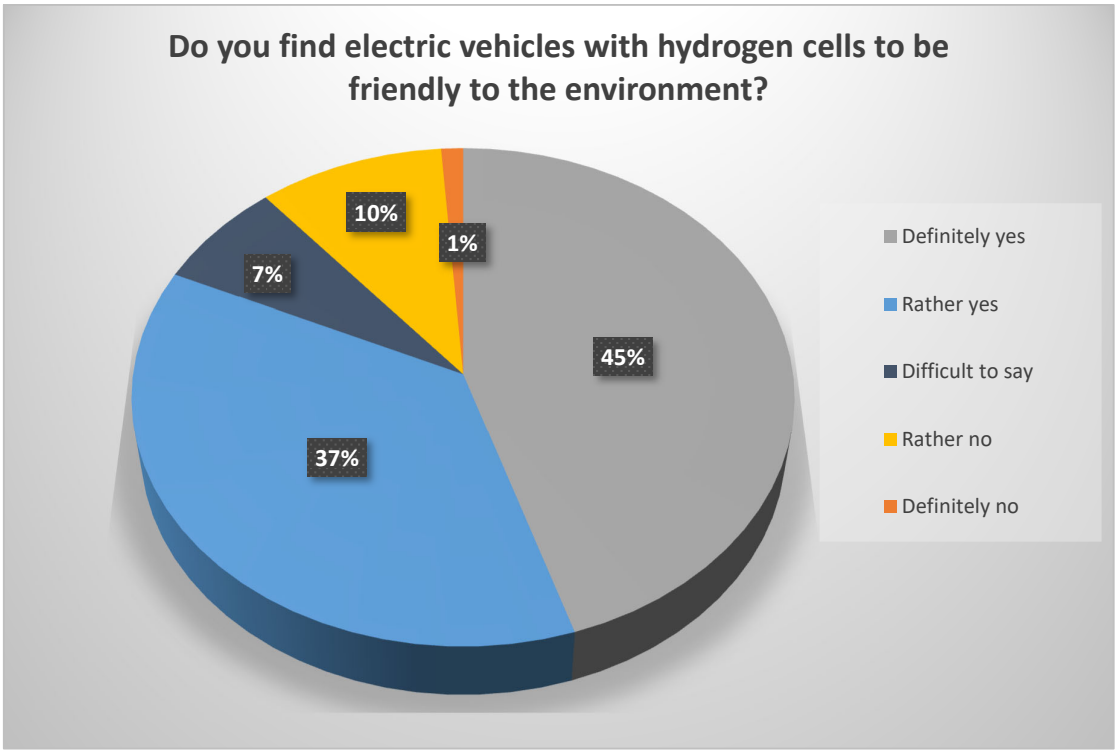

Figure 4. Survey question number 4. Source: own study.

While purchasing goods characterized by long-term use, such as cars, a very significant factor determining the purchase was the price. According to the vast majority of respondents—78%—the price for electric vehicles based on hydrogen cells was by far too high. Only 4% of the interviewees found the current prices for such vehicles to be appropriate, and nobody indicated that they were too low—see Figure 5.

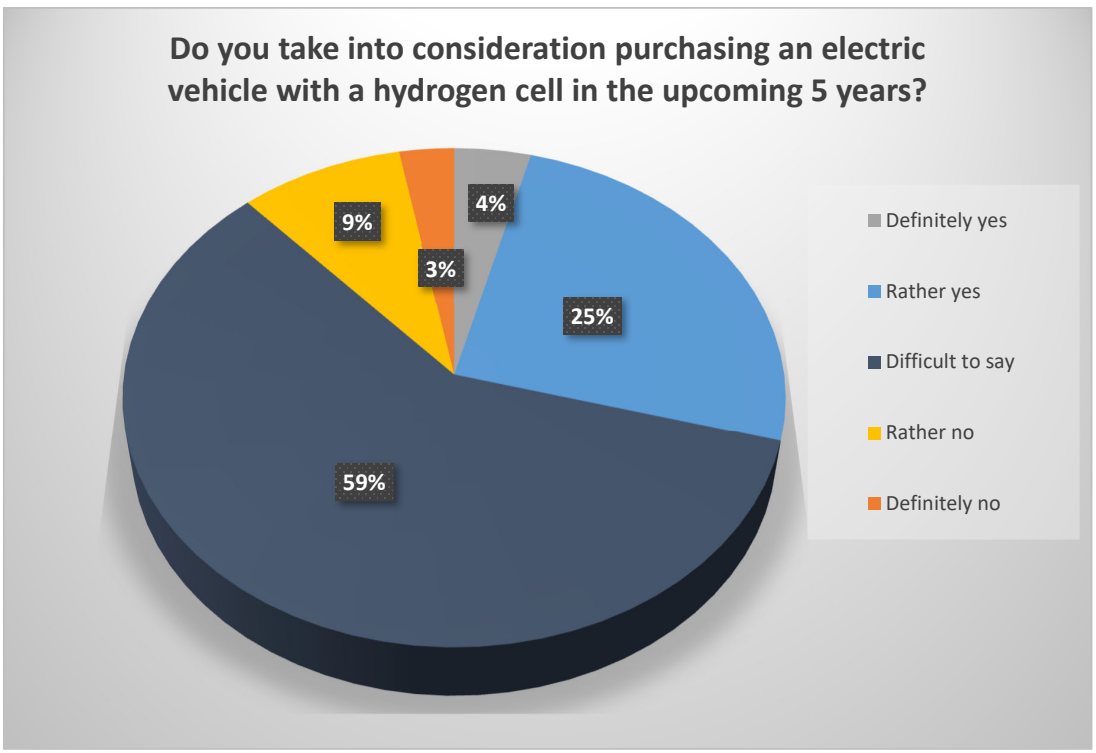

Figure 5. Survey question number 5. Source: own study.

The answers unequivocally indicated that, according to common belief, the price for purchasing a car in hydrogen technology is too high, especially that this was unequivocally indicated by users of vehicles who have already decided now to purchase relatively more expensive vehicles than the standard combustion cars.

A total of 72% of the respondents thought that the State should determine co-financing the development of electromobility for cars in the hydrogen technology, in relation to other electric cars, a priority. In total, 13% of the respondents had an opposite standpoint—see Figure 6. It must be remembered that the respondents were current users of hybrid and electric vehicles, who, despite this fact, indicated the need to establish a priority in co-financing electric vehicles based on hydrogen cells.

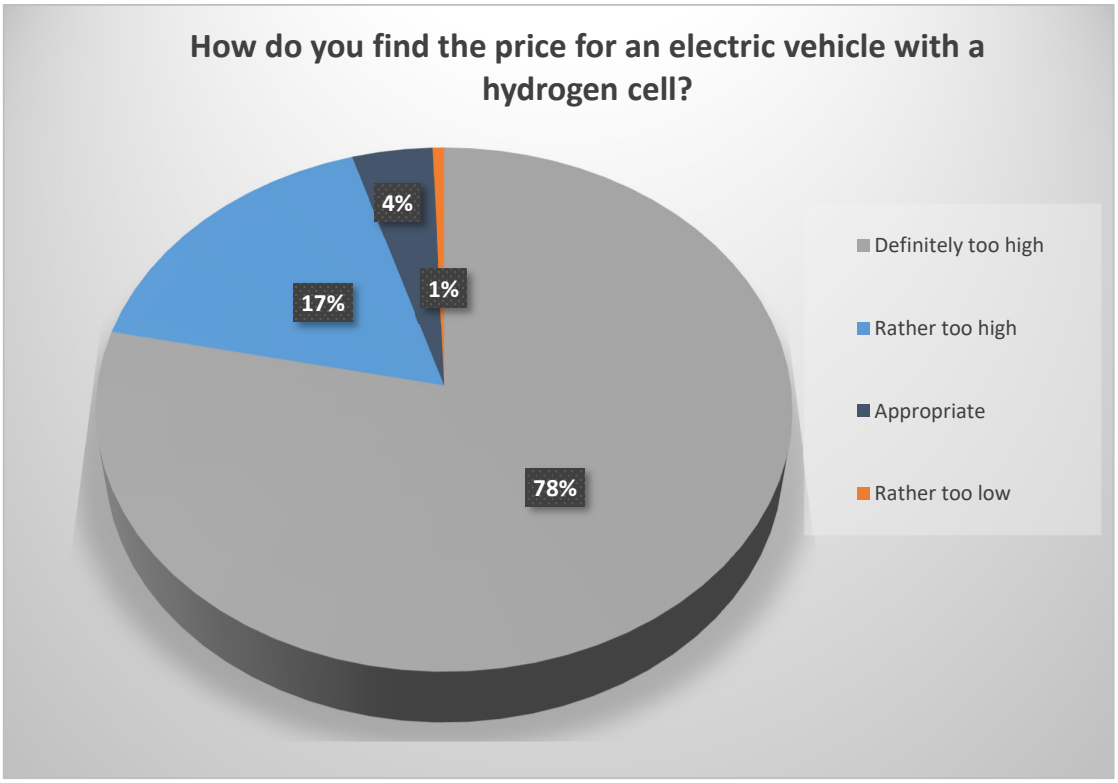

Figure 6. Survey question number 6. Source: own study.

Amongst the barriers to the development of motorization in the hydrogen technology, the interviewees mainly indicated an insufficient number of hydrogen-refueling points—nearly 90% of the answers; and, again too high price of this technology—85% of the answers. More than 1/3 of the respondents paid attention to the danger for users related to the properties of hydrogen. Inaccessibility of hydrogen fuel, as well as the mentality and habits of users, were considered by the interviewees to be much less significant—see Figure 7. The answers clearly showed that to decrease the barriers to the development of electromobility based on hydrogen cells, it is necessary to ensure an appropriate infrastructure for refueling hydrogen fuel and to reduce costs of the hydrogen technology in motorization.

Amongst the factors, which may have a positive impact on the development of electromobility based on hydrogen cells, the respondents in more than 90% indicated financial and fiscal incentives during the purchase of cars in this technology and the extension of the networks of hydrogen charging points in 89% of the answers. By far, the broader choice of car models in this technology and an increase in zero-emission zones in the cities were also mentioned by the interviewees as essential. Respectively, 68% and 45% of the answers—see Figure 8. Again, the price and infrastructural factors turned out to be the most significant.

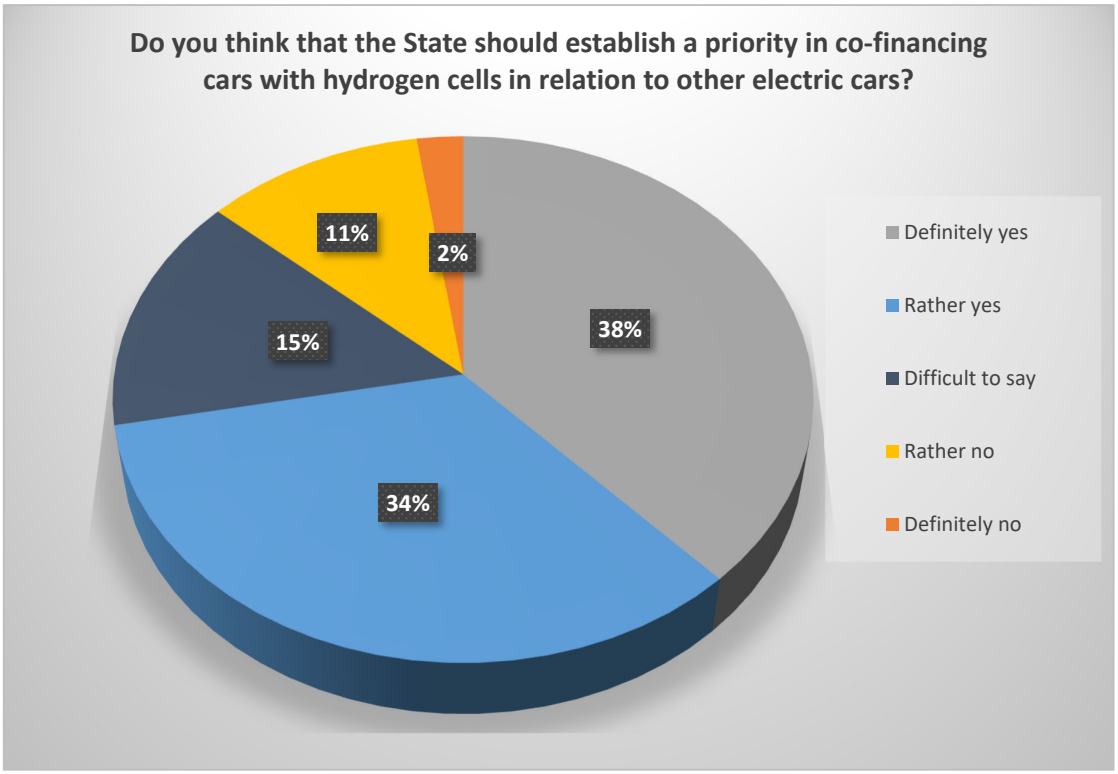

Figure 7. Survey question number 7. Source: own study.

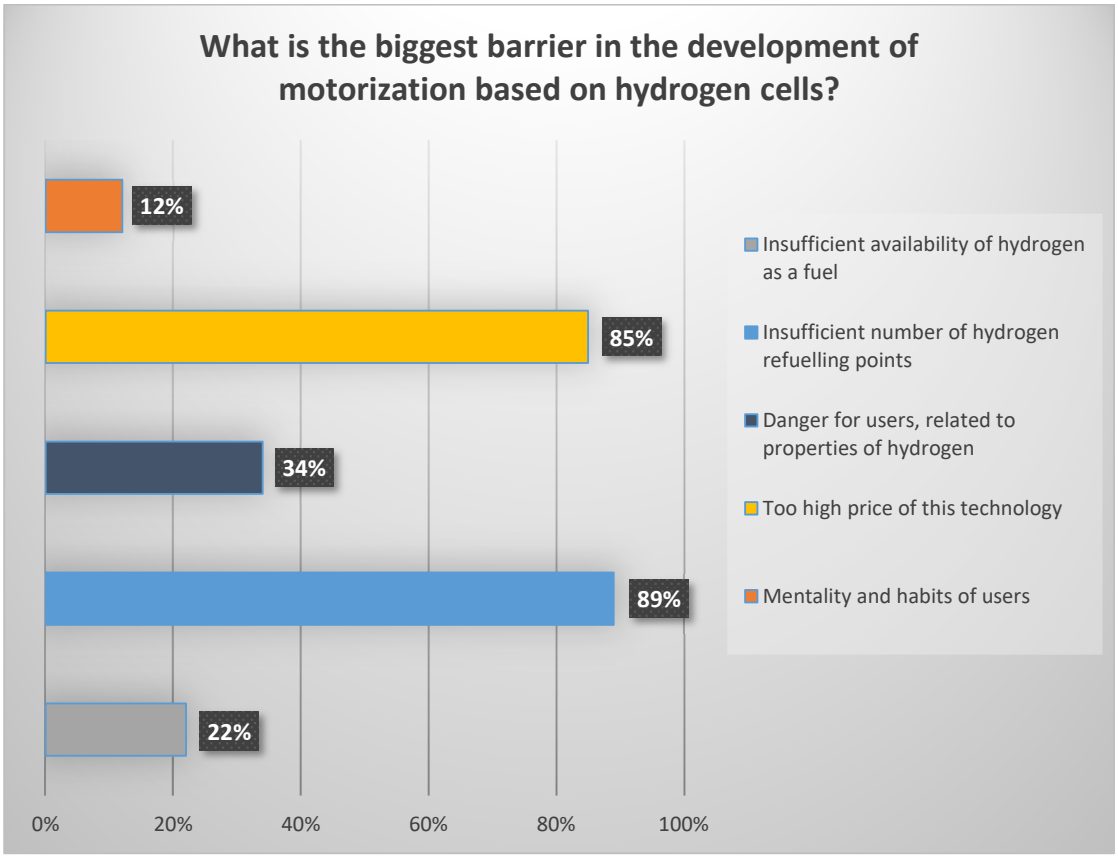

Figure 8. Survey question number 8. Source: own study.

The hydrogen technology in electromobility is a novelty amongst vehicle users, which does not mean that they do not have expectations towards further thrive thereof. Among the most essential areas requiring further development within the framework of this technology, the respondents indicated towards an increased safety of users—82% of the answers; and economy of exploitation of electric vehicles based on hydrogen cells—77% of the answers. The comfort of traveling, the autonomy of the vehicles, and the durability thereof turned out to be much less significant to the interviewees—see Figure 9.

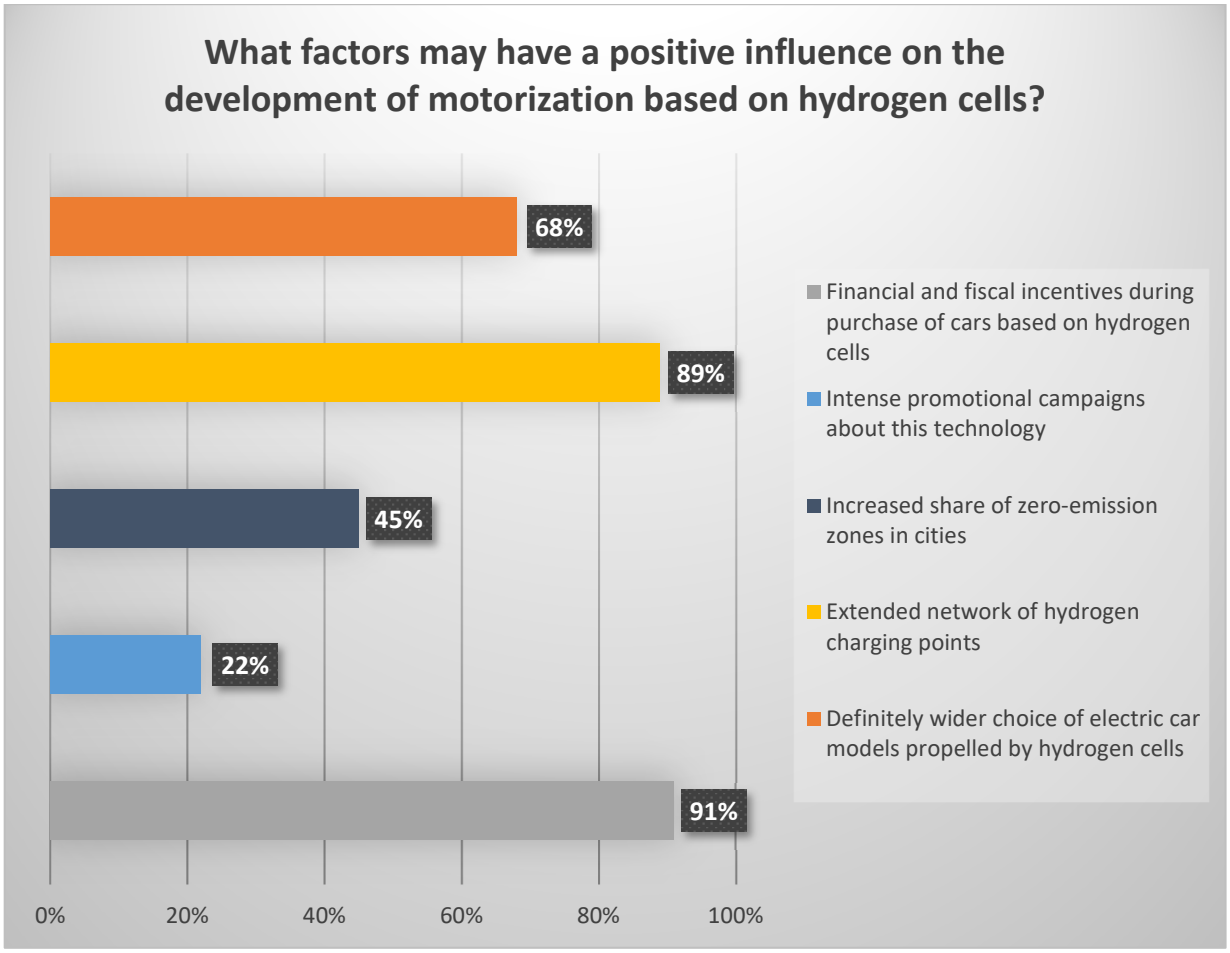

Figure 9. Survey question number 9. Source: own study.

In the final issue—see Figure 10, the respondents indicated the most sensitive areas related to the development of electromobility for vehicles powered by hydrogen energy. Two areas stands out: the costs related to the operation of the vehicle and the safty of use. The least important feature was selected by the respondents as the intense promotional campaigns about the durability of the battery itself (28 % of the respodents). However, vehicle battery life can be a significant issue. Travel comfort (45% of respodents) and vehicle autonomy (38%) are classified at similar levels.

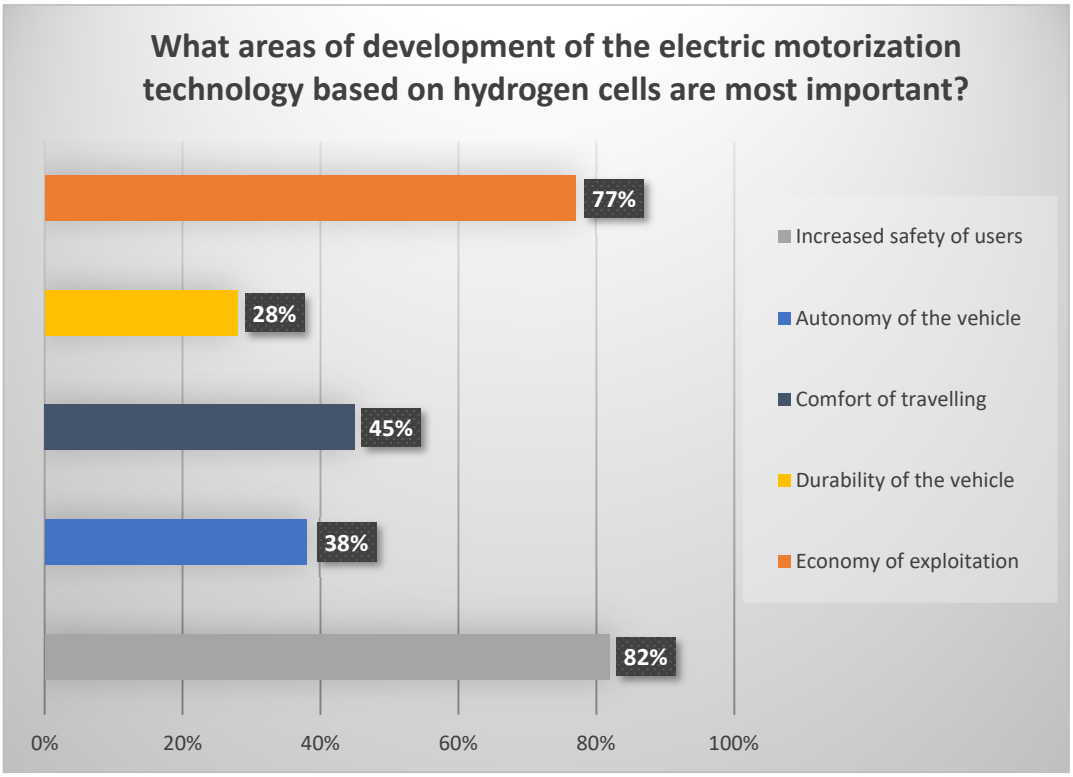

Figure 10. Survey question number 10. Source: own study.

6. Summary and Conclusions

It was an attempt to present a topic related to hydrogen-powered electromobility, based on a legal analysis, economic and social conditions. Although the research was conducted in Poland, based on a research group composed of electric vehicle users and on the basis of the Polish legal system, outwardly, the results of these studies can be applied to other European Union countries. Of course, this requires further research in other EU countries. This will enable a better understanding of the hydrogen cell challenges in the automotive industry.

Summing up, it must be stated that for the development of electromobility based on hydrogen cells in Poland, an overly significant matter was the construction and implementation of the law order based on the European and national legal acts because the current ones include residual provisions on the hydrogen technology only. Equally important to the development of this technology was an increase in its economic effectiveness and competitiveness in relation to other technologies used in motorization and an increase in the level of social trust for electric vehicles based on hydrogen cells. The research constituted an attempt to fill the gap in the relevant literature indicating the possible directions of development of the legal system and primary preferences of current Polish users of electric and hybrid vehicles in relation to vehicles in the hydrogen technology.

Author Contributions: Conceptualization, W.D.; F.E., J.D. and B.B.; methodology W.D., F.E., J.D. and B.B.; software, W.D., F.E., J.D. and B.B.; validation W.D., F.E., J.D. and B.B.; formal analysis.; investigation, resources and data curation W.D, F.E., J.D. and B.B, writing—original draft preparation, W.D., F.E., J.D. and B.B.; writing—review and editing W.D. and J.D., visualization W.D., J.D. and B.B.; supervision W.D., F.E., J.D. and B.B.; project administration W.D., F.E., J.D. and B.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research is funded by University of Szczecin; Research Center for Management of Energy Sector, Institute of Management, Cukrowa Street 8, 71-004 Szczecin, Poland.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. 2020 Climate & Energy Package. Available online: https://ec.europa.eu/clima/policies/strategies/2020_en#tab-0-1 (accessed on 1 March 2020).
2. Biała Księga Komisji Europejskiej z 28 Marca 2011 r. Plan Utworzenia jednolitego Europejskiego Obszaru Transportu. Available online: https://ec.europa.eu/transport/sites/transport/files/themes/strategies/doc/2011_white_paper/white-paper-illustrated-brochure_pl.pdf (accessed on 1 March 2020).
3. Ramy Polityki w Zakresie Klimatu i Energii do Roku 2030 (Aktualizacja Pakietu Klimatyczno-Energetycznego). Available online: https://ec.europa.eu/clima/policies/strategies/2030_pl#tab-0-1 (accessed on 2 March 2020).
4. Czysta Energia dla Transportu: Europejska Strategia w Zakresie Paliw Alternatywnych. Available online: https://eur-lex.europa.eu/legal-content/pl/TXT/?uri=CELEX%3A52013PC0017 (accessed on 2 March 2020).
5. Europejska Strategia na Rzecz Mobilności Niskoemisyjnej. Available online: https://eur-lex.europa.eu/legal-content/pl/TXT/?uri=CELEX%3A52016DC0501 (accessed on 2 March 2020).
6. Clean Mobility Package z 2017 r. Available online: https://ec.europa.eu/transport/modes/road/news/2017-11-08-driving-clean-mobility_en (accessed on 5 March 2020).
7. Europejski Zielony Ład —The European Green Deal. Available online: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en (accessed on 5 March 2020).
8. Journal of Law UE from 28.10.2014, L 307/1. Available online: https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=OJ%3AL%3A2014%3A307%3ATOC (accessed on 5 March 2020).
9. Rządowy Projekt Ustawy o Elektromobilności i Paliwach Alternatywnych. Available online: https://www.sejm.gov.pl/Sejm8.nsf/druk.xsp?nr=2147 (accessed on 17 December 2019).
10. EUR-Lex. Available online: https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=CELEX:52020DC0301 (accessed on 18 December 2019).
11. Komunikat Komisji. Available online: https://eur-lex.europa.eu/legal-content/PL/TXT/PDF/?uri=CELEX:52020DC0456&from= (accessed on 29 March 2020).
12. Polska Strategia Wodorowa do Roku 2030. Available online: https://www.teraz-srodowisko.pl/media/pdf/aktualnosci/9801-Projekt-Polskiej-Strategii-Wodorowej-do-roku-2030-z-perspektywa-do-2040-r.pdf (accessed on 29 March 2020).
13. International Energy Agency, The Future of Hydrogen Dotyczące Wodoru za 2019 rok, Strona 42. Available online: https://www.iea.org/reports/the-future-of-hydrogen# (accessed on 18 March 2020).
14. Wiącek, D. Wodór jako paliwo przyszłości, Autobusy—Technika, Eksploatacja, Systemy Transportowe, nr 10/201. Available online: https://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-article-BWAW-0016-0061?q=d0898281-8b3d-46d9-98ee-c1494c638b19$2&qt=IN_PAGE (accessed on 18 March 2020).
15. Trwają Prace nad Strategią Wodorową Dla Polski. Potrzeba Innowacji i inwestycji. Available online: https://www.rynekinfrastruktury.pl/wiadomosci/drogi/trwaja-prace-nad-strategia-wodorowa-dla-polski-potrzeba-innowacji-i-inwestycji-74658.html (accessed on 21 May 2020).
16. Skłodowska, M.; Zasuń, R. Czy Polska ma Szanse Wyrosnąć na Wodorowego Potentata? Na Razie Sporo Nam Brakuje. Available online: https://wysokienapiecie.pl/31614-czy-polska-ma-szanse-wyrosnac-nawodorowego-potentata-na-razie-sporo-nam-brakuje/ (accessed on 12 January 2021).
17. Wodór -Paliwo Przyszłości. Available online: http://www.ichpw.pl/wp-content/uploads/2018/10/%C5%9Aci%C4%85%C5%BCko-Wodor-paliwo-przysz%C5%82o%C5%9Bci.pdf (accessed on 12 January 2021).
18. Czy Wodór ma Szansę Zostać Paliwem Przyszłości? Polska ma go pod Dostatkiem. Available online: https://moto.pl/MotoPL/7,88389,23160601,czy-wodor-ma-szanse-zostac-paliwem-przyszlosci-polska-ma-go.html (accessed on 19 March 2020).
19. Journal of Law 2004, no. 90 pos. 864/2 from 30 April 2004. Available online: http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20040900864 (accessed on 19 March 2020).
20. Europejski Zielony Ład. Available online: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_pl (accessed on 22 March 2020).
21. Gov.pl. p 07.01.2021 r. Available online: https://www.gov.pl/web/fundusze-regiony/informacje-o-strategii-na-rzecz-odpowiedzialnego-rozwoju,dostę (accessed on 23 March 2020).
22. Elektromobilność w Polsce (Wersja Archiwalna). Available online: https://www.gov.pl/web/aktywa-panstwowe/elektromobilnosc-w-polsce (accessed on 11 December 2019).
23. Aktualizacja Projektu Polityki Energetycznej z 8 września 2020 r. Available online: https://www.gov.pl/web/klimat/projekt-polityki-energetycznej-polski-do-2040-r (accessed on 7 January 2020).
24. Krajowy Plan na Rzecz Energii i Klimatu na Lata 2021–2030 Przekazany do KE. Available online: https://www.gov.pl/web/aktywa-panstwowe/krajowy-plan-na-rzecz-energii-i-klimatu-na-lata-2021-2030-przekazany-do-ke (accessed on 23 March 2020).

25. Polityka energetyczna Polski do 2040 r. Available online: https://www.gov.pl/web/klimat/polityka-energetyczna-polski (accessed on 25 March 2020).
26. Journal of Law 2020 r. poz. 833. Available online: http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20200000833 (accessed on 2 March 2020).
27. Podpisanie Listu Intencyjnego o Ustanowieniu Partnerstwa na Rzecz Budowy Gospodarki Wodorowej. Available online: https://www.gov.pl/web/klimat/podpisanie-listu-intencyjnego-o-ustanowieniu-partnerstwa-na-rzecz-budowy-gospodarki-wodorowej (accessed on 30 March 2020).
28. Journal of Law UE z 5.6.2009, L 140. Available online: https://eur-lex.europa.eu/legal-content/PL/TXT/PDF/?uri=OJ:L:2009:140:FULL&from=LT (accessed on 15 March 2020).
29. Journal of Law 2020 r., Item 110. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20200000110 (accessed on 15 March 2020).
30. Journal of Law 25.7.2019 L 198/241. Available online: https://eur-lex.europa.eu/legal-content/PL/TXT/HTML/?uri=OJ:L:2019:198:FULL&from=EN (accessed on 14 March 2020).
31. Journal of Law 2019 r. Item 1124. Available online: https://www.dziennikustaw.gov.pl/D2012000112401.pdf (accessed on 14 March 2020).
32. Journal of Law 2018 r., Item 1356. Available online: https://dziennikustaw.gov.pl/D2020000135601.pdf (accessed on 15 March 2020).
33. Journal of Law 2006 nr 169 poz. 1199. Available online: http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=wdu20061691199 (accessed on 18 March 2020).
34. Journal of Law 2019 r., Item 2189. Available online: https://dziennikustaw.gov.pl/D2020000218901.pdf (accessed on 18 March 2020).
35. Journal of Law 2019 r., Item 2526. Available online: http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20180002526 (accessed on 21 March 2020).
36. Journal of Law 2019 r., Item 2538. Available online: http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20180002538 (accessed on 21 March 2020).
37. Journal of Law 2020 Item 1565. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20200001565 (accessed on 30 March 2020).
38. Journal of Law 2018 r. Item 799 and 1356. Available online: http://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20180001356/O/D20181356.pdf (accessed on 21 March 2020).
39. Journal of Law 2020 r. Item 110, 284, 568, 695, 1087 and 1517. Available online: http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20200000110 (accessed on 18 March 2020).
40. NFOŚiGW Konsultuje Wsparcie dla Gospodarki Wodorowej. Available online: http://nfosigw.gov.pl/o-nfosigw/aktualnosci/art,1684,nfosigw-konsultuje-wsparcie-dla-gospodarki-wodorowej.html (accessed on 30 March 2020).
41. Nowa Energia. Available online: http://nfosigw.gov.pl/gfx/nfosigw/userfiles/files/prezentacja_nowa_energia_sielamowicz_wydzial_innowacji.pdf (accessed on 14 March 2020).
42. Programy 2015–2020. Available online: http://nfosigw.gov.pl/oferta-finansowania/srodki-krajowe/programy-priorytetowe/ (accessed on 3 March 2020).
43. Biznes Alert. Available online: https://biznesalert.pl/ustawa-prawo-wodorowe-prace-ministerstwo-klimatu-trzecikwartal-2021-energetyka-wodor-innowacje/ (accessed on 12 January 2020).
44. Journal of Law 2016, Item. 283. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20200000283 (accessed on 18 March 2020).
45. Ewidencja Infrastruktury Paliw Alternatywnych. Available online: https://eipa.udt.gov.pl/ (accessed on 3 March 2020).
46. European Comission. Available online: https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy (accessed on 26 November 2020).
47. Tworzenie Gospodarki Neutralnej dla Klimatu: Komisja Przedstawia Plany Dotyczące Systemu Energetycznego Przyszłości i Czystego Wodoru. Available online: https://ec.europa.eu/commission/presscorner/detail/pl/ip_20_1259 (accessed on 19 November 2020).
48. Narodowy Fundusz. Available online: https://www.nfosigw.gov.pl (accessed on 2 April 2021).
49. Journal of Law of 2020, Item 1333. Available online: https://dziennikustaw.gov.pl/D2020000133301.pdf (accessed on 30 March 2020).