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Article

Biothanol Production in Poland in the Context of Sustainable Development-Current Status and Future Prospects

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Abstract: The high dependence on imported fuels, the need to reduce greenhouse gas (GHG) emissions and the need to develop a low-carbon economy are reasons for the development of the renewable energy market in Poland. The wider use of biofuels can be a method for reducing oil dependence and reducing CO_2 emission. Opportunities to reduce emissions and meet international requirements in the field of environmental protection are seen, among others, in the development of the production and greater use of biocomponents, including bioethanol. This article presents the current state of development in the area of bioethanol production in Poland. An outline of legal regulations in the examined area and statistical data, as well as the largest producers and their production capacity, are presented. The basic time range of analyses covered the years 2015–2019. According to the analyses, liquid biofuels in Poland are used on a small scale, although over 2015–2019, the production of bioethanol as a biocomponent in motor fuels increased by 43,537 tonnes. However, production potential is still underused. In recent years, there have been major changes in the structure of the use of raw materials for bioethanol production. The share of maize has significantly decreased (although it is still dominant in the consumption structure) in favour of waste raw materials.

Keywords: bioethanol; progress; Poland; production status; raw material; sustainability

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1. Introduction

Moving away from fossil energy sources (oil, coal and natural gas) is a direction not only for energy and transport in selected countries, but for the global economy as a whole. According to the assumptions of the Organisation for Economic Co-operation and Development (OECD), the share of biofuels in the global transport sector is estimated to reach 15–23% by 2050 [1]. All petroleum fuels can be replaced with renewable biomass fuels (bioethanol, biodiesel and bio-hydrogen) [2]. In a broader context, in addition to biomass, renewable sources for the energy industry are wind, water, sun and geothermal heat [3]. Biofuels are fast advancing as alternative sources of renewable energy due to their non-polluting features and cost competitiveness in comparison to fossil fuels [4]. Currently, in the studied subject, opportunities for further development are seen in the use of algae biomass for energy purposes (the production of alcohol, biodiesel and methane). Algae, like plants grown for energy purposes, accumulate in their cells large amounts of storage substances that can be converted into energy in various ways (thermochemical processes, etc.). However, the first- and second-generation fuels (arable crops, energy crops, agricultural waste and other agribusiness sectors) still play a dominant role in the production of bioethanol.

The production of bioethanol is widespread in many regions of the world, and due to the natural and economic possibilities of producing raw materials, there are large differences in the scope of the main raw materials for production. In South America (including mainly Brazil), it is sugar cane, while in North America (the USA and Canada), it is corn [5,6].

Biofuel markets, including for bioethanol, are also developing in African [7–9] and Asian countries [10,11]. The world leader in the production of bioethanol is the USA [12]. Global ethanol production has rapidly increased from 18 billion L at the turn of the century to 110 billion L in 2019 [13]. Data on the production of bioethanol in the world are presented in Table 1.

Table 1. Annual world fuel ethanol production in 2015–2019 [14].

Region	2015		2016		2017		2018		2019	
	Billion L	%	Billion L	%	Billion L	%	Billion L	%	Billion L	%
USA	56.05	57.5	58.34	58.9	60.32	59.8	60.91	56.1	59.72	54.3
Brazil	27.25	27.9	25.59	25.8	25.29	25.1	30.32	27.9	32.44	29.5
European Union	5.25	5.4	5.21	5.3	5.30	5.3	5.41	5.0	5.45	5.0
China	3.08	3.2	3.20	3.2	3.26	3.2	3.97	3.7	3.41	3.1
Canada	1.65	1.7	1.65	1.7	1.78	1.8	1.82	1.7	1.89	1.7
India	0.74	0.8	1.04	1.1	0.79	0.8	1.51	1.4	2.01	1.8
Thailand	1.26	1.3	1.21	1.2	1.40	1.4	1.48	1.4	1.59	1.4
Argentina	0.80	0.8	1.00	1.0	1.10	1.1	1.10	1.0	1.10	1.0
Rest of World	1.48	1.5	1.48	1.9	1.57	1.6	2.08	1.9	2.27	2.1
Total	96.08	100.0	98.72	100.0	100.80	100.0	108.60	100.0	109.87	100.0

The ethanol produced in the USA in 2019 reached 54.3% of total global production. More than 94% of US bioethanol is obtained from corn starch, with the remaining part coming from cellulosic biomass [15]. Brazil is also among the largest producers of bioethanol. Bioethanol has been generally the most cost-efficient fuel in Brazil [16,17]. In the European Union countries, corn, cereals, potatoes and molasses are widely used for the production of bioethanol on a large scale [18]. The development of the biofuels market is one of the strategic goals of the EU energy policy.

Increasing the use of renewable energy sources, including biofuels, is also declared in Polish energy policy. Transport in Poland contributes to significant amounts of emissions of harmful substances into the atmosphere resulting from the combustion of traditional fuels [19–21]. At the same time, it is worth noting that biofuels do not significantly reduce pollution compared to traditional fossil fuels, especially given the full life cycle of biofuel production. Obviously, depending on the type and source of biofuel, the benefits and environmental impacts can vary considerably [22].

The main purpose of the article is to describe the current state of bioethanol production in Poland, taking into account the production volume and raw material base, as well as the main market entities and the efficiency of the installation. The considerations are made against the background of changes resulting from scientific and technical progress (development towards the second and third generation of biofuels) and legal conditions (national indicator targets).

A sustainable economy, including the area of energy, is based on pillars vital for economics, technology and the environment, which is why a diagnosis of the current state is crucial for planning future strategic activities. This is particularly important in relation to the transition from the production of the first-generation biofuels to the production of next-generation biofuels (second and third generation). In this regard, this study is part of the topic of sustainable development in the field of energy in Poland.

2. Materials and Methods

The analysis of the literature on the subject of the production and use of bioethanol in various spatial ranges (globally, in the largest markets, including the USA, Brazil and the EU area, mainly Poland) was helpful in achieving the goal of the publication. Secondary data were presented, including from the RFA (Renewable Fuels Association) database. In order to show the state and dynamics of the development of bioethanol production, figures from the National Support Centre for Agriculture (NCAS) were used. The figures for the Polish bioethanol market presented in the study were taken from quarterly reports submitted by enterprises producing biocomponents and liquid biofuels. On the basis of legal provisions in Poland, i.e., the Act of 25 August 2006 on biocomponents and liquid biofuels (Journal of Laws of 2019, item 1155, as amended), the General Director of the National Centre for Agricultural Support (NCAS) is the body competent to receive quarterly reports submitted by biocomponent manufacturers. The information collected by the NCAS is subject to publication in the Public Information Bulletin (PIB). In addition to statistical data, many legal acts were analysed, in particular those relating to the minimum size of biocomponents in fuels.

In this article, the term "biocomponents", following the Act of 25 August 2006 on biocomponents and liquid biofuels, means bioethanol, biomethanol, biobutanol, ester, bio-dimethyl ether, pure vegetable oil, bio-liquid hydrocarbons, bio-propane–butane, bio-propane, liquefied biomethane, compressed biomethane and biohydrogen, which are processed from biomass for fuel production, excluding other renewable fuels.

The Polish Organization of Oil Industry and Trade estimates that in 2019, direct sales of B100 fuel amounted to about 300 million L. However, this fuel was practically unavailable in the retail trade in Poland, and enjoyed very little popularity in the wholesale trade. The vast majority went abroad. The most common and cheapest method of implementing the National Indicative Target (NIT) in Poland is currently the use of bioethanol added to motor gasolines (as a biocomponent, mainly in E5 fuels). Therefore, the analyses in this article only apply to biocomponents.

3. Bioethanol and Sustainable Development—The Ecological, Social and Economic Order

Bioethanol is a widely recognized alternative to fossil fuel that can be used to abate greenhouse gas (GHG) emissions [23]. Increasing the production and use of bioethanol allows not only for socio-economic and environmental sustainability on a local scale, but above all on a global scale [24,25]. The most important advantages of biofuels (environmental, economic and social) are listed in Table 2.

Table 2. Advantages of biofuels contributing to environmental, economic and social order [24,25].

Environmental	Economic	Social
Renewable character	Creating additional demand for agricultural raw materials and waste	Rural development, agricultural subsidies
Lower oil production	Waste management from agricultural production and other areas of agribusiness, development of advanced conversion technologies	Reorientation of public awareness.
Limiting environmental devastation and climate change	Development of trade in biofuels and derivatives	Security of energy supply

Despite numerous indications for the production and use of biofuels, there are also negative factors of both an economic and ecological nature. The literature on the subject also mentions the negative effects of increased biofuel production, including threat to food security and trade barriers incompatible with World Trade Organization (WTO) principles [26–28]. Problems relating to the different standards in the area of biofuels [29,30], changes in the development of arable land (monoculture) and problems relating to land use on the African continent for the production of biosurets for energy purposes are also underlined [31]. Furthermore, the possible risks posed by biofuels to employees during production and use are highlighted [32].

Calculating the GHG savings that may be attributed to biofuels (also bioethanol) is problematic [33–35]. Critical remarks particularly refer to the first-generation biofuels.

There is no doubt that the production of energy crops should be mainly limited to marginal areas [36]. The development of bioethanol mainly concerns the production of second-generation ethyl alcohol (from lignocellulosic raw materials). The use of nanobiocatalysts for the catalysis of lignocellulosic biomass is interesting from the point of view of sustainable development [37]. Key processes and recommendations for cost-effective and environmentally friendly technologies for biomass pre-treatment for bioethanol production have been included by Kumar et al. [38] and Yao et al. [39].

The production and use of bioethanol is part of the practical implementation of the concept of sustainable development. In essence, sustainable development requires the integration of the economic, social and environmental orders. This idea is best reflected in the discussed topic relating to third-generation fuels. Significantly, marine algae are promising alternative feedstocks for bioethanol production [40]. The use of microalgae biomass for the production of liquid biofuels has many advantages. Their high carbon dioxide binding potential and fast growth rate contribute to environmental protection. The advantages of algae are the fact that they can be grown in places that exclude the possibility of farming (meaning there is no competition for land and freshwater resources with crops) [41]. These factors make bioethanol from algae a more sustainable alternative than the production of first- and second-generation biofuels. Maximizing efficiency and economic profitability (pre-treatment costs, losses in the course of biochemical processes, etc.) is currently an important research direction. It is worth emphasizing that several different types of biofuels can be obtained from algae biomass: biomethane, biodiesel, bioethanol and photo-biologically produced biohydrogen [42–46].

4. Bioethanol Market in Poland—Legal Regulations, Production Volume, Raw Materials and Characteristics of the Main Producers

Many years of tradition are associated with the production and use of ethanol as a fuel in Poland. Smuga-Kogut [47] reports that the production of raw spirit for transport purposes has a long tradition in Poland dating back to the pre-war period. In the 1950s, large amounts of ethanol were added to gasoline, and later ethanol was replaced with bioethanol. On an industrial scale, bioethanol was introduced to the Polish market at the beginning of the 1990s. As Kupczyk and Szlachta [48] indicate, in that period, the largest consumption in the petrochemical industry occurred in 1997 (it amounted to approx. 111 million L). This record-breaking production year was followed by a period with large fluctuations (with a downward trend in production volume). The basic raw material for the production of bioethanol at that time was agricultural distillate, produced in agricultural distilleries from rye and potatoes. In 2004 (on 1 May 2004 Poland joined the EU), about 48.5 million L of bioethanol was produced in Poland. Since 2004, the development of the liquid biofuels sector in Poland has taken place against the backdrop of changes in legal regulations in the European Union [49]. The detailed characteristics of the recommendations, guidelines and views arising from EU and national guides and studies are beyond the scope of this article. Nevertheless, the outline of regulations in this area is presented below, with particular emphasis on bioethanol.

In 2003, the European Parliament and the EU Council adopted Directive 2003/30/EC relating to the support for the use of biofuels and other renewable fuels in transport, which recommended an increase in the use of biofuels. The share of biofuels in the structure of transport fuel consumption in the member states, in accordance with this directive, should amount to not less than 2.0% in 2005 and not less than 5.75% in 2010. In March 2007, the European Council adopted a binding target recognizing that by 2020 all Member States will achieve a minimum 10% share of biofuels in the total consumption of transport fuels. The goal was expressed in Directive 2009/28/EC (RED) on the promotion of the use of energy from renewable sources (Journal of Laws EU L 09.140.16) [50].

Legal regulations regarding the biofuels market in Poland are entirely based on European legislation. Pursuant to Directive 2003/30/EC, the Act of 25 August 2006 on biocomponents and liquid biofuels and on the fuel quality monitoring and control system was introduced into Polish legislation. The Act introduced many changes into Polish law, including the introduction, as of 1 January 2008, of the obligation to ensure a specific share of biocomponents in the transport fuel market. This goal was defined as the National Indicative Target (NIT), i.e., the minimum share of biocomponents and other renewable fuels in the total amount of liquid fuels and liquid biofuels consumed in transport during the calendar year, calculated according to calorific value. On the basis of the ordinance of the Council of Ministers, the NIT was appointed for a period of 6 years (2008–2013). It was assumed that the ratio would gradually increase from 3.45% in 2008 to 7.1% in 2013. Another regulation of the Council of Ministers (from 2013) set the NIT levels for 2013–2018. In 2018, this target was set at 8.5%. In 2016, taking into account the raw materials and production capabilities of the fuel industry and EU regulations, the NIT levels were changed for the following years. The Council of Ministers also agreed that the levels of the NIT would be: in 2017—7.1 percent; in 2018—7.5 percent; in 2019—8 percent and in 2020—8.5 percent. It was also established that the biocomponents included in the NIT implementation would have to meet the 50% greenhouse gas emission reduction criterion only from 1 January 2018. On 19 July 2019, the Sejm adopted an amendment to the Act on biocomponents and liquid biofuels and certain other acts. The NIT was set until 2024, forecasting a gradual and mild increase: 8.7%—for 2021; 8.8%—for 2022; 8.9%—for 2023; 9.1%—for 2024.

According to statistical data, the volume of bioethanol production in 2015–2019 increased by 59,793 tonnes (Figure 1).

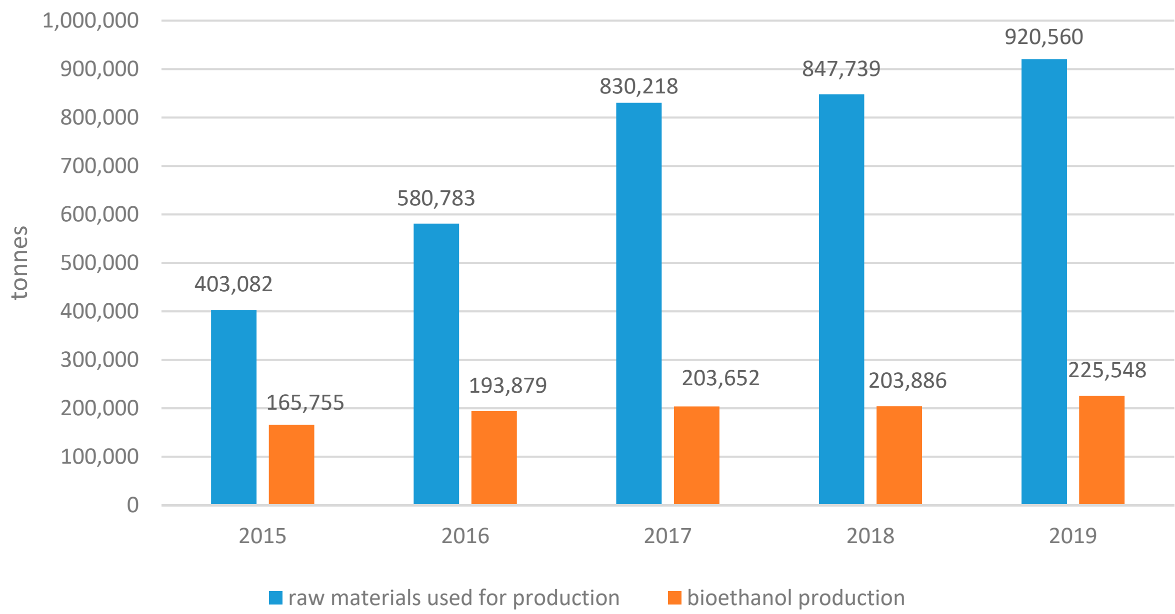

Figure 1. Volume of raw materials used for production and the volume of bioethanol production in Poland in 2015–2019 [51].

The most important raw material for the production of bioethanol in Poland in the analysed period was maize, and its share in the quantitative consumption of raw materials decreased by 24.92% points in the analysed period, from 80.53% in 2015 to 55.61% in 2019. In 2019, in this structure, the suspension of waste starch (with the waste code 02 03 80) constituted 30%.

It is noteworthy, from the perspective of the examined subject matter, that the development of the surveyed market does not result from changes in the structure of land use and sowing that are unfavourable from the point of view of biodiversity (Table 3). Due to the fundamental importance of maize as a raw material for the production of bioethanol in Poland, Table 4 presents selected elements from the maize balance sheet in Poland in the period under review.

Table 3. General characteristics of the sowing area in Poland in 2010–2019 (thousand ha) [52].

Specification	2010	2015	2018	2019
Total sowings	10,366	10,753	10,829	10,898
Cereals	7597	7512	7806	7891
Potatoes	375	292	291	303
Sugar beet	206	180	239	242
Rapeseed and colza	945	947	845	875
Other	1243	1822	1648	1587

Table 4. Maize balance sheet in Poland [53].

Specification	2015/16	2016/17	2017/18	2018/19	2019/20
Cultivation area (thousand ha)	670	594	562	645	665
Yields (tonnes per hectare)	4.71	7.32	7.15	5.99	5.62
Production (thousand tonnes)	3156	4343	4022	3864	3734
Total domestic consumption (thousand tonnes)	3046	3787	4100	4133	3755
Consumption for industrial purposes (thousand tonnes)	612	727	776	817	816
Export (thousand tonnes)	718	1674	1194	1334	1666

What is more, the changes are also not the result of the allocation of forest areas for agricultural purposes. When it comes to forest area, Poland is at the forefront of Europe. Currently, the area of forests in Poland is over 9.2 million ha [54].

Legal regulations have a strong impact on shaping the biofuels market. The scale and pace of development of the biofuels sector are largely determined by administrative and fiscal regulations. An important element of these regulations is the percentage of biocomponents that can be introduced into the fuel. Price regulations (surcharges, etc.) are also important [55]. Figure 2 summarizes the achieved shares of renewable energy sources in final energy consumption in transport against the background of the levels set by the national indicator targets (2014–2019).

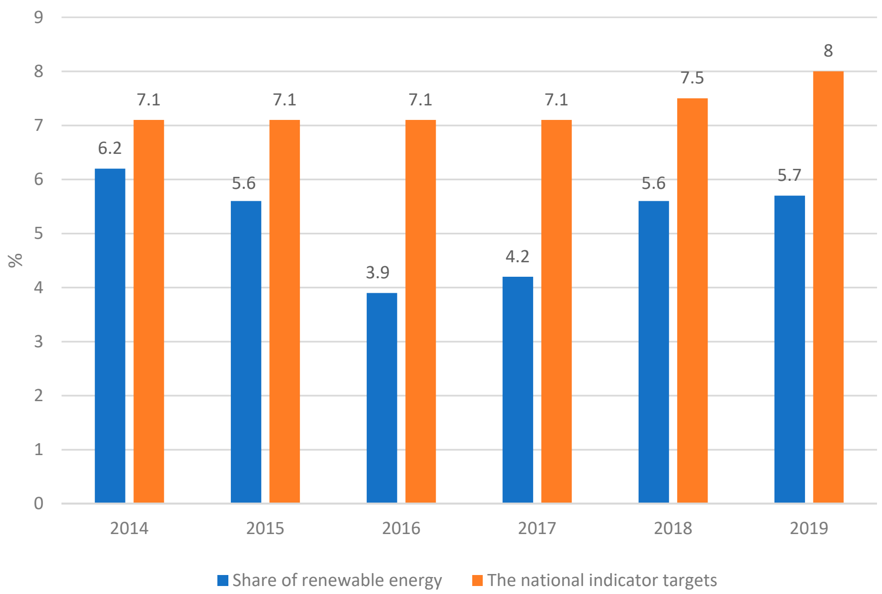

Figure 2. Share of renewable energy in final energy consumption in transport and the national indicator targets in 2014–2019 [56,57].

The share of renewable energy sources in Poland, compared to Western European countries, is at a relatively low level. The structure of obtaining energy from renewable sources in Poland results primarily from the geographical conditions characteristic of our country and broadly understood economic conditions. In 2020, renewable energy came mainly from solid biofuels (over 72%). Wind energy (11%) and liquid biofuels (less than 8%) were in further positions [58].

As Kupczyk et al. [59] indicates, from the perspective of assessing the second-generation bioethanol sector, an important demand factor is the possibility of double crediting biofuels produced, among others from waste, residues or lignocellulosic materials for the implementation of the NIT. Table 5 presents data on the use of raw materials for bioethanol production in Poland in 2018–2019, taking into account raw materials that meet the sustainability criteria (mainly waste raw materials).

Table 5. The raw materials used in Poland to produce bioethanol in 2018–2019 [51].

Specification	Amount of Used Raw Material				Amount of Produced Biocomponent			
	Raw Materials [1]		Raw Materials [2]		A Biocomponent [3]		A Biocomponent [4]	
	(Tonnes)	(%)	(Tonnes)	(%)	(Tonnes)	(%)	(Tonnes)	(%)
2018	672,192.25	79.29	175,547.06	20.71	197,620.03	96.93	6,265.79	3.07
2019	625,245.85	67.92	295,314.50	32.08	213,144.31	94.50	12,403.55	5.50

[1] Raw materials meeting the criteria of sustainable development that do not entitle the biocomponents produced from them to be credited twice to the NIT implementation. [2] Raw materials meeting the criteria of sustainable development that do entitle the biocomponents produced from them to be credited twice to the NIT implementation. [3] A biocomponent meeting the criteria of sustainable development, which is not entitled to be double credited to the implementation of the NIT. [4] A biocomponent meeting the criteria of sustainable development, which is entitled to be double credited to the implementation of the NIT.

In the years 2018–2019, the share of raw materials meeting the sustainability criteria that entitle the biocomponents produced from them to be included in the NIT implementation increased by 11.37 pp, reaching 32.08% in 2019. Such a high increase in the ratio was the effect of allocating 276,593.65 tonnes of waste starch suspension as a raw material input for the production of bioethanol. In 2018, waste starch suspension was consumed much less in these processes (167,125.64 tonnes). Corn remains the basic raw material for bioethanol production in Poland; however, in 2019, it accounted for 55.6% in the structure of raw material consumption. It is worth emphasizing that the share of maize as a raw material for bioethanol production is steadily decreasing in Poland (in 2015, maize constituted 80.5% in the quantitative structure of the consumption of raw materials for bioethanol production).

In the register of producers kept by the Director General of the National Centre for Agricultural Support (as of 4 February 2020), there are 13 economic entities producing bioethanol in Poland. The largest bioethanol producers in Poland include two business entities—BIOAGRA S.A. and DESTYLACJE POLSKIE Sp. z o.o. Table 6 presents the manufacturers with their annual installation capacity.

Table 6. Manufacturers and annual capacity of bioethanol production installations in Poland [51].

No.	Company	Annual Capacity (Million L)
1	BIOAGRA S.A.	210.00
2	DESTYLACJE POLSKIE Sp. z o.o.	150.00
3	HGBS FINANSE S.A.	95.00
4	BGW Sp. z o.o.	90.00
5	GRUPA AWW Spółka z ograniczoną odpowiedzialnością Spółka komandytowa	70.00

Table 6. *Cont.*

No.	Company	Annual Capacity (Million L)
6	WRATISLAVIA-BIODIESEL S.A.	70.00
7	BIOETANOL AEG Sp. z o.o.	39.00
8	CARGILL POLAND Sp. z o.o.	35.00
9	"Komers International" Sp. z o.o.	32.00
10	ARCTICA POLAND Sp. z o.o.	16.00
11	IMA POLSKA S.A.	16.00
12	Podlaskie Gorzelnie SURWIN Sp. z o.o.	12.00
13	Grupa Producencka AGRO-ŻABICE Sp. z o.o.	4.40
	Total	839.40

BIOAGRA S.A. (Poland) is one of the major producers of dehydrated ethanol for fuel purposes (bioethanol) in Poland. The production plant of this company (Ethanol Production Plant "Goświnowice", Nysa, Poland) is located in Głębinów and started production in 2009. In the first period of operations, it processed annually around 350,000 tons of corn per 140 million L of ethanol [60]. The current annual plant capacity is 210 million L. The company is based on the license of KATZEN International Inc. (Cincinnati, OH, USA). In turn, the Polish Distillation Company was established in 2005. The recipients of bioethanol from this entity are not only Polish fuel companies, but also foreign industry contractors.

The relatively low use of bioethanol in Poland results not only from the supply and internal situation of the liquid fuels market in Poland (involving the adaptation to the actual technical and technological conditions of fuel producers and distributors), but also from demand. The average age of a car on Polish roads in 2018 was about 14 years, which may cause a lack of technical possibilities to use biocomponents on a larger scale. Many cars on Polish roads, due to technical factors, should not use, among others, gasoline containing more than 5% biocomponents. E10 is gasoline with a 10% admixture of bioethanol that is increasingly popular in Europe (with such fuels available in Belgium, Finland, France, Germany, Denmark, Hungary, Slovakia, Romania, Bulgaria, Estonia, Lithuania, the Netherlands and Luxembourg). Poland faces many challenges in this respect. Similarly, further research on technology is needed. One of the main goals of industrial biotechnology in the area of bioethanol production is to develop an effective production method using lignocellulosic biomass [61,62]. From the research of Cerazy-Waliszewska et al., it follows that there is a large potential in Poland for energy crops to include miscanthus biomass [63].

The issue of further development in the field of second-generation bioethanol, especially analyses at the interface between technology, economy and environmental protection, is interesting as a research topic. The production of bioethanol from second-generation feedstocks, which are mainly lignocellulosic biomass, creates opportunities for the production of low-carbon biofuel that can be used as an alternative to fossil fuels [64]. As emphasized earlier, this is particularly important for the situation of Poland due to the very high share of hard coal and lignite in energy production.

Despite the evident benefits and the advantages of second-generation bioethanol, serious problems are encountered in the area of lignocellulosic ethanol commercialization, especially in the context of pre-treatment [65]. Scientific and technical progress in the area of more and more effective and energy-saving production technologies concerns, among other things, the optimization of process parameters (in addition to pre-treatment, also enzymatic hydrolysis) and the selection of microorganisms capable of optimal use of substrates that allow achieving maximum efficiency of the fermentation process.

Numerous studies confirm the high potential of Poland in the area of using biomass for energy purposes, including the production of second-generation bioethanol. The research concerns both the possibility of using dedicated crops—e.g., the aforementioned miscanthus [63]—as well as plants with long traditions in cultivation and breeding in Poland (e.g., triticale) [1]. There is also a great potential for using waste from fruit processing. Poland is a leader in the production of apples in the European Union, generally in the fifth position in the European Union in terms of the production value of processed fruit and vegetables [66]. Taking into account the volume of production in Poland, apple pomace in particular can be used as a valuable raw material during ethanol fermentation. Kut et al. [67] presented interesting research in the field of bioethanol production using the hemicellulolytic hydrolysate of apple pomace.

Big opportunities in the studied area are noticed by businesses, including leaders such as PKN Orlen (Poland). It is the largest fuel and energy concern in Poland, and, at the same time, a leader among petrochemical companies in Central and Eastern Europe. According to media reports, a modern installation for the production of second-generation bioethanol will be built at the Jedlicze refinery, with a capacity of 25 thousand tonnes of bioethanol per year. According to Orlen's press release, the bioethanol complex is to include a main installation and a modern combined heat and power plant based on a lignin-fired biomass boiler. The lignin used in the CHP (Combined Heat and Power) plant will be a waste product of the bioethanol installation. Lignin will be burned in a 48 MW fluidized bed boiler. The heat energy generated in this way will be entirely allocated to the needs of the complex of installations for the production of second-generation bioethanol [68]. The installation is to ensure that Poland a high position on the European market of new-generation biofuels. It is worth noting that in 2018, an experimental installation was launched at the PKN Orlen refinery in Płock, which includes the cultivation of microalgae intended for the production of third-generation biofuels [69].

EU's 'Infrastructure and Environment' programme involves subsidising the production of biofuels for companies. As part of competition No. 1/PO IiŚ/9.5/2009, PLN 66.9 million was distributed among the beneficiaries for this purpose, with the total cost of awarded projects amounting to PLN 135.3 million [70]. Subsidies for renewable energy sources for companies and farms are also being implemented, which include investments in the construction of new facilities or increasing the capacity of units generating electricity and heat from biomass. Co-financing is provided by the European Regional Development Fund under Priority axis V.

All these activities are important from the point of view of climate policy and the development strategy of a carbon-neutral economy in Poland. It is primarily an important element of the decarbonisation of the transport sector in Poland. In the short term, as emphasized by Puricelli et al. [71], it is precisely the reduction of emissions in the life cycle of vehicles with internal combustion engines (ICEV) that is important. Carbon dioxide emissions from cars powered by fossil fuels is a very serious problem in Polish road transport [72,73].

5. Conclusions

Poland is a country with a large amount of potential in the production of biofuels, but this potential is largely untapped. Bioethanol is widely used on the American and Brazilian markets. The production of bioethanol, on a scale much lower than in America, can be an important element of the bioenergetic sector in Poland. In the context of the ongoing energy transformation, there is an urgent need to take action in the legislative sphere in the area of increasing motivation, ambition and stronger commitment to achieving the goals related to sustainable transport in Poland. It is true that there is a gradual diversification towards the next generation of biofuels (in 2015–2019, the share of corn as a raw material for bioethanol production decreased by 25 pp). Changes in this area are not the result of unfavourable changes in the area of land development and sowing structure in Poland. More and more technological processes in the area of bioethanol use raw materials that are organic waste or by-products from agricultural production. The possibility of decarbonising transport through an increase in the use of bioethanol is also associated with the necessary improvement in the material situation of Polish society and the renewal of the vehicle rolling stock, as well as educating drivers about the advantages of biofuel. It is necessary to further develop modern technologies (pyrolysis process, Fischer–Tropsch synthesis and hydro treatment). The implementation of the Renewable Energy Sources Directive (the so-called RED II), as well as the emergence of increasing social pressure to reduce greenhouse gas emissions, will increase the importance of second- and third-generation biofuels, and may thus contribute to a greater rate of development of bioethanol production in Poland. Sustainable development in this field will affect all areas of life. The economic, ecological and environmental aspects of the production and use of bioethanol is a topic worthy of attention in the context of seeking a balance among the quality and harmony of the natural environment, quality of life and economic development.

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