energies

MDPI

Article

The Role of State Aid in the Achievement of the Energy Efficiency Objective in the Food Industry—The Example of Poland

Maria Zuba-Ciszewska [1,*] and Aneta Suchoń [2]

[1] Institute of Economics and Finance, Faculty of Social Sciences, The John Paul II Catholic University of Lublin, Al. Racławickie 14, 20-950 Lublin, Poland
[2] Department of Agricultural, Food and Environmental Protection Law, Faculty of Law and Administration, Adam Mickiewicz University, Al. Niepodległości 53, 61-714 Poznań, Poland; aneta.suchon@amu.edu.pl
* Correspondence: maria.zuba-ciszewska@kul.pl

Abstract: The aims of the article are to assess the legal conditions for improving energy efficiency in the energy-intensive food industry in Poland, including the rules for financing enterprises from public funds, and to assess the extent of state aid for these enterprises in their pursuit of energy saving goals. A critical analysis of the literature and of legal regulations on energy efficiency in EU and Polish law has been performed. The analysis of state aid is based on SUDOP data, and it takes into account the time span, the food industry structure, the enterprise size, the type and purpose of aid granted, and the degree of aid concentration. The conducted research showed that the largest share of state aid is received by energy-intensive industries, i.e., meat, fruit and vegetables, and dairy products (65.5%), and by large- and medium-sized enterprises (82.4%). This aid was allocated through various programmes and in various forms, the most important of which were subsidies. The aid focused on three objectives, i.e., promotion of energy from renewable sources, high-efficiency cogeneration, and measures supporting energy efficiency. The study shows the development of legislation on energy efficiency and possibilities for financing investments, both at the EU and national levels. Tightening climate policy will enhance the importance of energy efficiency in the food industry, which should be reflected in an increase in the relatively low current level of this aid (amounting to 0.04% of total state aid and 0.17% of aid for environmental protection and energy purposes).

Keywords: energy efficiency; state aid; food industry; public policies; policy instruments; legal and regulatory framework

Citation: Zuba-Ciszewska, M.; Suchoń, A. The Role of State Aid in the Achievement of the Energy Efficiency Objective in the Food Industry—The Example of Poland. *Energies* **2024**, *17*, 2895. https://doi.org/10.3390/en17122895

Academic Editors: Matheus Koengkan and Fernanda Oliveira

Received: 22 April 2024
Revised: 10 June 2024
Accepted: 11 June 2024
Published: 13 June 2024

1. Introduction

The world's food systems currently face significant challenges, not only in terms of production or nutritional goals but also in terms of environmental impacts, including energy use [1–3]. The modern agri-food system involves a wide range of energy users, starting with farmers, from processing, packaging, transport, retail, and households to waste disposal [4]. Energy is required in the processes related to the production, processing, distribution, consumption, and disposal of food [5]. It is also important for the sustainability of agriculture and food systems, rural development, renewable energy, and the depleting natural resources of fossil fuels [6]. Demand for energy is increasing, and this is also the case in the food system, which is partly due to the increase in global food production stemming from growing consumption [7–9]. Although fossil fuels meet most of the primary energy needs of the food system, there is a growing need for renewable energy [10]. This energy transition is also important in the context of climate change and the war in Ukraine, resulting in high prices and risk of energy supplies [11,12].

According to the FAO, the challenges for energy-smart agri-food systems (ESAFSs) include improving energy efficiency, i.e., the ratio of outputs to energy inputs all along the agri-food chain, using a variety of energy sources, with a focus on renewable energy

and contributing to renewable energy production [13]. The principle of "energy efficiency" (i.e., using energy more efficiently at all stages of the energy chain, from production to final consumption), is one of the key European Union (EU) regulations and should be taken into account in all sectors [14]. Improving energy efficiency, including in the food industry, means increasing it, e.g., through technological changes such as cogeneration, i.e., the simultaneous generation of heat and electricity or mechanical energy in the same process (combined heat and power—CHP) [15,16]. Energy efficiency is recognised as a significant factor in achieving various societal goals related to environmental and climate protection, competitiveness, and energy security. Its main advantage is its potential to reduce both the economic and environmental costs and negative environmental side effects associated with the transition to low-carbon energy systems [17–19].

This principle should be applied in conjunction with and in accordance with other policy objectives of the EU. Even if other policy objectives are considered overriding, this principle should not be automatically rejected [20–22]. The new Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency [23] states that increasing the EU's energy-efficiency target can lead to lower energy prices and can also have a decisive impact on reducing greenhouse gas emissions (a reduction in these gas emissions of at least 55% below 1990 levels is to be achieved in the coming years). Such measures will have a positive influence on the environment and the living conditions of the population [24].

The development of production in the food industry, modernisation of production processes, increases in the profitability and competitiveness of plants, and adaptation to the challenges of the fourth industrial revolution can all be achieved thanks to investments in fixed assets [25]. Improving the energy efficiency of industry is achievable thanks to investments [26]. Such investments often entail a financial challenge for the food industry, as it is characterised by its relatively low average profitability, although this varies in individual industries in Poland [27,28]. Improving energy efficiency therefore requires state support [29]. State aid can only be granted if the legal requirements are met. These regulations, such as those concerning the implementation of renewable energy sources in the agri-food sector, have an impact on the development of ESAFSs [30]. The implementation of investments with the participation of state aid is usually indispensable for companies that contribute to the process of increasing energy efficiency.

The EU and Polish national legislation on the granting of state aid through public funds, EU competition rules, horizontal aid rules, and energy efficiency is extensive, complicated, and difficult to put into practice. There is a lack of research showing a detailed analysis of public aid aimed at goals related to the current problem of energy saving in such an important part of the economy in Poland as the food industry. Consequently, only a combined legal and economic approach allows for the issue to be presented fully and in an interdisciplinary manner.

Therefore, the first aim of this article is to assess the legal conditions for improving energy efficiency in the Polish food industry, in particular, the rules for financing projects from public funds. The second aim is to assess the extent of state aid for enterprises in all sectors of the food industry in their pursuit of energy saving goals. The paper attempts to answer several research questions:

1. What is the legal scope of the concept of energy efficiency? Does energy efficiency affect environmental protection and the struggle to combat climate change? If so, how? Is efficiency a challenge for EU policies? What are the links between a just energy transition and efficiency?
2. Do EU state aid and competitiveness rules allow for derogations from the general rule of Article 107 of the Treaty on the Functioning of the European Union [31] in the field of energy-efficiency investments, including in particular renewable energy, and if so, to what extent?
3. To what extent are efficiency rules being developed in EU and Polish legislation?

4. What is the scope of state aid for energy-efficiency purposes in the energy-intensive food industry in Poland?
5. Does aid for enterprises vary depending on the type of food industry, size of enterprises, aid programme, form of aid, or its purpose?

The responses to questions 1–3 related to the first aim will be presented in the part analysing legal acts in Section 2. Answers to questions 4–5 related to the second aim will be provided through empirical analysis in Section 4.

2. Legal Regulations and Literature Review

2.1. Energy Consumption in the Food Industry

Energy consumption in food processing and food distribution accounts for some 40% of that in the entire food system and is slightly higher in high-GDP countries and lower in low-GDP countries [13]. Indeed, according to research conducted in the US, energy consumption in the processing industry, e.g., for cooking, cooling, or freezing processes, averages some 14–20% of the total energy consumption in the food system [32–34]. In some of the branches of the food industry, we can find over forty energy-intensive processes [35]. Energy consumption in agri-food processing plants depends, among other things, on the thermophysical properties of raw materials, volume and structure of production, plant technical equipment, production technology, degree of mechanisation of production operations, organisation of production, and level of utilisation of processing capacity [36].

Research indicates that increased energy consumption in slaughterhouses results from an expansion in the use of automated equipment, temperature control, and hot cleaning water, as well as freezing, slicing, and boning processes [37,38]. The fruit and vegetable processing and preservation industries also consume substantial amounts of energy due to such aspects as drying processes for fruits and vegetables that contain large amounts of water [39] and the energy-intensive freeze-drying process, which allows processors to maintain the high quality of the raw material, especially that with a short shelf life, such as soft fruits [40]. The drying process requires a lot of energy; hence, it frequently involves devices used to reduce non-renewable energy consumption, e.g., solar dryers [41,42]. Milk manufacturing involves energy-intensive thermal processes such as pasteurisation [43] and heat treatments that are important for the safe consumption of milk compounds, including proteins and their antioxidant properties [44]. The largest consumers in Poland's food and beverage production sector are meat and milk processing (20% in 2022), and at the same time, these industries have the largest share in sold production in this industry (24%); therefore, the energy intensity of sold production is low [45,46].

Food industry enterprises occupy an important position in the EU economy, as in 2022, their sales revenues amounted to EUR 1.5 trillion, i.e., as much as 59% more than in 2010. Poland ranks seventh in terms of the value of revenues (EUR 96.6 billion) and demonstrated a dynamic growth by 114%. In Poland, the food industry generates almost one-fifth of the total value of sold industrial products [47], and the growing domestic production in most plant and animal products covers domestic consumption, ensuring food self-sufficiency for the inhabitants of Poland [48] and also Europe. This is because surpluses in production are exported, mostly to other EU members, and the balance of foreign trade in agri-food products is both positive and constantly growing [49]. Such a situation has global relevance, the reason being that if Europe loses its food self-sufficiency, this situation might aggravate ecological problems in other parts of the world if an additional amount of food, understood as an energy resource, had to be produced in areas that are valuable from the point of view of environmental protection [50].

Between 2010 and 2022, energy consumption in the food, beverage, and tobacco industry increased in most of the EU's 28 Member States (Figure 1), with a rise of 27% in Poland. Poland belongs to the group of countries with significant energy consumption in this sector (94.5 PJ in 2022). A positive phenomenon is the growing share of renewables and biofuels in energy consumption in the food industry in the EU, which rose from 3.4% to 4.7% between 2010 and 2022 and from 0.7% to 1.7% in Poland, thanks to an almost

threefold increase in volume to 1.6 PJ. The share of combined heat and power (CHP) in energy consumption in the EU food industry surged from 4.9% to 5.7%. In Poland, however, despite the expansion in the level of cogeneration by 88% to 2.6 PJ, its share in energy consumption in this industry increased only by one percentage point to 2.8% [51]. The food industry in Poland, just like the entire economy, is undergoing modernisation changes in the energy economy [52,53]. Despite the growing demand for electricity in the food industry, which results from, among others, investments in fixed capital and the automation and digitisation of production technologies, the energy intensity of sold production in the industry and most of its branches is decreasing, which indicates an improvement in energy efficiency. This is important in the context of cost competitiveness and meeting growing environmental protection requirements [52].

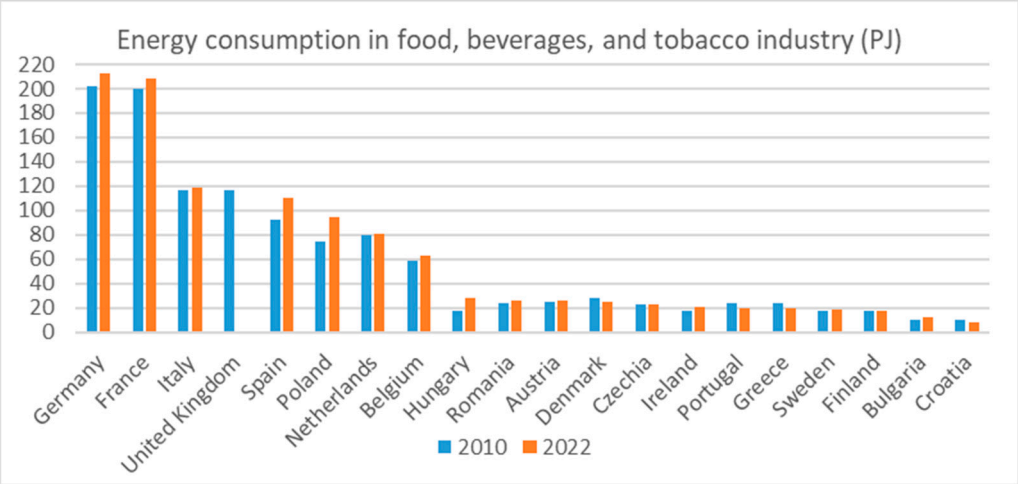

Figure 1. Energy consumption in the food, beverage, and tobacco industry in the EU countries, where the values are over 10 PJ. Source: own work based on [51].

The rise in energy consumption in the food industry is influenced by such factors as the growing total consumer demand for food, including energy-intensive food, for example, highly processed goods, fresh processed food, and ready-to-eat food. These types of food require energy-intensive production technologies or more energy to avoid spoilage on the way from the field to the table [32,54]. The overall growth in energy consumption in the EU is due to the rise in the level of production of the food industry generated, among others, by the increase in the number of entities operating in the industry. Between 2010 and 2022, in EU-28, the number of food industry enterprises expanded by over 25,000 to 316,000, of which 88% were engaged in the production of food products and 12% in the production of beverages. Poland accounted for almost one-fifth of the new entities. In Poland, in 2022, there were 19,100 enterprises from this sector (of which 96% produced food products), ranking it fifth in the EU [55].

Financial support for investments is crucial to accelerate the transition to a low-carbon economy [56]. The implementation of some renewable energy solutions is still associated with high initial costs, e.g., the cost of the technologies themselves, which is why state support with various instruments proves crucial [53,57]. The support policy implemented in this respect should be targeted, flexible, and adapted to local needs and should take into account innovation in order for entities to use products with higher added value in the field of renewable energies [58–61]. State investment support increases profitability and competitiveness and promotes efficient resource management of supported food industry enterprises [62].

State aid for environmental protection and energy in Poland is increasing (by 148% to EUR 1.9 billion in 2016–2022) [63,64], but comparing its amount to that of other countries in the EU, it is a low value [65,66]. Research on state aid for environmental protection and energy in the selected branches of the food industry in Poland indicates its low level and

low share (7.6%) of total aid for the dairy industry [67]. There is a lack of research that would indicate the level of state aid in the food industry in Poland and all its branches directed specifically to the goal related to energy efficiency. There are no studies indicating forms of aid or specific goals in this area. We will try to analyse the scope of this aid also in the context of applicable legal acts at the national and EU level.

The development of the food industry is influenced by micro- and macroeconomic conditions. The first ones include the enterprise management system, organisational and ownership structure of the enterprise, sources of financing, level of investment, technology, and innovation. The second group includes the economic situation in the country; the implemented fiscal, monetary, investment, and credit policies; foreign policy supporting exports; new food consumption patterns; and the state's legislative policy [68]. The rest of this section will be devoted to the analysis of legal acts affecting energy efficiency in the Polish food industry.

2.2. Improving Energy Efficiency in the Context of EU Policies

A fair transition towards achieving the Union's climate neutrality by 2050 is crucial for the implementation of the European Green Deal [69], European Union policies, democracy, and equality [70]. Article 194 of the Treaty on the Functioning of the European Union [31] states that within the framework for the establishment or functioning of the internal market, and with regard to the need to preserve and improve the environment, Union policy on energy shall aim, firstly, in the spirit of solidarity between Member States; secondly, to ensure that the energy market functions; thirdly, to ensure security of the energy supply in the Union; and fourthly, to promote energy efficiency and energy saving and to develop new and renewable forms of energy [71]. It should be emphasised that the energy sector is a shared competence, which means that the EU has the primary competence to legislate in the energy sector. The Member States, on the other hand, can only exercise their competence to the extent that the EU has not done so [71].

For many years, the EU has focused on implementing a climate and energy policy framework. Energy strategy is therefore linked to EU environmental policy and also to the agri-food industry, regional development, and transport. It should be noted that there has been an interest in energy efficiency in the EU for many years. Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency has been implemented by Member States [15], for example, in Portuguese Decree-Law No. 68-A/2015—Diario da Regublica No. 84/2015, Supplement 1st, Series I, 30 April 2015 Ministry of Environment, Spatial Planning and Energy, which establishes regulations on energy efficiency and cogeneration production, transposing Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency [72]. Other examples are the Dutch Act on Implementation of EU Directives on Energy Efficiency and the Dutch Act of 28 February 2015 amending the Act on Implementation of EU Directives on Energy Efficiency, the Electricity Act 1998, the Gas Act, and the Heat Act in connection with the implementation of Directive 2012/27/EU on energy efficiency [73].

Member States should be encouraged to make full use of the Structural and Cohesion Funds to stimulate investment in energy-efficiency measures. On the other hand, banks and other financial institutions should be actively involved in providing information on how they can participate in the financing of energy-efficiency measures, including through the creation of public–private partnerships. Furthermore, Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency expands on the efficiency challenge and highlights how energy-efficiency measures have a positive impact on the environment and contribute in a cost-effective way to achieving the EU's air-quality policy objectives, in particular those set out in Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants [74,75].

According to Directive (EU) 2023/1791, "system efficiency" means the choice of energy-efficient solutions that also allow for a cost-effective decarbonisation pathway, additional

flexibility, and efficient use of resources; on the other hand, "energy efficiency improvement" indicates an increase in energy efficiency as a result of any technological, behavioural, or economic change (Art. 2 of the Directive). Energy generated on or in buildings [76] using renewable energy technologies or agro-voltaics reduces the amount of energy supplied by fossil fuels [77], which is part of the current challenge to achieve such objectives as those of the European Green Deal (presented by the European Commission on 11 December 2019) [78]. These include the promotion of green finance and investment, more ambitious EU climate change targets; clean, affordable, and secure energy; and the development of circular economies.

As mentioned above, the development of renewable energy is important to achieve climate neutrality. According to Articles 2 and 4 of the Regulation of 30 June 2021 establishing a framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ("European Climate Law") [79], Union-wide emissions and removals of greenhouse gases regulated in Union law shall be balanced at the latest by 2050, thus reducing emissions to net zero by that date, with the Union moving towards negative emissions. The Union's binding climate change target for 2030 is a reduction of at least 55% in its net greenhouse gas emissions (emissions minus removals) by 2030 compared to 1990 levels. Efforts for developing renewable energy and improving energy efficiency also aim to implement the UN's 2030 Agenda for Sustainable Development [80] and are in line with the principles of the green economy. The latter emphasises that the economy should be low-carbon, resource-efficient, and "inclusive". There is a need to increase energy and resource efficiency and prevent the loss of biodiversity and ecosystem services [81]. Some of these actions are driven by the European Climate Change legislation, which aims to achieve zero net greenhouse gas emissions by 2050.

The communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, and the Committee of the Regions, "Ready for 55": meeting the EU's 2030 [82] climate target on the road to climate neutrality, highlights that energy consumption accounts for 75% of emissions in the European Union. Transforming the energy system is therefore key to achieving the ambitious climate targets that have been set. Accordingly, the share of renewable energy sources in the European Union's energy mix should increase from 32% to 40%. Directive (EU) 2023/1791 recommends reducing final energy consumption by at least 11.7% in 2030 compared to energy consumption projections in 2020.

Energy efficiency is also an important issue in the EU Member States. In Germany, for example, the Energy Efficiency Act of 13 November 2023 entered into force on 18 November 2023 [83]. Some of the aims of this legislation are to increase energy efficiency, improve security of supply, and mitigate global climate change. It also seeks to ensure that national energy-efficiency targets are met and consistent with European targets. For the period after 2030, the German government aims to reduce Germany's final energy consumption by 45 per cent by 2045 compared to that in 2008. The new final energy savings are to be achieved not only through investment but also through strategic measures by the Länder. The latter should focus on information, advice, education, and promotion. section 6 on climate-neutral enterprises is of particular interest. The federal government is empowered to establish exceptions and exemptions for climate-neutral companies from the obligations under sections 11–13 and 15–17. It is emphasised that only companies that are compatible with the goal of a sustainable energy supply and the achievement of national and European climate protection goals can be considered climate neutral. Important points were highlighted regarding the requirements for declaring companies as climate neutral, the obligations to provide evidence for declaring companies as climate neutral, and the monitoring of these declarations. It is also worth mentioning that an energy audit is a systematic procedure for identifying measures to increase energy efficiency and reduce energy consumption in a company, including obtaining sufficient information on the energy consumption profile of the organisation, its buildings, and the operation of its equipment; identifying and quantifying the potential for final energy savings; and identifying the

potential for the use and production of renewable energy [83]. Italy also has extensive legislation on renewable energy and energy efficiency; for example, Legislative Decree No 102 of 4 July 2014 "Implementation of Directive 2012/27/EU on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC" [84], or Law 181 of 9 December 2023, contains provisions on national energy security, the promotion of the use of renewable energy sources, support for energy-intensive enterprises, and the reconstruction of areas affected by exceptional floods [85]. Among other things, it emphasises the need to promote and accelerate investment in the self-generation of renewable energy in energy-intensive sectors.

2.3. Energy-Efficiency Legislation in Poland

The basic act on energy efficiency in Polish law is the Act of 20 May 2016 on Energy Efficiency [86]. According to these regulations, an energy-efficiency improvement project is an action that consists of introducing changes or improvements to a building, technical device, or installation, resulting in energy savings [87,88]. Examples include insulating industrial facilities; energy generation in renewable energy facilities; reconstruction or renovation of a building together with its facilities and technical equipment; energy recovery, including energy recovery in industrial processes; reducing losses, e.g., those related to reactive energy consumption and network losses related to the transmission or distribution of electricity, natural gas, or liquid fuels. As a rule, such projects are extremely expensive [89]. The source of funding is therefore very important, and this includes EU grants, soft loans, or financing. In principle, public support is complicated by Article 107 of the Treaty on the Functioning of the European Union. This states that any aid granted by a Member State or through State resources in any form whatsoever which distorts or threatens to distort competition by favouring certain undertakings or the production of certain goods is, in so far as it affects trade between Member States, incompatible with the common market. At the same time, it should be noted that public aid is permitted, for example, in the form of horizontal or regional aid [90].

The legislation provides a number of instruments to improve efficiency and assess the current situation. An entrepreneur within the meaning of the Act of 6 March 2018 on Entrepreneurs Law [91], with the exception of micro-, small, or medium-sized businesses, shall carry out or have carried out an energy audit of the enterprise every 4 years. This must be conducted by an entity independent of the audited entrepreneur, with knowledge and professional experience in carrying out this type of audit or an expert of the audited entrepreneur, if he is not directly involved in the audited activity of this enterprise. Energy efficiency is not only important for large companies. It is also significant for all businesses because it allows the current energy situation to be assessed and action to be taken to reduce energy consumption. Lower energy costs and a positive impact on the environment are evident [92]. In practice, this also indicates a need to increase energy security, raise productivity, boost innovation and competitiveness, meet legal requirements and standards, build an image of a pro-environmental company, reduce greenhouse gas emissions, decrease pollutant emissions, promote social benefits, and increase occupational safety.

It is worth referring to the concept of energy efficiency, which, in the context of the Act under discussion, is the ratio of the achieved magnitude of the useful effect of a given object, technical device, or installation, under typical conditions of its use or operation, to the amount of energy consumed by this object, technical device, or installation or as a result of the performed service necessary to achieve this effect. According to the announcement from the Minister of Climate and Environment of 30 November 2021 on a detailed list of energy-efficiency improvement projects [93], such investments include those related to the insulation of industrial installations; the reconstruction or renovation of a building together with technical installations and equipment, including thermo-modernisation and renovation projects; the modernisation or replacement of equipment and installations used in industrial, telecommunications, or IT processes and in energy processes; own-use equipment and installations used in energy processes carried out in fuel combustion

installations covered by the Emissions Trading Scheme; the construction of a connection to a district heating network; and the purchase or modernisation of a heat distribution centre in order to replace heat from heat sources with low energy efficiency with heat from a district heating network generated by an installation using renewable energy sources in a high-efficiency cogeneration plant or in the form of waste heat from industrial installations. There is no doubt that the scope is wide, and individual entrepreneurs can make investment choices taking into account their own situations. At the same time, it should be emphasised that the Energy Efficiency Act has to be amended due to the new challenges such as social development and climate change.

The announcement of the Polish Minister of Climate and Environment of 2 March 2021 on the State Energy Policy until 2040 states the following [94]: "Renewable energy sources will play an increasingly important role—their share in the structure of the net national electricity consumption will not be less than 32% in 2030, which will primarily enable the development of photovoltaics and offshore wind farms, which enjoy the greatest development prospects due to economic and technical conditions. The development of grid infrastructure and energy storage technologies is necessary to achieve this level of renewable energy in the balance". The amended Act of 20 February 2015 on Renewable Energy Sources [95] creates new opportunities for the development of renewable energy in Poland. It is also worth mentioning cogeneration, which is defined in Article 3(33) of the Act of 10 April 1997 on energy [96] as the simultaneous production of heat and electricity or mechanical energy during the same technological process [97,98], e.g., gas cogeneration [99]. To be called high-efficiency, savings of a certain order must be achieved in this process [100]. As can be seen from the literature, the aforementioned methods of energy production are conducive to improving energy efficiency. This allows for the production of two different types of energy while conserving raw materials from a single source [101]. Cogeneration also contributes to the reduction in greenhouse gas emissions and other pollutants by decreasing the amount of fuel used for the combined production of heat and electricity [102]. The Act of 14 December 2018 on the promotion of electricity from high-efficiency cogeneration [103] sets out the rules for providing support for electricity generated in high-efficiency cogeneration units and for issuing guarantees of origin for electricity from high-efficiency cogeneration.

It is also worth mentioning a legal instrument that also encourages entrepreneurs in the agri-food industry to make investments leading to greater energy efficiency, namely energy efficiency certificates ("white certificates"). These confirm that the planned investments will lead to a reduction in the amount of final energy and serve to improve energy efficiency. It is important to note that in accordance with the Polish Energy Efficiency Act of 20 May 2016, such a certificate is not entitled to a project or projects of the same type for improving energy efficiency if the granting of this certificate will result in a permissible amount of public aid for this project or these projects stipulated in the Act being exceeded (Art. 20–32 of the Polish Energy Efficiency Act). The certificate is issued by the President of the Energy Regulatory Office at the request of the entity planning to commence the implementation of one or more projects of the same type aimed at improving energy efficiency. The property rights resulting from the energy efficiency certificate are a commodity in the sense of the Commodity Exchange Act of 26 October 2000 [92,104].

A summary of the legal acts discussed so far is provided in Table 1.

2.4. Public Support Instruments for Energy Efficiency in the Food Industry

According to the concept of state aid in the Treaty on the Functioning of the European Union, the implementation of an energy-efficiency pre-project requires significant financial resources, which are very often public funds. According to Art. 9 of the Polish Act of 27 August 2009 on Public Finance [105], public funds are public revenues, funds from the budget of the European Union, and non-refundable funds from aid granted by member states of the European Free Trade Agreement (EFTA); revenues of the state budget and budgets of local government units and other units of the public finance sector, which result

from factors such as repayments of loans granted from public funds and from loans and credits received; and the revenues of public sector bodies resulting from their activities and from other sources.

Table 1. Selected energy-efficiency regulations.

EU Regulations on Energy Efficiency	Example Regulations of Selected EU Countries Implementing the Directive	Polish Regulations on Efficiency
Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC [15]	Italian Legislative Decree No 102 of 4 July 2014 "Implementation of Directive 2012/27/EU" [84]	Announcement by the Minister of Climate and Environment of 30 November 2021 on a detailed list of energy-efficiency improvement projects [93]
Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency [23]	Dutch Act on Implementation of EU Directives on Energy Efficiency [73]	Act of 20 May 2016 on Energy Efficiency [86]
	German Energy Efficiency Act of 13 November 2023 [83]	
	Portuguese Decree-Law No. 68–A/2015—Diario da Regublica No. 84/2015 [72]	

Source: own work based on [15,23,72,73,83,84,86,93].

There is no definition of state aid in Polish legislation. In the everyday meaning, it is broadly understood to include all public funds granted from state resources by national, regional, or local authorities, as well as banks, foundations using public funds, etc. [106]. This includes, in particular, public funds as defined in the Public Finance Act. The concept of state aid has a narrower meaning when used in EU legislation. On the basis of the Treaty on the Functioning of the European Union, state aid can be considered prohibited support granted to an enterprise if the following conditions are simultaneously met: first, it is granted by the state or comes from state resources; second, it is granted on terms more favourable than those offered on the market; third, it is selective (favours a particular undertaking or undertakings or the production of particular goods); and fourth, it threatens to distort or does distort competition and affects trade between EU Member States. Thus, for support to constitute state aid, the above conditions must be cumulative [107]. According to the Commission's July 2016 Notice on the concept of state aid as referred to in Article 107(1) of the Treaty on the Functioning of the European Union (2016/C 262/01), an advantage within the meaning of Article 107(1) of the Treaty means any economic advantage that the concerned undertaking could not obtain under normal market conditions, i.e., without state intervention. If one of the above conditions is not met, there is no state aid under the EC Treaty or, referring to the nomenclature used in the literature, the state aid in question is not anti-competitive [90,108].

Aid measures fulfilling the above criteria are in principle incompatible with the common market under Article 107(1) of the EC Treaty. At the same time, it should be noted that this does not mean that such aid is prohibited altogether. Aid may be considered compatible with the common market if, for example, it is intended to promote the economic development of areas where the standard of living is abnormally low or where there is serious underemployment, or of regions with structural, economic, and social difficulties. Public aid may also be authorised to promote the execution of an important project of common European interest; to remedy a serious disturbance in the economy of a Member State; or to facilitate the development of certain economic activities or of certain economic areas, where such aid does not adversely affect trading conditions to an extent contrary to the common interest. Such aid may be authorised, and the Council may determine this by a decision on a proposal from the Commission. Article 108 of the Treaty on the Functioning of the European Union provides that, at the request of a Member State, the Council, acting unanimously, may decide that aid which that State is granting or intends to grant shall be

considered compatible with the internal market by way of derogation from the provisions of Article 107 or from the regulations provided for in Article 109. It should be underlined that such a decision may be taken if justified by exceptional circumstances. The Council, acting on a proposal from the Commission and after consulting the European Parliament, may adopt regulations for the application of Articles 107 and 108 and, in particular, may determine the conditions for the application of Article 108(3) and the categories of aid exempted from this procedure (Article 109 of the Treaty). Examples of acts adopted by the Council on the basis of Article 109 are Regulation (EC) No 659/1999 laying down detailed rules for the application of Article 88 of the EC Treaty and, on this basis, the Commission's implementation of Regulation (EC) No 794/2004 [109], as well as Council Regulation (EC) No 994/98 of 7 May 1998 on the application of Articles 107 and 108 of the Treaty on the Functioning of the European Union to certain categories of horizontal state aid [110,111].

The above-mentioned Regulation No 994/98 of 7 May 1998 stipulates that the Commission may (by means of a regulation adopted in accordance with the procedure laid down in Article 8 of the Regulation), declare, in accordance with Article 92 of the Treaty, that certain categories of aid are compatible with the common market and are not subject to the notification requirement of Article 93(3) of the Treaty, namely, aid for small and medium-sized enterprises; for research, development, and innovation; for the protection of the environment; for the promotion of food products not listed in Annex I to the TFEU; for employment and training; for repairing damage caused by natural disasters; for repairing damage caused by certain adverse weather conditions in the fisheries sector; and for forestry. This regulation was subsequently repealed by Council Regulation (EU) 2015/1588 of 13 July 2015 on the application of Articles 107 and 108 of the Treaty on the Functioning of the European Union to certain categories of horizontal state aid [112]. This provides for the financing of renewable energy and other environmental and energy-efficiency investments [89]. Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency Article 30 states that, without prejudice to Articles 107 and 108 TFEU, Member States shall facilitate the creation of financial instruments or the use of existing instruments for measures aimed at improving energy efficiency. The main objective is to maximise the benefits of funding from different sources and the use of a combination of grants, financial instruments, and technical assistance. Member States may establish a national energy-efficiency fund whose purpose is to implement energy-efficiency measures to support Member States in the implementation of their national energy-efficiency contributions. It may be created as a dedicated fund within an existing national investment support facility. It could be financed by revenues from the auctioning of allowances under the EU Emissions Trading Scheme. It is important to increase the uptake of private investment in energy efficiency and innovative schemes.

2.5. Horizontal State Aid for Environmental Protection

Council Regulation (EU) 2015/1588 of 13 July 2015 on the application of Articles 107 and 108 of the TFEU to certain categories of horizontal state aid [112] provides that the Commission may declare that certain categories of aid are compatible with the internal market and are not subject to the notification requirement of Article 108(3) TFEU. Such aid includes aid for environmental protection. On the basis of Article 107(3)(c) of the Treaty, the Commission may declare state aid that facilitates the development of certain economic activities in the European Union to be compatible with the internal market, where such aid does not adversely affect trading conditions to an extent contrary to the common interest. For example, this includes the guidelines on state aid for environmental and energy-related objectives 2014–2020 applied to state aid granted for environmental or energy-related objectives in all sectors subject to the provisions of the Treaty, to the extent that such measures are covered by point 1.2 in the guidelines. The general objective of aid under the environmental guidelines is to raise the level of environmental protection compared to the level that would have been achieved without aid [113]. In particular, the Europe 2020 strategy sets targets for sustainable economic growth that would support the transition

to a resource-efficient, competitive, low-carbon economy. A low-carbon economy with a significant share of variable energy production from renewable sources requires adaptation of the energy system and, in particular, significant investment in energy networks (37). The main objective of state aid in the energy sector is to ensure a competitive, sustainable, and secure energy system in a well-functioning EU energy market (38). The Commission has identified a number of environmental and energy-related measures for which, under certain conditions, state aid may be compatible with the internal market on the basis of Article 107(3)(c) of the Treaty on the Functioning of the European Union. For example, this includes aid for the production of energy from renewable sources; aid for energy-efficiency measures, including cogeneration and district heating and cooling; aid for CO_2 capture, transport, and storage, including individual elements of the carbon capture and storage (CCS) chain; aid in the form of reductions in or exemptions from environmental taxes; and aid in the form of reductions in the financing of support for renewable electricity. It was emphasised that aid for environmental protection and energy-related objectives cannot be granted to undertakings in a difficult situation, as defined for the purposes of these guidelines in the applicable guidelines on state aid for rescuing and restructuring firms in difficulty (19). It was pointed out that energy-efficiency measures are undertaken in relation to negative externalities, creating individual incentives to achieve environmental objectives in terms of energy efficiency and reductions in greenhouse gas emission.

In terms of state aid earmarked, for example, for energy efficiency, reference should be made to the Regulation of the Polish Minister of the Environment of 21 December 2015 on the detailed conditions for granting horizontal public aid for environmental protection purposes [114]. This legal act sets out the detailed conditions for granting horizontal public aid for environmental protection purposes from the funds at the disposal of the Polish National Fund for Environmental Protection and Water Management and the provincial funds for environmental protection and water management. This executive act was issued on the basis of Article 400a(2) of the Act of 27 April 2001—the Environmental Protection Law [115]. The financing of environmental protection and water management includes support for the use of local renewable energy sources and the introduction of more environmentally friendly energy carriers or other environmental protection and water management tasks resulting from the principle of sustainable development and consistent with environmental policy. The horizontal aid scheme for environmental protection is based on Commission Regulation (EU) No 651/2014 of 17 June 2014, declaring certain categories of aid compatible with the internal market [107,116]. According to the Polish Ordinance of the Minister of the Environment of 21 December 2015, aid may be granted for investments enabling increases in energy efficiency, as referred to in Art. 2(103) of Commission Regulation (EU) No. 651/2014; investments serving to generate energy in high-efficiency cogeneration, as referred to in Art. 2(107) of Commission Regulation (EU) No 651/2014; investments for the production of energy from renewable energy sources, as referred to in Article 2(110) of Commission Regulation (EU) No 651/2014 or investments for the production of sustainable biofuels; investments in energy-efficient heating and cooling; and investments in energy infrastructure. Aid could also be granted in the form of grants, including interest subsidies on bank loans or interest-bearing loans, or as partial write-offs of interest-bearing loans. The granting of aid would have been subject to the submission of an application before the investment or environmental studies had been started. The application contains information referred to in Commission Regulation (EU) No 651/2014, as well as other information indicated by the body granting the aid and necessary for the assessment of the application.

Also of interest are the data contained in the final reports of the evaluation study entitled "Assessment of the impact of the ROP WP 2014–2020 on energy efficiency and emissions in the individual voivodships" [117]. In these documents, an evaluation was conducted of the actual and potential impact of the support offered under the individual measures of OP III of the ROP WP 2014–2020 on the volume of energy consumption and the resulting emission of pollutants. The study was divided into three research areas, renewable energy sources (RES), energy modernisation of buildings and air quality, and

emission reduction, and used both quantitative and qualitative research methods. The European Commission's Guidelines on state aid for climate and environmental protection and energy 2022, 2022/C 80/0 [118] indicate that the Commission has identified a number of categories of environmental and energy-related measures for which state aid may, under certain conditions, be compatible with the internal market on the basis of Article 107(3)(c) of the EC Treaty, e.g., aid for reducing and eliminating greenhouse gas emissions, including through the promotion of renewable energy and energy efficiency; aid for the improvement of the energy and environmental performance of buildings; aid for resource efficiency and to promote the transition to a closed economy; aid for the prevention of or reduction in pollution other than greenhouse gases; aid for the security of electricity supply; aid for energy infrastructure; aid for heating and cooling systems; and aid for studies or consultancy services related to climate, environmental, and energy objectives. The Ordinance of the Minister of Funds and Regional Policy of 11 December 2022 on granting aid for investments in high-efficiency cogeneration systems and for the promotion of energy from renewable sources within the framework of regional programmes for 2021–2027 [119] specifies the purpose, conditions, and procedure for granting the following types of aid to entrepreneurs within the framework of regional programmes for 2021–2027: (1) aid for investments in high-efficiency cogeneration systems, (2) investment aid for the promotion of energy from renewable sources, and (3) aid for environmental studies. Renewable energy investments can also be financed under the Rural Development Plan. Some of the beneficiaries, such as agricultural production cooperatives, are also involved in food processing and distribution [120]. Some actors in the food industry are also involved in energy cooperatives [121]. The latter are found in many countries around the world and may benefit from government support [122,123].

It is also worth mentioning the National Plan for Reconstruction and Increasing Resilience in Poland (KPO), which is compatible with Regulation (EU) 2021/241 of the European Parliament and of the Council of 12 February 2021 establishing the Recovery and Resilience Facility [124]. Its aim is to bolster the development potential of the economy and to support the sustainable competitiveness of the economy. The objective is also to support energy efficiency, facilitate energy companies' efforts to meet their energy saving obligations, and improve conditions for the development of hydrogen and other decarbonised gas technologies. For improving conditions for the development of renewable energy sources [125], the Regulation of the Minister of State Assets of 15 November 2023 on granting public aid for investments supporting energy efficiency and renewable energy sources in enterprises within the framework of the National Plan for Reconstruction and Increasing Resilience was established [126]. This ordinance specifies the detailed purpose, conditions, and procedure for granting entrepreneurs public aid constituting investment aid: (1) enabling the improvement of energy efficiency other than in buildings, (2) enabling the achievement of energy efficiency in buildings, (3) promoting energy from renewable energy sources, and (4) promoting renewable hydrogen and high-efficiency cogeneration—from the funds of the Instrument for Reconstruction and Increasing Resilience under investment B1.2.1 "Energy efficiency and RES in enterprises—investments with the highest potential for greenhouse gas reduction", covered by the National Plan for Reconstruction and Increasing Resilience, hereinafter referred to as "aid". This aid is granted under the rules set out in Commission Regulation (EU) No. 651/2014 of 17 June 2014 declaring certain types of aid compatible with the internal market in the application of Articles 107 and 108 of the Treaty. It is dedicated to large entrepreneurs in order to reduce both final energy consumption and greenhouse gas emissions by increasing the energy efficiency of industrial and manufacturing processes of enterprises, fostering the decarbonisation of industrial enterprises, and increasing the share of low-carbon sources for energy generation in enterprises through investments in renewable energy sources and low-carbon and efficient use of the energy generated [127]. Horizontal public aid for environmental protection purposes from funds at the disposal of the provincial funds for environmental protection and water management is granted in accordance with Commis-

sion Regulation (EU) No 651/2014 of 17 June 2014, for example, declaring certain types of aid to be compatible with the internal market in the application of Articles 107 and 108 of the Treaty. Examples are investments promoting energy efficiency other than in buildings; investments promoting energy efficiency in buildings; actions facilitating energy performance contracts; investments promoting renewable energy and promoting renewable hydrogen; investments in high-efficiency cogeneration; and investments in energy-efficient district heating and cooling. Aid may be provided in the form of grants, loans, or partial loan waivers.

A summary of the legal acts on financial support from public funds is provided in Table 2.

Table 2. Selected legal regulations on financial support from public funds.

EU Regulations and Guidelines on State Aid and Aid Allowed	Polish Regulations on Financial Support for Energy-Efficiency Investments
Articles 107, 108, and 109 of the Treaty on the Functioning of the European Union [31]	Polish Act of 27 August 2009 on Public Finance [105]
Commission Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market [116]	Regulation of the Polish Minister of the Environment of 21 December 2015 on the detailed conditions for granting horizontal public aid for environmental protection purposes [114]
Council Regulation (EU) 2015/1588 of 13 July 2015 on the application of Articles 107 and 108 of the Treaty on the functioning of the European Union to certain categories of horizontal State aid [112]	The Ordinance of the Minister of Funds and Regional Policy of 11 December 2022 on granting aid for investments in high-efficiency cogeneration systems and for the promotion of energy from renewable sources within the framework of regional programmes for 2021–2027 [119]
Guidelines on State aid for climate, environmental protection, and energy 2022 (2022/C 80/01) [118]	Regulation of the Minister of State Assets of 15 November 2023 on granting public aid for investments supporting energy efficiency and renewable energy sources in enterprises within the framework of the National Plan for Reconstruction and Increasing Resilience [126]
Regulation (EU) 2021/241 of the European Parliament and of the Council of 12 February 2021 establishing the Recovery and Resilience Facility [124]	Announcement of the Minister of Climate and Environment of 23 November 2023 on the list of programmes and financial instruments concerning end-user energy-efficiency improvement projects [128]
	Regulations concerning the financing of the Common Agriculture Policy EU [129,130]

Source: own work based on [31,105,112,114,116,118,119,124,126,128–130].

3. Materials and Methods

The study employs a critical analysis of the literature and legal regulations on energy efficiency in the laws of EU and Poland. We discuss the state support instruments in the implementation of the energy-efficiency target in the food industry, as well as the horizontal state support tools for environmental protection. In the theoretical part of the work, the methods of descriptive, comparative, deductive, and synthetic analysis were applied. Data from the Public Aid Data Sharing System (SUDOP) database [131] were used to conduct empirical research. The information, made available via the SUDOP system, originates from aid reports prepared via the SHRIPM (System of Scheduling, Registration and Monitoring of Public Aid—as used to monitor public aid) IT application. These are reports prepared by entities providing support on the basis of the Act of 2004 on proceedings in state aid cases [132]. Such reports shall provide information on the beneficiaries of the support and on the types, forms, amount, and purpose of the aid granted.

The SUDOP database contains no information on support measures that expired before 2016. The period of analysis for the purpose of the present article begins in 2016 and ends in 2023. The article does not include de minimis aid because that is a specific

type of aid that does not meet all the criteria for state support declared incompatible with the common market [133]. Data were collected for food industry enterprises (NACE Rev. 2 Division 10 Group 10.1–10.9 and Division 11 Group 11.0). The study also uses secondary statistical data on the food industry, including its structure, effects of operation, and energy consumption from the statistical yearbooks of the Central Statistical Office in Poland (GUS) and Eurostat, as well as the level of state aid from reports of the Polish Office of Competition and Consumer Protection (UOKiK), whose president, in accordance with the Act, is the body monitoring state aid in Poland. We applied quantitative methods for the practical part of our research. The results of the analysis were based on the authors' own calculations. The analysis of state financial support takes into account the time range, the structure of the food industry, the size of enterprises, the types of aid granted, and the purpose of the aid granted. The degree of concentration of the aid provided was also calculated by means of frequency distribution. To determine whether there is a statistical relationship between the value of state aid and other variables, i.e., the size of the enterprise, group of the industry, purpose of aid, and type of aid, the chi-square test of independence was used. The hypothesis H_0 was put forward that the value of aid does not depend on these subsequent factors, compared to the hypothesis H_1 that this aid depends on these subsequent factors. The calculations were performed using Excel 2016 and IBM SPSS Statistics version 29. A p-value less than $\alpha = 0.05$ was considered statistically significant.

4. Results

On 648 occasions in the years 2016–2023, public aid for energy-efficiency purposes was granted to enterprises involved in the production of food and beverages. This amounted to EUR 41.1 million (Table 3), and, throughout the period being analysed, the frequency of granting aid, the sums of this aid, and the average value of the aid all increased. However, since 2021, despite the persistently high frequency of aid grants (amounting to more than 90 times a year), the value of aid granted has dropped from EUR 11.1 million to EUR 3.4 million. This has resulted in a decrease in the average value of the aid from EUR 104,600 to EUR 30,400.

Table 3. The value of public aid for energy-efficiency purposes in food industry enterprises in Poland in 2016–2023.

Years	Frequency of Aid	Value of Aid (EUR in Thousands)					
		Sum	Average	Median	Min	Max	Vs (%)
2016	22	489.01	22.23	11.19	0.77	92.95	121.15
2017	88	5507.54	62.59	9.67	0.08	1688.70	333.12
2018	89	6679.52	75.05	9.22	0.15	3111.29	448.66
2019	48	4434.51	92.39	7.69	0.86	1282.54	254.01
2020	91	4543.58	49.93	15.04	0.14	998.65	252.34
2021	106	11,084.54	104.57	14.05	0.01	1949.04	303.04
2022	93	5001.37	53.78	7.00	0.04	779.54	241.87
2023	110	3373.24	30.39	7.52	0.08	760.48	266.18

Vs—coefficient of variation. Source: own work based on [131].

We noted a very large variation in the value of aid provided in each of the years subjected to our analysis. Therefore, for half of the aid measures, their value was much lower than the mean value of the respective year. This is particularly evident in the case of years when the difference between the extreme values was very large. In some years (2017–2019, 2021), the range was even above EUR 1 million. Indeed, throughout the period being analysed, the minimum value of aid ranged from EUR 0.01 thousand to EUR 0.86 thousand, while the maximum value ranged from EUR 0.1 million to EUR 3.1 million.

In 2023, 62 enterprises of the food industry were granted public aid. Here, the total amount was three times that in 2016 (Figure 2). In addition, the increasing subjective scope of aid was accompanied by an increase in the mean value of aid granted to enterprises (from EUR 22,200 to EUR 54,400). Moreover, the largest mean aid for an entity occurred in

2021 (over EUR 165,000), and, at this time, the largest number of entities also received such support (67), with a high total value of the aid granted (over EUR 11 million). Overall, in the period being analysed, the mean number of aid activities implemented for any entity increased from 1 to almost 2.

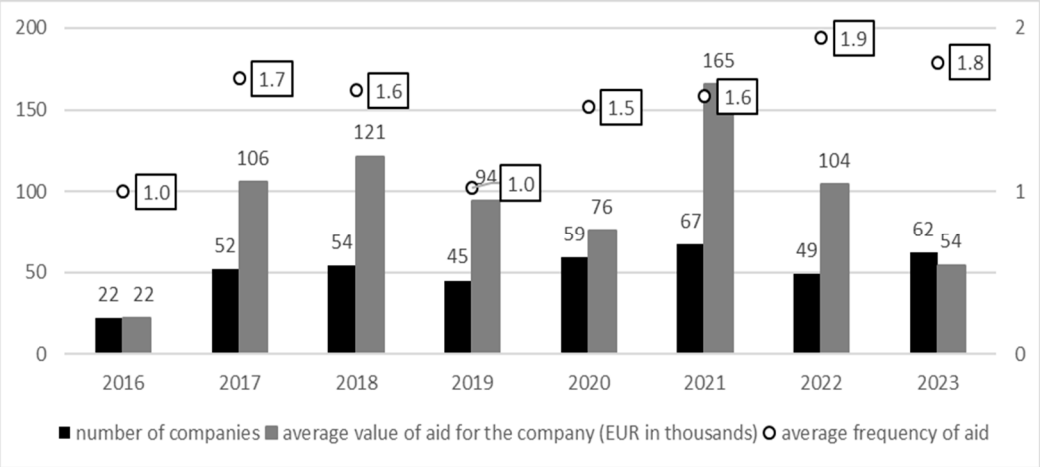

Figure 2. Number of food industry enterprises in Poland covered by public aid for energy-efficiency purposes, average value of aid, and frequency of aid in 2016–2023. Source: own work based on [131].

In the years 2016–2023, we observed a very large variation between the individual sectors of the food industry in terms of the public aid received for energy-efficiency purposes (in terms of its amount and value) (Table 4). The most significant aid, i.e., EUR 12.6 million, went to the meat processing and preserving industry and to the production of meat products. Therefore, with only 36 cases of aid, the average value of the aid measure was also the largest (over EUR 350,000).

Table 4. The value of public aid for energy-efficiency purposes in various food industries in Poland.

Group	Frequency of Aid	Value of Aid (EUR in Thousands)					
		Sum	Average	Median	Min	Max	Vs (%)
10.1	36	12,647.05	351.31	34.18	0.04	3111.29	186.99
10.2	1	27.89	-	-	-	-	-
10.3	435	8709.02	20.02	4.81	0.01	627.42	230.11
10.4	56	1361.81	24.32	10.05	0.59	116.06	117.89
10.5	21	5579.11	265.67	189.76	20.93	741.29	94.40
10.6	21	915.12	43.58	5.90	0.12	760.48	368.36
10.7	28	1956.07	69.86	38.33	8.46	398.80	115.93
10.8	10	1411.46	141.15	40.40	18.18	926.47	188.10
10.9	9	2724.06	302.67	102.60	16.58	935.65	110.65
11.0	31	5781.72	186.51	17.25	0.52	1688.70	211.24

Vs—coefficient of variation. Groups: 10.1 processing and preserving of meat and production of meat products; 10.2 processing and preserving of fish, crustaceans, and molluscs; 10.3 processing and preserving of fruit and vegetables; 10.4 manufacture of vegetable and animal oils and fats; 10.5 manufacture of dairy products; 10.6 Manufacture of grain mill products, starches, and starch products; 10.7 manufacture of bakery and farinaceous products; 10.8 manufacture of other food products; 10.9 manufacture of prepared animal feeds; 11.0 manufacture of beverages. Source: own work based on [131].

The lowest aid (one aid measure—amounting to nearly EUR 28,000) was provided to the industry dealing with the processing and preservation of fish, crustaceans, and molluscs. In contrast, the fruit and vegetable processing and preservation industry used the allotted aid most frequently (435 cases in total), which meant that despite the relatively high amount of provided aid, on average, there was only EUR 20,000 allocated per aid measure. In industries dealing with the production of oils and fats of vegetable and animal origin; the production of cereal mill products, starches, and starch products; and the production

of other foodstuffs, the value of the aid provided did not exceed EUR 2 million. On the other hand, in the industry producing ready-made feed and animal feed, the dairy industry, and the beverage industry, the value of the aid granted was relatively high (from EUR 2.7 to EUR 5.8 million), which, when accompanied by a low frequency of granting aid (from 9 to 31 cases), generated a high average value of the individual aid measures (from EUR 186.5 thousand to EUR 302.7 thousand). At the same time, there was a very large variation in the value of the aid provided between the industries. Therefore, for half of the aid measures, their value was much lower than the mean value. This is particularly evident in the case of industries where the difference between the extreme values was very large. In some industries (meat, beverages), the range was even above EUR 1 million. Overall, the minimum value of aid ranged from EUR 0.01 thousand to EUR 21 thousand, while the maximum value ranged from EUR 0.1 million to EUR 3.1 million.

In the period in question, there were 179 companies that benefitted from the allotted aid, of which the majority were involved in fruit and vegetable processing (67), meat (29), bakery (23), dairy (15), and beverage production (13) industries (Figure 3). These industries (apart from bakery) were also characterised by having high average support awarded per company (from EUR 130,000 to EUR 445,000) due to the large amount of aid granted. Herein, the companies that received aid most often came from the oil and fat industry (9.3) because, in total, there were few companies that benefitted from such public aid (6). Only three industries benefitted from public aid offered every year, i.e., the fruit and vegetable, oil and fat, and beverage industries. In the case of the last two industries, this concerned a small number of entities, so most participated in the aid programme quite regularly.

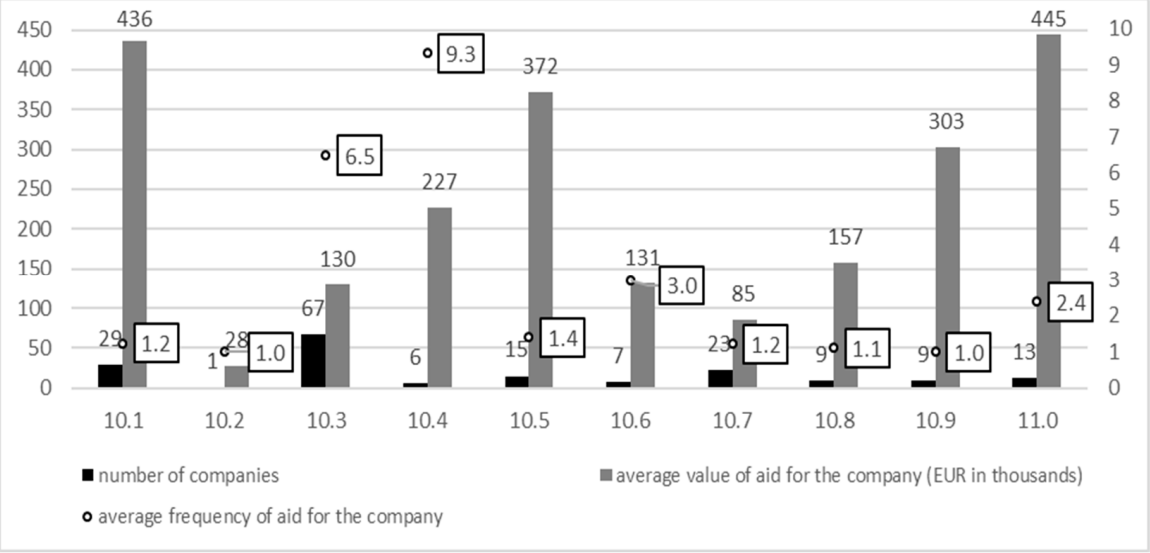

Figure 3. Number of enterprises in Poland covered by public aid for energy-efficiency purposes, average value of aid, and frequency of aid in various food industries. Source: own work based on [131].

On a yearly basis (Table 5), every year (apart from 2022), aid addressed to large enterprises was greatest, as was the average value of aid per beneficiary in this group of entities (apart from 2017). Indeed, throughout the period under review, large entities received EUR 24.2 million, i.e., 58.9% of all funds; medium-sized entities obtained 23.5%; small enterprises gained 15.9%; and micro-sized ones secured only 1.7% (and were also the ones to use aid the least frequently). On average, each of the types of entities received financial assistance no more than twice each year.

Table 5. Level of public aid for energy-efficiency purposes granted to micro-sized, small, medium-sized, and large food industry enterprises in Poland.

Year	Number of Enterprises				Frequency of Aid				Value of Aid (EUR in Thousands)			
	Micro	Small	Medium	Large	Micro	Small	Medium	Large	Micro	Small	Medium	Large
2016	0	2	10	10	0	2	10	10	0.00	37.75	128.00	323.26
2017	1	10	18	23	2	16	29	41	102.26	849.26	2097.41	2458.60
2018	5	14	17	19	5	19	29	36	134.70	1303.03	706.40	4535.39
2019	3	6	15	23	3	6	16	23	130.01	73.21	1538.71	2692.58
2020	3	13	18	26	3	15	30	43	115.04	334.52	725.77	3368.24
2021	7	15	23	22	7	21	39	39	190.51	3720.89	892.19	6280.95
2022	0	6	23	19	0	10	45	38	0.00	85.75	2664.18	2251.44
2023	2	7	28	25	2	10	50	49	34.20	120.68	929.29	2289.08
Total	21	73	152	167	22	99	248	279	706.72	6525.09	9681.95	24,199.55

Source: own work based on [131].

We noted a very high level of concentration of the funds received. Herein, in the meat industry (group 10.1), four enterprises (three large and one small) received almost EUR 8.5 million, i.e., 67% of all funds directed to this industry (Table 6), and each entity received between EUR 1 million and EUR 3.1 million. The beverage industry (11.0) also revealed a high level of concentration, and of the companies in this sector that received at least EUR 1 million of aid, two medium-sized entities were allotted almost EUR 3 million, i.e., more than 51% of all funds. In the dairy industry (10.5), two large dairies received at least EUR 1 million, and another seven dairies (including six large and one medium-sized) received from EUR 100,000 to EUR 1 million. These entities accounted for EUR 5.4 million, i.e., for over 97% of all funds from that industry. In other industries, the degree of concentration of the value of aid measures for entities that received from 100,000 to 1 million euros was also high, i.e., from 68.5% (production of bakery products, 10.7), to over 99% (production of oils, 10.4; production of feed, 10.9). In summary, almost 61% of all entities (i.e., 109) were those that received up to EUR 100,000 of aid, but the aid value constituted EUR 3.5 million, i.e., 8.6% of all funds allocated to the food industry.

Table 6. Degree of concentration of the value of aid for energy-efficiency purposes in various food industries in Poland *.

Value of Aid for One Entity (EUR in Thousands)	10.1		10.3		10.4		10.5		10.6		10.7		10.8		10.9		11.0	
	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V	N	V
(0–1)	1	0.04	2	1.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<1–10)	2	16.8	7	34.5	1	6.3	0	0	1	6.0	1	8.5	0	0	0	0	2	8.1
<10–100)	14	357.3	35	1580.3	0	0	6	194.2	5	133.7	16	608.2	7	305.3	4	102.1	4	128.9
<100–1000)	8	3802.3	23	7093.1	5	1355.5	7	3338.7	1	775.4	6	1339.5	2	1106.2	5	2621.9	5	2673.6
<1000–3121.5>	4	8470.6	0	0	0	0	2	2046.2	0	0	0	0	0	0	0	0	2	2971.2

* without group 10.2, in which there was one entity during the period under review. N—number of entities, V—value of aid (EUR in thousands). Source: own work based on [131].

There were 16 aid programmes in the years 2016–2023. The largest financial resources, i.e., EUR 14.7 million, were provided via the SA.43907 programme, with aid granted 19 times to 19 entities over five years (2017–2021) (Table 7). The objective of this programme was to implement high-efficiency cogeneration (HC). The source of the funding was foreign. The programme was implemented in various forms, i.e., subsidy (S), fee reductions (F), preferential loans (PL), or conditional forgiven loans (CL). The programme that the entities used most often, i.e., on 249 occasions during the entire period of 2016–2023, was SA.37345. Its value amounted to almost EUR 7.3 million. This was operating aid in the form of a reduction in the amount of the fee (F) for the promotion of energy from renewable sources

(OR). The source of this aid was national. Another important programme was SA.47030, which was used only three times but provided a total amount of over EUR 4 million. SA.47030 offered investment aid for the promotion of renewable energy (IR) in the form of subsidy or other non-repayable benefits (S). The investment programmes SA.43254 (EUR 3.4 million) and SA.43229 (almost EUR 3 million), which were available for five years (2016–2020 and 2017–2021), were also significant in terms of the amount of aid granted. The first was intended for projects supporting energy efficiency in buildings (EE), and the second was for the promotion of energy from renewable sources (IR). Both were provided in the form of grants or other non-refundable benefits (S). A programme which in 2020–2021 was used relatively often, that is, in 68 cases, was the national SA.52530 programme of aid, which lowered the fee (F) for high-efficiency cogeneration (HC). However, its value was relatively low, totalling EUR 190,000. The value of aid granted under other programmes ranged from EUR 73,000 to almost EUR 2 million.

Table 7. Public aid measure for energy-efficiency purposes in food industry enterprises in Poland in 2016–2023.

Years	Aid Programme	Number of Entities	Frequency of Aid	Value of Aid (EUR in Thousands)	Form of Aid	Purpose of Aid
2016	SA.37345 (2015/NN)	21	21	462.54	F	OR
	SA.43254 (2015/X)	1	1	13.28	S	EE
2017	SA.37345 (2015/NN)	34	34	968.31	F	OR
	SA.43229 (2015/X)	5	5	1043.67	S	IR
	SA.43254 (2015/X)	7	8	690.20	S	EE
	SA.43697 (2015/N)	37	37	67.75	F	OR
	SA.43907 (2015/X)	3	3	2727.39	S	HC
	SA.44685 (2016/X)	1	1	10.22	PL	EE
2018	SA.37345 (2015/NN)	32	32	980.50	F	OR
	SA.43229 (2015/X)	12	14	862.65	S	IR
	SA.43254 (2015/X)	6	6	947.17	S	EE
	SA.43697 (2015/N)	35	35	103.55	F	OR
	SA.43907 (2015/X)	2	2	3785.66	S	HC
2019	SA.37345 (2015/NN)	35	35	313.50	F	OR
	SA.43229 (2015/X)	4	4	118.71	S	IR
	SA.43254 (2015/X)	4	4	1496.48	S	EE
	SA.43907 (2015/X)	5	5	2505.82	S	HC
2020	SA.37345 (2015/NN)	32	33	792.29	F	OR
	SA.43229 (2015/X)	13	13	633.95	S	IR
	SA.43254 (2015/X)	4	4	251.73	S	EE
	SA.43907 (2015/X)	4	4	1392.21	S	HC
	SA.44685 (2016/X)	2	2	119.75	PL	HC
	SA.47030 (2016/X)	1	1	998.65	S	IR
	SA.52530 (2019/N)	32	32	150.61	F	HC
	SA.55396 (2019/X)	2	2	204.40	S	IR
2021	SA.37345 (2015/NN)	38	38	943.36	F	OR
	SA.43229 (2015/X)	13	13	304.00	S	IR
	SA.43907 (2015/X)	5	5	4281.50	S	HC
	SA.47030 (2016/X)	2	2	3028.45	S	IR
	SA.52530 (2019/N)	36	36	39.77	F	HC
	SA.55396 (2019/X)	3	3	136.28	S	IR
	SA.59143 (2020/X)	3	3	72.96	S	IR
	SA.59387 (2020/X)	1	1	371.59	S	IR
	SA.64582 (2021/X)	3	5	1906.63	S	IR

Table 7. *Cont.*

Years	Aid Programme	Number of Entities	Frequency of Aid	Value of Aid (EUR in Thousands)	Form of Aid	Purpose of Aid
2022	SA.101484	2	4	327.46	CL	HC
	SA.101484	1	1	6.10	PL	EE
	SA.101484	2	2	270.14	PL	IR
	SA.101556	3	3	1228.62	S	HC
	SA.101607	4	4	1377.18	S	IR
	SA.101633	1	3	683.18	S	EE
	SA.37345 (2015/NN)	40	40	1049.46	F	OR
	SA.43697 (2015/N)	36	36	59.23	F	OR
2023	SA.101484	3	3	409.23	PL	IR
	SA.101484	1	1	71.36	CL	HC
	SA.101607	6	6	81.29	PL	IR
	SA.37345 (2015/NN)	50	50	2729.74	F	OR
	SA.43697 (2015/N)	51	51	81.62	F	OR

F—lowering the fee, S—subsidy or other non-refundable benefit, PL—preferential loan, CL—loans conditionally forgiven, OR—operating aid for the promotion of energy from renewable sources, IR—investment aid for the promotion of energy from renewable sources, HC—aid for high-efficiency cogeneration, EE—investment aid for measures supporting energy efficiency. Source: own work based on [131].

Most programmes (as many as 11) took the form of subsidies. More than three-fourths of the value of the aid granted, i.e., EUR 31.1 million, took the form of a subsidy or other non-refundable benefit (Figure 4) and was given over 118 times. Most often, as many as 510 times, the aid took the form of a reduction in the amount of fees, which constituted 21.3% (EUR 8.7 million) of the value of aid for the sector. Three programmes were provided in this form. The other two programmes were preferential or conditionally forgiven loans, which made up 3.2% of the aid value. Almost half of the funds were allocated to the promotion of energy from renewable sources (Figure 4). Still, 28.8% (i.e., EUR 11.8 million) was allocated to investment aid for the promotion of energy from renewable sources, mainly in the form of grants or other non-repayable benefits. This objective was pursued 81 times. Another 20.8% of all available funds (EUR 8.6 million) was directed towards promoting energy from renewable sources in the form of operating aid as a reduction in the amount of fees. This objective was the most often implemented, with 442 cases. The second most important objective of the aid received was high-efficiency cogeneration. EUR 16.6 million was allocated for this purpose, i.e., over 40% of all funds. This task was implemented in 97 cases. EUR 4.1 million was allocated for investment aid for projects supporting energy efficiency, e.g., in buildings. This type of aid was granted 28 times.

Large enterprises received the largest share of the funds allocated for operating aid for the promotion of energy from renewable sources (67.3%) and for high-efficiency cogeneration (85.4%) (Figure 5). The advantage enjoyed by large entities is more clearly visible in terms of their greater share in the value of aid than in the frequency of receiving aid (they practically did not participate in the allocation of funds for energy efficiency). In the case of investment aid for the promotion of energy from renewable sources, the largest beneficiaries were small entities (41.9%), and in the case of investment aid for measures supporting energy efficiency, they were medium-sized entities (61.8%).

The meat processing industry received the most funds for investment aid for the promotion of energy from renewable sources (47.1%) (Figure 6). In contrast, almost three-fourths of all funds aimed to popularise energy from renewable sources in the form of operating aid were received by the fruit and vegetable industry. Of the funds for high-efficiency cogeneration, the majority was allocated to two sectors, i.e., meat (41.5%) and dairy (26.3%). Moreover, two-thirds of all investment aid for projects supporting energy efficiency was allotted to enterprises involved in the production of beverages. Apart from fish processing, other food industries benefitted from funds directed at various purposes.

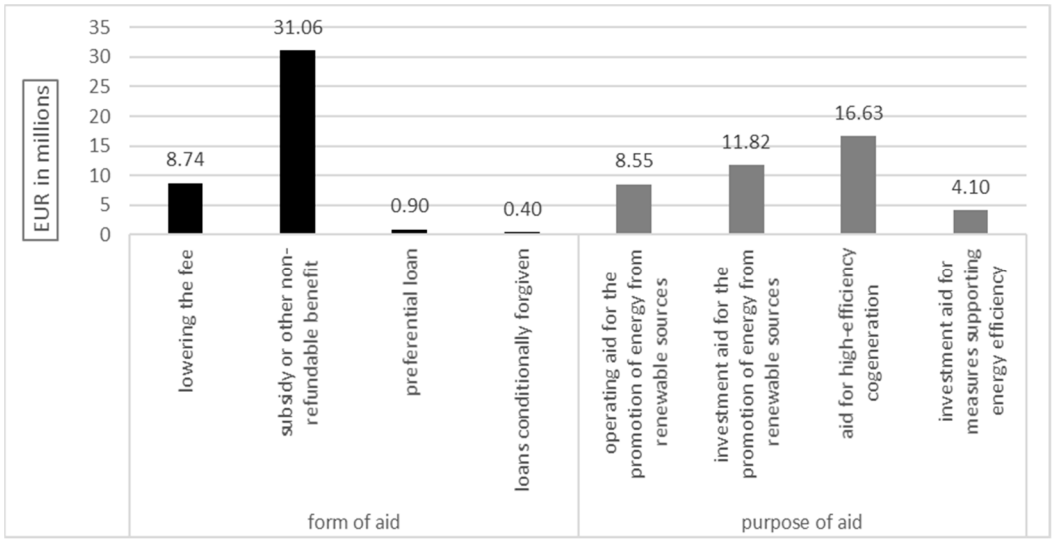

Figure 4. Structure of the aid value according to the form of aid and the purpose of aid for energy-efficiency tasks in food industry enterprises in Poland. Source: own work based on [131].

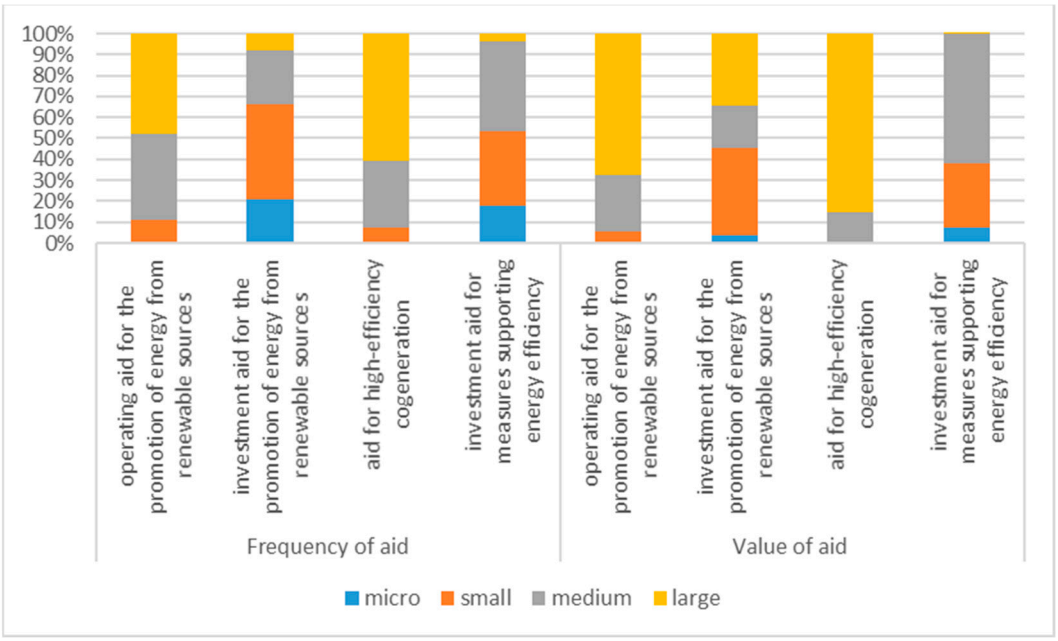

Figure 5. Structure of the value of aid for energy-efficiency purposes, according to the size of food industry enterprises in Poland. Source: own work based on [131].

To determine whether there is a statistical relationship between the value of state aid and other variables, i.e., the size of the enterprise, group of the industry, purpose of aid, or type of aid, the chi-square test of independence was used (Table 8). Since the obtained p-value in each case is greater than the significance level, there are no grounds to reject the null hypothesis that the variables are independent, which indicates the independence of state aid from the size of the enterprise, group of industry, form of state aid, and purpose of aid.

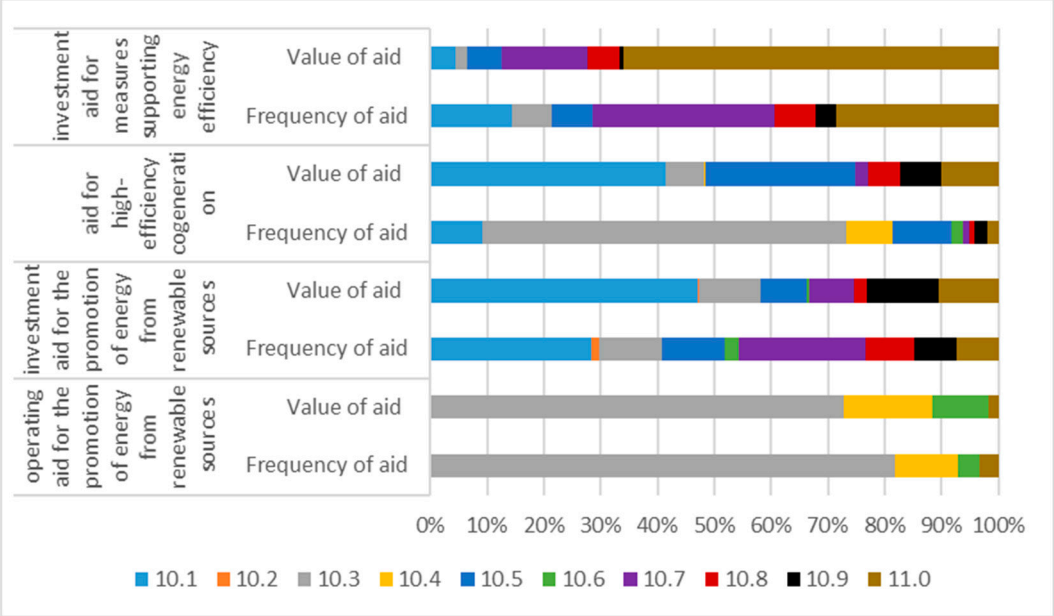

Figure 6. Structure of the value of aid for energy-efficiency purposes, according to the various food industries in Poland. Source: own work based on [131].

Table 8. Results of the verification of the chi-square test for independence (significance level $\alpha = 0.05$).

Factors	χ^2 Value	Degrees of Freedom	*p*-Value
Size of the enterprise	1922.62	1932	0.556
Group of industry	5832.00	5796	0.367
Form of state aid	1944.00	1932	0.419
Purpose of aid	1939.99	1932	0.445

Source: own work based on [131].

5. Discussion

In answering questions 1–3, an analysis of the legislation and literature shows that EU and national legislators are recognising the growing importance of energy efficiency and its positive impact on environmental protection and the fight against climate change. Efficiency is broadly defined as including the reduction in energy consumption and, among other things, cogeneration, i.e., the simultaneous production of electricity and heat. Such measures help to cut the emissions of greenhouse gases and other harmful substances by reducing the amount of fuel used for combined heat and power generation. Cogeneration continues to be an important part of the electricity and heat production market in Poland. In 2018, cogeneration accounted for 11.6% [100] of electricity generation, and it is increasing every year. The "energy efficiency first" principle was mentioned, e.g., in Regulation (EU) 2018/1999 of the European Parliament and of the Council [134], and implies a comprehensive integration of the energy system, security of supply, and cost-effectiveness, working towards the most efficient solutions for the environment along the entire value chain from energy production to use, e.g., in food processing, transport, and final energy consumption. The idea is to achieve efficiency in both primary and final energy consumption. Reducing energy consumption contributes to an equitable energy transition and reduces energy poverty. It is worth noting that one of the main policy objectives of the European Union is precisely the transition to a climate-neutral and circular economy. The transition needs to be equitable and inclusive. The Union, the Member States, and their regions must therefore take account of the social, economic, and environmental conditions in the countries concerned [135].

The granting of state aid is complicated but possible if the requirements are met, e.g., horizontal aid. EU and national legislators provide funds for investments in renewable

energy and other areas of energy efficiency, but their receipt and subsequent disbursement and implementation require compliance with a number of regulatory requirements related to state aid. It is important to note the development not only of legislation but also of policies. Energy efficiency is taken into account in many policies, not only in energy and environmental protection but also in the Common Agricultural Policy. The Polish CAP Strategic Plan 2023–2027 and legal regulations foresee the financing of measures related to renewable energy or the modernisation of buildings [129,130]. Despite very strict state aid rules, the EU legislator provides many examples of permissible state aid, such as horizontal aid. The importance of energy efficiency varies due to different climatic conditions. In countries such as Poland, where winters are cold and there is still a high proportion of coal, investment in renewable energy is particularly important. These investments are financed not only by public funds but often by an entity's own resources or loans.

The research also showed that energy-efficiency tools are diverse. Most of them relate to large enterprises, e.g., energy audits. Member States have adopted the principles of Directive 2012/27/EU, but some have also introduced other legal instruments. For example, in different countries there are tax incentives, access to finance, subsidies or grants, the provision of information and training on energy efficiency, and the use of certification labels. Member States are also responsible for enforcing national legislation implementing the Directive, which only requires that they provide for effective sanctions to ensure compliance with the provisions of the energy-efficiency obligation scheme. Such remarks also came out of studies such as that by [136].

This study and many others deal with the implementation of the 2012 Directive. However, there is a lack of such publications on the role of state aid in achieving the energy-efficiency targets of the food industry in Poland. At the same time, the new Directive 2023/1791 poses innovative challenges regarding the transposition of its provisions into national regulations. Member States are likely to take additional account of their energy-efficiency needs and circumstances. As far as public support is concerned, it can be divided into several types in Poland. According to the Decree of the Minister of Climate and Environment of 23 November 2023 on the list of programmes and financial instruments for projects to improve the energy efficiency of end users, programmes and financial instruments for projects to improve the energy efficiency of end users [128] can be divided into the following: firstly, those for which funds have been obtained from the state budget; secondly, those for which funds have been obtained from the budget of the European Union and from the assistance granted by the Member States of the European Free Trade Agreement (EFTA) or from other foreign sources; thirdly, those for the implementation of funds obtained from the budgets of local government units; fourthly, those for which funds have been obtained from the National Fund for Environmental Protection and Water Management; and fifthly, those for which funds have been obtained from provincial funds for environmental protection and water management. However, only some of these funds can be accessed by entrepreneurs. The majority are addressed to households or municipalities. In addition, public funds from the National Plan for Reconstruction and Increasing Resilience and the Common Agricultural Policy should also be noted.

In summary, the discussion here shows that the framework of the formulation of regulations on energy efficiency is related to the current challenges of climate change, environmental pollution, renewable energy, and increasingly scarce carbon resources. The regulatory framework is very broad. It includes substantive laws of environmental, energy, and financial law and also the administrative procedural regulation of institutions and elements of civil law. The law takes into account political, social, economic, and environmental aspects. Comprehensive legislation is in place to finance investments in energy efficiency, dissemination of knowledge, and innovation in this field. In terms of details, the general provisions of the Treaty on the Functioning of the EU and the Energy Efficiency Directive 2012/27/EU and 2023/1791 of the European Parliament and of the Council should be mentioned first. There are also EU rules on state aid, including horizontal and other rules under other policies such as agricultural and regional, which bring in a

wide range of funding opportunities for agri-food entrepreneurs. Guidelines and decisions should also be mentioned. All forms of sources of EU law have been used in formulating regulations on energy efficiency and financing such investments. An extensive regulatory framework also exists at the level of EU Member States' national legislation, as they have implemented the 2012 EU Directive using existing sources of law in their countries. For example, in Poland, there is the Act on Energy Efficiency of 2016, a broad catalogue of Ministry regulations for this legislation. Equally broad and extensive are the regulations on financing energy-efficiency investments. In this regard, there are both acts and Ministry regulations. Some forms of support also occur at the local level, for example, on the basis of resolutions passed by municipalities. There is also wide and extensive legislation and documents on efficiency in other countries outside the EU, such as the USA. Research has shown that the actions of the European Union legislators and national legislators are in line with Transforming Our World: the 2030 Agenda for Sustainable Development, adopted by the United Nations (UN), a programme of action that defines a model for sustainable development at the global level [80].

Answering question no. 4, concerning the scope of state aid for energy-efficiency purposes in the energy-intensive food industry in Poland, it should be stated that between 2016 and 2023, the frequency of granting state support in Poland for energy-efficiency purposes for enterprises involved in the production of food and beverages, the amount of this aid, and the average value of the aid increased. This coincided with a surge in the value of state support for environmental protection and energy purposes in Poland (by 148%) and an enlargement of its share in the value of total state aid from 19.2% to 24.4% [63,64]. Although the scale of support for energy-efficiency purposes for enterprises involved in the production of food and beverages in public funds for environmental protection and energy purposes has clearly increased (by 186%), the share itself remains very low (0.17%). This research is confirmed by in-depth research on the allocation of state aid in a selected food industry, where the entire dairy industry was allocated only 13% of the obtained state support for investments in renewable energy or in high-efficiency cogeneration [67]. Research on the structure of state aid in other EU countries indicates a much higher share of aid for environmental protection and energy than in Poland [65].

Although the level of state analysed aid to the food industry in Poland is increasing (since 2016, it has increased almost sevenfold to EUR 3.37 million in 2023), it remains quite low in relation to the investments made in the sector. Companies in the food industry make high and increasing investments in fixed assets (increasing by 122% from 2010 to EUR 3 billion in 2022). This investment is mainly in the form of machinery and equipment as well as in buildings and structures, which is due to the high and increasing wear and tear of fixed assets [46]. In addition, in the food industry, expenditure on new fuel combustion techniques and technologies for air and climate protection, including the modernisation of boiler and heating plants, is growing (more than 11 times since 2010), although the level of these investments is not very high (EUR 24.5 million in 2022) [46,137].

With regard to question 5, "Does aid to enterprises vary according to the type of food industry, the size of the enterprise, the aid programme, the form of the aid, or its purpose?", we can say that our survey also revealed a very large variation in the amount of state aid received by individual sectors of the food industry. The largest share of the aid, i.e., 30.7%, went to the meat processing and preserving industry and to the manufacture of meat products. More than one-fifth of all aid was allocated to the processing and preserving of fruit and vegetables. Dairies also occupy an important position, with a share of almost 14% of the aid granted. This is justified because the largest share of energy consumption in the production of food and beverages comes from meat, milk, fruit, and vegetable processing [46].

Every year, the largest amount of public aid was received and most often used by large and medium-sized enterprises. Throughout the period under review, large entities received EUR 24.2 million, i.e., 58.9% of all funds; medium-sized entities accounted for 23.5%, small—15.9%, and micro-sized—only for 1.7%. This corresponded to the structure

of turnover generated by the food industry, where the share of large entities in the sector's turnover was 59.3% in 2020. This is still a smaller share than, for example, those in France (76%), Germany (70%), or in the UK (72.3%) but still a good result considering the small number of these entities (272) [48]. Research on Polish industrial enterprises indicates that among the various goals of eco-innovation, the reduction in energy consumption during production processes is implemented mostly by medium-sized and large enterprises [138].

The enterprises in the food industry benefitted from numerous programmes, the purpose of which in the field of energy efficiency was focused on three objectives. Almost half of the funds were allocated to the promotion of energy from renewable sources as investment aid in the form of grants or other non-repayable benefits, as well as operating aid as a reduction in the amount of fees due. The second objective of the aid received was high-efficiency cogeneration (over 40% of the funds), and 10% of the funds were allocated to investment aid for projects supporting energy efficiency, e.g., in buildings. This is confirmed by the fact that more and more Polish enterprises in this sector mainly carry out activities in the field of reducing energy consumption by installing more energy-efficient production equipment, energy-saving boilers, energy-saving refrigeration systems, and energy recovery systems [139]. At the same time, in addition to expensive technologies for improving energy efficiency, better energy management is important, such as financing smart metering and monitoring of energy, including its losses [21,45]. State aid programmes took various forms. The most important form (three-fourths of the value of the aid granted) were subsidies or other non-refundable benefits, which were bequeathed 118 times in total. Most often, as many as 510 times, the aid took the form of a reduction in the amount of fees, which constituted 21.3% of the full value of aid for the sector. The loan form was the least frequently used. The multitude of public support programmes and tools, including a large variety of direct subsidies, is typical, as in other EU countries, for the implementation of energy-efficiency policy [140]. In particular, subsidies and access to capital measures are politically and socially popular because they reduce the initial investment costs and eliminate financial barriers hindering energy efficiency [141].

Differences in the value structure of the allocation of energy-efficiency aid according to the size of enterprises, e.g., where we observed the dominance of large entities in aid for high-efficiency cogeneration (85%), is due to the fact that they are very strongly affected by the constant increase in energy consumption and therefore invest in the most modern and energy-saving technologies and processes [142]. Due to their specificity, various food production entities have had different shares in the individual energy-related objectives, e.g., 67.8% of all funds for high-efficiency cogeneration went to the meat and dairy industries, which are very energy intensive due to high production hygiene standards [115]. An example of such activities is the construction of a new unit of electricity and heat generation in high-efficiency cogeneration technology with a total nominal electrical capacity of 0.99 MW by Mlekovita, the largest dairy in Poland [143]. The cogeneration system built at its largest plant ensures the production of electricity in quantities that allow it to avoid the necessity of purchasing electricity from external sources, and the production of heat from cogeneration is used for the production of its dairy products. The project, worth over EUR 1 million, secured one-third of this amount via government funding.

The present study confirms that in the context of climate policy objectives, such a low level of state funds for energy-efficiency purposes for enterprises in Poland, including those in the food industry, may result in the need to increase private spending by these enterprises [66]. This also indicates the need to adapt the country's policy on supporting innovation in the consumption of energy, especially in less technologically advanced sectors, such as agri-food production [144], where processes of diversification of energy sources take place [145]. Sector strategies are important and include designing appropriate instruments to support energy-efficiency policy such as grants, loans, and other forms of public financing [146]. Appropriate policies should be developed to support enterprises in implementing energy-efficiency strategies, especially when changing processes, including purchasing technologies related to intelligent food processing [147] and monitoring energy

losses and implementing immediate solutions to avoid them [148]. Taking into account the high costs associated with investments in energy efficiency [149], this is particularly important for the sector of small and medium-sized enterprises in the food industry. These enterprises have less equity capital, and the increase in costs particularly affects their profitability and competitiveness [150].

6. Conclusions

In making this assessment, it is important to highlight the development of energy-efficiency legislation at both EU and national levels. Examples include regulations and directives such as Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955, which states, inter alia, that increasing the EU's energy-efficiency target can lead to lower energy prices and have a decisive impact on reducing greenhouse gas emissions. This can be achieved mainly through reducing energy consumption and improving energy savings; adapting buildings and production, including those related to food, and also through investing in renewable energy and innovative solutions. The legislators rightly point out that energy efficiency is increasingly recognised as an important factor in achieving various societal objectives related to environmental and climate protection, competitiveness, and energy security. Energy efficiency is an important element of EU policy under the European Green Deal. It is important to note the development of public funding opportunities for energy-efficiency measures. In this respect, a regulation on permissible horizontal aid has been adopted, in which the categories of aid specified are compatible with the Single Market and Articles 107 and 108 of the Treaty on the Functioning of the European Union. In Poland, various sources of funding for energy-efficiency measures are in line with EU rules. Investment in renewable energy sources and thermo-modernisation of buildings are increasingly common. Other such measures are important in the food industry, which produces energy-intensive food that is essential for everyone's life. This food should be affordable, and the lower costs associated with energy and energy efficiency will have a positive impact on food and energy security. EU and national legislation is focusing more attention on energy efficiency, emphasising the positive impact on the environment, financial savings, and caring for future generations.

The scope of state aid for energy-efficiency purposes in the energy-intensive food industry in Poland is relatively low. Despite the increase in state aid to food and beverage companies for energy-efficiency purposes, it is still small in relation to both the investments made by companies in the sector and the total amount of state aid in the country. Investment expenditure related to adapting to climate policy requirements is extremely high. For the food industry, which is energy intensive due to its specific technological processes, and which has low profitability, the question of the role of state aid raised here seems to be quite relevant.

The aid for enterprises varies depending on the type of food industry, size of enterprises, aid programme, form of aid, and its purpose. As most of the aid has been assigned to large and medium-sized enterprises, this may indicate that small enterprises have not yet started to adapt and will require even greater state support to implement eco-innovations in the field of energy. The tightening of climate policy will boost the importance of the energy saving target in the coming years, which should be reflected in an increase in the value of aid granted to companies for this purpose. The contemporary geopolitical situation indicates that while improving energy consumption in the food industry is advisable for reasons of cost competitiveness or growing environmental requirements, it requires spreading over time. Due to the fact that investments in this area often exceed the financing possibilities by enterprises, state support is important.

It should also be noted that the complexity of regulations, which change frequently, is precisely what leads some entrepreneurs to use their own resources or loans instead of applying for public funds. Many entrepreneurs use public funds for energy-efficiency

investments, and with the new EU funding opportunities, the number of beneficiaries will increase.

Our study fills a research gap. The level of public aid for energy-efficiency purposes in the food industry in Poland and all its branches was indicated. Forms of aid and specific goals in this area were indicated. This aid was also analysed in the context of applicable legal acts at the national and EU level.

However, the article does have its limitations; e.g., the impact of energy-efficiency support, such as the number of investments realised, is not indicated. Further research should seek to show the concrete effects of state aid on at least a selected sample of companies. Another issue could be to analyse the criteria employed by the different authorising bodies when granting or refusing state aid. A further step would be to conduct an analysis comparing state aid and its effects on food industry enterprises in different countries.

Author Contributions: Conceptualization, M.Z.-C. and A.S.; methodology, M.Z.-C. and A.S; software, M.Z.-C.; validation, M.Z.-C.; formal analysis, M.Z.-C.; investigation, M.Z.-C. and A.S.; resources, M.Z.-C. and A.S.; data curation, M.Z.-C.; writing—original draft preparation, M.Z.-C. and A.S.; writing—review and editing, M.Z.-C. and A.S.; visualization, M.Z.-C.; supervision, M.Z.-C.; project administration, M.Z.-C.; funding acquisition, M.Z.-C. All authors have read and agreed to the published version of the manuscript.

Funding: The language correction was funded by The John Paul II Catholic University of Lublin, grant number 1/6-20-23-05-0601-0002-1030.

Data Availability Statement: The data presented in this study are available in open databases Eurostat and SUDOP. These data can be found here: https://ec.europa.eu/eurostat/data/database (accessed on 1 April 2024); https://sudop.uokik.gov.pl/home (accessed on 1 April 2024).

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

References

1. FAO. *Climate-Smart Agriculture. Policies, Practices and Financing for Food Security, Adaptation and Mitigation*; Food and Agriculture Organisation of the United Nations: Rome, Italy, 2010. Available online: https://www.fao.org/3/i1881e/i1881e00.htm (accessed on 10 November 2023).
2. Bogdanski, A. Integrated food–energy systems for climate-smart agriculture. *Agric. Food Secur.* **2012**, *1*, 9. [CrossRef]
3. Thornton, P.; Dijkman, J.; Herrero, M.; Szilagyi, L.; Cramer, L. Viewpoint: Aligning vision and reality in publicly funded agricultural research for development: A case study of CGIAR. *Food Policy* **2022**, *107*, 102196. [CrossRef]
4. Mohareb, E.; Heller, M.; Novak, P.; Goldstein, B.; Fonoll, X.; Raskin, L. Considerations for reducing food system energy demand while scaling up urban agriculture. *Environ. Res. Lett.* **2017**, *12*, 125004. [CrossRef]
5. Pimentel, D.; Williamson, S.; Alexander, C.E.; Gonzalez-Pagan, O.; Kontak, C.; Mulkey, S.E. Reducing energy inputs in the US food system. *Hum. Ecol.* **2008**, *36*, 459–471. [CrossRef]
6. Suchoń, A. Introductory Considerations. In *Energy Cooperatives in Selected Countries of the World. Legal and Economic Aspects*; Suchoń, A., Marzec, T., Eds.; Wydawnictwo Naukowe UAM: Poznań, Poland, 2023; pp. 19–32.
7. Mc Carthy, U.; Uysal, I.; Badia-Melis, R.; Mercier, S.; O'Donnell, C.; Ktenioudaki, A. Global food security—Issues, challenges and technological solutions. *Trends Food Sci. Technol.* **2018**, *77*, 11–20. [CrossRef]
8. WFP. *Energy for Food Security. Enhancing People's Food Security with Improved Energy Access*; World Food Programme: Rome, Italy, 2019. Available online: https://www.wfp.org/publications/energy-food-security (accessed on 10 November 2023).
9. FAO. *World Food and Agriculture—Statistical Yearbook 2023*; Food and Agriculture Organisation of the United Nations: Rome, Italy, 2023. Available online: https://www.fao.org/documents/card/en?details=cc8166en (accessed on 10 January 2024).
10. Sims, R.; Flammini, A.; Puri, M.; Bracco, S. *Opportunities for Agri-Food Chains to Become Energy-Smart*; Food and Agriculture Organisation of the United Nations: Rome, Italy, 2015. Available online: https://www.fao.org/publications/card/es/c/0ca1c73e-/ (accessed on 20 November 2023).
11. Kuzemko, C.; Blondeel, M.; Dupont, C.; Brisbois, M.C. Russia's war on Ukraine, European energy policy responses & implications for sustainable transformations. *Energy Res. Soc. Sci.* **2022**, *93*, 102842. [CrossRef]
12. LaBelle, M.C. Breaking the era of energy interdependence in Europe: A multidimensional reframing of energy security, sovereignty, and solidarity. *Energy Strategy Rev.* **2024**, *52*, 101314. [CrossRef]
13. FAO. *Climate-Smart Agriculture Sourcebook*; Food and Agriculture Organisation of the United Nations: Rome, Italy, 2013; Available online: https://www.fao.org/climate-smart-agriculture-sourcebook/en/ (accessed on 20 November 2023).

14. Langenheld, A.; Mellwig, P.; Pehnt, M.; Oehsen, A.; von Blömer, S.; Lempik, J.; Werle, M.; Ganal, I.; Gerhardt, N.; Becker, S.; et al. *Building Sector Efficiency: A Crucial Component of the Energy Transition*; Agora Energiewende: Berlin, Germany, 2018; Available online: https://www.agora-energiewende.org/publications/building-sector-efficiency-a-crucial-component-of-the-energy-transition (accessed on 20 November 2023).
15. Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on Energy Efficiency, Amending Directives 2009/125/EC and 2010/30/EU and Repealing Directives 2004/8/EC and 2006/32/EC. Available online: https://eur-lex.europa.eu/eli/dir/2012/27/oj (accessed on 10 January 2024).
16. Philipp, M.; Schumm, G.; Peesel, R.H.; Walmsley, T.G.; Atkins, M.J.; Schlosser, F.; Hesselbach, J. Optimal energy supply structures for industrial food processing sites in different countries considering energy transitions. *Energy* **2018**, *146*, 112–123. [CrossRef]
17. Oikonomou, V.; Eichhammer, W. Energy efficiency first principle in the regional governance. In Proceedings of the ECEEE Summer Study Proceedings, Stockholm, Sweden, 7–11 June 2021. Available online: https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2021/3-policy-finance-and-governance/energy-efficiency-first-principle-in-the-regional-governance/ (accessed on 25 January 2024).
18. Akella, A.K.; Saini, R.P.; Sharma, M.P. Social, economical and environmental impacts of renewable energy systems. *Renew. Energy* **2009**, *34*, 390–396. [CrossRef]
19. Akorede, M.F.; Hizam, H.; Pouresmaeil, E. Distributed energy resources and benefits to the environment. *Renew. Sustain. Energy Rev.* **2010**, *14*, 724–734. [CrossRef]
20. Commission Recommendation (EU) 2021/1749 of 28 September 2021 on Energy Efficiency First: From Principles to Practice—Guidelines and Examples for its Implementation in Decision-Making in the Energy Sector and Beyond. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021H1749 (accessed on 25 January 2024).
21. Tanaka, K. Review of policies and measures for energy efficiency in industry sector. *Energy Policy* **2011**, *39*, 6532–6550. [CrossRef]
22. Fawcett, T.; Rosenow, J.; Bertoldi, P. Energy efficiency obligation schemes: Their future in the EU. *Energy Effic.* **2019**, *12*, 57–71. [CrossRef]
23. Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on Energy Efficiency and Amending Regulation (EU) 2023/955 (Recast). Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:JOL_2023_231_R_0001 (accessed on 25 January 2024).
24. Gołyńska-Minkiewicz, M. Efektywność energetyczna w nowej perspektywie unijnej. *M. Zam. Pub.* **2023**, *7*, 16–19. Available online: https://www.monitor-zamowien.pl/artykul/efektywnosc-energetyczna-w-nowej-perspektywie-unijnej (accessed on 25 January 2024).
25. Łącka, I. Działalność innowacyjna i inwestycje w maszyny i urządzenia w przemyśle spożywczym w Polsce a wyzwania współczesnej gospodarki. *Rocz. Nauk. Ekon. Rol. I Rozw. Obsz. Wiej.* **2018**, *105*, 93–109. [CrossRef]
26. Brinkerink, J.; Chegut, A.; Letterie, W. Energy performance and capital expenditures in manufacturing industries. *Energy Effic.* **2019**, *12*, 2011–2038. [CrossRef]
27. Gołaś, Z.; Kurzawa, I. Profitability of the food industry in Poland: An ordered logit model approach. *Bus. Adm. Manag.* **2016**, *4*, 73–88. [CrossRef]
28. Martínez, D.M.; Ebenhack, B.W.; Wagner, T.P. Policy instruments to foster energy efficiency. In *Energy Efficiency*; Martínez, D.M., Ebenhack, B.W., Wagner, T.P., Eds.; Elsevier: Amsterdam, The Netherlands, 2019; pp. 271–305. [CrossRef]
29. ESMAP (Energy Sector Management Assistance Program). *Regulatory Indicators for Sustainable Energy (RISE)*; World Bank: Washington, DC, USA, 2022.
30. Gómez, J.; Luis Cordova, J. Theoretical and Legal Perspectives on Energy-Smart Agri-Food Systems: Sustainability and the Right to Food. *Global Jurist* **2024**, *24*, 1–24. [CrossRef]
31. Consolidated Version of the Treaty on the Functioning of the European Union, OJ C 326, 26.10.2012, p. 47–390. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:12012E/TXT (accessed on 26 May 2024).
32. Canning, P.; Charles, A.; Huang, S.; Polenske, K.; Waters, A. Energy Use in the U.S. Food System, ERR-94, U.S. Dept. of Agri., Econ. Res. Serv. March 2010. Available online: https://www.ers.usda.gov/webdocs/publications/46375/8144_err94_1_.pdf?v=0 (accessed on 25 January 2024).
33. Cuellar, A.; Webber, M. Wasted food, wasted energy: The embedded energy in food waste in the United States. *Environ. Sci. Technol.* **2010**, *44*, 6464–6469. [CrossRef] [PubMed]
34. Pelletier, N.; Audsley, E.; Brodt, S.; Garnett, T.; Henriksson, P.; Kendall, A.; Kramer, K.J.; Murphy, D.; Nemecek, T.; Troell, M. Energy intensity of agriculture and food systems. *Annu. Rev. Environ. Resour.* **2011**, *36*, 223–246. [CrossRef]
35. Klemeš, J.; Perry, S.J. Process optimisation to minimise energy use in food processing. In *Handbook of Waste Management and Co-Product Recovery in Food Processing*; Woodhead Publishing Series in Food Science, Technology and Nutrition; Woodhead Publishing: Sawston, UK, 2007; Volume 1, pp. 59–89. [CrossRef]
36. Wojdalski, J.; Drozdz, B. Efektywność energetyczna zakładów przemysłu spożywczego. Zarys problematyki i podstawowe definicje. *Inżynieria Przetwórstwa Spożywczego* **2012**, *3*, 37–50. Available online: http://agro.icm.edu.pl/agro/element/bwmeta1.element.agro-14bd20a0-bb3a-44c7-9030-a875ff23e2e9 (accessed on 25 January 2024).
37. Ramirez, C.; Patel, M.; Blok, K. How much energy to process one pound of meat? A comparison of energy use and specific energy consumption in the meat industry of four European countries. *Energy* **2006**, *31*, 2047–2063. [CrossRef]

38. Ladha-Sabur, A.; Bakalis, S.; Fryer, P.J.; Lopez-Quiroga, E. Mapping energy consumption in food manufacturing. *Trends Food Sci. Technol.* **2019**, *86*, 270–280. [CrossRef]
39. Wu, H.; Tassou, S.A.; Karayiannis, T.G.; Jouhara, H. Analysis and simulation of continuous food frying processes. *Appl. Therm. Eng.* **2013**, *53*, 332–339. [CrossRef]
40. Stamenković, Z.; Radojčin, M.; Pavkov, I.; Bikić, S.; Ponjičan, O.; Bugarin, R.; Kovács, S.; Gere, A. Ranking and multicriteria decision making in optimization of raspberry convective drying processes. *J. Chemom.* **2020**, *34*, e3224. [CrossRef]
41. Ahmadi, M.; Samimi-Akhijahani, H.; Salami, P. Thermo-economic and drying kinetic analysis of Oleaster using a solar dryer integrated with phase change materials and recirculation system. *J. Energy Storage* **2023**, *68*, 107351. [CrossRef]
42. Catorze, C.; Tavares, A.P.; Cardão, P.; Castro, A.; Silva, M.E.; Ferreira, D.W.; Lopes, S.; Brás, I.J.E.R. Study of a solar energy drying system-Energy savings and effect in dried food quality. *Energy Rep.* **2022**, *8*, 392–398. [CrossRef]
43. Fardet, A.; Rock, E. Ultra-Processed Foods and Food System Sustainability: What Are the Links? *Sustainability* **2020**, *12*, 6280. [CrossRef]
44. Stobiecka, M.; Król, J.; Brodziak, A. Antioxidant activity of milk and dairy products. *Animals* **2022**, *12*, 245. [CrossRef] [PubMed]
45. Szymańska, E.J.; Mroczek, R. Energy Intensity of Food Industry Production in Poland in the Process of Energy Transformation. *Energies* **2023**, *16*, 1843. [CrossRef]
46. GUS. *Statistical Yearbook of Industry 2023*; GUS: Warsaw, Poland, 2024.
47. GUS. *Statistical Yearbook of Agriculture 2023*; GUS: Warsaw, Poland, 2023.
48. Zuba-Ciszewska, M. Rola przemysłu spożywczego w gospodarce Polski. *Nierówności Społeczne A Wzrost Gospod.* **2020**, *64*, 69–86. [CrossRef]
49. Kowalczyk, S.; Kwasek, M. Agricultural sector in economy of Poland in 1950–2020. *West. Balk. J. Agric. Econ. Rural. Dev.* **2020**, *2*, 77–98. [CrossRef]
50. Sadowski, A.; Baer-Nawrocka, A. Food self-sufficiency of the European Union countries–energetic approach. *J. Agribus. Rural. Dev.* **2016**, *2*, 407–414. [CrossRef]
51. Eurostat. Energy Statistics. Available online: https://ec.europa.eu/eurostat/databrowser/explore/all/envir?lang=en&subtheme=nrg.nrg_quant&display=list&sort=category (accessed on 25 January 2024).
52. Szczepaniak, I.; Szajner, P. Challenges of Energy Management in the Food Industry in Poland in the Context of the Objectives of the European Green Deal and the "Farm to Fork" Strategy. *Energies* **2022**, *15*, 9090. [CrossRef]
53. Paska, J.; Surma, T.; Terlikowski, P.; Zagrajek, K. Electricity generation from renewable energy sources in Poland as a part of commitment to the polish and EU energy policy. *Energies* **2020**, *13*, 4261. [CrossRef]
54. Azzam, A. Energy Consumption in the U.S. Food System. In *Cornhusker Economics. 598*; University of Nebraska—Lincoln: Lincoln, NE, USA, 2012. Available online: https://digitalcommons.unl.edu/agecon_cornhusker/598 (accessed on 25 January 2024).
55. Eurostat. Business Structure and Dynamics. Available online: https://ec.europa.eu/eurostat/databrowser/explore/all/icts?lang=en&subtheme=bsd&display=list&sort=category (accessed on 26 January 2024).
56. Jóźwik, B.; Doğan, M.; Gürsoy, S. The Impact of Renewable Energy Consumption on Environmental Quality in Central European Countries: The Mediating Role of Digitalization and Financial Development. *Energies* **2023**, *16*, 7041. [CrossRef]
57. Bogdanski, A.; Dubois, O.; Jamieson, C.; Krell, R. *Making Integrated Food-Energy Systems Work for People and Climate*; Food and Agriculture Organisation of the United Nations: Rome, Italy, 2010; Available online: http://www.fao.org/docrep/013/i2044e/i2044e.pdf (accessed on 20 November 2023).
58. Jebli, M.B.; Youssef, S.B. The role of renewable energy and agriculture in reducing CO_2 emissions: Evidence for North Africa countries. *Ecol. Indic.* **2017**, *74*, 295–301. [CrossRef]
59. Azimoh, C.L.; Klintenberg, P.; Wallin, F.; Karlsson, B.; Mbohwa, C. Electricity for development: Mini-grid solution for rural electrification in South Africa. *Energy Conv. Manag.* **2016**, *110*, 268–277. [CrossRef]
60. Bößner, S.; Devisscher, T.; Suljada, T.; Ismail, C.J.; Sari, A.; Mondamina, N.W. Barriers and opportunities to bioenergy transitions: An integrated, multi-level perspective analysis of biogas uptake in Bali. *Biomass Bioenergy* **2019**, *122*, 457–465. [CrossRef]
61. Bößner, S.; Laderach, P.; Pacillo, G. *The Climate Security and Energy (Transition) Nexus: Winds of Change*; CGAIR FOCUS Climate Security: Montpellier, France, 2022. Available online: https://hdl.handle.net/10568/117581 (accessed on 20 November 2023).
62. Špička, J. Dynamic effects of public investment support in the food and beverage industries. *Agris Online Pap. Econ. Inform.* **2018**, *10*, 91–110. [CrossRef]
63. UOKiK. *Raport o Pomocy Publicznej w Polsce Udzielonej Przedsiębiorcom w 2016 Roku*; UOKiK: Warsaw, Poland, 2017. Available online: https://uokik.gov.pl/bip/raporty-pomoc-publiczna (accessed on 26 January 2024).
64. UOKiK. *Raport o Pomocy Publicznej w Polsce Udzielonej Przedsiębiorcom w 2022 Roku*; UOKiK: Warsaw, Poland, 2023. Available online: https://uokik.gov.pl/bip/raporty-pomoc-publiczna (accessed on 26 January 2024).
65. Ambroziak, A.A. Poland towards a new approach to state aid policy after accession to the European Union. In *Poland in the European Union. Report 2021*; Ambroziak, A.A., Ed.; Wydawnictwo SGH: Warszawa, Poland, 2021; pp. 37–56.
66. Ambroziak, A.A. State Aid Trends in Poland and Finland–Similarities and Differences. *Stud. Eur. Aff.* **2022**, *26*, 217–232. [CrossRef]
67. Zuba-Ciszewska, M. The role of state aid for the food industry-Based on the example of dairies in Poland. *Int. J. Manag. Econ.* **2023**, *59*, 101–116. [CrossRef]
68. Firlej, K. *Przemysł Spożywczy w Polsce. Nowa Ścieżka Rozwoju*; Wydawnictwo Naukowe PWN: Warszawa, Poland, 2017; pp. 125–131.

69. Communication from the Commission to the European Parliament, the European Council, the European Economic and Social Committee and the Committee of the Regions. The European Green Deal COM/2019/640 Final. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52019DC0640 (accessed on 20 November 2023).
70. Weatherill, S. *Law and Values in the European Union*; Oxford University Press: Oxford, UK, 2016; p. 432.
71. Huhta, K. The scope of state sovereignty under article 194(2) TFEU and the evolution of EU competences in the energy sector. *Int. Comp. Law Q.* **2021**, *70*, 991–1010. [CrossRef]
72. Decree-Law No. 68-A/2015—Diario da Regublica No. 84/2015, Supplement 1st, Series I, 2015-04-30 Ministry of Environment, Spatial Planning and Energy It Establishes Regulations on Energy Efficiency and Cogeneration Production, Transposing Directive 2012/27/EU of the European Parliament and of the Council of October 25, 2012 on Energy Efficiency. Available online: https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32012L0027 (accessed on 20 May 2024).
73. Wet van 28 Februari 2015 tot Wijziging van de Wet Implementatie EU-Richtlijnen Energie-Efficiëntie, de Elektriciteitswet 1998, de Gaswet en de Warmtewet in Verband Met de Implementatie van Richtlijn 2012/27/EU Betreffende Energie-Efficiëntie, Official Publication: Staatsblad (Bulletin des Lois et des Décrets royaux). Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=NIM:225468 (accessed on 20 May 2024).
74. Christiernsson, A.; Geijer, M.; Malafry, M. Legal Aspects on Cultural Values and Energy Efficiency in the Built Environment-A Sustainable Balance of Public Interests? *Heritage* **2021**, *4*, 3507–3522. [CrossRef]
75. Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the Reduction of National Emissions of Certain Atmospheric Pollutants. OJ L 344, 17.12.2016, p. 1–31. Available online: https://eur-lex.europa.eu/eli/dir/2016/2284/oj (accessed on 26 May 2024).
76. Popescu, D.; Bienert, S.; Schützenhofer, C.; Boazu, R. Impact of energy efficiency measures on the economic value of buildings. *Appl. Energy* **2012**, *89*, 454–463. [CrossRef]
77. Bukowski, M.; Majewski, J.; Sobolewska, A.; Stawicka, E.; Suchoń, A. *Wybrane Ekonomiczne i Prawne Aspekty Wytwarzania Energii z Instalacji Fotowoltaicznych w Gospodarstwach Rolnych Województwa Mazowieckiego*; Wydawnictwo SGGW: Warsaw, Poland, 2022; pp. 27–100. Available online: https://www.ieif.sggw.pl/wp-content/uploads/2022/11/Wybrane-ekonomiczne-i-prawne-aspekty_fotowoltaiczne_MajewskiJ-wersja-el-1.pdf (accessed on 26 January 2024).
78. Council of the EU and the European Council. European Green Deal. Available online: https://www.consilium.europa.eu/en/policies/green-deal/ (accessed on 20 November 2023).
79. Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 Establishing the Framework for Achieving Climate Neutrality and Amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law') PE/27/2021/REV/1 OJ L 243, 9.7.2021, p. 1–17. Available online: https://eur-lex.europa.eu/eli/reg/2021/1119/oj (accessed on 28 May 2024).
80. United Nations, Transforming our World: The 2030 Agenda for Sustainable Development. Available online: https://sdgs.un.org/2030agenda (accessed on 28 May 2024).
81. Gillespie, A. *International Environmental Law, Policy and Ethics*; Oxford University Press: Oxford, UK, 2014; pp. 20–25.
82. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. 'Fit for 55': Delivering the EU's 2030 Climate Target on the Way to Climate Neutrality COM/2021/550 Final. Available online: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2021:550:FIN (accessed on 20 November 2023).
83. Gesetz zur Steigerung der Energieeffizienz und zur Änderung des Energiedienstleistungsgesetzes Vom 13. November 2023. Available online: https://www.recht.bund.de/bgbl/1/2023/309/regelungstext.pdf?__blob=publicationFile&v=2 (accessed on 20 May 2024).
84. Decreto Legislativo 4 Luglio 2014, n. 102 "Attuazione Della Direttiva 2012/27/UE Sull'efficienza Energetica, Che Modifica le Direttive 2009/125/CE e 2010/30/UE e Abroga le Direttive 2004/8/CE e 2006/32/CE". Available online: https://www.gazzettaufficiale.it/eli/id/2014/07/18/14G00113/sg (accessed on 20 May 2024).
85. Decreto-Legge 9 Dicembre 2023, n. 181 Disposizioni Urgenti per la Sicurezza Energetica del Paese, la Promozione del Ricorso alle Fonti Rinnovabili di Energia, il Sostegno alle Imprese a Forte Consumo di Energia e in Materia di Ricostruzione nei Territori Colpiti Dagli Eccezionali Eventi Alluvionali Verificatisi a Partire dal 1° Maggio 2023. (23G00195). Available online: https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:decreto.legge:2023-12-09;181 (accessed on 20 May 2024).
86. Ustawa z Dnia 20 Maja 2016 r. o Efektywności Energetycznej. Dz. U. z 2021 r. poz. 2166, z 2023 r. poz. 1681. Available online: https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20160000831/U/D20160831Lj.pdf (accessed on 20 November 2023).
87. Czarnecka, M.; Ogłódek, T. (Eds.) *Ustawa o Efektywności Energetycznej*; Komentarz; Wydawnictwo C.H.Beck: Warszawa, Poland, 2023.
88. Gieroń, K. *Efektywność Energetyczna*; Komentarz; Wolters Kluwer: Warszawa, Poland, 2021; pp. 5–20.
89. Sikora, A. Wybrane aspekty publicznego finansowania energii odnawialnej w świetle zasad pomocy państwa. *Eur. Przegląd Sądowy* **2015**, *4*, 28–33.
90. Popardowski, P. Pomoc państwa na rzecz produkcji energii ze źródeł odnawialnych (analiza z zakresu prawa krajowego i unijnego). In *Ekonomiczne, Prawne i Społeczne Uwarunkowania Produkcji i Korzystania z Odnawialnych Źródeł Energii*; Gołasa, P., Litwiniuk, P., Eds.; Wydawnictwo SGGW: Warszawa, Poland, 2023; pp. 13–26.

91. Ustawa z Dnia 6 Marca 2018 Prawo Przedsiębiorców, Dz. U. 2018, poz. 646. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20180000646 (accessed on 28 May 2024).
92. Glibowski, K. *Białe Certyfikaty i Świadectwa Efektywności Energetycznej w UE. Analiza Porównawcza Regulacji Systemowych Przyjętych w Wielkiej Brytanii, Francji, we Włoszech i w Polsce*; Wydawnictwo C.H.Beck: Warszawa, Poland, 2018; pp. 12–22.
93. Obwieszczenie Ministra Klimatu i Środowiska z Dnia 30 Listopada 2021 r. w Sprawie Szczegółowego Wykazu Przedsięwzięć Służących Poprawie Efektywności Energetycznej. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WMP20210001188 (accessed on 20 November 2023).
94. Obwieszczenie Ministra Klimatu i Środowiska z dnia 2 Marca 2021 r. w Sprawie Polityki Energetycznej Państwa do 2040 r. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WMP20210000264 (accessed on 20 November 2023).
95. Ustawa z Dnia 20 Lutego 2015 r. o Odnawialnych źródłach Energii. Dz. U. 2023 r. poz. 1436, 1681, 1597, 1762. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=wdu20150000478 (accessed on 20 November 2023).
96. Ustawa z Dnia 10 Kwietnia 1997 r. Prawo Energetyczne, t.j. Dz. U. z 2024 r. poz. 266. Available online: https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU19970540348/U/D19970348Lj.pdf (accessed on 29 May 2024).
97. Ziarkowski, M. Szanse i kierunki transformacji ciepłownictwa systemowego w Polsce. *Internetowy Kwart. Antymonop. I Regul. IKAR* **2020**, *6*, 28–42. [CrossRef]
98. Onovwiona, H.I.; Ugursal, V.I. Residential cogeneration systems: Review of the current technology. *Renew. Sustain. Energy Rev.* **2006**, *10*, 389–431. [CrossRef]
99. Kogeneracja Wysokosprawna—Nowoczesny Sposób na Tańszą Energię. Available online: https://nowa-energia.com.pl/2023/03/17/kogeneracja-wysokosprawna-nowoczesny-sposob-na-tansza-energie/ (accessed on 20 November 2023).
100. Bałdowski, M.; Maruszak, M. Nowy system wsparcia dla energii wytwarzanej z wysokosprawnej kogeneracji—Wybrane aspekty prawne. *Internetowy Kwart. Antymonop. I Regul. IKAR* **2020**, *6*, 54–65. [CrossRef]
101. Kalam, A.; King, A.; Moret, E.; Weerasinghe, U. Combined heat and power systems: Economic and policy barriers to growth. *Chem. Cent. J.* **2012**, *6*, S3. [CrossRef]
102. Mancarella, P.; Chicco, G. Assessment of the greenhouse gas emissions from cogeneration and trigeneration systems. Part II: Analysis techniques and application cases. *Energy* **2008**, *33*, 418–430. [CrossRef]
103. Ustawa z Dnia 14 Grudnia 2018 r. o Promowaniu Energii Elektrycznej z Wysokosprawnej Kogeneracji. Dz.U. 2019 poz. 42. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20190000042 (accessed on 20 November 2023).
104. Oikonomou, V. *Interactions between White Certificates for Energy Efficiency and Other Energy and Climate Policy Instruments*; In The Social and Behavioral Aspects of Climate Change: Linking Vulnerability, Adaptation and Mitigation; Routledge: London, UK, 2017; pp. 177–200.
105. Ustawa z Dnia 27 Sierpnia 2009 r. o Finansach Publicznych. Dz.U. 2023 r., poz. 1270, 1273. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=wdu20091571240 (accessed on 20 November 2023).
106. Suchoń, A. De Minimis Aid in Agriculture in Poland—Selected Legal Issues. In *Jahrbuch des Agrarrechtps: Band XV (Schriften zum Agrar-, Umwelt- und Verbraucherschutzrecht, vol. 86)*; José, M., Ed.; Nomos Verlagsgesellschaft: Baden-Baden, Germany, 2021; pp. 139–152. [CrossRef]
107. Pamuła-Wróbel, K.; Grzegorzewska, B. Podstawowe pojęcia i system źródeł prawa pomocy publicznej. In *Pomoc Publiczna dla Przedsiębiorców. Wybrane Zagadnienia. Perspektywa Podmiotu Udzielającego Pomocy i jej Beneficjenta w Polsce*; Ambroziak, A.A., Pamuła-Wróbel, K., Zenc, R., Eds.; Wolters Kluwer Polska: Warszawa, Poland, 2019; pp. 25–50.
108. Hancher, L.; Salerno, F.M.; Hauteclocque, A.D. State Aid and the Energy Sector. Bloomsbury Publishing: London, UK, 2018; p. 110.
109. Commission Regulation (EC) No 794/2004 of 21 April 2004 Implementing Council Regulation (EC)No 659/1999 Laying Down Detailed Rules for the Application of Article 93 of the EC Treaty, OJ L 140, 30.4.2004. Available online: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32004R0794 (accessed on 20 November 2023).
110. Council Regulation (EC) No 994/98 of 7 May 1998 on the Application of Articles 92 and 93 of the Treaty Establishing the European Community to Certain Categories of Horizontal State Aid, OJ L 142, 14.5.1998. Available online: https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:31998R0994 (accessed on 20 November 2023).
111. Kurcz, B. Komentarz do art. 107-109. In *Komentarz do Traktatu o funkcjonowaniu Unii Europejskiej Tom II*; Wróbel, K., Kowalik-Bańczyk, K., Szwarc-Kuczer, M., Eds.; Wolters Kluwer: Warszawa, Poland, 2012; pp. 107–109.
112. Council Regulation (EU) 2015/1588 of 13 July 2015 on the Application of Articles 107 and 108 of the Treaty on the Functioning of the European Union to Certain Categories of Horizontal State Aid (Codification), OJ L 248, 24.9.2015. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015R1588 (accessed on 20 November 2023).
113. Kaznowski, A. Pomoc inwestycyjna umożliwiająca przedsiębiorstwom zastosowanie norm surowszych niż normy unijne w zakresie ochrony środowiska lub podniesienie poziomu ochrony środowiska w przypadku braku norm unijnych. In *Pomoc Publiczna dla Przedsiębiorców. Wybrane Zagadnienia*; Ambroziak, A.A., Pamuła-Wróbel, K., Zenc, R., Eds.; Wolters Kluwer Polska: Warszawa, Poland, 2019; pp. 191–193.
114. Rozporządzenie Ministra Środowiska z dnia 21 Grudnia 2015 r. w Sprawie Szczegółowych Warunków Udzielania Horyzontalnej Pomocy Publicznej na cele z Zakresu Ochrony Środowiska. Dz.U. 2015 poz. 2250. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20150002250 (accessed on 20 November 2023).

115. Ustawa z dnia 27 Kwietnia 2001 r. Prawo Ochrony Środowiska. Dz.U. 2001 nr 62 poz. 627. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=wdu20010620627 (accessed on 20 November 2023).
116. Commission Regulation (EU) No 651/2014 of 17 June 2014 Declaring Certain Categories of Aid Compatible with the Internal Market in Application of Articles 107 and 108 of the Treaty Text with EEA Relevance, OJ L 187, 26.6.2014. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.187.01.0001.01.ENG (accessed on 20 November 2023).
117. RPO. Available online: https://www.rpo.malopolska.pl/download/program-regionalny/o-programie/przeczytaj-analizy-aporty-i-podsumowania/ewaluacja/2024/01/Raport_koncowy_energia_1412.pdf (accessed on 20 November 2023).
118. Communication from the Commission—Guidelines on State Aid for Climate, Environmental Protection and Energy 2022, OJ C 80, 18.2.2022. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52022XC0218(03) (accessed on 20 November 2023).
119. Rozporządzenie Ministra Funduszy i Polityki Regionalnej z dnia 11 Grudnia 2022 r. w Sprawie Udzielania Pomocy na Inwestycje w układy Wysokosprawnej Kogeneracji oraz na Propagowanie Energii ze Źródeł Odnawialnych w Ramach Regionalnych Programów na lata 2021–2027. Dz.U. 2022 poz. 2693. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20220002693 (accessed on 20 November 2023).
120. Suchoń, A. The Contribution of Different Types of Cooperatives to the Production and Use of Renewable Energy in Poland. In *Energy Cooperatives in Selected Countries of the World. Legal and Economic Aspects*; Suchoń, A., Marzec, T., Eds.; Wydawnictwo Naukowe UAM: Poznań, Poland, 2023; pp. 191–227.
121. Marzec, T. Legal Determinants of Energy Cooperatives' Development in Poland. In *Energy Cooperatives in Selected Countries of the World. Legal and Economic Aspects*; Suchoń, A., Marzec, T., Eds.; Wydawnictwo Naukowe UAM: Poznań, Poland, 2023; pp. 155–175.
122. Huang, H. Powering Up: Exploring Energy Cooperatives in Taiwan through a Case Study. In *Energy Cooperatives in Selected Countries of the World. Legal and Economic Aspects*; Suchoń, A., Marzec, T., Eds.; Wydawnictwo Naukowe UAM: Poznań, Poland, 2023; pp. 229–238.
123. Loureiro de Matos, I. Energy Cooperatives in Brazil. In *Energy Cooperatives in Selected Countries of the World. Legal and Economic Aspects*; Suchoń, A., Marzec, T., Eds.; Wydawnictwo Naukowe UAM: Poznań, Poland, 2023; pp. 239–250.
124. Regulation (EU) 2021/241 of the European Parliament and of the Council of 12 February 2021 Establishing the Recovery and Resilience Facility, OJ L 57, 18.2.2021. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R0241 (accessed on 20 November 2023).
125. Krajowy Plan Odbudowy i Zwiększania Odporności. Available online: https://www.gov.pl/web/klimat/KPO (accessed on 20 January 2024).
126. Rozporządzenie Ministra Aktywów Państwowych z dnia 15 Listopada 2023 r. w Sprawie Udzielania Pomocy Publicznej na Inwestycje Wspierające Efektywność Energetyczną i Odnawialne Źródła Energii w Przedsiębiorstwach w Ramach Krajowego Planu Odbudowy i Zwiększania Odporności. Dz.U. 2023 poz. 2515. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20230002515 (accessed on 20 November 2023).
127. Rozporządzenie Ministra Klimatu i Środowiska z dnia 15 Lutego 2024 r. w Sprawie Szczegółowych Warunków Udzielania przez Wojewódzkie Fundusze Ochrony Środowiska i Gospodarki Wodnej Horyzontalnej Pomocy Publicznej na Cele z Zakresu Ochrony Środowiska. Dz.U. 2024 poz. 213. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20240000213 (accessed on 20 November 2023).
128. Obwieszczenie Ministra Klimatu i Środowiska z dnia 23 listopada 2023 r. w Sprawie Wykazu Programów i Instrumentów Finansowych Dotyczących Przedsięwzięć Służących Poprawie Efektywności Energetycznej u Odbiorcy Końcowego M.P. 2023 poz. 1302. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WMP20230001302 (accessed on 29 May 2024).
129. Plan Strategiczny dla Wspólnej Polityki Rolnej na lata 2023–2027 (PS WPR 2023–2027) i Regulacje Prawne. Available online: https://www.gov.pl/web/rolnictwo/plan-strategiczny-dla-wspolnej-polityki-rolnej-na-lata-2023-27 (accessed on 29 May 2024).
130. Regulation (EU) 2021/2115 of the European Parliament and of the Council of 2 December 2021 Establishing Rules on Support for Strategic Plans to be Drawn up by Member States under the Common Agricultural Policy (CAP Strategic Plans) and Financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and Repealing Regulations (EU) No 1305/2013 and (EU) No 1307/2013. OJ L 435, 6.12.2021, p. 1–186. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R2115 (accessed on 29 May 2024).
131. SUDOP. Available online: https://sudop.uokik.gov.pl (accessed on 26 January 2024).
132. Ustawa z Dnia 30 Kwietnia 2004 r. o Postępowaniu w Sprawach Dotyczących Pomocy Publicznej. Dz.U. 2004 nr 123 poz. 1291. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20041231291 (accessed on 20 May 2023).
133. Commission Regulation (EU) No 1407/2013 of 18 December 2013 on the Application of Articles 107 and 108 of the Treaty on the Functioning of the European Union to de Minimis aid Text with EEA Relevance, OJ L 352, 24.12.2013. Available online: https://eur-lex.europa.eu/eli/reg/2013/1407/oj (accessed on 20 November 2023).
134. Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, Amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and Repealing Regulation (EU) No

525/2013 of the European Parliament and of the Council (Text with EEA Relevance). OJ L 328, 21.12.2018, p. 1–77. Available online: https://eur-lex.europa.eu/eli/reg/2018/1999/oj (accessed on 20 May 2024).
135. Regulation (EU) 2021/1056 of the European Parliament and of the Council of 24 June 2021 Establishing the Just Transition Fund; OJ L 231, 30.6.2021, p. 1–20. Available online: https://eur-lex.europa.eu/eli/reg/2021/1056/oj (accessed on 20 May 2024).
136. Princen, S.; Hoppe, A.; Hübner, M.; Svec, M.; Mak, E.; Taimr, A. Flexible Implementation and the Energy Efficiency Directive. 2022. Available online: https://cadmus.eui.eu/bitstream/handle/1814/74413/RSC_2022_31.pdf?sequence=1&isAllowed=y (accessed on 29 May 2024).
137. GUS. *Statistical Yearbook of Industry 2011*; GUS: Warsaw, Poland, 2012.
138. Jakimowicz, A.; Rzeczkowski, D. Diversification of innovation strategies of Polish industrial processing enterprises depending on their size after the global financial crisis. *J. Entrep. Manag. Innov.* **2019**, *15*, 35–76. [CrossRef]
139. Zielińska-Chmielewska, A. Greening of production process in food processing enterprises in Poland. In Proceedings of the 8th International Scientific Conference Rural Development 2017, Aleksandras Stulginskis University, Kaunas, Lithuania, 23–24 November 2017; Raupelienė Asta; pp. 1457–1462. [CrossRef]
140. Markandya, A.; Labandeira, X.; Ramos, A. Policy Instruments to Foster Energy Efficiency. In *Green Energy and Efficiency. Green Energy and Technology*; Ansuategi, A., Delgado, J., Galarraga, I., Eds.; Springer International Publishing: London, UK, 2015; pp. 93–110. [CrossRef]
141. Wiese, C.; Larsen, A.; Pade, L.L. Interaction effects of energy efficiency policies: A review. *Energy Effic.* **2018**, *11*, 2137–2156. [CrossRef]
142. Wang, L. Energy efficiency technologies for sustainable food processing. *Energy Effic.* **2014**, *7*, 791–810. [CrossRef]
143. Mlekovita. Available online: https://mlekovita.com.pl/pl/strona/kogeneracja-o-99-mw-w-lubawie (accessed on 26 January 2024).
144. Kijek, T.; Kijek, A.; Bolibok, P.; Matras-Bolibok, A. The Patterns of Energy Innovation Convergence across European Countries. *Energies* **2021**, *14*, 2755. [CrossRef]
145. Rokicki, T.; Perkowska, A.; Klepacki, B.; Bórawski, P.; Bełdycka-Bórawska, A.; Michalski, K. Changes in Energy Consumption in Agriculture in the EU Countries. *Energies* **2021**, *14*, 1570. [CrossRef]
146. Mandel, T.; Pató, Z.; Broc, J.S.; Eichhammer, W. Conceptualising the energy efficiency first principle: Insights from theory and practice. *Energy Effic.* **2022**, *15*, 41. [CrossRef]
147. Clairand, J.M.; Briceno-Leon, M.; Escriva-Escriva, G.; Pantaleo, A.M. Review of energy efficiency technologies in the food industry: Trends, barriers, and opportunities. *IEEE Access* **2020**, *8*, 48015–48029. [CrossRef]
148. Kang, H.S.; Lee, J.Y.; Choi, S.; Kim, H.; Park, J.H.; Son, J.Y.; Kim, B.H.; Noh, S.D. Smart manufacturing: Past research, present findings, and future directions. *Int. J. Precis. Eng. Manuf.-Green Technol.* **2016**, *3*, 111–128. [CrossRef]
149. Sovacool, B.K.; Bazilian, M.; Griffiths, S.; Kim, J.; Foley, A.; Rooney, D. Decarbonizing the food and beverages industry: A critical and systematic review of developments, sociotechnical systems and policy options. *Renew. Sustain. Energy Rev.* **2021**, *143*, 110856. [CrossRef]
150. Grau, A.; Reig, A. Operating leverage and profitability of SMEs: Agri-food industry in Europe. *Small Bus. Econ.* **2021**, *57*, 221–242. [CrossRef]